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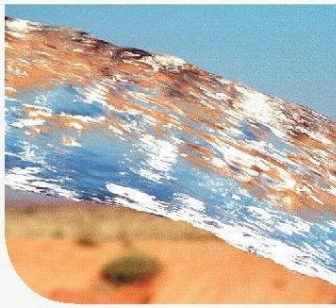

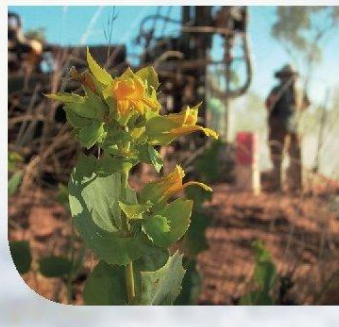

ABRA LEAD-SILVER PROJECT

HYDROLOGY AND SURFACE-WATER ASSESSMENT

REPORT FOR

GALENA MINING LTD

SEPTEMBER 2018

Rockwater
HYDROGEOLOGICAL AND ENVIRONMENTAL CONSULTANTS

Report No. 496-0/18/02rev

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REVISION	AUTHOR	REVIEW	AUTHORISED	ISSUED
0	CC	PHW		29/8/18
1	CC	PHW		13/9/18

1. INTRODUCTION

Galena Mining Ltd is conducting a pre-feasibility study for mining its Abra lead-silver deposit, located 200 km north of Meekatharra in the Jillawarra sub-basin of the Proterozoic Edmund Basin. The project lies on a south-east facing slope. There are two major drainage lines about 200 m south and 400 m east of the project. Also, some of the project's planned infrastructure intersects or lies between two small creeks.

Rockwater Pty Ltd was commissioned by Galena Mining Ltd to prepare a surface water management plan to assess the potential impact of flood flows on surface infrastructure and to determine the bunding and drainage requirements.

Applicable catchments are shown in Figures 1 and 3, together with topographic contours (1 m interval).

The scope of work covered in this report includes the following:

- Identification of catchment areas and natural water courses that could impact the project's surface installations;
- Hydrological analyses to estimate peak flows for 1 in 2, 5, 10, 20, 50 and 100-year ARI rainfalls for the critical storm duration in the relevant catchment areas; and for a 1-in-2000-year rainfall, taken to be the Probable Maximum Precipitation (PMP) event;
- Surface water hydraulic analyses at critical locations and sections in order to examine the impact of the 1 in 100 year ARI peak flow and Probable Maximum Flood; and
- Identifying and providing advice and concept design and recommendations for perimeter bunds and any diversion channels needed to prevent flooding during the 1 in 100 year ARI flow event, and drainage requirements.

1.1. INFORMATION PROVIDED BY GALENA

The following information and data were provided by Galena Mining Ltd:

- The planned layout of the site; and
- 1.0 m-interval topographic contours covering the catchments that could impact on the project.

2. SURFACE WATER HYDROLOGY

The Abra project is elevated well above the surrounding major drainage lines. However, the project's planned infrastructure intersects or lies close to two minor creeks. There are two major catchments (A and B, Fig. 1) with the potential for peak flows to impact the project area and underground mine, and three smaller catchments (C, D and E, Fig. 3) that could impact the project's surface infrastructure.

For this assessment, the methods described in the Australian Rainfall and Runoff 1987 (AR&R, 1987) Guideline and later versions were used. However, recent studies showed that the guideline presented in AR&R 1987 for the Pilbara region tends to over-estimate the peak flows. More recent and less conservative methods were developed for analyses in the Pilbara region (e.g. Flavell 2012, Davies & Yip 2014, and the revised Australian Rainfall and Runoff 2016). However, no strict guidelines were established

for this region using the recent methods, and so the results from the AR&R 1987 were assumed to be appropriate for the purpose of this report.

2.1. RAINFALL ANALYSIS

Intensity-Frequency-Duration (IFD) curves for the Abra site were obtained from the Bureau of Meteorology web-site, and are based on the statistical and meteorological analyses given in the AR&R 1987 Guideline (Pilgrim et. al., 1987). The IFD tables and curves are included in Appendix I.

The Probable Maximum Precipitation (PMP) was taken to be a 1-in-2000 year event, with a probability of it occurring in any year of 0.05%. The design rainfall for this event is also included in a table and chart in Appendix I. The Probable Maximum Flood (PMF) would result from a PMP event.

2.2. IDENTIFICATION OF CATCHMENT AREAS

The relevant catchment areas were identified from the 1.0 m interval contour plan (Fig. 1 and Fig. 3) where they would impact on key points on the drainage lines. Note that Catchment B forms part of the larger Catchment A, and Catchment C is a sub-catchment of Catchment D. These areas were used in the peak flow estimation analysis as described in Section 2.6.

2.3. TIME OF CONCENTRATION

The time of concentration is required to estimate the critical storm duration for peak flows in each catchment. This was estimated using Equation 1 for the Pilbara Region of Western Australia as recommended by AR&R 1987 and later editions:

$t_c = 0.56 \cdot A^{0.38}$ Equation 1

Where:
t_c is the time of concentration (hours)
A is the catchment area (km^2)

2.4. RATIONAL METHOD

The Statistical Rational Method, used in peak-flow estimation, is presented in Equation 2.

$$Q_y = 0.278 \cdot C_y \cdot I_{tcy} \cdot A$$ Equation 2

Where:
Q_y is the peak flow for return period of y years (m^3/s)
0.278 is a dimensionless metric conversion factor
C_y is the runoff coefficient for y years (dimensionless)
I_{tcy} is rainfall intensity (mm/hr)
A is catchment area (km^2)

2.5. FLOOD INDEX METHOD

The Flood Index Method for the Pilbara Region, also used in peak-flow estimation, is presented in Equation 3.

$$Q_5 = 6.73 \times 10^{-4} \cdot \mathrm{A}^{0.72} \cdot \mathrm{P}^{1.51} \qquad \text{Equation 3}$$

Where:

Q_5 is the peak discharge for the 5-year ARI flow (m^3/s)

A is the catchment area (km^2)

P is the average annual rainfall (mm)

2.6. HYDROLOGY RESULTS FOR THE MINE, INFRASTRUCTURE AND ACCESS ROAD CATCHMENTS

The characteristics of the catchments which could impact the Abra project are listed in Tables 1 and 2. The nearest Bureau of Meteorology (BoM) station is Tangadee (Stn. 007179), located 45 km east-north-east of Abra. Annual Rainfall (1960 to 2018) averages 269 mm.

Table 1: Major Catchment Characteristics (Fig. 1)

Catchment	Area (km^2)	Length (km)
A	40.5	7.6
B	5.5	4.0

Table 2: Minor Catchment Characteristics (Fig. 3)

Catchment	Area (km^2)	Length (km)
C	0.12	0.7
D	0.74	1.5
E	1.17	2.1

A summary of the design peak flows, as estimated using the Rational and Flood Index Methods, is shown in Table 3. The detailed calculations are presented in Appendix I.

Table 3: Estimated Peak Flows for Each Catchment

Catchment A	ARI (years) / Discharge (m³/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	23.88	52.81	98.22	197.32	361.81	633.25	
Index	22.99	45.11	79.65	136.38	256.59	404.80	
Adopted (average)	**23.43**	**48.96**	**88.93**	**166.85**	**309.20**	**519.03**	**894.55**
Catchment B	ARI (years) / Discharge (m³/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	6.30	13.61	25.00	49.69	89.90	156.06	
Index	5.67	10.72	17.83	28.61	49.75	82.71	
Adopted (average)	**5.98**	**12.16**	**21.42**	**39.15**	**69.82**	**119.38**	**205.76**
Catchment C	ARI (years) / Discharge (m³/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	0.41	0.87	1.59	3.15	5.67	9.80	
Index	0.40	0.69	1.03	1.46	2.19	3.35	
Adopted (average)	**0.40**	**0.78**	**1.31**	**2.31**	**3.93**	**6.58**	**11.33**
Catchment D	ARI (years) / Discharge (m³/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	1.37	2.97	5.46	10.90	19.76	34.31	
Index	1.40	2.54	3.98	5.98	9.61	15.29	
Adopted (average)	**1.38**	**2.75**	**4.72**	**8.44**	**14.68**	**24.80**	**42.74**
Catchment E	ARI (years) / Discharge (m³/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	1.81	3.93	7.24	14.46	26.25	45.64	
Index	1.92	3.52	5.59	8.53	13.95	22.40	
Adopted	**1.86**	**3.72**	**6.41**	**11.49**	**20.10**	**34.02**	**58.63**

** PMF estimated using multiplying factors from CRC-FORGE results*

3. HYDRAULIC ANALYSES

3.1. IMPACT OF MAJOR FLOWS ON THE PROJECT AREA

Flows in catchments A and B (Fig. 1) were analysed to assess whether the 1 in 100 year ARI peak flows and Probable Maximum Flood (PMF) could reach the project area and underground mines.

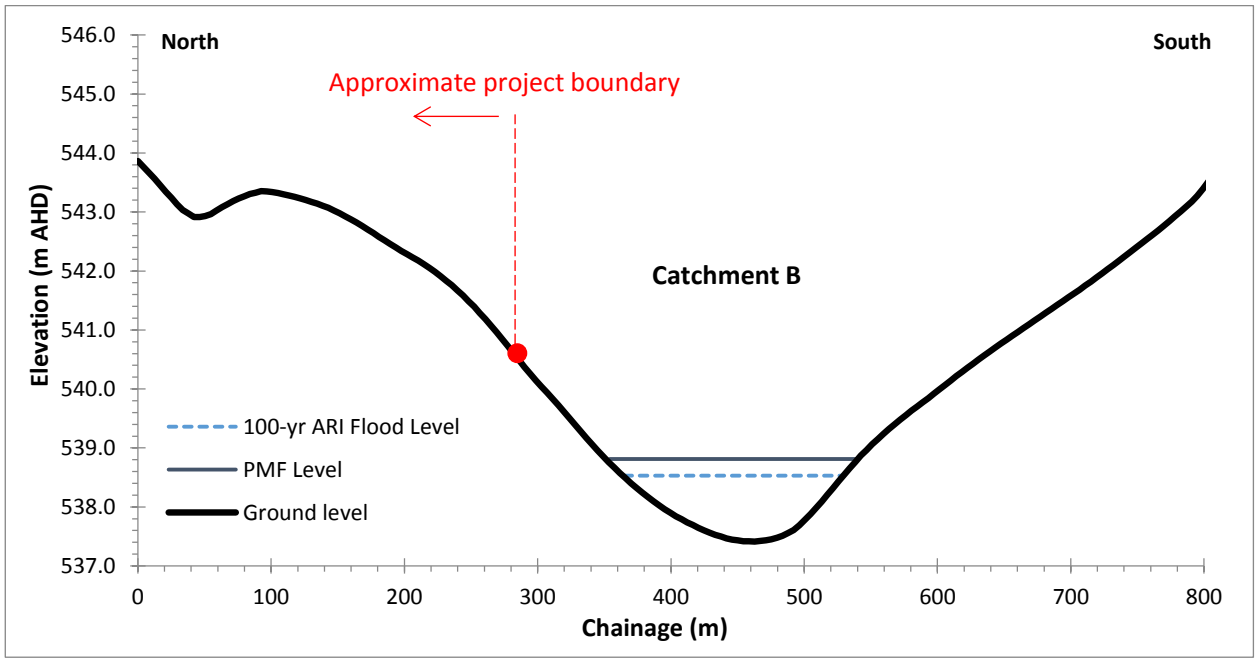
The locations of the major flow paths that could impact the project were identified from aerial photography and the 1 m contour plan (Fig. 1). The extent, velocity and flows within these flow paths were then determined at selected cross-sections where stage-discharge and stage-velocity relationships were calculated using Manning's equation.

Hydraulic analyses were conducted at four cross-sections (cross-sections 1 to 4, Fig. 2) to assess whether the peak flows would reach the project's boundaries. Note: all cross-sections presented in this report are looking downstream from the natural creeks.

3.1.1. CROSS-SECTION 1 – SOUTH OF THE PLANNED MINE

In a 1-in-100 year flood, the peak flood levels from Catchment B, south of the project, would be at about 538.53 m AHD with a width of about 165 m, and the level would be about 0.28 m higher in a Probable Maximum Flood (PMF). These flood levels would have significant flow, depth and extent; however, they should not impact the project area as shown in Text-Figure 1 below.

Text-Figure 1: Cross Section 1 with 100 year ARI flood level and PMF



The maximum depth of the 1-in-100 year flood would be about 1.12 m and the maximum velocity in the order of 1.0 m/s (Table 4).

Table 4: Cross-section 1*, 100-year ARI flood and PMF summary

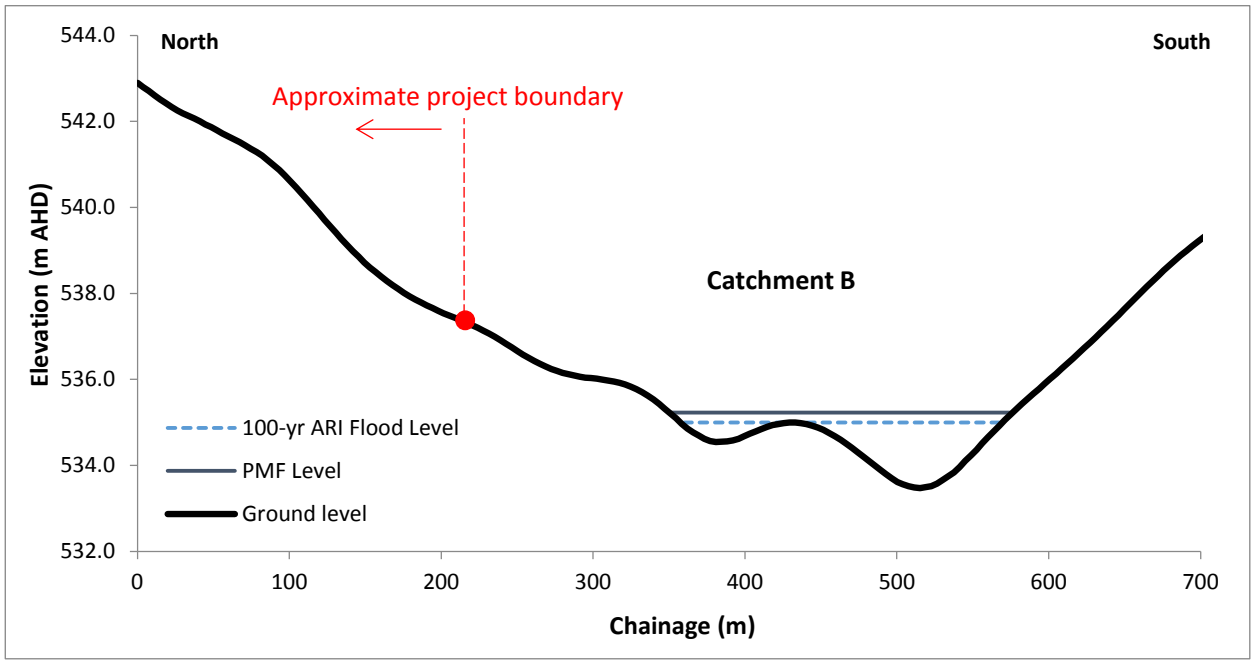
Flood Analysis	Flow (m^3/s)	Flood Level Elevation (m AHD)	Depth (m)	Velocity (m/s)	Extent of Flood Level (m)
100-yr	119	538.53	1.12	1.0	165
PMF	206	538.81	1.40	1.2	185

* Catchment B

3.1.2. CROSS-SECTION 2 – SOUTH-EAST OF THE PLAANNED MINE

In a 1-in-100 year flood, the peak flood levels from Catchment B, south and west of the project, would be at 535.00 m AHD with a width of about 212 m, and the level would be 0.23 m higher in a Probable Maximum Flood (PMF). These flood levels would be of significant flow, depth and extent, however, would not impact the project area as shown in Text-Figure 2 below.

Text-Figure 2: Cross Section 2 with 100 year ARI flood level and PMF



The maximum depth of the 1-in-100 year flood would be about 1.5 m and the maximum velocity in the order of 1.1 m/s (Table 5).

Table 5: Cross-section 2*, 100-year ARI flood and PMF summary

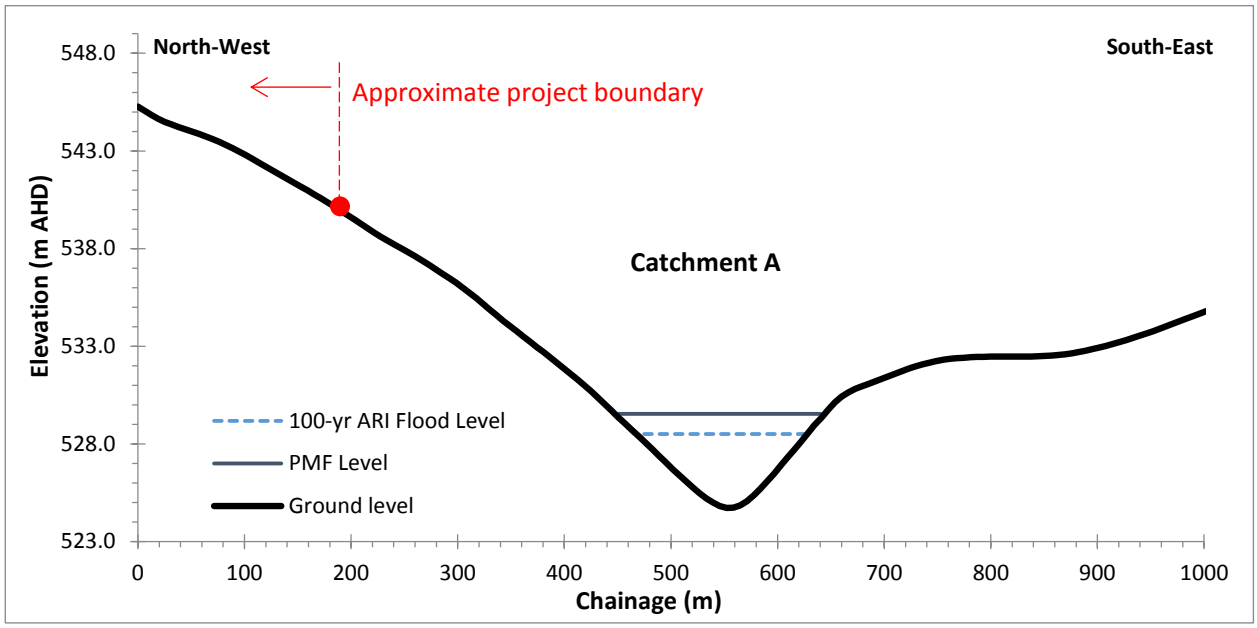
Flood Analysis	Flow (m^3/s)	Flood Level Elevation (m AHD)	Depth (m)	Velocity (m/s)	Extent of Flood Level (m)
100-yr	119	535.00	1.53	1.1	212
PMF	206	535.23	1.76	1.2	224

* Catchment B

3.1.3. CROSS-SECTION 3 – SOUTH-EAST OF THE PLANNED INFRASTRUCTURE

In a 1-in-100 year flood, the peak flood levels from Catchment A, south and east of the infrastructure, would be at 528.51 m AHD with a width of about 152 m, and the level would be 1.04 m higher in a Probable Maximum Flood (PMF). These flood levels would be of significant flow, depth and extent, however, would not impact the project area as shown in Text-Figure 3 below.

Text-Figure 3: Cross Section 3 with 100 year ARI flood level and PMF



The maximum depth of the 1-in-100 year flood would be about 3.78 m and the maximum velocity in the order of 1.5 m/s (Table 6).

Table 6: Cross-section 3*, 100-year ARI flood and PMF summary

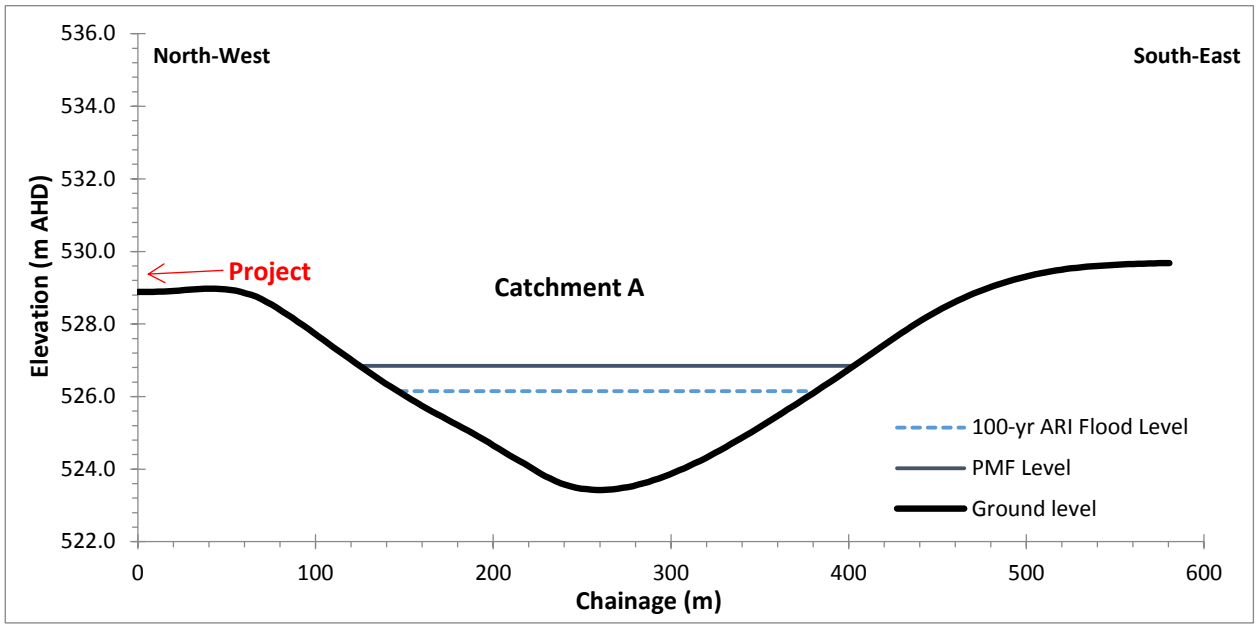
Flood Analysis	Flow (m^3/s)	Flood Level Elevation (m AHD)	Depth (m)	Velocity (m/s)	Extent of Flood Level (m)
100-yr	519	528.51	3.78	1.5	152
PMF	895	529.55	4.82	1.7	190

* Catchment A

3.1.4. CROSS-SECTION 4 –EAST OF THE PLANNED INFRASTRUCTURE

In a 1-in-100 year flood, the peak flood levels from Catchment A, east of the infrastructure, would be at 526.15 m AHD with a width of about 232 m, and the level would be 0.70 m higher in a Probable Maximum Flood (PMF). These flood levels would be of significant flow, depth and extent, however, would not impact the project area as shown in Text-Figure 5: Cross Section 5 with 100 year ARI flood level and PMF below.

Text-Figure 4: Cross Section 4 with 100 year ARI flood level and PMF



The maximum depth of the 1-in-100 year flood would be about 2.73 m and the maximum velocity in the order of 1.4 m/s (Table 7).

Table 7: Cross-section 4*, 100-year ARI flood and PMF summary

Flood Analysis	Flow (m^3/s)	Flood Level Elevation (m AHD)	Depth (m)	Velocity (m/s)	Extent of Flood Level (m)
100-yr	533	526.15	2.73	1.4	300
PMF	918	526.85	3.43	1.6	328

* Catchment A

The above hydraulic analyses show that the peak flows in the major catchments will be substantial, but would not reach the project boundaries and impact the planned mining and infrastructure areas.

3.2. IMPACT OF MINOR FLOWS ON THE SURFACE INFRASTRUCTURE

Flows in the minor catchments which could impact the infrastructure area were also analysed to assess the impact of the 1 in 100 year ARI peak flows and Probable Maximum Flood (PMF) on the surface infrastructure to determine the protective measures required.

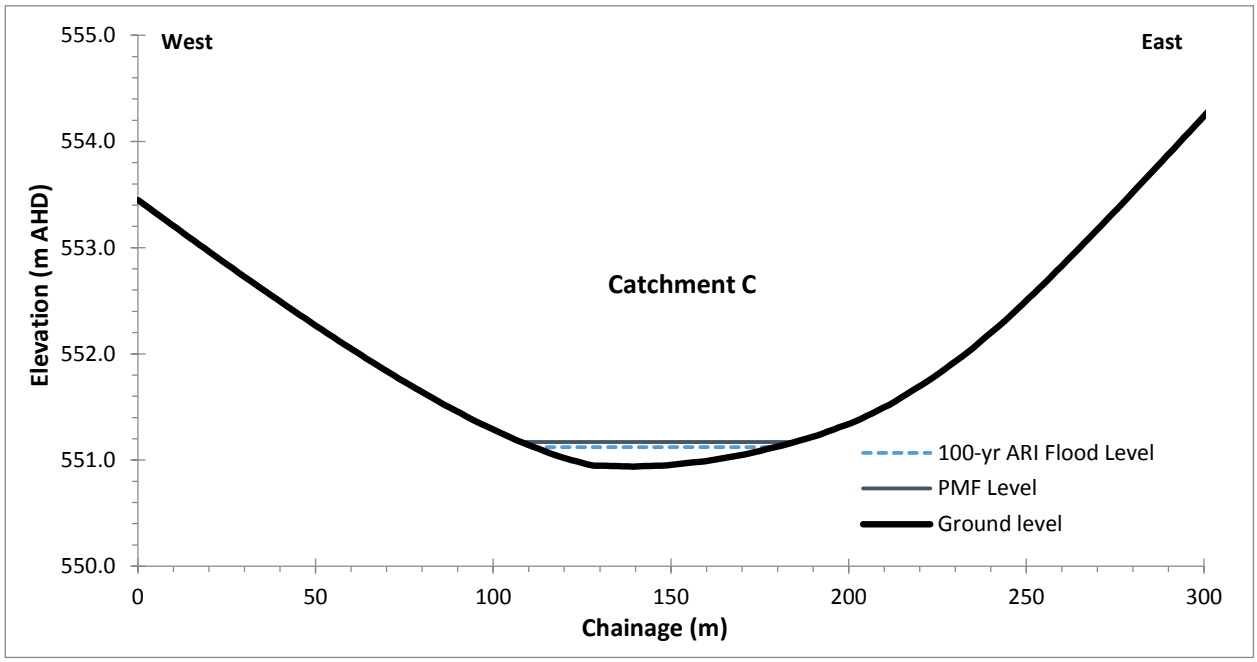
The locations of the minor flow paths that could impact the project's surface infrastructure were identified from aerial photography and the 1 m contour plan (Fig. 3). The planned infrastructure intersects or is very close to two small natural drainage lines that could impact the project during high rainfall events.

Hydraulic analyses were conducted at three critical locations (cross-section 5 to 7, Fig. 3) to assess the impact of the peak flows.

3.2.1. CROSS-SECTION 5 - IMPACT FROM CATCHMENT C

In a 1-in-100 year flood, the peak flood levels from Catchment C would be at about 551.12 m AHD with a width of about 66 m, and the level would be about 0.05 m higher in a Probable Maximum Flood (PMF). These flood levels would be of low flow, depth and velocity; therefore, they should have a limited impact on the project area, as shown in Text-Figure 5: Cross Section 5 with 100 year ARI flood level and PMF below.

Text-Figure 5: Cross Section 5 with 100 year ARI flood level and PMF



The maximum depth of the 1-in-100 year flood would be about 0.18 m and the maximum velocity in the order of 0.8 m/s (Table 8).

Table 8: Cross-section 5*, 100-year ARI flood and PMF summary

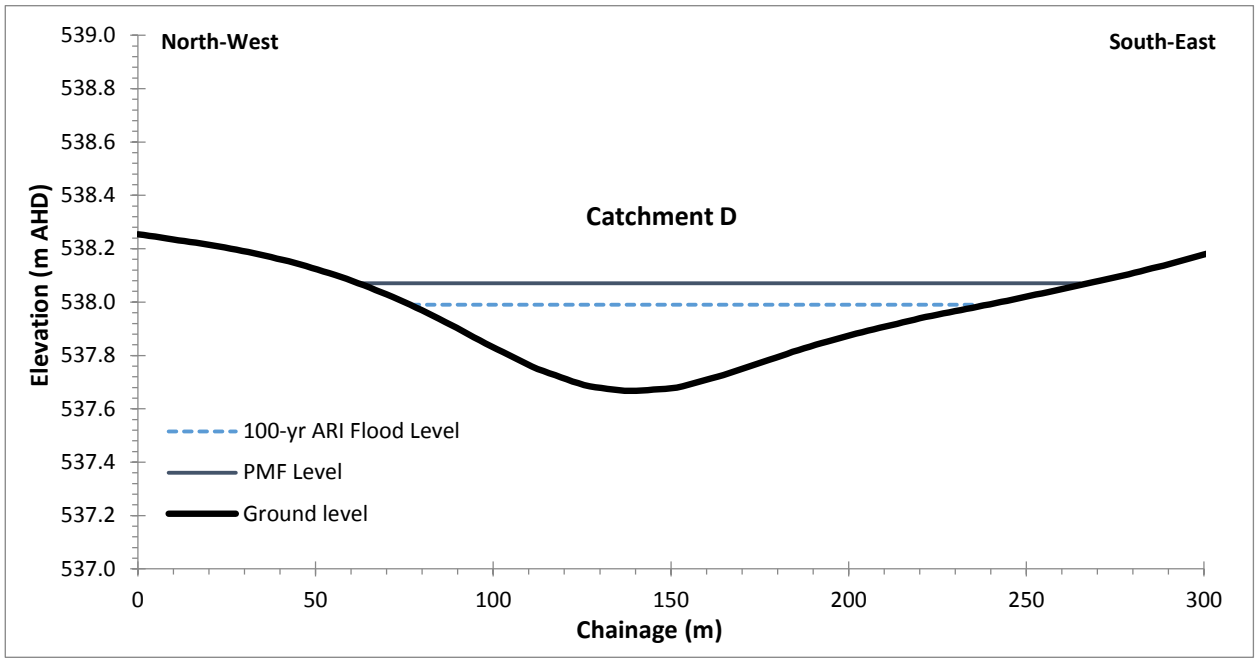
Flood Analysis	Flow (m^3/s)	Flood Level Elevation (m AHD)	Depth (m)	Velocity (m/s)	Extent of Flood Level (m)
100-yr	6.6	551.12	0.18	0.8	66
PMF	11.3	551.17	0.23	1.0	75

* Catchment C

3.2.2. CROSS-SECTION 6 – IMPACT FROM CATCHMENT D

In a 1-in-100 year flood, the peak flood levels from Catchment D would be at 537.99 m AHD with a width of about 161 m, and the level would be 0.08 m higher in a Probable Maximum Flood (PMF). These flood levels would be of significant extent, and could have an impact on the project's infrastructure.

Text-Figure 6: Cross Section 6 with 100 year ARI flood level and PMF



The maximum depth of the 1-in-100 year flood would be about 0.32 m and the maximum velocity in the order of 0.9 m/s (Table 9).

Table 9: Cross-section 6*, 100-year ARI flood and PMF summary

Flood Analysis	Flow (m^3/s)	Flood Level Elevation (m AHD)	Depth (m)	Velocity (m/s)	Extent of Flood Level (m)
100-yr	24.8	537.99	0.32	0.9	161
PMF	42.7	538.07	0.40	1.0	202

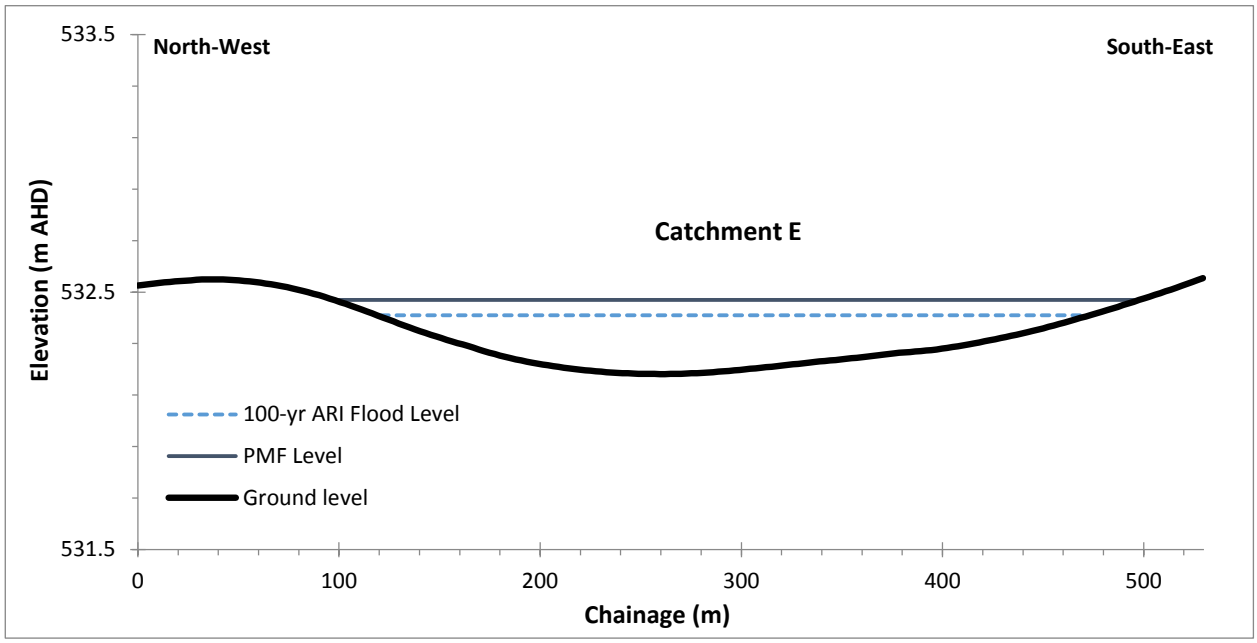
* Catchment D

The peak flows from catchment B could result in scouring and damage to the infrastructure. It is recommended to slightly change the footprint of the tailings storage facility (TSF) and to build a diversion channel (as shown in Figure 4). The diversion channel would reduce the extent of the peak floods and prevent any damage to the infrastructure. The conceptual design and hydraulic analyses for the channel are given in Section 4 of this report.

3.2.3. CROSS-SECTION 7 – IMPACT FROM CATCHMENT E

In a 1-in-100 year flood, the peak flood levels from Catchment E would be at 532.41 m AHD with a width of about 352 m, and the level would be 0.06 m higher in a Probable Maximum Flood (PMF). These flood levels would be of significant flow and extent, and could have an impact on the project's infrastructure, in particular the TSF. It is understood that the airstrip is likely to be relocated elsewhere, and so has not been considered in this analysis.

Text-Figure 7: Cross Section 7 with 100 year ARI flood level and PMF



The maximum depth of the 1-in-100 year flood would be about 0.23 m and the maximum velocity in the order of 0.7 m/s (Table 10).

Table 10: Cross-section 7*, 100-year ARI flood and PMF summary

Flood Analysis	Flow (m^3/s)	Flood Level Elevation (m AHD)	Depth (m)	Velocity (m/s)	Extent of Flood Level (m)
100-yr	34.0	532.41	0.23	0.7	352
PMF	58.6	532.47	0.29	0.8	400

* Catchment E

The peak flows from catchment E would be of shallow depth but of significant width and could have an impact on the infrastructure. It is recommended to change the footprint of the TSF and to dig a drain in the existing creek to limit the extent of the peak flows. The conceptual design and hydraulic analyses for the drain are given in Section 4 of this report, and the realigned TSF is shown in Figure 4.

4. RECOMMENDED PROTECTIVE MEASURES

4.1. CONSTRUCTION OF A DRAIN

As highlighted in Section 3.2.3, peak flows from Catchment E could have an impact on the TSF, even with the footprint realigned. A drain is recommended to enhance the natural drainage line (Fig. 4).

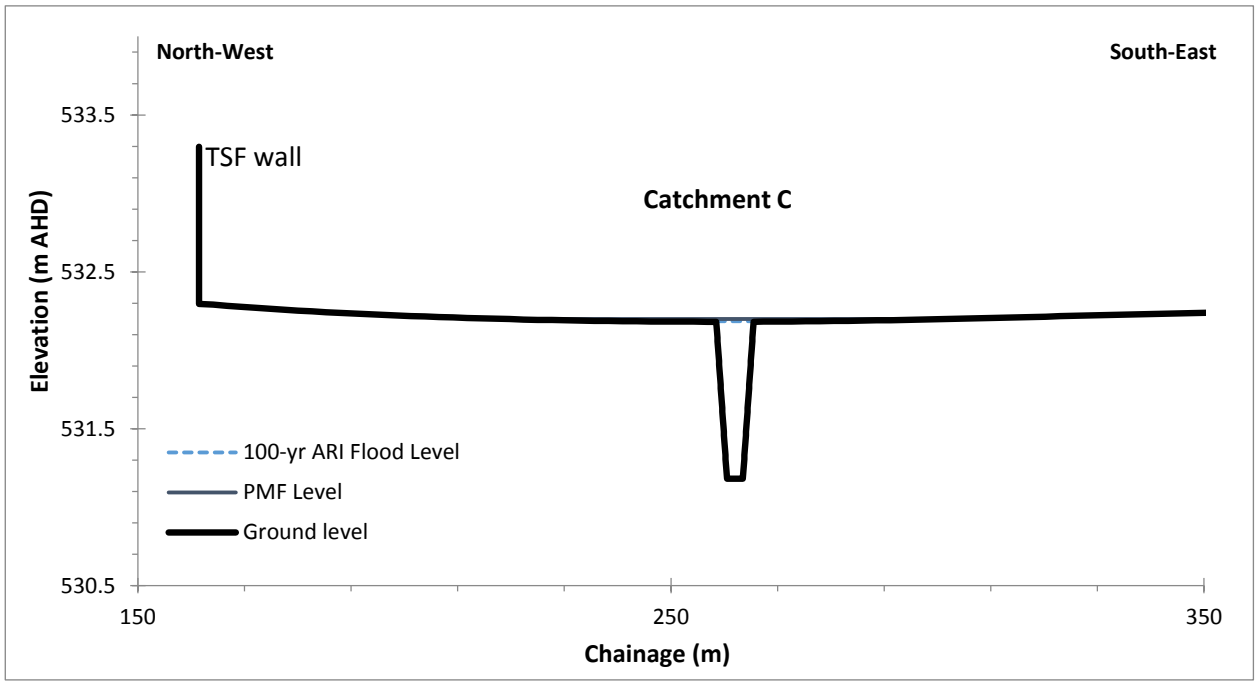
The recommended dimensions for the drain are presented in Table 11. Cross-section 8 (Text-Figure 8) is at the same location as cross-section 7 presented above to compare the estimated peak flood levels with and without the proposed drain.

Table 11: Proposed drain dimensions

Drain Bank Slope	Drain Bed Width (m)*	Drain Depth (m)*
1:2	3.0	1.0

**These values are indicative and should be considered as minimum requirements.*

Text-Figure 8: Cross Section 8 - Proposed drain with peak flood levels



With the proposed drain design, the 1-in-100 year flood would remain within the drain and the maximum velocity would be in the order of 5.5 m/s. The Probable Maximum Flood would be only 0.02 m above the drain with a width of 82 m. Table 12 summarises the 100-year flood characteristics with and without the proposed drain.

Table 12: 100-year flood comparison with and without proposed drain

Cross Section	Ground level (m AHD)	Drain Base (m AHD)	100-year ARI Flood Elevation (m AHD)	100-year ARI Flood Velocity (m/s)	100-year ARI Flood Width (m)
7*	532.18	No drain	532.42	0.7	360
8*	532.18	531.18	532.18	5.5	7

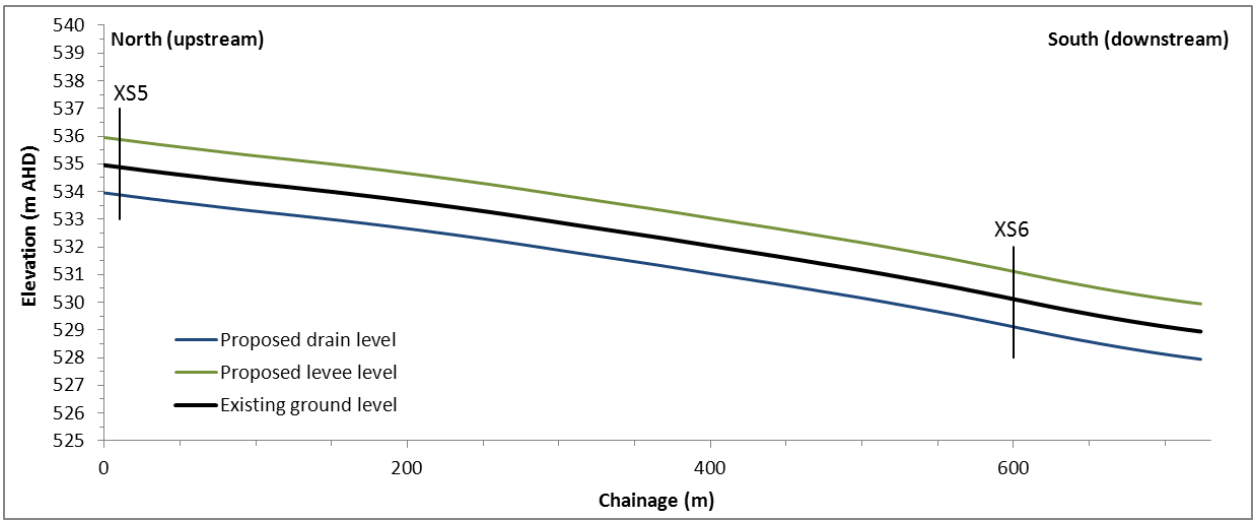
* Catchment E

4.2. RECOMMENDED DIVERSION CHANNEL

A diversion channel is also recommended to divert the natural creek and prevent the peak floods from Catchment D from impacting the northern side of the TSF. The proposed diversion channel is shown in Figure 4.

A conceptual long-section of the diversion channel is presented in Text-Figure 9 below.

Text-Figure 9: Conceptual long-section of Diversion Channel



Excavation of a drain will be required in conjunction with a levee to form the channel: the excavated material can be used for construction of the levee. The recommended dimensions for the drain and the levee forming the diversion channel are given in Table 13.

Table 13: Proposed diversion channel dimensions

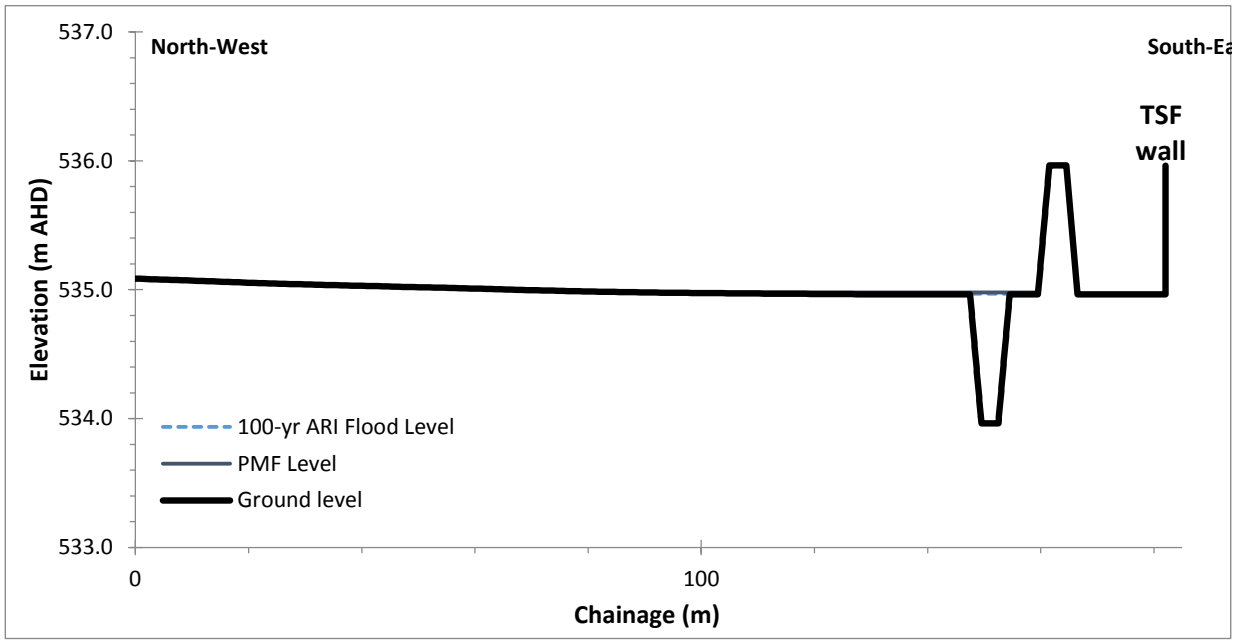
Drain/Levee Bank Slope	Drain Bed/Top of Levee Width (m)*	Drain Depth/Levee Height (m)*	Cross-sections
1:2	3.0	1.0	9 & 10

*These values are indicative and should be considered as minimum requirements

Cross-sections 9 and 10 below (Text-Figures 10 and 11) show the flood levels at the upstream and downstream ends of the proposed diversion channel.

4.2.1. HYDRAULIC ANALYSES – UPSTREAM END OF THE PROPOSED DIVERSION CHANNEL

Text-Figure 10: Cross Section 9 - Proposed diversion channel with peak flood levels



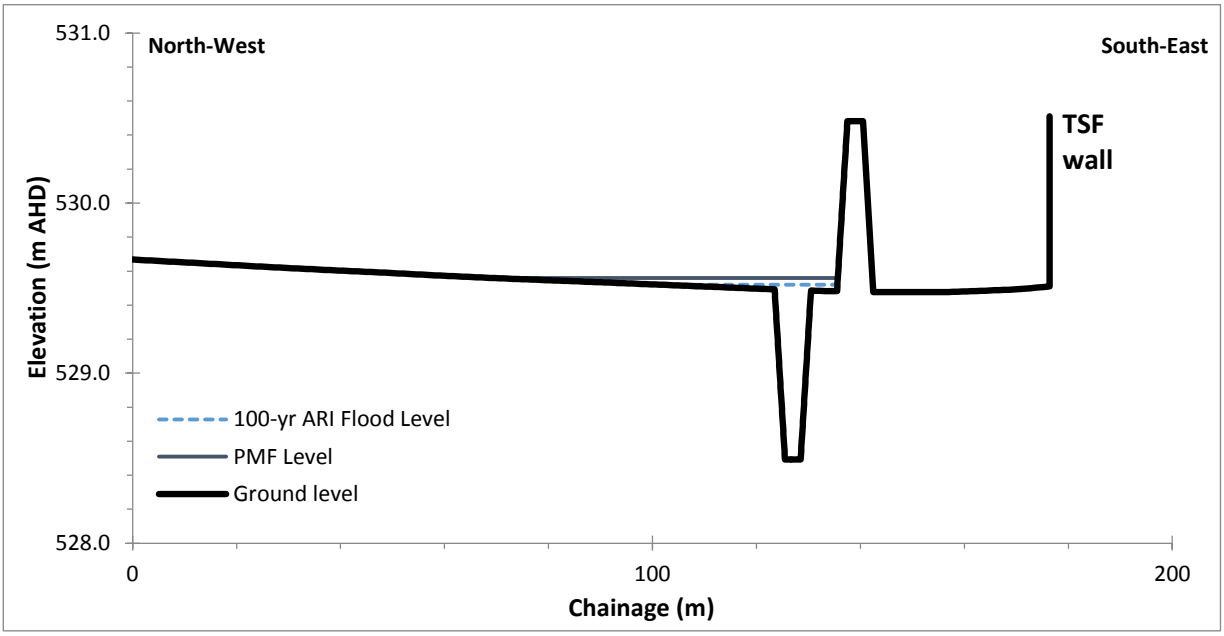
In the 1-in-100 year flood, the maximum level would be about 0.01 m above the drain, the maximum velocity in the order of 3.9 m/s (100-year flood comparison with and without proposed drain), and the Probable Maximum Flood would be 0.01 m higher.

Table 14: Cross-section 9, proposed drain/levee concept design and 100-year flood summary

Corresponding long-section chainage (m)	Flow (m^3/s)	Existing ground level (m AHD)	Proposed levee level (m AHD)	Proposed drain level (m AHD)	100-year ARI Flood Elevation (m AHD)	100-year ARI Flood Velocity (m/s)
0	26.6	534.96	535.96	533.96	534.97	3.9

4.2.2. HYDRAULIC ANALYSES – DOWNSTREAM END OF THE PROPOSED DIVERSION CHANNEL

Text-Figure 11: Cross Section 10 - Proposed diversion channel with peak flood levels



In the 1-in-100 year flood, the maximum level would be about 0.04 m above the drain, the maximum velocity in the order of 3.9 m/s (100-year flood comparison with and without proposed drain), and the Probable Maximum Flood would be 0.04 m higher.

Table 15: Cross-section 10, proposed drain/levee concept design and 100-year flood summary

Corresponding long-section chainage (m)	Flow (m^3/s)	Existing ground level (m AHD)	Proposed levee level (m AHD)	Proposed drain level (m AHD)	100-year ARI Flood Elevation (m AHD)	100-year ARI Flood Velocity (m/s)
600	29.0	529.48	530.48	528.48	529.52	3.9

The above analyses show the construction of a diversion channel would efficiently divert the natural creek away from the TSF wall. Also, it would significantly reduce the depths and widths of the peak flood levels.

For information purposes, a cross-section of a typical levee and drain system is provided in Appendix C.

5. SUMMARY OF FLOOD MANAGEMENT REQUIREMENTS

The Abra lead-silver deposit is located near major drainage lines (Fig. 1), in an area subject to high flood flows. However, it is located well above these major creeks, and the hydraulic analyses presented in this report indicate that the peak flows resulting from these catchments would not impact on the project area and underground mine.

However, the planned infrastructure, in particular the TSF, intersects or is close to two minor drainage lines which flow northwards (Fig. 3). High rainfall events could result in flooding and potential damage to the TSF walls.

Where recommended, the levees and drains have been designed to control the width of the flows.

Drainage from Catchment C would intersect an edge of the processing plant. However, given the small size of the catchment, the flood flows would be minor and dissipate rapidly. A small bund and drain can be constructed to control flows and protect the plant.

Drainage from Catchment D intersects the planned south-western wall of the TSF. Changing the TSF orientation is recommended (as shown in Figure 4); and a diversion channel together with a small levee will be required to protect and divert flows around the TSF.

Drainage from Catchment E will pass close to the south-eastern wall of the TSF. The 100-year ARI peak flow would cover a significant width and could impact the wall of the TSF. The excavation of a drain is recommended to contain runoff and to limit the extent of the flood flows (Fig. 4).

Dated: 13 September 2018

Rockwater Pty Ltd

C Corthier
Engineering Geologist

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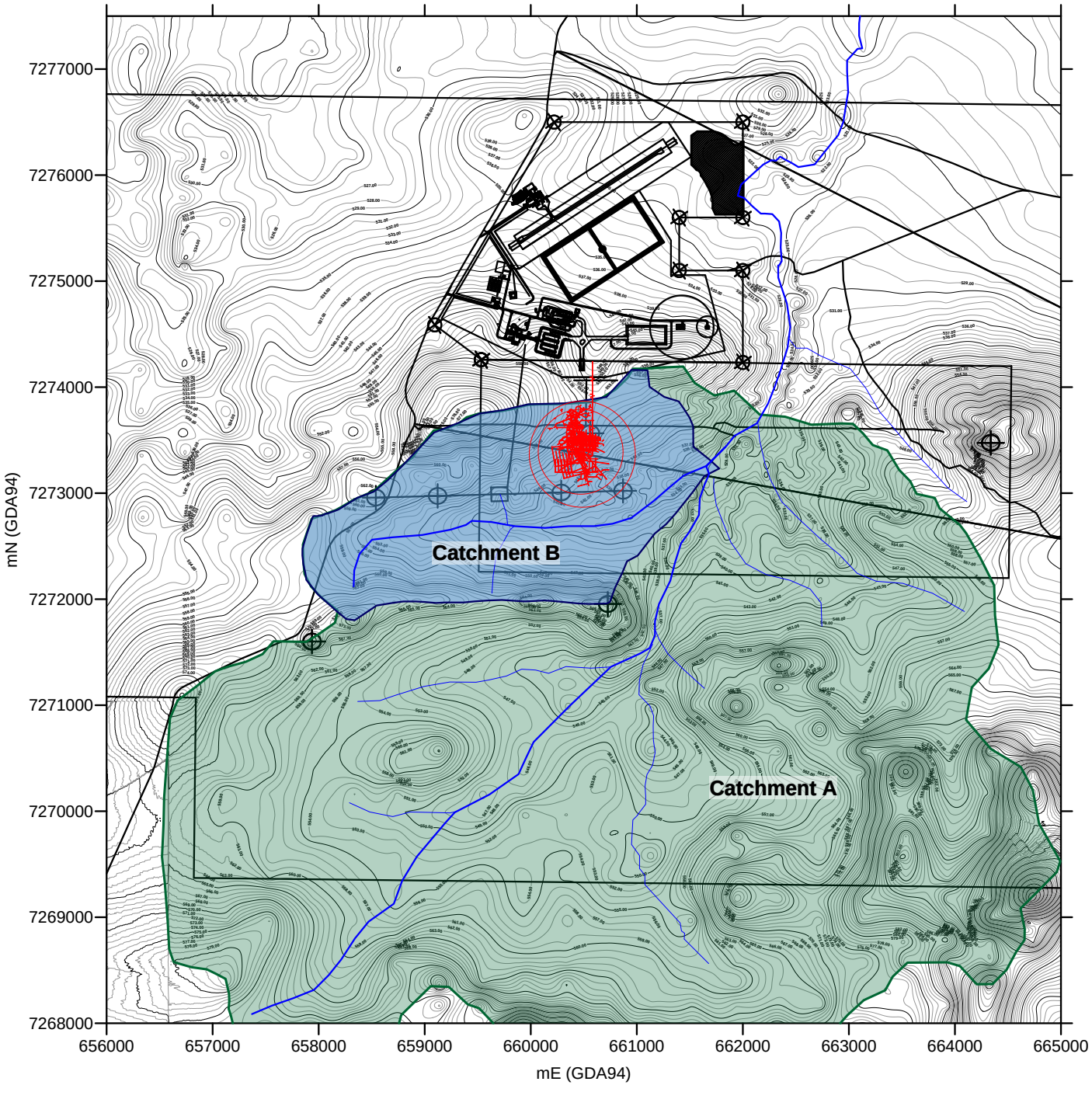
FIGURES

FIGURE 1



Major drainage lines

1 m topographic contours

Catchment A

Catchment B

Infrastructure Layout

Abra Deposit

major catchments.srf

CLIENT: Galena Mining

PROJECT: Abra Silver-lead Deposit

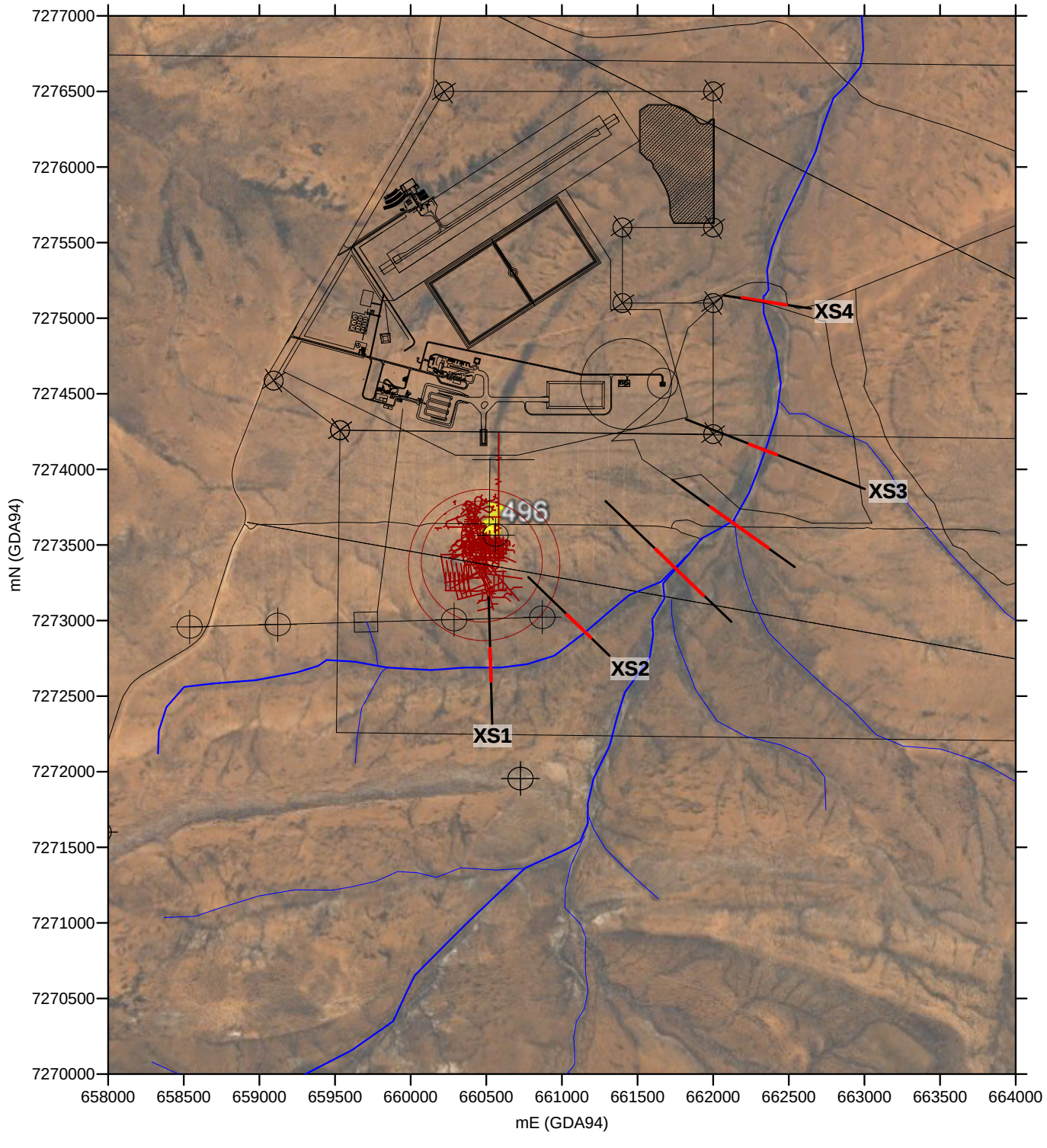
DATE: September 2018

Dwg No: 496-0/18/2-1

PROJECT AREA & MAJOR CATCHMENTS

Rockwater
PROPRIETARY LIMITED

FIGURE 2

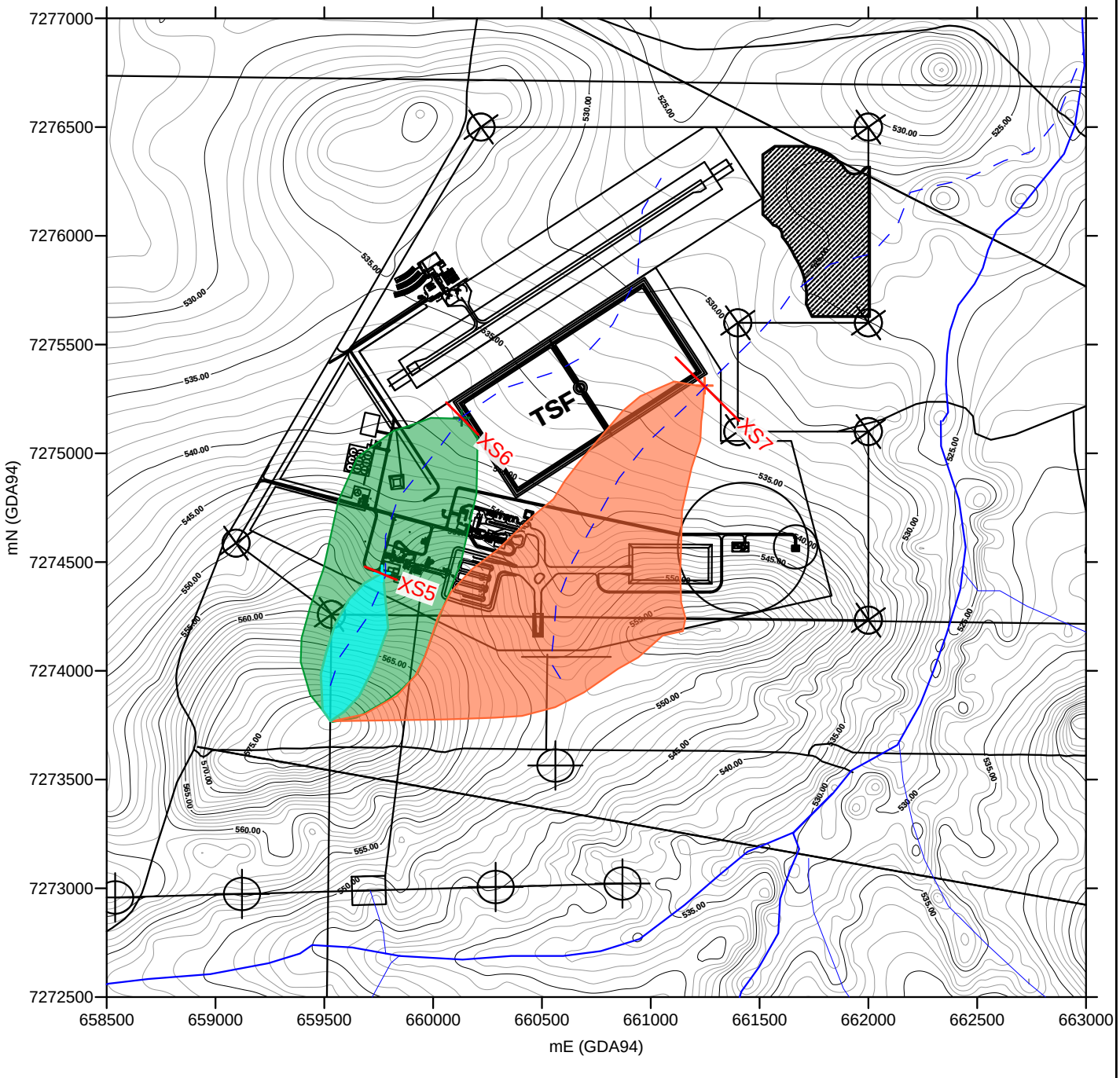


cross-sections.srf

CLIENT: Galena Mining	CROSS-SECTIONS & FLOOD EXTENT FROM MAJOR CREEKS
PROJECT: Abra Silver-lead Deposit	
DATE: September 2018	
Dwg No: 496-0/18/2-2	

Rockwater PROPRIETARY LIMITED

FIGURE 3



minor catchments.srf

CLIENT: Galena Mining

PROJECT: Abra Silver-lead Deposit

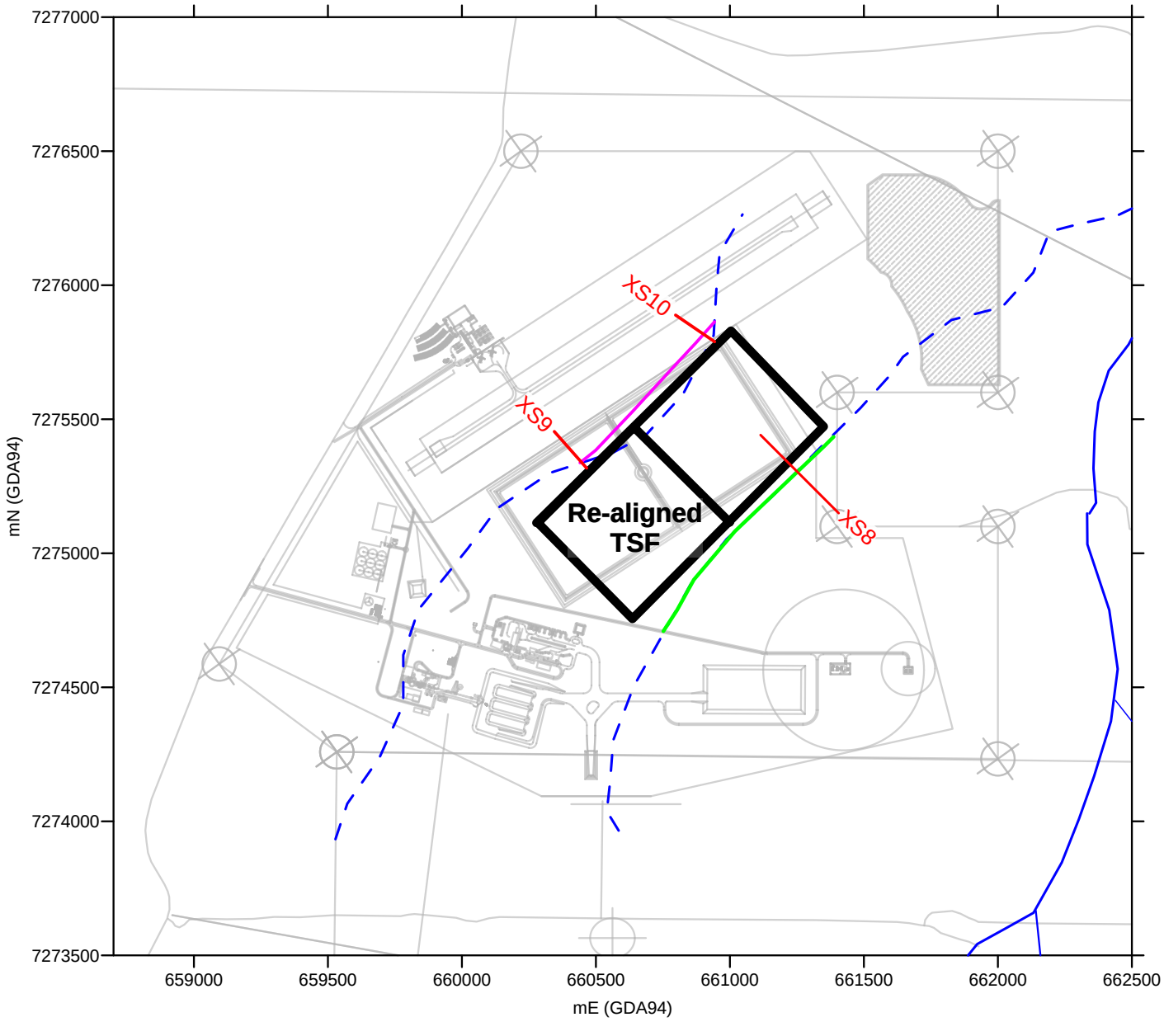
DATE: September 2018

Dwg No: 496-0/18/2-3

LAYOUT PLAN & MINOR CATCHMENTS

Rockwater
PROPRIETARY LIMITED

FIGURE 4



Major drainage lines		Cross-sections	
Minor creeks		Recommended Diversion Channel	
Planned Infrastructure Layout		Recommended Drain	

Protective measures.srf

CLIENT: Galena Mining

PROJECT: Abra Silver-lead Deposit

DATE: September 2018

Dwg No: 496-0/18/2-4

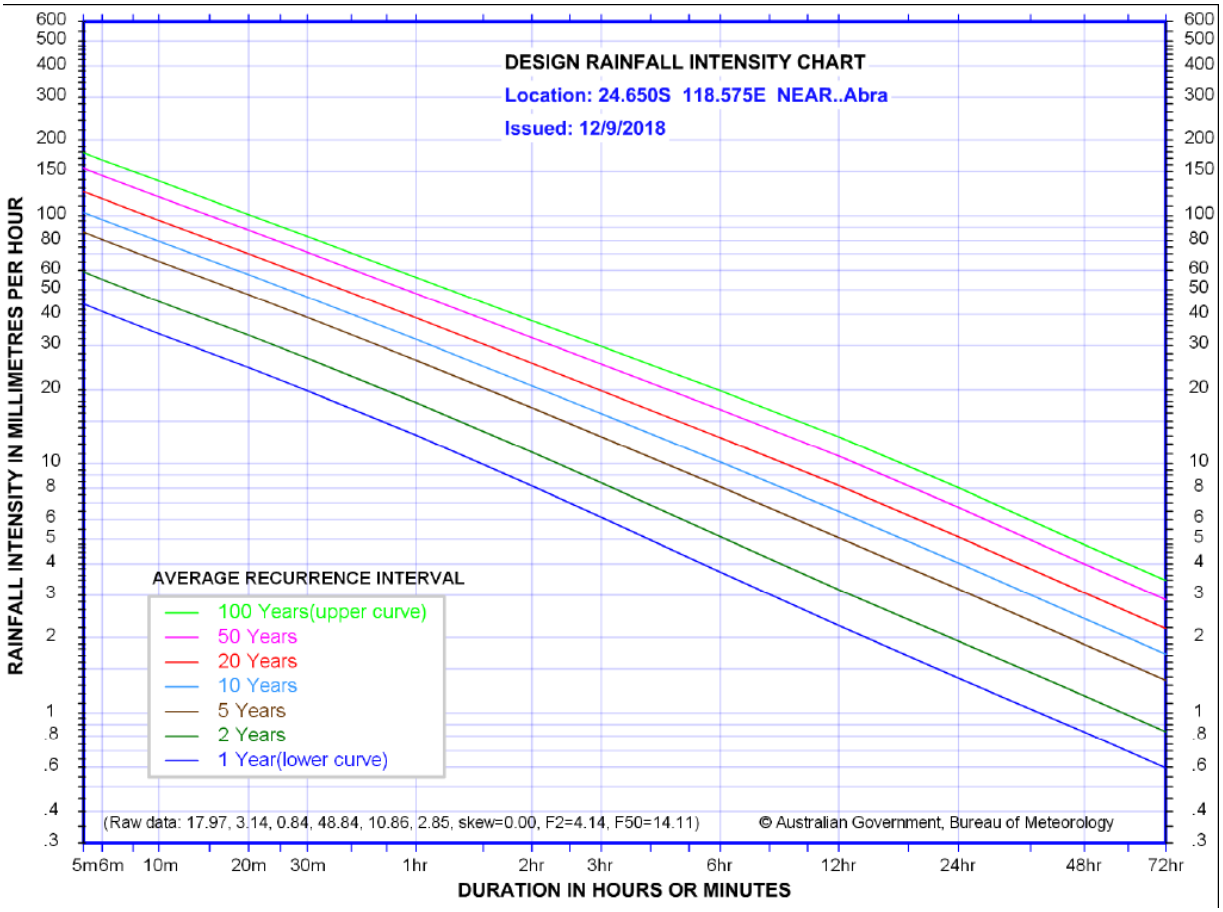
PROTECTIVE MEASURES

Rockwater PROPRIETARY LIMITED

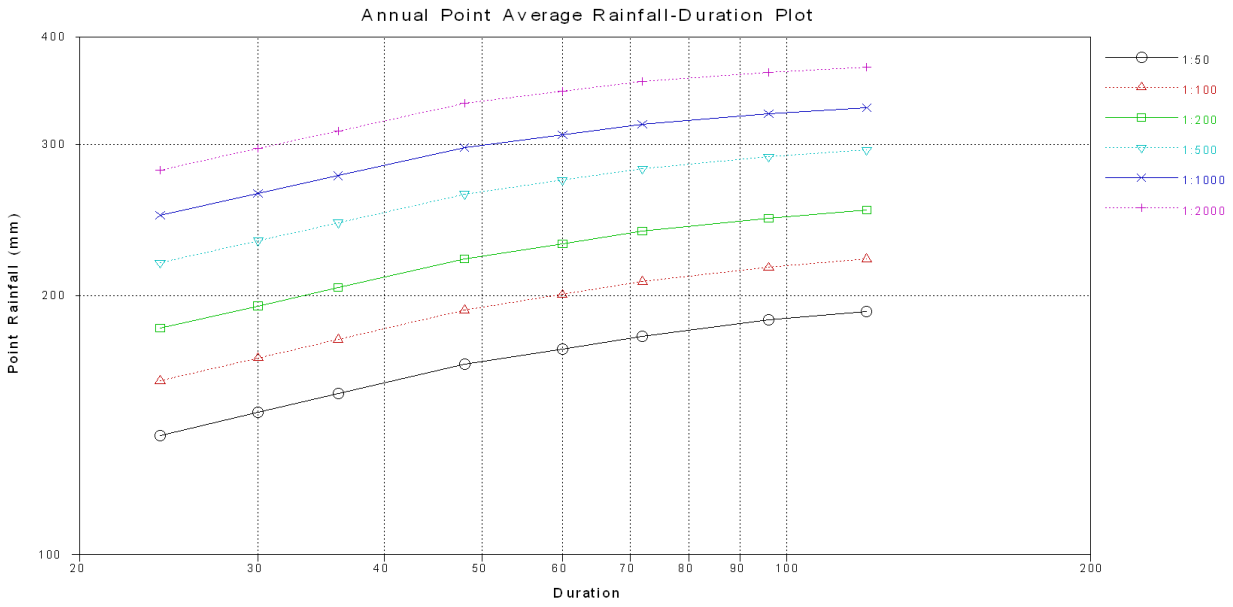
APPENDIX A: HYDROLOGY CHARTS AND CALCULATIONS

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

IFD Curves:



CRC Forge Results:



AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: A

Pilbara Region

Catchment Characteristics	A (km^2)	L (km)	S_e (m/km)	P (mm)
	40.5	7.6	6	269

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	7980	km^2
L =	10	-	194	km
S_e =	1.43	-	3.77	m/km
P =	230	-	400	mm

$Q_Y = 0.278 C_Y . I_{tc,Y} . A$ ..... **(1.1)**

$t_c = 0.56A^{0.38}$ ..... **(1.29)**

t_c = 2.29 Hrs

$C_2 = 3.07x10^{-1}L^{-0.20}$ ..... **(1.30)**

C_2 = 0.205

Frequency Factors (C_Y/C_{10})

	ARI (years)					
	2	5	10	20	50	*100*
C_Y/C_2	1.00	1.46	2.21	3.60	5.20	*7.76*

100 year ARI extrapolated using the logarithmic trend-line

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C_Y	0.20	0.30	0.45	0.74	1.06	1.59

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: A

RATIONAL METHOD:
CONTINUES

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

t_c = 2.29 hours

Use IFD curves

Duration	ARI (Years) [mm/hr]					
(hours)	2	5	10	20	50	100
2.29	10.4	15.7	19.3	23.8	30.2	35.4

Calculate peak discharge using equation (1.1)

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	23.9	52.8	98.2	197.3	361.8	633.3

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: A

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	49600	km^2
L =	10	-	498	km
S_e =	0.88	-	3.77	m/km
P =	230	-	400	mm

$Q_5 = 6.73x10^{-4}A^{0.72}P^{1.51}$ ..... **(1.31)**

Q_5 = 45.1 m^3/s

Frequency Factors (Q_Y/Q_5) interpolated for Catchment A

	ARI (years)					
40.5 km^2	2	5	10	20	50	*100*
Q_Y/Q_5	0.51	1.00	1.77	3.02	5.69	*8.97*

100 year ARI extrapolated using the power trend-line

Therefore the peak discharge

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	22.99	45.11	79.65	136.38	256.59	404.80

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: A

SUMMARY OF RATIONAL AND INDEX METHODS:

Pilbara Region

Catchment A	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	23.88	52.81	98.22	197.32	361.81	633.25	
Index	22.99	45.11	79.65	136.38	256.59	404.80	
Adopted (average)	**23.43**	**48.96**	**88.93**	**166.85**	**309.20**	**519.03**	**894.55**

*PMF estimated using multiplying factors from CRC-FORGE results

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: B

Pilbara Region

Catchment Characteristics	A (km^2)	L (km)	S_e (m/km)	P (mm)
	5.5	4.0	7	269

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	7980	km^2
L =	10	-	194	km
S_e =	1.43	-	3.77	m/km
P =	230	-	400	mm

$Q_Y = 0.278C_Y.I_{tc,Y}.A$ ..... **(1.1)**

$t_c = 0.56A^{0.38}$ ..... **(1.29)**

t_c = 1.07 Hrs

$C_2 = 3.07x10^{-1}L^{-0.20}$ ..... **(1.30)**

C_2 = 0.233

Frequency Factors (C_Y/C_2)

	ARI (years)					
	2	5	10	20	50	*100*
C_Y/C_2	1.00	1.46	2.21	3.60	5.20	*7.76*

100 year ARI extrapolated using the logarithmic trend-line

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C_Y	0.23	0.34	0.51	0.84	1.21	1.81

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: B

RATIONAL METHOD:
CONTINUES

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

t_c = 1.07 hours

Use IFD curves

Duration	ARI (Years) [mm/hr]					
(hours)	2	5	10	20	50	100
1.07	17.7	26.2	31.8	38.8	48.6	56.5

Calculate peak discharge using equation (1.1)

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	6.30	13.61	25.00	49.69	89.90	156.06

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: B

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	49600	km^2
L =	10	-	498	km
S_e =	0.88	-	3.77	m/km
P =	230	-	400	mm

$Q_5 = 6.73x10^{-4}A^{0.72}P^{1.51}$ ..... **(1.31)**

Q_5 = 10.7 m^3/s

Frequency Factors (Q_Y/Q_5) interpolated for Catchment A

	ARI (years)					
5.5 km^2	2	5	10	20	50	*100*
Q_Y/Q_5	0.53	1.00	1.66	2.67	4.64	7.72

100 year ARI extrapolated using the power trend-line

Therefore the peak discharge

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	5.67	10.72	17.83	28.61	49.75	96.15

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: B

SUMMARY OF RATIONAL AND INDEX METHODS:

Pilbara Region

Catchment B	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	6.30	13.61	25.00	49.69	89.90	156.06	
Index	5.67	10.72	17.83	28.61	49.75	82.71	
Adopted (average)	**5.98**	**12.16**	**21.42**	**39.15**	**69.82**	**119.38**	**205.76**

*PMF estimated using multiplying factors from CRC-FORGE results

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: C

Pilbara Region

Catchment Characteristics	A (km^2)	L (km)	S_e (m/km)	P (mm)
	0.123	0.71	39	269

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	7980	km^2
L =	10	-	194	km
S_e =	1.43	-	3.77	m/km
P =	230	-	400	mm

$Q_Y = 0.278 C_Y . I_{tc,Y} . A$ ..... **(1.1)**

$t_c = 0.56A^{0.38}$ ..... **(1.29)**

t_c = 0.25 Hrs

$C_2 = 3.07x10^{-1}L^{-0.20}$ ..... **(1.30)**

C_2 = 0.329

Frequency Factors (C_Y/C_{10})

	ARI (years)					
	2	5	10	20	50	*100*
C_Y/C_2	1.00	1.46	2.21	3.60	5.20	*7.76*

100 year ARI extrapolated using the logarithmic trend-line

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C_Y	0.33	0.48	0.73	1.18	1.71	2.55

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: C

RATIONAL METHOD:
CONTINUES

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

t_c = 0.25 hours

Use IFD curves

Duration	ARI (Years) [mm/hr]					
(hours)	2	5	10	20	50	100
0.25	36.2	53.0	63.9	77.8	97.0	112.3

Calculate peak discharge using equation (1.1)

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	0.41	0.87	1.59	3.15	5.67	9.80

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: C

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	49600	km^2
L =	10	-	498	km
S_e =	0.88	-	3.77	m/km
P =	230	-	400	mm

$Q_5 = 6.73x10^{-4}A^{0.72}P^{1.51}$ ..... **(1.31)**

Q_5 = 0.69 m^3/s

Frequency Factors (Q_Y/Q_5) interpolated for Catchment C

	ARI (years)					
0.123 km^2	2	5	10	20	50	*100*
Q_Y/Q_5	0.57	1.00	1.49	2.11	3.15	*4.83*

100 year ARI extrapolated using the power trend-line

Therefore the peak discharge

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	0.40	0.69	1.03	1.46	2.19	3.35

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: C

SUMMARY OF RATIONAL AND INDEX METHODS:

Pilbara Region

Catchment C	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	0.41	0.87	1.59	3.15	5.67	9.80	
Index	0.40	0.69	1.03	1.46	2.19	3.35	
Adopted (average)	**0.40**	**0.78**	**1.31**	**2.31**	**3.93**	**6.58**	**11.33**

*PMF estimated using multiplying factors from CRC-FORGE results

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: D

Pilbara Region

Catchment Characteristics	A (km^2)	L (km)	S_e (m/km)	P (mm)
	0.744	1.50	27	269

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	7980	km^2
L =	10	-	194	km
S_e =	1.43	-	3.77	m/km
P =	230	-	400	mm

$Q_Y = 0.278 C_Y . I_{tc,Y} . A$ ..... **(1.1)**

$t_c = 0.56A^{0.38}$ ..... **(1.29)**

t_c = 0.50 Hrs

$C_2 = 3.07x10^{-1}L^{-0.20}$ ..... **(1.30)**

C_2 = 0.283

Frequency Factors (C_Y/C_{10})

	ARI (years)					
	2	5	10	20	50	*100*
C_Y/C_2	1.00	1.46	2.21	3.60	5.20	*7.76*

100 year ARI extrapolated using the logarithmic trend-line

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C_Y	0.28	0.41	0.63	1.02	1.47	2.20

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: D

RATIONAL METHOD:
CONTINUES

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

t_c = 0.50 hours

Use IFD curves

Duration	ARI (Years) [mm/hr]					
(hours)	2	5	10	20	50	100
0.50	23.4	34.7	42.2	51.7	64.9	75.5

Calculate peak discharge using equation (1.1)

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	1.37	2.97	5.46	10.90	19.76	34.31

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: D

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	49600	km^2
L =	10	-	498	km
S_e =	0.88	-	3.77	m/km
P =	230	-	400	mm

$Q_5 = 6.73x10^{-4}A^{0.72}P^{1.51}$ ..... **(1.31)**

Q_5 = 2.54 m^3/s

Frequency Factors (Q_Y/Q_5) interpolated for Catchment D

	ARI (years)					
0.744 km^2	2	5	10	20	50	*100*
Q_Y/Q_5	0.55	1.00	1.57	2.36	3.79	*6.02*

100 year ARI extrapolated using the power trend-line

Therefore the peak discharge

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	1.40	2.54	3.98	5.98	9.61	15.29

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: D

SUMMARY OF RATIONAL AND INDEX METHODS:

Pilbara Region

Catchment D	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	1.37	2.97	5.46	10.90	19.76	34.31	
Index	1.40	2.54	3.98	5.98	9.61	15.29	
Adopted (average)	**1.38**	**2.75**	**4.72**	**8.44**	**14.68**	**24.80**	**42.74**

*PMF estimated using multiplying factors from CRC-FORGE results

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: E

Pilbara Region

Catchment Characteristics	A (km^2)	L (km)	S_e (m/km)	P (mm)
	1.17	2.10	13	269

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	7980	km^2
L =	10	-	194	km
S_e =	1.43	-	3.77	m/km
P =	230	-	400	mm

$Q_Y = 0.278C_Y.I_{tc,Y}.A$ ..... **(1.1)**

$t_c = 0.56A^{0.38}$ ..... **(1.29)**

t_c = 0.59 Hrs

$C_2 = 3.07x10^{-1}L^{-0.20}$ ..... **(1.30)**

C_2 = 0.265

Frequency Factors (C_Y/C_{10})

	ARI (years)					
	2	5	10	20	50	*100*
C_Y/C_2	1.00	1.46	2.21	3.60	5.20	*7.76*

100 year ARI extrapolated using the logarithmic trend-line

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C_Y	0.26	0.39	0.58	0.95	1.38	2.05

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: E

RATIONAL METHOD:
CONTINUES

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

t_c = 0.59 hours

Use IFD curves

Duration	ARI (Years) [mm/hr]					
(hours)	2	5	10	20	50	100
0.59	21.0	31.2	38.1	46.6	58.6	68.3

Calculate peak discharge using equation (1.1)

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	1.8	3.9	7.2	14.5	26.3	45.6

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: E

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	49600	km^2
L =	10	-	498	km
S_e =	0.88	-	3.77	m/km
P =	230	-	400	mm

$Q_5 = 6.73x10^{-4}A^{0.72}P^{1.51}$ ..... **(1.31)**

Q_5 = 3.52 m^3/s

Frequency Factors (Q_Y/Q_5) interpolated for Catchment E

	ARI (years)					
1.17 km^2	2	5	10	20	50	*100*
Q_Y/Q_5	0.55	1.00	1.59	2.42	3.97	*6.37*

100 year ARI extrapolated using the power trend-line

Therefore the peak discharge

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	1.92	3.52	5.59	8.53	13.95	22.40

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: E

SUMMARY OF RATIONAL AND INDEX METHODS:

Pilbara Region

Catchment E	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	1.81	3.93	7.24	14.46	26.25	45.64	
Index	1.92	3.52	5.59	8.53	13.95	22.40	
Adopted	**1.86**	**3.72**	**6.41**	**11.49**	**20.10**	**34.02**	**58.63**

*PMF estimated using multiplying factors from CRC-FORGE results

APPENDIX B: HYDRAULIC ANALYSES

Manning's Formula: $$Q = \frac{1}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

Cross-section 1 (Catchment B)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
537.4	0.0	0.0	0.0	0.06	0.0058	0.00	0.0
538.0	113.6	45.4	113.6	0.06	0.0058	0.69	31.3
538.1	126.2	57.8	126.2	0.06	0.0058	0.75	43.6
538.2	130.4	71.0	130.4	0.06	0.0058	0.85	60.1
538.3	138.8	84.9	138.8	0.06	0.0058	0.92	77.7
538.4	147.2	99.7	147.2	0.06	0.0058	0.98	97.7
538.5	159.8	116.0	159.9	0.06	0.0058	1.03	119.1
538.6	168.2	132.6	168.3	0.06	0.0058	1.08	143.9
538.7	176.7	150.2	176.7	0.06	0.0058	1.14	171.2
538.8	185.1	168.5	185.1	0.06	0.0058	1.19	201.2
538.9	193.5	187.7	193.5	0.06	0.0058	1.25	233.8
539.0	201.9	207.8	201.9	0.06	0.0058	1.30	269.2

Cross-section 2 (Catchment B)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
533.5	0.0	0.0	0.0	0.06	0.0065	0.00	0.0
534.0	56.0	19.2	56.0	0.06	0.0065	0.66	12.7
534.5	82.1	55.3	82.2	0.06	0.0065	1.03	57.1
535.0	209.1	127.7	209.1	0.06	0.0065	0.97	123.5
535.1	216.5	149.2	216.6	0.06	0.0065	1.05	156.4
535.2	220.3	170.7	220.3	0.06	0.0065	1.13	193.4
535.3	224.0	193.7	224.1	0.06	0.0065	1.22	236.1
535.4	231.5	217.2	231.5	0.06	0.0065	1.29	279.5
535.5	238.9	241.2	239.0	0.06	0.0065	1.35	326.0

Cross-section 3 (Catchment A)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
524.7	0.0	0.0	0.0	0.06	0.0025	0.00	0.0
525.0	25.4	6.0	25.4	0.06	0.0025	0.32	1.9
526.0	63.5	57.4	63.5	0.06	0.0025	0.78	44.8
526.5	88.9	98.8	88.9	0.06	0.0025	0.89	88.3
527.0	101.6	147.3	101.7	0.06	0.0025	1.07	157.1
527.5	120.6	207.7	120.7	0.06	0.0025	1.20	248.5
528.0	133.3	273.5	133.4	0.06	0.0025	1.34	367.8
528.5	152.3	351.0	152.5	0.06	0.0025	1.45	509.8
528.6	158.7	365.2	158.9	0.06	0.0025	1.45	530.0
528.7	158.7	381.0	158.9	0.06	0.0025	1.49	568.9
528.8	165.0	400.5	165.2	0.06	0.0025	1.50	602.2
528.9	165.0	417.0	165.2	0.06	0.0025	1.54	644.1
529.0	171.4	432.4	171.6	0.06	0.0025	1.54	667.3
529.1	177.7	453.0	177.9	0.06	0.0025	1.55	703.8
529.2	177.7	470.8	177.9	0.06	0.0025	1.59	750.4
529.3	177.7	488.5	177.9	0.06	0.0025	1.63	798.2
529.4	190.4	508.7	190.7	0.06	0.0025	1.60	815.4
529.5	190.4	527.7	190.7	0.06	0.0025	1.64	866.9
529.6	190.4	546.8	190.7	0.06	0.0025	1.68	919.6
529.7	190.4	565.8	190.7	0.06	0.0025	1.72	973.6

Cross-section 4 (Catchment A)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
523.4	0.0	0.0	0.0	0.06	0.0038	0.00	0.0
524.0	81.3	31.7	81.3	0.06	0.0038	0.55	17.3
524.5	119.0	83.4	119.0	0.06	0.0038	0.80	67.1
525.0	153.8	153.0	153.9	0.06	0.0038	1.02	155.6
525.5	188.7	240.0	188.7	0.06	0.0038	1.20	287.6
526.0	220.6	344.6	220.7	0.06	0.0038	1.37	473.4
526.1	229.3	367.8	229.4	0.06	0.0038	1.40	514.3
526.2	238.0	391.2	238.1	0.06	0.0038	1.42	556.0
526.3	243.8	415.4	243.9	0.06	0.0038	1.46	604.6
526.4	249.6	440.2	249.7	0.06	0.0038	1.49	655.6
526.5	255.4	465.6	255.5	0.06	0.0038	1.52	709.0
526.6	261.2	491.6	261.3	0.06	0.0038	1.56	764.7
526.7	267.0	518.3	267.1	0.06	0.0038	1.59	822.8
526.8	272.8	545.5	272.9	0.06	0.0038	1.62	883.4
526.9	278.6	573.3	278.7	0.06	0.0038	1.65	946.4
527.0	284.4	601.8	284.5	0.06	0.0038	1.68	1011.9

Cross-section 5 (Catchment C)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
550.9	0.0	0.0	0.0	0.06	0.039	0.00	0.0
551.0	39.2	1.7	39.2	0.06	0.039	0.40	0.7
551.1	61.1	6.9	61.1	0.06	0.039	0.77	5.3
551.2	79.9	14.2	79.9	0.06	0.039	1.04	14.8
551.3	95.5	23.2	95.5	0.06	0.039	1.28	29.7
551.4	109.6	33.7	109.6	0.06	0.039	1.50	50.5

Cross-section 6 (Catchment D)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
537.67	0.0	0.0	0.0	0.06	0.0273	0.00	0.0
537.7	32.6	0.8	32.6	0.06	0.0273	0.22	0.2
537.8	75.0	6.4	75.0	0.06	0.0273	0.54	3.4
537.9	115.8	16.1	115.8	0.06	0.0273	0.74	11.9
538.0	166.3	30.3	166.3	0.06	0.0273	0.88	26.8
538.1	220.1	49.7	220.1	0.06	0.0273	1.02	50.8
538.2	277.2	74.7	277.2	0.06	0.0273	1.15	85.8

Cross-section 7 (Catchment E)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
532.18	0.0	0.0	0.0	0.06	0.020	0.00	0.0
532.2	82.1	1.0	82.1	0.06	0.020	0.12	0.1
532.3	251.5	18.8	251.5	0.06	0.020	0.42	7.8
532.4	344.1	49.2	344.1	0.06	0.020	0.64	31.7
532.5	423.6	87.7	423.6	0.06	0.020	0.83	72.4

Cross-section 8 (Catchment E)

In drain							
Stage	**Top Length (m)**	**A (m2)**	**P (m)**	**Manning's n**	**Slope (m/m)**	**V (m/s)**	**Q (m3/s)**
531.18	0.0	0.0	0.0	0.02	0.020	0.00	0.0
531.2	3.0	0.1	3.0	0.02	0.020	0.49	0.0
531.3	3.4	0.4	3.4	0.02	0.020	1.63	0.6
531.4	3.8	0.7	3.9	0.02	0.020	2.36	1.8
531.5	4.2	1.2	4.3	0.02	0.020	2.93	3.4
531.6	4.6	1.6	4.8	0.02	0.020	3.41	5.5
531.7	5.0	2.1	5.2	0.02	0.020	3.83	8.0
531.8	5.4	2.6	5.7	0.02	0.020	4.22	11.0
531.9	5.8	3.2	6.1	0.02	0.020	4.57	14.6
532.0	6.2	3.8	6.6	0.02	0.020	4.90	18.6
532.1	6.6	4.4	7.0	0.02	0.020	5.21	23.1
532.18	6.9	5.0	7.4	0.02	0.020	5.45	27.2
Above drain							
Stage	**Conveyance K**		**Manning's n**		**Channel slope (m/m)**		**Q (m3/s)**
532.185	239.8		0.06		0.020		33.9
532.19	321.8		0.06		0.020		45.5
532.195	398.8		0.06		0.020		56.4
532.20	472.0		0.06		0.020		66.7

Cross-section 9 (Catchment D)

In drain							
Stage	**Top Length (m)**	**A (m2)**	**P (m)**	**Manning's n**	**Slope (m/m)**	**V (m/s)**	**Q (m3/s)**
533.96	0.0	0.0	0.0	0.02	0.010	0.00	0.0
534.0	3.1	0.1	3.1	0.02	0.010	0.55	0.1
534.1	3.5	0.4	3.6	0.02	0.010	1.27	0.6
534.2	3.9	0.8	4.0	0.02	0.010	1.77	1.4
534.3	4.3	1.2	4.5	0.02	0.010	2.17	2.7
534.4	4.7	1.7	4.9	0.02	0.010	2.51	4.2
534.5	5.1	2.2	5.3	0.02	0.010	2.81	6.1
534.6	5.5	2.7	5.8	0.02	0.010	3.08	8.4
534.7	5.9	3.3	6.2	0.02	0.010	3.33	11.0
534.8	6.3	3.9	6.7	0.02	0.010	3.56	13.9
534.9	6.7	4.6	7.1	0.02	0.010	3.78	17.3
534.96	6.9	5.0	7.4	0.02	0.010	3.93	19.5

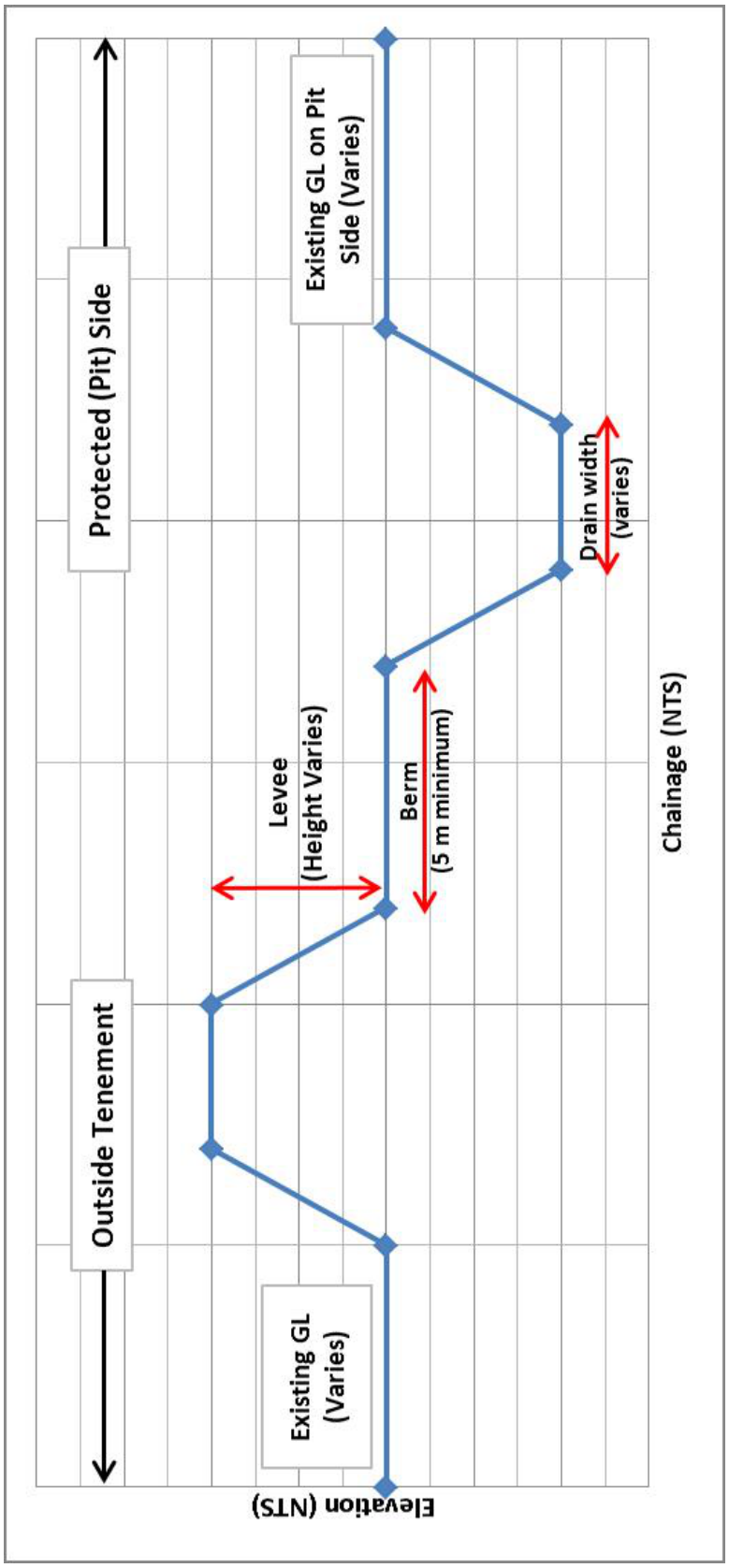
Above drain				
Stage	**Conveyance K**	**Manning's n**	**Channel slope (m/m)**	**Q (m3/s)**
534.965	229.2	0.06	0.010	23.4
534.97	303.9	0.06	0.010	31.0
534.98	429.8	0.06	0.010	43.9
534.99	529.7	0.06	0.010	54.1
535.00	615.4	0.06	0.010	62.8
535.10	1352.6	0.06	0.010	138.1

Cross-section 10 (Catchment D)

In drain							
Stage	**Top Length (m)**	**A (m2)**	**P (m)**	**Manning's n**	**Slope (m/m)**	**V (m/s)**	**Q (m3/s)**
528.48	0.0	0.0	0.0	0.02	0.010	0.00	0.0
528.5	3.0	0.0	3.0	0.02	0.010	0.21	0.0
528.6	3.4	0.3	3.4	0.02	0.010	1.11	0.4
528.7	3.8	0.7	3.9	0.02	0.010	1.64	1.2
528.8	4.2	1.1	4.3	0.02	0.010	2.06	2.3
528.9	4.6	1.6	4.8	0.02	0.010	2.41	3.8
529.0	5.0	2.0	5.2	0.02	0.010	2.72	5.6
529.1	5.4	2.6	5.7	0.02	0.010	3.00	7.7
529.2	5.8	3.1	6.1	0.02	0.010	3.26	10.2
529.3	6.2	3.7	6.6	0.02	0.010	3.50	13.1
529.4	6.6	4.4	7.0	0.02	0.010	3.72	16.3
529.48	6.9	4.9	7.4	0.02	0.010	3.91	19.3

Above drain				
Stage	**Conveyance K**	**Manning's n**	**Channel slope (m/m)**	**Q (m3/s)**
529.5	227.1	0.06	0.010	23.2
529.52	306.7	0.06	0.010	31.3
529.56	522.4	0.06	0.010	53.3
529.60	757.5	0.06	0.010	77.3
529.70	1268.4	0.06	0.010	129.5

APPENDIX C: CROSS-SECTION OF A TYPICAL DIVERSION CHANNEL



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CLIENT:	Galena Mining
PROJECT:	Abra Silver-lead Deposit
DATE:	September 2018
DWG NO:	496-0/18-02/App C

Typical Cross-Section
Drain/Levee System

Rockwater
PROPRIETARY LIMITED

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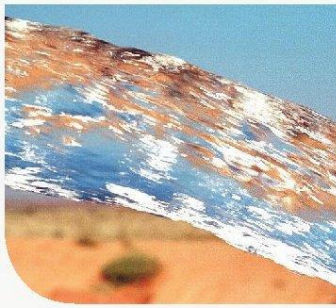

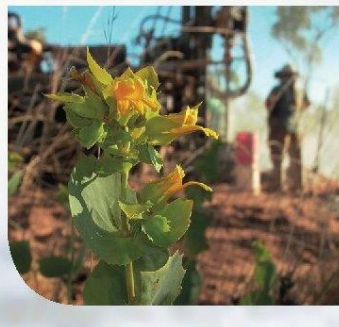

ABRA LEAD-SILVER PROJECT

HYDROLOGY AND SURFACE-WATER ASSESSMENT ADDENDUM

REPORT FOR

GALENA MINING LTD

FEBRUARY 2019

Report No. 496-0/19/01

Rockwater

HYDROGEOLOGICAL AND ENVIRONMENTAL CONSULTANTS

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TABLE OF CONTENTS

REVISION	AUTHOR	REVIEW	AUTHORISED	ISSUED
0	CC/PHW	JG		11/2/19

1. INTRODUCTION

Galena Mining Ltd is conducting a pre-feasibility study for mining its Abra lead-silver deposit, located 200 km north of Meekatharra in the Jillawarra sub-basin of the Proterozoic Edmund Basin. The project lies on a south-east facing slope. There are two major drainage lines about 200 m south and 400 m east of the project. Also, some of the project's planned infrastructure intersects or lies between two small creeks.

Rockwater Pty Ltd was commissioned by Galena Mining Ltd to prepare a surface water management plan to assess the potential impact of flood flows on surface infrastructure and to determine the bunding and drainage requirements. The results were presented in a report (Rockwater, 2018).

The Tangadee Road crosses a major tributary of the Ethel River (5 Mile Creek), 4 km north-east of the Abra Deposit (Fig. 1). The road will be used as the main access to the air-strip, and so Rockwater was asked to investigate the hydrology and hydraulics of the creek at the road crossing, and to make recommendations for construction of the crossing to maintain trafficability after rainfalls. This Addendum to the 2018 surface water management plan presents the results of the investigation, and should be read in conjunction with that report (Rockwater, 2018).

2. SURFACE WATER HYDROLOGY

2.1. RAINFALL ANALYSIS

Intensity-Frequency-Duration (IFD) curves for the Abra site and the rainfall analysis are given in the main report (Rockwater, 2018). The nearest Bureau of Meteorology (BoM) station is Tangadee (Stn. 007179), located 45 km east-north-east of Abra. Annual Rainfall (1960 to 2018) averages 269 mm.

2.2. CATCHMENT DETAILS

The catchment area for the road crossing (Catchment A) is shown in Fig. 1, and covers an area of 47.8 km^2. Details of the catchment used in the hydrological calculations are as follows:

Catchment Area	47.8 km^2
Catchment Length	10 km
Time of Concentration	2.43 hours
Average annual rainfall	269 mm

2.3. PEAK FLOW ESTIMATION

Two methods recommended in n the Australian Rainfall and Runoff 1987 (AR&R, 1987) Guideline and later versions were used to estimate peak flows. The new 2016 peak flow estimation method gives unrealistic numbers and so was not used.

2.3.1. RATIONAL METHOD

The Statistical Rational Method, used in peak-flow estimation, is presented in Equation 1.

$$Q_y = 0.278 \cdot C_y \cdot I_{tcy} \cdot A$$ **Equation 1**

Where:

- Q_y is the peak flow for return period of y years (m^3/s)
- 0.278 is a dimensionless metric conversion factor
- C_y is the runoff coefficient for y years (dimensionless)
- I_{tcy} is rainfall intensity (mm/hr)
- A is catchment area (km^2)

2.3.2. FLOOD INDEX METHOD

The Flood Index Method for the Pilbara Region, also used in peak-flow estimation, is presented in Equation 2.

$$Q_5 = 6.73 \times 10^{-4} \cdot \mathrm{A}^{0.72} \cdot \mathrm{P}^{1.51}$$ **Equation 2**

Where:

- Q_5 is the peak discharge for the 5-year ARI flow (m^3/s)
- A is the catchment area (km^2)
- P is the average annual rainfall (mm)

2.3.3. DESIGN PEAK FLOWS

A summary of the design peak flows, as estimated using the Rational and Flood Index Methods, is shown in Table 1. The detailed calculations are presented in Appendix I.

Table 1: Estimated Peak Flows

Catchment A	**ARI (years) / Discharge (m^3/s)**						
Method:	2	5	10	20	50	100	PMF*
Rational	22.03	49.20	92.12	186.03	342.62	601.62	
Index	25.83	50.83	90.18	155.26	294.02	512.75	
Adopted	**23.93**	**50.01**	**91.15**	**170.64**	**318.32**	**557.18**	**960.31**

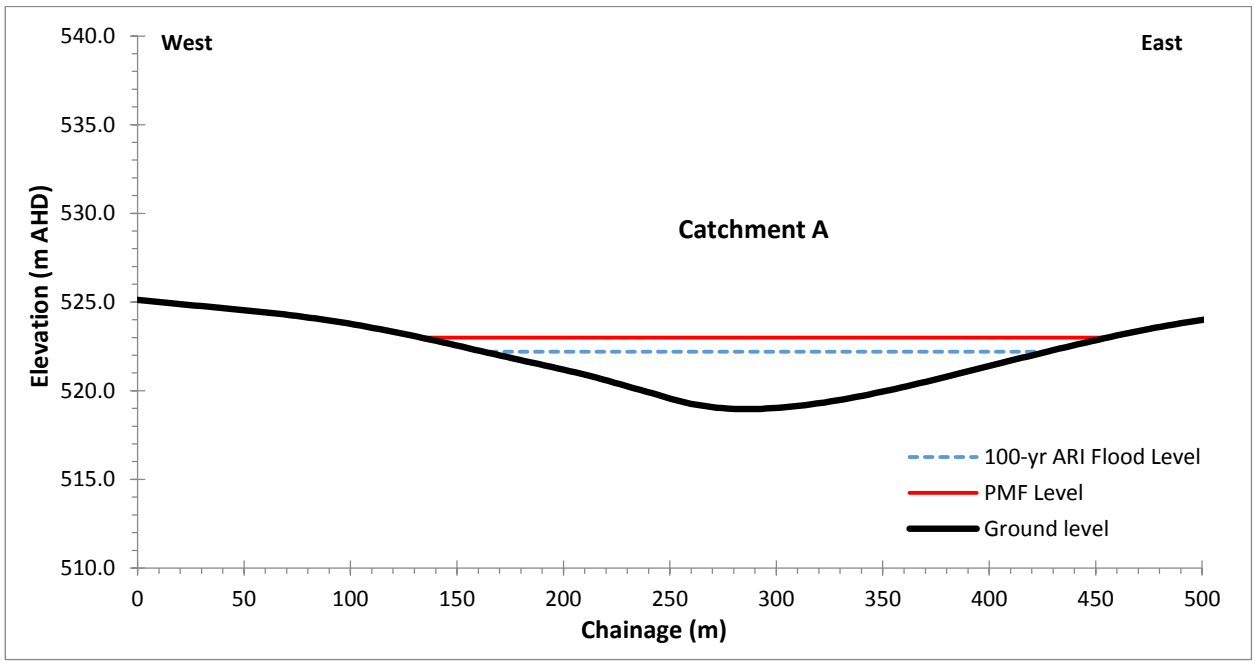
** PMF (probable maximum flood) estimated using multiplying factors from CRC-FORGE results*

3. HYDRAULIC ANALYSES

Hydraulic analyses were conducted to assess the depths, widths and velocities of flood and more-frequent flows at the creek crossing in order to recommend engineering requirements for the crossing. Stage-discharge and stage-velocity relationships were calculated using Manning's equation. The topographic contours along the creek include several "bullseyes" (Fig. 1) that either indicate local holes in the creek bed or errors in the data. These were ignored in the hydraulic analysis for which a constant bed gradient upstream and downstream of the cross-section was assumed.

The analyses indicate that in a 1-in-100 year flood, the peak flood levels at the crossing from Catchment A would be at about 522.2 m AHD with a width of about 263 m, and the level would be about 0.8 m higher in a Probable Maximum Flood (PMF) (Text-Figure 1).

Text-Figure 1: Cross Section with 100 year ARI flood level and PMF



The maximum depth of the 1-in-100 year flood would be about 3.2 m and the maximum velocity in the order of 1.1 m/s (Table 2).

Table 2: Cross-section at road crossing – 100-year ARI flood and PMF summary

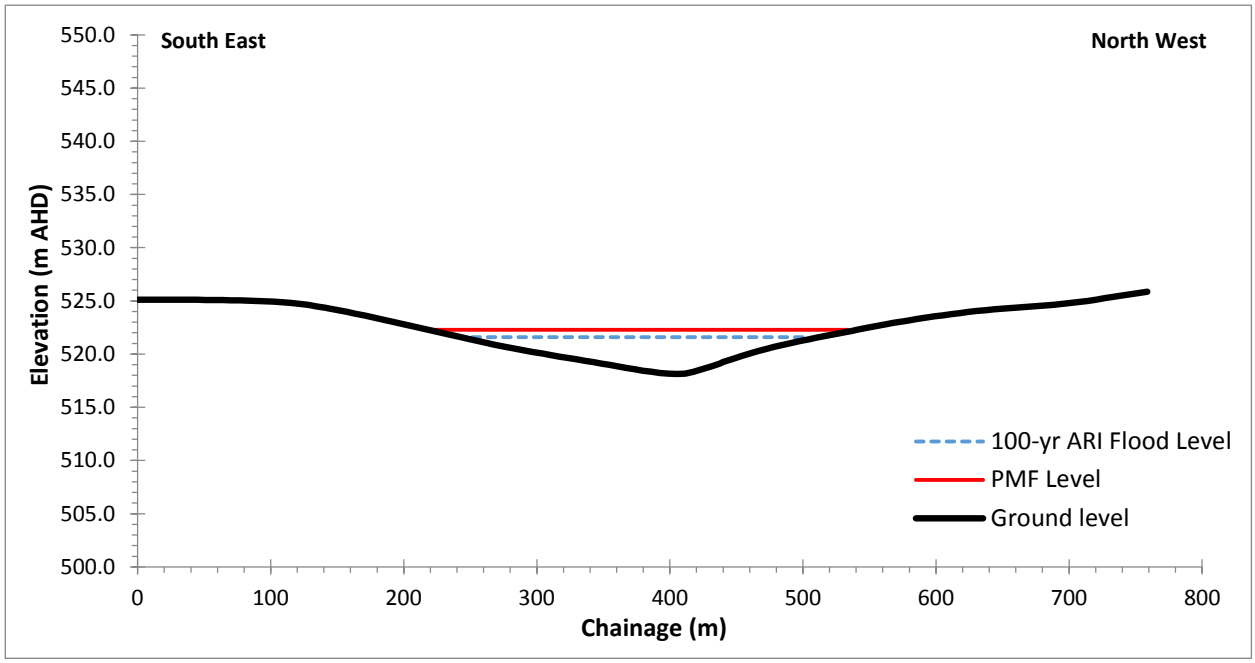
Flood Analysis	Flow (m^3/s)	Flood Level Elevation (m AHD)	Depth (m)	Velocity (m/s)	Extent of Flood Level (m)
100-yr	557	522.2	3.2	1.1	263
PMF	960	523.0	4.0	1.3	319

4. RECOMMENDED CROSSING DESIGN

4.1. EXISTING ROAD CONDITIONS

It is assumed that the existing road is an unformed un-sheeted road following the natural topographic contours as provided.

Text-Figure 2: Long-Section of the existing road at the creek crossing



With the existing road conditions, the road would be closed in every flood event for both light and heavy vehicles. The times of closure in different flood events are presented in Table 3.

Table 3: Closure periods of the existing road

Event	Q (m^3/s)	V (m/s)	Elevation (m AHD)	Depth (m)	Extent (m)	Time of closure (hrs)	
						Light vehicles	Heavy vehicles
1-in-2 yr	24	0.5	519.0	0.9	80	7.1	5.7
1-in-5 yr	50	0.6	519.4	1.3	100	7.2	6.5
1-in-10 yr	91	0.7	519.8	1.7	140	7.2	6.9
1-in-20 yr	171	0.9	520.2	2.1	160	7.3	7.1
1-in-50 yr	318	1.0	520.9	2.8	210	7.3	7.2
1-in-100 yr	557	1.2	521.6	3.5	260	7.3	7.2

The existing road would operate as an open channel with a natural velocity in the order of 1.0 m/s. While severe scouring is not likely to occur, sediment transport of bedload could require some maintenance.

Depending on the desired serviceability, a floodway-culvert system will likely be required in order to keep the road passable in minor flood events and reduce the time of closure in major flood events. The suggested broad crested weir conceptual design is presented below.

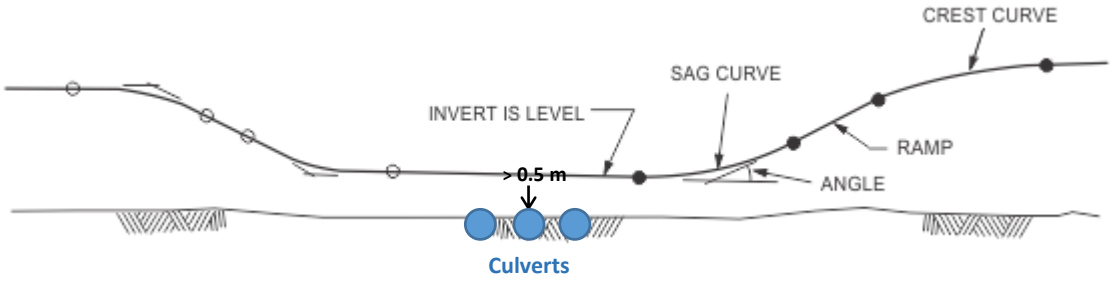
4.2. RECOMMENDATIONS - BROAD CRESTED WEIR

It is recommended that nominal concrete or corrugated steel culverts be installed to drain the normal annual minor flows in order to ensure no bogging at the road embankment and a raised floodway be constructed to pass the rare flood events.

The culverts should be at a minimum of 600mm diameter to avoid obstruction from sediment transportation. The number, size and locations of the culverts are to be decided on site.

The culverts should be placed at the lowest possible level. Also, a minimum of 0.5 m cover above the culverts is required in order to prevent the road-way from failing due to vertical tyre loading of heavy vehicles, as presented in Text-Figure 3 below.

Text-Figure 3: Typical long-section of a floodway (MRWA)



4.2.1. SERVICEABILITY

To be serviceable, the critical depth of the flood flow above the floodway should be no greater than 200 mm for light vehicles and 500 mm for heavy vehicles.

Considering these requirements, the length of the floodway permitting the road to be passable in case of peak flows were calculated using the broad crested weir capacity equation and are shown in Table 4. Note that in the calculations below, the discharge through the culverts is considered nominal and was ignored.

Table 4: Required floodway length for the road to be serviceable in major flood events

		Length of floodway for serviceability (m)	
Flood Event	**Q (m^3/s)**	**Light vehicles (i.e. depth of flow over road = 200mm)**	**Heavy vehicles (i.e. depth of flow over road = 500mm)**
1-in-2 year	24	85	22
1-in-5 year	50	178	45
1-in-10 year	91	324	82
1-in-20 year	171	607	154
1-in-50 year	318	1133	287
1-in-100 year	557	1983	502

4.2.2. CLOSURE PERIODS IN HIGH FLOOD FLOW

Two options are compared in Table 5 below:

- An 85 m length floodway that would allow the road to remain serviceable in the 1-in-2 year flood for light vehicles and the 1-in-10 year flood for heavy vehicles; and
- A 180 m length floodway that would allow light vehicles to cross the creek in the 1-in-5 year flood and heavy vehicles to cross it in the 1-in-20 year flood.

Note that it would probably be more cost-effective to lower the invert level of the floodway rather than shortening the length if the option of lower serviceability is preferred.

Table 5: Closure periods with the two options

Flood Event	Q (m^3/s)	Closure periods (hours) 85 length floodway		Closure periods (hours) 180 length floodway	
		Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles
1-in-2 year	24	NA	NA	NA	NA
1-in-5 year	50	3.8	NA	NA	NA
1-in-10 year	91	5.4	NA	3.3	NA
1-in-20 year	171	6.3	3.3	5.1	NA
1-in-50 year	318	6.8	5.1	6.1	2.7
1-in-100 year	557	7.0	6.1	6.6	4.7

With both options, the road is likely to be vulnerable to scouring damage in rare flood events and scour protections and/or a scour management plan are required.

4.3. SCOUR PROTECTION RECOMMENDATIONS

Given the low velocity of the 1-in-100 year ARI flow, it is recommended that the protection on the downstream shoulder and batter slope be graded rocks with a maximum diameter of 200-300 mm.

Depending on the planned operational duration of the Abra lead-silver deposit, the probability of actual closure and damage of the floodway should be balanced with the serviceability and cost requirements. Scour protections on the downstream shoulder and batter slope should be considered. However, the floodway could be left unprotected and scour damage during normal overtopping would require minor maintenance and major repair if the unlikely rare flood event occurs.

The risk of damage to the downstream shoulder can be reduced by rounding the shoulder as much as possible, to avoid the generation of negative pressures at the change of flow direction.

If a decision is made not to use scour protection (e.g. graded rocks) on the road, a plan needs to be put in place for a quick repair of the road after damage from scouring.

For information purposes, a typical floodway protection design, as recommended by MRWA for low velocity floods, is presented in Appendix C.

5. CONCLUSIONS

Flood flows from the catchment defined in Figure 1 are likely to be in the form of wide sheet flows. A floodway and nominal drainage culvert system type of waterway structure is probably the most effective way to keep the road passable in minor flood events, and to reduce the time of closure in major flood events. Rockwater recommends that the floodway be designed for a serviceability of 1-in-2 years ARI event.

In the 1-in-100 year ARI flood, the road is likely to be closed for about 7 hours. Residual flow following a flood event could persist for a few days. The risk of scour damage to the road should be taken into considerations in subsequent detailed-design assessments. It is recommended that the floodway be protected by graded rocks with a maximum diameter of 200-300 mm on the downstream shoulder and batter slope.

The floodway should include nominal drainage culverts of at least 600 mm diameter.

All recommendations presented in this report are part of a conceptual design and require adjustments depending on specific site conditions.

Dated: 11 February 2019

Rockwater Pty Ltd

C Corthier
Engineering Geologist

REFERENCES

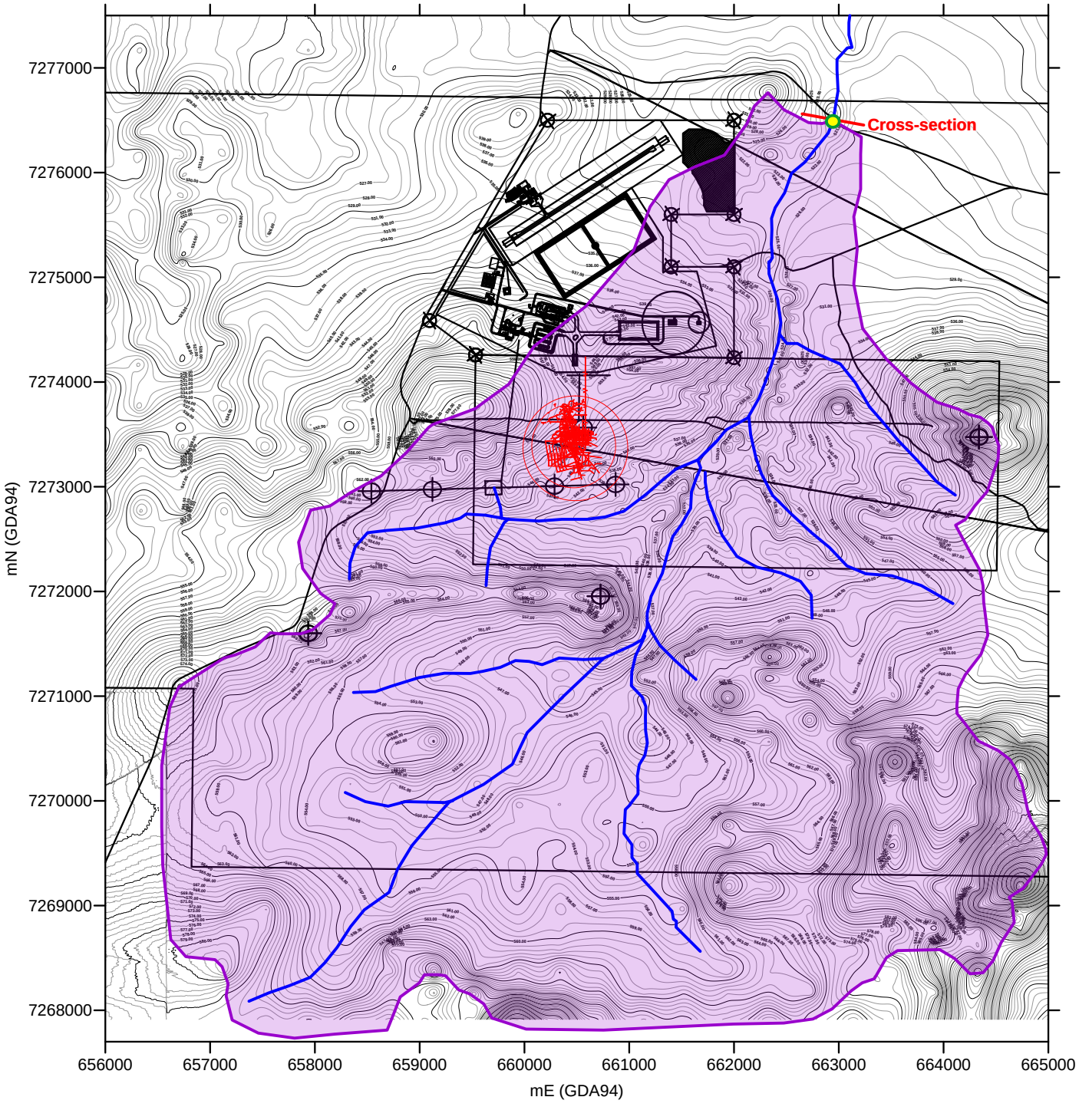
Pilgrim, D.H., et al, 1987, (AR&R 1987) Australian Rainfall and Runoff. The Institution of Engineers, Australia.

Rockwater, 2018, Abra Lead-Silver Project, Hydrology and surface-water assessment. Report for Galena Mining Ltd.

Main Roads Western Australia & BG&E Pty Ltd, 2006, Floodway Design Guide.

FIGURE

FIGURE 1



Major drainage lines

1 m topographic contours

Catchment A

Road crossing

Infrastructure Layout

Abra Deposit

catchment.srf

CLIENT: Galena Mining

PROJECT: Abra Silver-lead Deposit

DATE: February 2019

Dwg No: 496-0/18/2-1

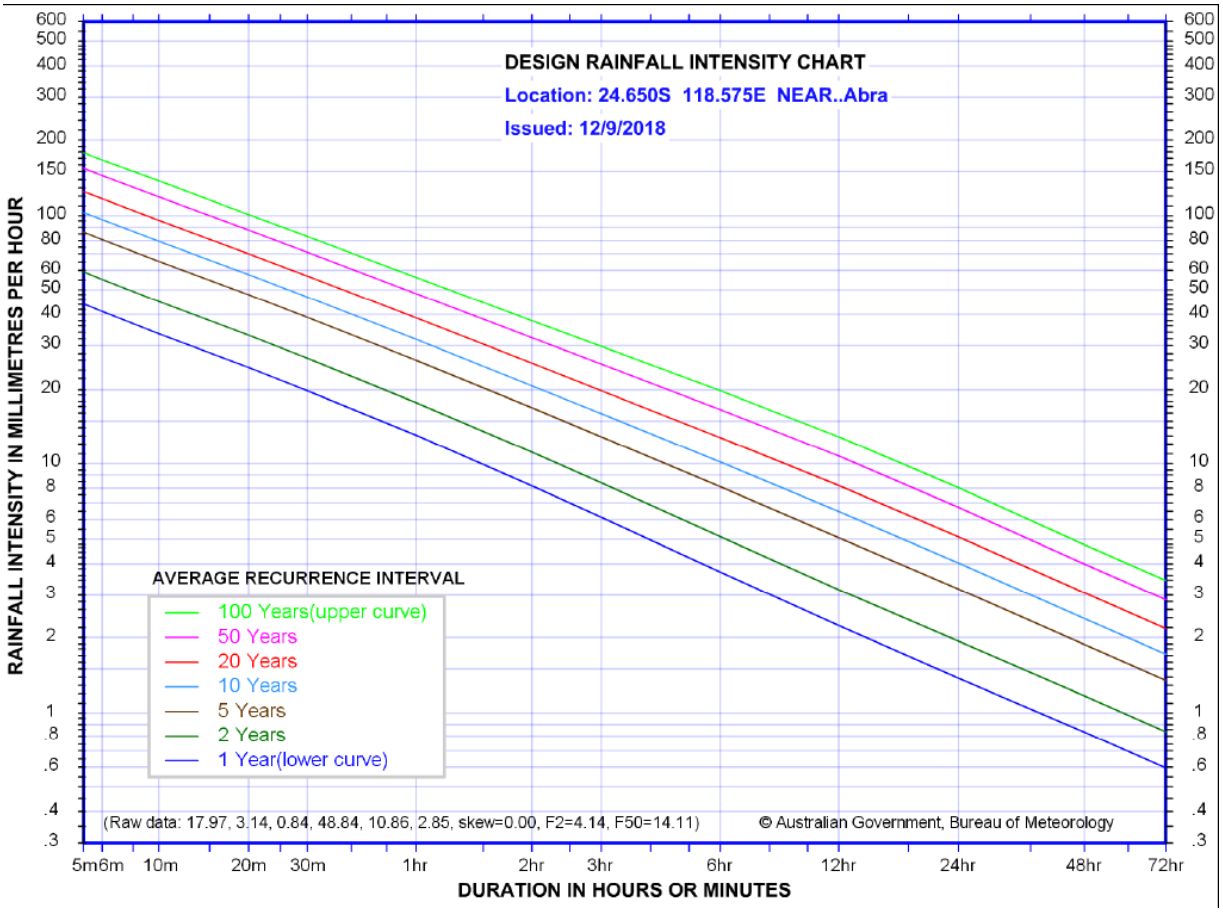
CATCHMENT & CROSSING LOCATION

Rockwater
PROPRIETARY LIMITED

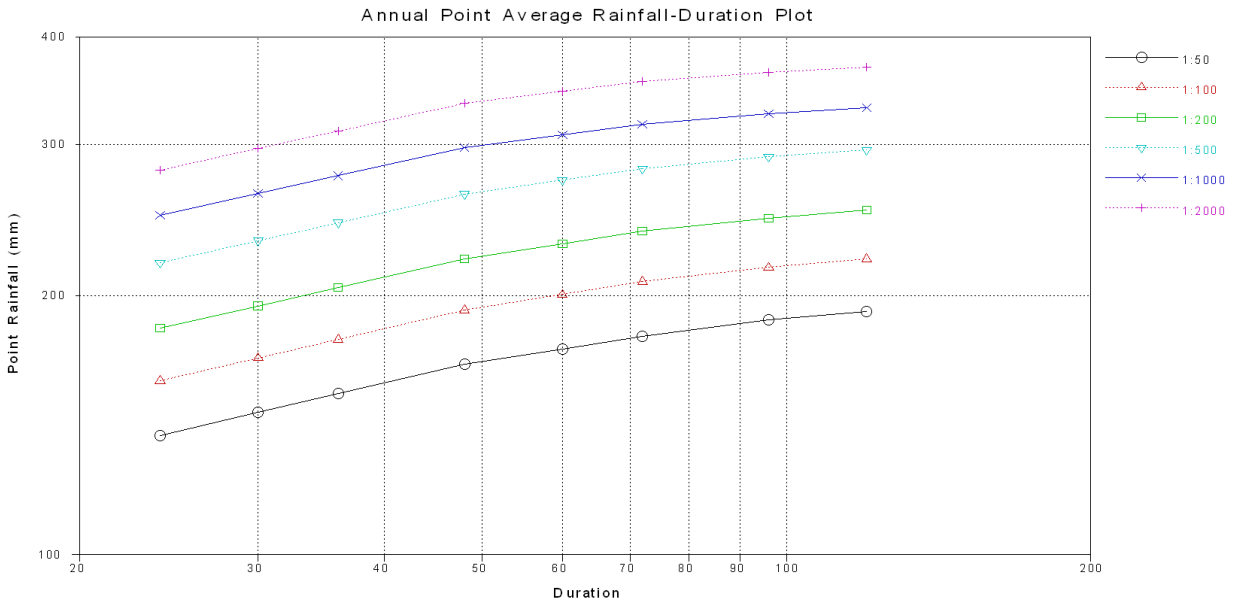
APPENDIX A: HYDROLOGY CHARTS AND CALCULATIONS

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

IFD Curves:



CRC Forge Results:



AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: A

Pilbara Region

Catchment Characteristics	A (km^2)	L (km)	S_e (m/km)	P (mm)
	47.8	10	7.6	269

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	7980	km^2
L =	10	-	194	km
S_e =	1.43	-	3.77	m/km
P =	230	-	400	mm

$Q_Y = 0.278 C_Y . I_{tc,Y} . A$ ..... **(1.1)**

$t_c = 0.56A^{0.38}$ ..... **(1.29)**

t_c = 2.43 Hrs

$C_2 = 3.07x10^{-1}L^{-0.20}$ ..... **(1.30)**

C_2 = 0.194

Frequency Factors (C_Y/C_{10})

	ARI (years)					
	2	5	10	20	50	*100*
C_Y/C_2	1.00	1.46	2.21	3.60	5.20	*7.76*

100 year ARI extrapolated using the logarithmic trend-line

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C_Y	0.19	0.28	0.43	0.70	1.01	1.50

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: A

RATIONAL METHOD:
CONTINUES

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

t_c = 2.43 hours

Use IFD curves

Duration	ARI (Years) [mm/hr]					
(hours)	2	5	10	20	50	100
2.43	8.6	13.1	16.2	20.1	25.6	30.1

Calculate peak discharge using equation (1.1)

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	22.0	49.2	92.1	186.0	342.6	601.6

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: A

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	40.5	-	49600	km^2
L =	10	-	498	km
S_e =	0.88	-	3.77	m/km
P =	230	-	400	mm

$Q_5 = 6.73x10^{-4}A^{0.72}P^{1.51}$ ..... **(1.31)**

Q_5 = 50.8 m^3/s

Frequency Factors (Q_Y/Q_5) interpolated for Catchment A

	ARI (years)					
47.8 km^2	2	5	10	20	50	*100*
Q_Y/Q_5	0.51	1.00	1.77	3.05	5.78	*10.09*

100 year ARI extrapolated using the power trend-line

Therefore the peak discharge

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	25.83	50.83	90.18	155.26	294.02	512.75

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA

REGION: **PILBARA**

LOCATION: Abra

CATCHMENT: A

SUMMARY OF RATIONAL AND INDEX METHODS:

Pilbara Region

Catchment A	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational	22.03	49.20	92.12	186.03	342.62	601.62	
Index	25.83	50.83	90.18	155.26	294.02	512.75	
Adopted	**23.93**	**50.01**	**91.15**	**170.64**	**318.32**	**557.18**	**960.31**

*PMF estimated using multiplying factors from CRC-FORGE results

APPENDIX B: HYDRAULIC ANALYSES

Manning's Formula: $$\mathbf{Q = \frac{1}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}}$$

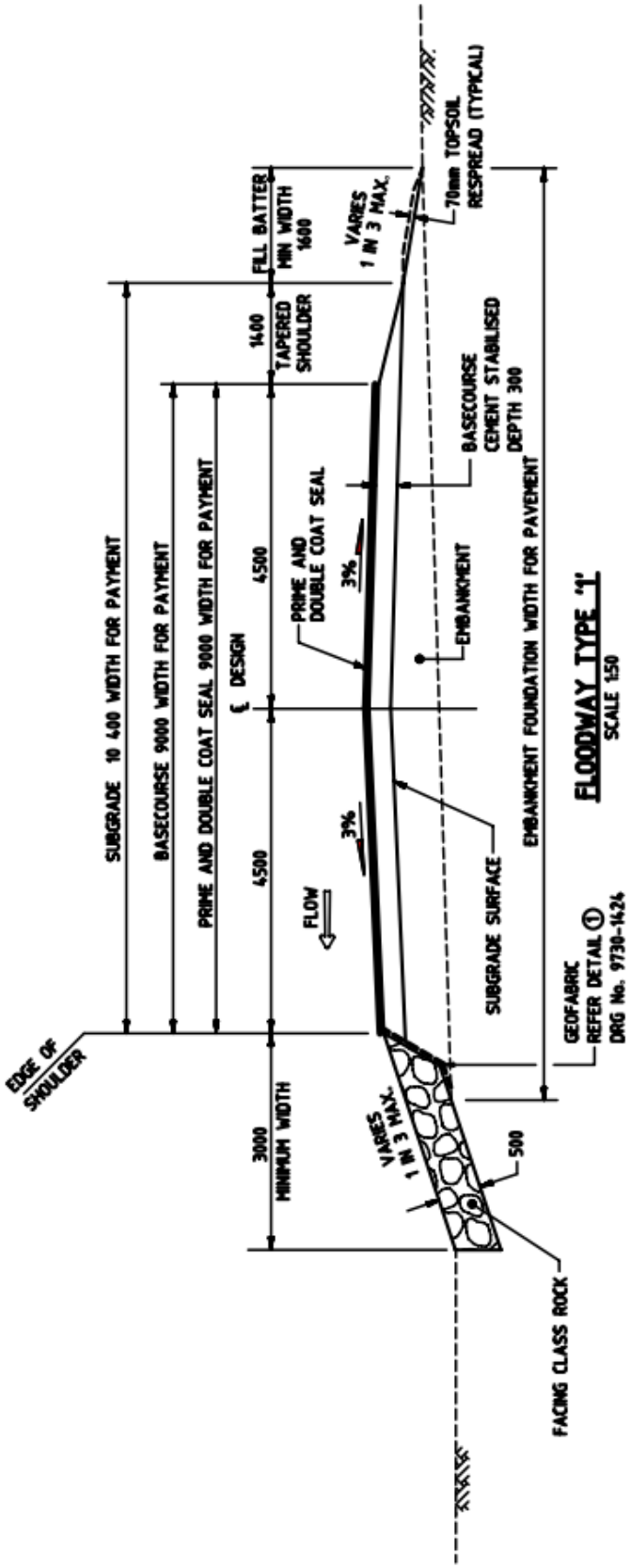
Cross-section at crossing (Catchment A)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
519.0	0.00	0.00	0.00	0.06	0.002	0.00	0.00
519.5	74.67	27.72	74.68	0.06	0.002	0.39	10.89
520.0	110.52	76.36	110.54	0.06	0.002	0.59	45.39
520.5	143.37	141.99	143.41	0.06	0.002	0.76	107.30
521.0	176.23	223.64	176.28	0.06	0.002	0.89	199.37
521.5	212.07	322.32	212.14	0.06	0.002	1.01	324.05
522.0	247.92	439.16	248.00	0.06	0.002	1.11	488.99
522.2	262.85	490.41	262.94	0.06	0.002	1.15	565.28
522.4	277.79	545.01	277.88	0.06	0.002	1.19	649.64
522.6	289.73	602.13	289.83	0.06	0.002	1.24	745.78
522.8	304.67	661.93	304.77	0.06	0.002	1.28	844.49
523.0	319.60	725.24	319.71	0.06	0.002	1.31	952.48

Road long-section at crossing (Catchment A)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
518.1	0.00	0.00	0.00	0.06	0.002	0.00	0.00
518.5	38.24	10.92	38.24	0.06	0.002	0.33	3.60
519.0	76.68	42.96	76.70	0.06	0.002	0.52	22.20
519.5	104.06	91.29	104.09	0.06	0.002	0.70	63.63
520.0	142.50	158.89	142.55	0.06	0.002	0.82	129.94
520.5	187.35	244.03	187.42	0.06	0.002	0.91	221.36
521.0	217.61	347.19	217.69	0.06	0.002	1.04	360.54
521.5	256.05	469.37	256.15	0.06	0.002	1.14	534.68
522.0	294.49	610.70	294.60	0.06	0.002	1.24	755.30
522.5	332.93	768.98	333.05	0.06	0.002	1.33	1021.90

APPENDIX C: TYPICAL FLOODWAY SCOUR PROTECTION DESIGN



I/496-0/Surfer/18/02/App C/App C-Typical CS of a diversion channel.srf

CLIENT:	Galena Mining
PROJECT:	Abra Silver-lead Deposit
DATE:	February 2019
DWG NO:	496-0/19-01/App C

Typical Floodway
Scour Protection Design
(MRWA standards)

Rockwater
PROPRIETARY LIMITED

Appendix J. DMIRS Correspondence

Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

Our ref EARS-MPMCP-76773
Enquiries Lawson Brandis
Ph 9222 3718
lawson.brandis@dmirs.wa.gov.au

The Registered Manager
Galena Mining Limited
Suite 5, 245 Churchill Avenue
SUBIACO WA 6008

Attention: Troy Flannery

FURTHER INFORMATION REQUESTED - MINING PROPOSAL WITH MINE CLOSURE PLAN – GALENA MINING LIMITED – G52/292, M52/776 and L52/194 – ABRA BASE METALS PROJECT – REGISTRATION ID 76773

The Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety (DMIRS) has commenced assessment of your Mining Proposal (MP) and accompanying Mine Closure Plan (MCP) dated 25 October 2018. As part of the assessment further clarification on the below items is required. Please note a revised MP and MCP will be required to be resubmitted to the Resource and Environmental Compliance Division, DMIRS, to finalise assessment, however for the interim it is recommended that the below concerns be addressed via a return letter.

MINING PROPOSAL (MP)

Mining Proposal Checklist

1. The MP checklist is not complete (please see Q10 and Q11). Please complete the checklist for the revised document. Please note that the checklist will need to be re-signed and dated with the revised version.

Mine Activities Detail

2. The last row of Table 5 Mine Activities has not been completed. Please include the total mine activity area.
3. The Key Mine Activity tables should be numbered (i.e. Table 6-10), as these tables will be imposed as tenement condition for the Abra Project at approval.
4. Key Mine Activity Information
    - It is noted that there will be a Paste Plant installed to support the Abra Project, however it is not clear if the disturbance for this has been included in Table 5. Furthermore, a Key Mine Activity table is not provided. Please confirm whether the Paste Plant is included as part of the 'Process Plant' disturbance footprint, otherwise please update this section to include the Paste Plant.
    - As the Key Mine Activities tables will be imposed as tenement conditions, the information within these tables should be succinct and specific to the design details. The lengthy discussions should be removed from the tables and placed into the body text of the MP, which then references the relevant table. Please refer to Table H2 of the 2016 MP Guidelines to identify what specific design details are required in the Key Mine Activity table. Furthermore, the details provided within these tables should be complete without references to other sections of the MP.
    - Please provide information on final batters of the TSF embankment and WRD.

Stakeholder Consultation

5. It would be beneficial to have a list of key stakeholders in this section, to clearly identify who the key stakeholders are (as done so for the MCP). It is noted in the MCP that the Port of Geraldton has been included as a key stakeholder. Please be advised that the MP still states that the export location is yet to be determined. If a decision has been made, the MP should be updated.
6. It is positive to see that Galena have undertaken some early stakeholder engagement as part of the development of the Abra Project's proposal. However, there is no evidence of stakeholder consultation in relation to the Aboriginal Heritage survey conducted over the Project area with the Jidi Jidi Aboriginal Corporation, the Nharnuwangga Wajarri and Ngarlawangga Indigenous Land Use Agreement, or engagement with lease holder of Mulgul Station (Yaluning Aboriginal Corporation).
7. Please ensure that the Stakeholder Consultation Register for the MP and MCP are up to date and consistent with one another.

Baseline Data

8. The baseline data only partially meet the requirements under the MP Guidelines. An appropriate description, analysis and interpretation of the baseline data must be provided in each sub-section, so that DMIRS can see that this information has informed the risk assessment and environmental outcomes. Please refer back to Section 3.8 of the DMIRS 2016 Guidelines for Mining Proposal in Western Australia (MP Guidelines). I have provided some examples below explaining where the baseline data does not meet the MP Guidelines, however please note that this list is not exhaustive and Galena should review their entire baseline data for the Project.
    - **Materials Characterisation:** The baseline data states that the Kianga Creek lower conglomerate unit, Upper Iregully dolomitic unit, and the Iregully Chloritic sediment unit contains varying quantities of sulphides. The risk assessment control measures state, '*Baseline materials characterisation studies quantify the risk of PAF material in mine waste. Encapsulate high risk material (if identified)'*. The supporting technical reports appears to only provide information on tailings characterisation, therefore it is unclear what the findings of the materials characterisation studies are. As no interpretation of the baseline data has been provided in the Materials Characterisation baseline sub-section, it is unclear whether there is PAF or not.
    - **Soils:** Adequate characterisation of the soils has not been presented clearly in the MP, including information on the chemical/physical properties that will affect stability of successful rehabilitation. Please refer to section 3.8.3 of the MP Guidelines which outlines the required information.
    - **Hydrology:** This section does not include any baseline data regarding surface water within the project area, however the risk assessment and environmental outcomes table refers to sediment basins, drainage basins and stormwater systems. It is unknown whether these proposed surface water management measures are adequate. Please refer to section 3.8.5 of the MP Guidelines which outlines the required information.
9. Please note that in Section 4.2 Landscape, it refers to Figure 1. However, Figure 1 is the regional view of the general site location. Please confirm whether this should have referred to a new figure.

Given that further baseline data is required for the Project, a complete review of the risk assessment and proposed environmental outcomes could not be undertaken. However, please see below the general comments for the current risk assessment and proposed environmental outcomes. Please be advised that DMIRS may request further for information or have additional comments, dependent on the update/changes to the baseline data in the revision.

Risk Assessment

10. Overall, the risk assessment for the Abra Project does not meet the MP Guidelines and will require an update. Please be reminded that the risk assessment required in the MP is an environmental risk assessment. The environmental consequence criteria is generic, and therefore may be skewing the consequence level applied to the risk to be lower than what DMIRS would expect. This criteria should be updated to be specific for each environmental factor/aspect. Please refer

to Appendix J (Table J2) of the MP Guidelines for examples. DMIRS invites Galena Mining (or Jacobs on behalf of Galena) to submit the revised consequence criteria prior to undertaking the full risk assessment again. It is further recommended that the revised risk assessment be submitted to DMIRS prior to the submission of the revised MP.

11. All residual risk except for risk No.13 have been dropped to Low. When assessing the risk of an unwanted event (i.e. potential impacts), the consequence can only change where an activity has been eliminated or avoided. Therefore, internal procedures typically would not warrant a drop in consequence. The likelihood is the factor which changes, and then only usually by one degree, unless the controls are exceptional and are demonstrated across the industry to result in a greater change to likelihood. Majority of the likelihood and consequences in this risk assessment have been dropped without the elimination or avoidance of the risk pathway. Therefore, DMIRS considers the drop in likelihood and consequence (and therefore risk) is unjustified in many cases. An example is provided below, however please review the risk assessment in its entirety.
    - **Waste Rock Dump:** The risk of '*sediment in surrounding vegetation and surface water systems'* is Moderate, then with the control measure of '*conduct planning to see if WRD can be used for TSF capping'*, the risk drops to Low. The control measure in this case is to 'conduct planning', which does not eliminate or avoid the unwanted activity. Therefore, the drop in likelihood or consequence is not warranted in this case. Once the studies are completed and conclude that the WRD is suitable for TSF capping, then can the risk be dropped.
12. Risk No.2 and No.8 (which are the same) has the risk of '*Vegetation loss / Loss of fauna habitat'*. Regardless of whether there is a clearing procedure in place or not, vegetation and fauna habitat will be lost within the process of clearing native vegetation when developing the mine. If this risk refers to the unwanted event of clearing of vegetation and loss of habitat outside the permitted area, then it should be reworded to clearly state this.
13. There are numerous other documents that can assist when reviewing the risk assessment;
    - DMIRS has published a guidance on Risk Assessment and Environmental Outcomes that can be find here: http://www.dmp.wa.gov.au/News/DMIRS-guidance-on-Risk-23499.aspx
    - AS/NZS ISO 3100:2009 Risk Management – Principles and Guidelines
    - Australian Standard HB 203:2006 Environmental Risk Management

Environmental Outcomes, Performance Criteria and Monitoring

14. Once the baseline data and risk assessment has been updated, the revised information should facilitate the development of the revised environmental outcomes table. However, please see below some additional comments in relation to the requirements of the environmental outcomes table as outlined in the MP Guidelines.
    - The risk pathways should be clearly described for all environmental factors without reference to the risk assessment. Please see Appendix L for an example.
    - The performance criteria should be specific, measurable, achievable, realistic and time bound (SMART). However, being overly prescriptive can also be unrealistic. For example, the environmental outcome of '*no escape of hazardous materials to the environment'* would mean that if Galena had one minor hydrocarbon spill, then this outcome cannot be met. Furthermore, this outcome is contradictive to the outcome of '*all spills are quickly and effectively cleaned up*', which assumes that a spill may occur. Please also note that '*quickly and effectively'* is also an example of an outcome that is not measurable (e.g. what is considered to be quick and effective? 1 hour? 24 hours? This needs to be refined).
    - An environmental outcome of '*Above targets are met*' is not considered to be an environmental outcome and should be removed.
    - Performance criteria should wherever possible refer to key actions from a management plan/procedure and not just the plan/procedure itself. Please refer to addition guidance on writing outcomes and criteria available from the DMIRS website: http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-023.pdf.

Appendices

15. Please ensure that the appendices provided in the MP are correct. It does not appear that Appendix D, Vegetation Clearing Application has been included, and there is a duplication of Appendix E, Environmental Management System.
16. The groundwater report and materials characterisation should also be appended to the MP, not just within the Mine Closure Plan.

GEOTECHNICAL REVIEW

A review by a DMIRS Inspector of Mines – Geotechnical was undertaken of the TSF design, and further information is required on the following items:

17. Provide a PMP assessment to demonstrate impact to mine site designed final infrastructure (i.e. impact on TSF Embankments, remaining diversion channels if applicable).
18. The Third Party Independent Technical Reviewer declaration for the TSF has not been endorsed by Galena Mining Limited. Provide a completed declaration (page 467).
19. Based on the nature of the tailings (i.e. dispersive, high settling density etc.) describe any implications to the use of tailings in the backfill paste (i.e. describe the work completed to confirm the tailings will be acceptable to use underground).

MINE CLOSURE PLAN (MCP)

Identification of Closure Obligations and Commitments

20. The current Compliance Register does not provide information on what the actual closure obligations and commitments are, but a list of the source of the obligations/commitments (e.g. Tenement Condition, MP Commitments, Works Approval, etc.). Therefore, the current Compliance Register may be a useful internal register to keep, but it does not meet the requirements of the MCP Guidelines. It is noted that non-legal obligations or commitments under the Heritage Agreement are not included in this register. This section will need to be updated to include all closure related obligations and commitments. Please refer to Section 4.6 and Appendix E of the MCP Guidelines.

Please note that an additional information request may be required when comments from the Department of Water and Environmental Regulation (DWER) are received.

Galena Mining Limited are required to provide a written response (via a return letter) addressing the above concerns **within 30 working days (prior to 29 MARCH 2019).**

If you have any questions or if it is not possible to provide the information within 30 working days, please contact the undersigned via telephone on (08) 9222 3718.

Yours sincerely

Lawson Brandis

_____

Lawson Brandis
Environmental Officer
21 February 2019

DMIRS letter dated 21/2/2019 (Ref EARS-MPMCP-76773).

Each point in the letter has been reproduced in red text below. Galena's response is in black text.

Mining Proposal Checklist

1. The MP checklist is not complete (please see Q10 and Q11). Please complete the checklist for the revised document. Please note that the checklist will need to be re-signed and dated with the revised version.

Question 10 and 11 have been completed and the checklist re-signed in Rev 2 of the MP.

Mine Activities Detail

2. The last row of Table 5 Mine Activities has not been completed. Please include the total mine activity area.

Last row of Table 5 has been completed

3. The Key Mine Activity tables should be numbered (i.e. Table 6-10), as these tables will be imposed as tenement condition for the Abra Project at approval.

Key mine activity tables have been numbered in Revision 2.

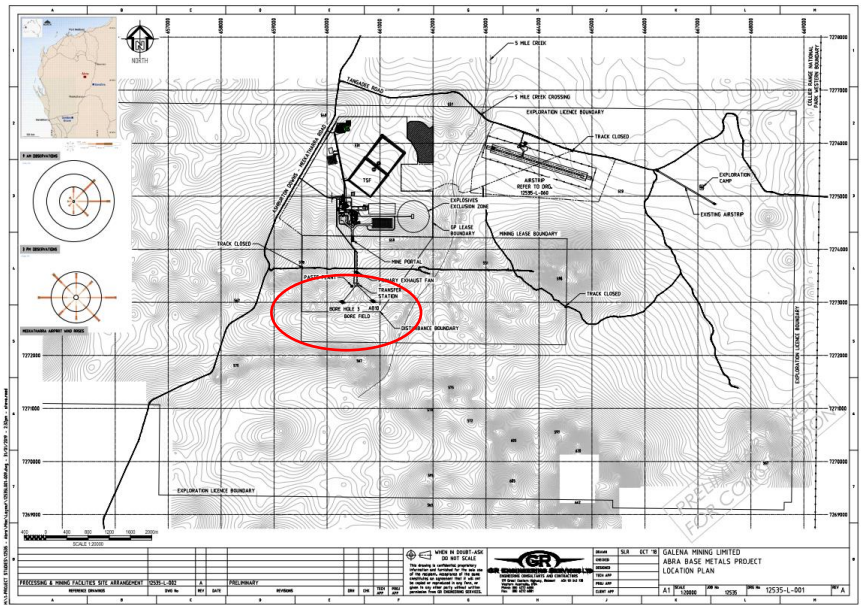
4. Key Mine Activity Information

i. It is noted that there will be a Paste Plant installed to support the Abra Project, however it is not clear if the disturbance for this has been included in Table 5. Furthermore, a Key Mine Activity table is not provided. Please confirm whether the Paste Plant is included as part of the 'Process Plant' disturbance footprint, otherwise please update this section to include the Paste Plant.

i The paste plant is not located within the main flotation process plant area. MP Rev 1 Figure 2 (reproduced below) shows the paste plant located above the orebody. Tailings will be pumped to the paste plant from the process plant. Surplus water from tailings dewatering will be pumped back to the process plant.

The area required for the paste plant is small. An area of 50m x 50m = 2,500m^2. This will be included in Table 6 (Rev2) - Key mine activity for m52/776.

Location of paste plant



ii. As the Key Mine Activities tables will be imposed as tenement conditions, the information within these tables should be succinct and specific to the design details. The lengthy discussions should be removed from the tables and placed into the body text of the MP, which then references the relevant table. Please refer to Table H2 of the 2016 MP Guidelines to identify what specific design details are required in the Key Mine Activity table. Furthermore, the details provided within these tables should be complete without references to other sections of the MP.

ii. Tables have been reworded as requested. See below.

Table 1: TSF Information

Tailings or residue storage facility			
Mine Activity Reference	TSF Cell A and B		
Area	64.000 ha		
Area per tenement	64.000 ha on G52/292		
Design	Design – Paddock Max Height -15 metres Number of Cells - 2 Construction method – Upstream Lining – Yes, geosynethic clay liner (GCL)		
Material Characteristics	Fibrous minerals – see WRD text	☐- Yes ☒- No	*Details*
	Radioactive material – see WRD text	☐- Yes ☒- No	*Details*
	Materials capable of generating acid and metalliferous drainage, including neutral drainage and saline drainage	☐- Yes ☒- No	*NAF mine waste used to construct embankment*
	Highly erodible material that is capable of compromising the structure of the storage facility.	☐- Yes ☒- No	*Outer embankment sheeted with competent mine waste from decline development*

Table 2: WRD information

Table WRD Information **Waste dump or overburden stockpile**			
Mine Activity Reference	Waste Rock Dump (WRD)		
Area	7.276 ha		
Area per tenement	7.276 ha in G52/292		
Design	Max Height - 20 metres		
Material Characteristics	Fibrous minerals The host geology for the Abra deposit is 100% Proterozoic sediments dominated by sandstones, siltstones, shales, conglomerates and dolomites. These rocks do not contain fibrous material and asbestiform minerals.	☐- Yes ☒- No	*Details*
	Radioactive material Uranium can possibly occur in sedimentary rocks. There have been 2,423 samples assayed for U with an average U content of 81.7ppm, which is considered a very low level.	☐- Yes ☒- No	*Details*
	Materials capable of generating acid and/or metalliferous drainage, including neutral drainage and saline drainage Waste characterisation has identified minor quantity of mine waste with potential to generate acid and significant quantity of mine waste with potential to neutralise acid.	☒- Yes ☐- No	*Details*
	Highly erodible material that is capable of compromising the structure of the waste dump. Underground mine waste is competent material	☐- Yes ☒- No	*Details*

Table 3: Boxcut information

Mining void			
Mine Activity Reference	Boxcut		
Area	0.473 ha		
Area per tenement	0.473 ha in M52/776		
Design	Design – Boxcut Depth – 15 metres		
Material Characteristics	Fibrous minerals – See text on WRD.	☐- Yes ☒- No	*Details*
	Radioactive material -– See text on WRD.	☐- Yes ☒- No	*Details*
	Materials capable of generating acid and metalliferous drainage, including neutral drainage and saline drainage, within pit walls or underground workings	☐- Yes ☒- No	*Details*
	Highly erodible material that is capable of compromising the long-term stability of the pit or underground workings	☐- Yes ☒- No	*Details*

Table 4: Process plant information

Plant Site	
Mine Activity Reference	Process Plant
Area	3.126 ha
Area per tenement	3.126 in G52/292
Type/ Design	Process plant design : • Three stage crushing; • Ball mill with a flash flotation cell; • Flotation and concentrate regrind to produce a lead/silver concentrate; • Concentrate dewatering utilising a thickener and a filter to produce transportable concentrates; • Tailings thickening • Tailings storage in a designated facility.

Table 5: ROM information

Run-of-mine Pad	
Mine Activity Reference	Run of Mine (ROM)
Area	3.209 ha
Area per tenement	3.209 in G52.292
Material Characteristics	ROM Core – constructed from NAF waste from boxcut and early decline development. ROM Extension – constructed of low grade (Pb 2.5 0 5%) mine waste. AMD analysis of samples of this material shown it is NAF. C

iii. Please provide information on final batters of the TSF embankment and WRD.

Text in the TSF design report states the maximum slope angle of the TSF embankments will be no more than 20^0, with no intermediate benches. The drawings show the embankment angle as 1:3, which is 18^o.

Text in the MP Rev 1 states that final design for the WRD has not been determined. Current materials balance information (MCP Rev 1 Table 9) shows all the material in the WRD will be used in the TSF embankments and top cover, plus an additional 153,125m^3 of borrow will be required. ie; there is a mine closure waste material deficit. There will be no WRD remaining at mine closure. If this situation changes (ie there will be a residual WRD at closure) subsequent revisions of the MCP will document this fact and include final designs of the landform.

The same is true for the ROM. The site layout figure shows the ROM will be constructed in 2 stages. Stage 1 will be constructed from inert mine waste taken from construction of the boxcut. Stage 2, enlargement of the Stage 1 footprint, will occur progressively through the life of mine and be made from Low Grade ore. This action serves to eliminate Low Grade ore from being deposited in the WRD. This has the benefit of;

(i) Not diluting Low Grade material with mine waste, to the point it becomes unrecoverable
(ii) Not contaminating the WRD with lead
(iii) Provides ready access from the ROM to recover this material for blending purposes, or (later in the mine life) to process this resource.

The intention is therefore to not have a residual ROM at mine closure. As with the WRD, if this situation changes (ie there will be a residual ROM at closure) subsequent revisions of the MCP will document this fact, characterise the remaining material and include final designs of the landform.

Stakeholder Consultation

5. It would be beneficial to have a list of key stakeholders in this section, to clearly identify who the key stakeholders are (as done so for the MCP). It is noted in the MCP that the Port of Geraldton has been included as a key stakeholder. Please be advised that the MP still states that the export location is yet to be determined. If a decision has been made, the MP should be updated.

MP Rev 2 will include a new table of key stakeholders, consistent with the table in the MCP (reproduced below).

Stakeholder Type	Stakeholder
State Government regulators	DMIRS DWER Department of Health (DoH) DLPH DPIRD
Local Governments	Shire of Meekatharra Shire of Cue Shire of Mount Magnet

Stakeholder Type	Stakeholder
	Shire of Yalgoo City of Greater Geraldton
Project stakeholders	Port of Geraldton Pilbara Port Authority
Pastoral lease holder	Mulgul pastoral lease – LPL N049800 Mingah Springs pastoral lease – LPL N049520 Woodlands pastoral lease – LPL N 050315 Tangadee pastoral lease – LPL N050276
Indigenous/ traditional land owners	Jidi Jidi Aboriginal Corporation, being the traditional owner representatives for the Nharnuwangga Wajarri who have granted Native Title for the area.
Non-government organisations (NGOs)	To be identified
Contractors	To be identified

6. It is positive to see that Galena have undertaken some early stakeholder engagement as part of the development of the Abra Project's proposal. However, there is no evidence of stakeholder consultation in relation to the Aboriginal Heritage survey conducted over the Project area with the Jidi Jidi Aboriginal Corporation, the Nharnuwangga Wajarri and Ngarlawangga Indigenous Land Use Agreement, or engagement with lease holder of Mulgul Station (Yaluning Aboriginal Corporation).

The comment is not entirely correct. The fact that Aboriginal Heritage survey was conducted over the land, with Traditional Owner participants, is evidence that the survey was undertaken in consultation with the Traditional Owners.

Consultation is ongoing with the Jidi Jidi Aboriginal Corporation. Records of this have been included in the Consultation Register in MP Rev 2. As members of the the Jidi Jidi Aboriginal Corporation are also board members of the pastoral lease holder (Yaluning Aboriginal Corporation) Galena considers consultation with these members constitutes consultation with both organisations.

7. Please ensure that the Stakeholder Consultation Register for the MP and MCP are up to date and consistent with one another.

The Consultation Register has been updated and is consistent in both MP Rev 2 and MCP Rev 2. It should be noted that this register is a dynamic document. An uncontrolled hardcopy will only be 'current' until the next consultation is undertaken. Then it will be obsolete.

Date	Description of Engagement	Stakeholder	Attendees	Description / Stakeholder Comments / Issues	Galena Response	Outcome / record filed in…
21/05/2018	Initial phonecall and then follow up letter from Galena	Shire of Meekatharra	Chris East – Deputy CEO	Introduction letter from Galena sent to introduce the project to local governments along the transport route from the mine to the port of Geraldton. All stakeholders were appreciative of the early contact. Cue, Mt Magnet and Yalgoo already have similar product transported through their towns and were not concerned. Meekatharra raised the issue of road maintenance on the unsealed Ashburton Downs road. CoGG were very interested and offered to host a meeting for interested stakeholders.	Galena to follow up with Meekatharra on a road maintenance agreement. Galena to follow up with CoGG to organize a meeting of local stakeholders	
		Shire of Cue	Rob Madson -CEO			
		Shire of Mount Magnet	Kelvin Matthews - CEO			
		Shire of Yalgoo	Silvio Brenzi -CEO			
		City of Greater Geraldton (CoGG)	Trish Palmonari			
30/6/2018	Meeting at Yulga Jinna	Jidi Jidi Aboriginal Corporation (JJAC)	Galena mgt; JJAC	Discussion on the Abra project	Consultation continuing	
11/7/2018	Meeting at Yulga Jinna	JJAC	Galena mgt; JJAC	Discussion on the Abra project	Consultation continuing	
17/7/2018	Meeting	DMIRS	Danielle Risbey;Erika Eto; Nicole Tucker; Emma Ryan Reed / Paul Rokich; Troy Flannery	Scoping meeting on the project. Included mining proposal and MCP components. Notes recorded from the meeting Meeting minutes taken. Galena is addressing these issues	NA	
1/8/2018	Meeting	DWER	Tim Gentle; Jamie Pioprowski; Sharmain; Alana Kidd (phone) / Paul Rokich; Troy Flannery	Scoping meeting on the project. Discuss Part V approvals required. Notes recorded from the meeting Meeting minutes taken. Galena is addressing these issues	No comment	
13/8/2018	Meeting	CoGG	Trish Palmonari; Anne Finlay; Glen Whistler-Carr plus other community members / Troy Flannery; Paul Rokich	Meeting at Geraldton with local government and key community stakeholders Meeting minutes taken. Galena is addressing these issues	No comment	
15/8/2018	Meeting at Abra minesite	JJAC	Galena mgt; JJAC	Discussion on the Abra project	Consultation continuing	
20/8/2018	Meeting	Mid West Port Authority	Sabdra Pigdon; Russell Stevens; Geoff Mackin / Troy Flannery; Paul Rokich	Meeting with port management to discuss project, environmental and commercial aspects of export. Meeting minutes taken. Galena is addressing these issues	No comment	
26&27/9/2018	Meeting at Perth galena office	JJAC	Galena mgt; JJAC	Discussion on the Abra project	Consultation continuing	
12/10/2018	Meeting	Pilbara Ports Authority	Lial Banks; Peter King; Jaren; Ash / Paul Rokich; Troy Flannery	Meeting with GM and Commercial Trade Manager to discuss project and commercial aspects of export	No comment	
7/12/2018	Meeting	DMIRS Safety Branch	[DMIRS -Peter Capon; Peter Nissen; Steve Stirling; Dave Harvey; Nicole Tucker]. [Galena - Troy Flannery; Paul Rokich; Roger Bryant; Melanie Flynn]	Meeting to discuss project and draft PMP. Meeting notes taken. Galena is addressing these issues during preparation of the PMP.		
30/1/2019	Meeting at Meekatharra	JJAC	Galena mgt; JJAC	Discussion on the Abra project	Consultation continuing	
30/1/19	Meeting at Meekatharra	Shire of Meekatharra	Kry East, Norm Trenfield / Melanie Flynn	Discussion on the Abra project, project timeline, road access and maintenance	Consultation continuing	
14/3/2019	Teleconference	Meekatharra shire	Roy McClymont; Norm Trenfield / Paul Rokich; Melanie Flynn	Discussion on the Abra project and possible haul road options from the mine to the GNH	Periodic consultation to continue	

Baseline Data

8. The baseline data only partially meet the requirements under the MP Guidelines. An appropriate description, analysis and interpretation of the baseline data must be provided in each sub-section, so that DMIRS can see that this information has informed the risk assessment and environmental outcomes. Please refer back to Section 3.8 of the DMIRS 2016 Guidelines for Mining Proposal in Western Australia (MP Guidelines). I have provided some examples below explaining where the baseline data does not meet the MP Guidelines, however please note that this list is not exhaustive and Galena should review their entire baseline data for the Project.

A new subheading has been included in each baseline data section titled **Analysis and Interpretation of [heading] data.** Summary points are included that inform the risk assessment.

(i) Materials Characterisation: The baseline data states that the Kianga Creek lower conglomerate unit, Upper Iregully dolomitic unit, and the Iregully Chloritic sediment unit contains varying quantities of sulphides. The risk assessment control measures state, 'Baseline materials characterisation studies quantify the risk of PAF material in mine waste. Encapsulate high risk material (if identified)'. The supporting technical reports appears to only provide information on tailings characterisation, therefore it is unclear what the findings of the materials characterisation studies are. As no interpretation of the baseline data has been provided in the Materials Characterisation baseline sub-section, it is unclear whether there is PAF or not.

A new section **4.3.3 – Waste Rock Characterisation** has been included to provide additional geochemistry information and analysis to support the text included in Rev 1. The additional information shows mine waste types are mostly NAF; all waste rock types tested have some ANC; only one waste type is PAF-HC and only minor quantities of this will be mined. The dominance of NAF/ANC waste provides a significant pH buffer against the small quantity of PAF material. This supports a 'co-disposal' option rather than a dedicated encapsulation cell in the WRD. Text in MP Rev 2 has been amended to delete reference to an encapsulation cell.

The additional information also indicates all types of material tested as Low Grade ore are NAF, with final NAGpH between 6-7. This indicates the Stage 2 extension of the ROM using Low Grade ore will not produce acid and metalliferous drainage impacts.

The revised text is reproduced below.

- **Waste Rock Characterisation**

Acid-Base Accounting (ABA) evaluates the balance between acid generating processes and acid neutralising processes (DITR 2007). This involves determining the maximum potential acidity (MPA) and the inherent acid-neutralising capacity (ANC) of a material, expressed in units of kg H_2SO_4/ tonne. The Net Acid Producing Potential (NAPP) is the difference between these two factors; the capacity of a material to generate acid and its capacity to neutralise acid and is calculated as:

NAPP = MPA-ANC

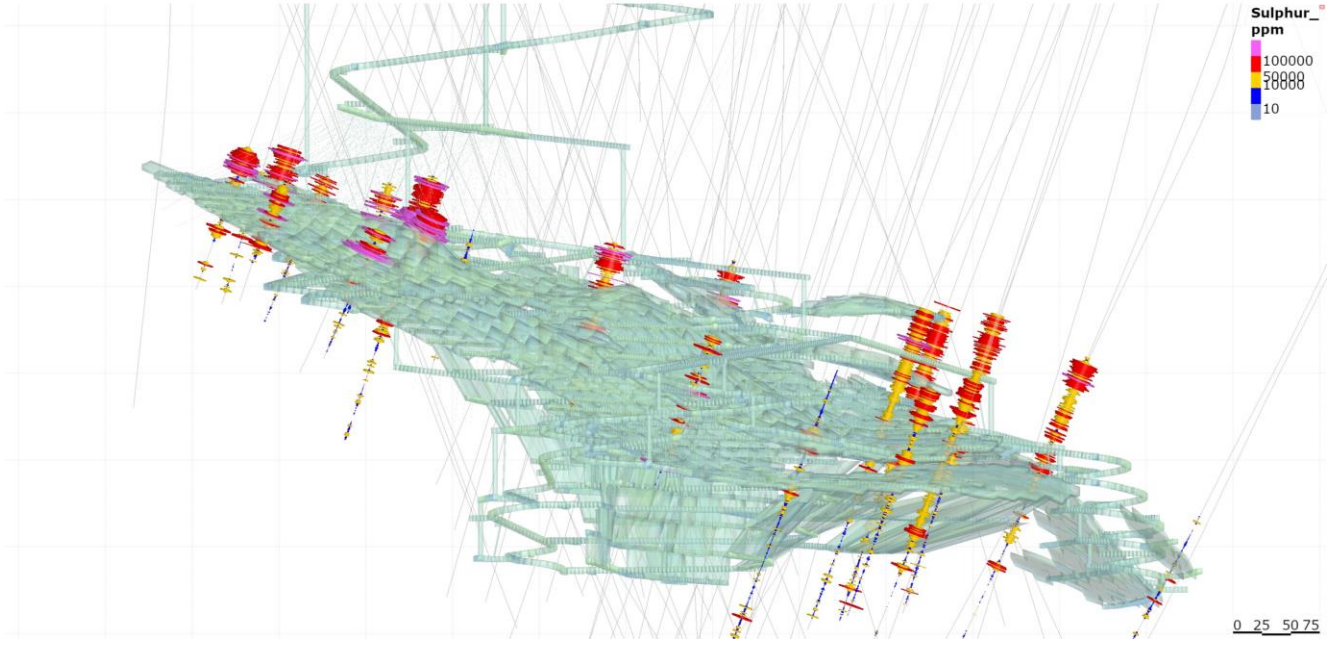
NAPP is negative if the material's acid neutralising capacity is greater than its ability to generate acid (ANC>MPA). If it is highly negative (<-40) the material is regarded as acid consuming. Conversely, if NAPP is positive, the material is likely to be net acid-generating, with highly positive numbers (>40) regarded as strongly acid generating.

Total sulfur content, expressed as a percentage (%S) is commonly used as an estimate to calculate MPA, on the assumption that, when oxidised, sulphur is converted to sulphuric acid. (MPA = %S x 30.6 [to convert units to kg H2SO4/ t]).

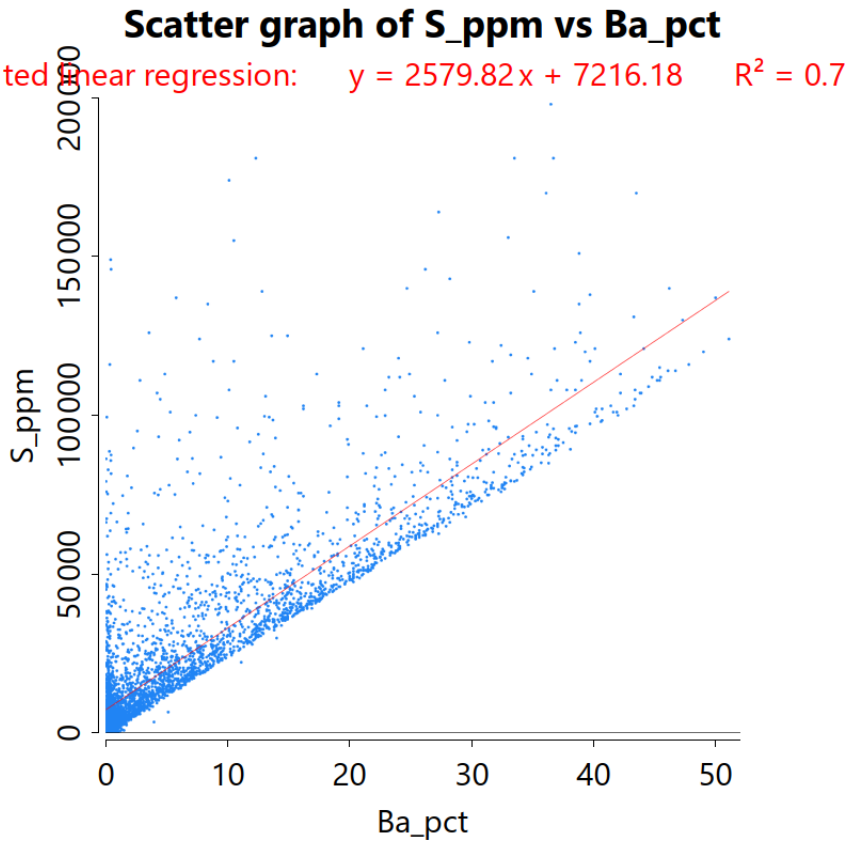
However, not all minerals containing sulphur are acid generating, so total sulphur content often over estimates MPA. Some minerals contain sulphur in forms that are already oxidised to a sulphate (SO_4) which are very stable and rarely react further to produce sulphuric acid. For example, barite, gypsum, anhydrite, alunite and native sulfur, are non acid generating sulfur forms. Also, sulfur may occur as other metal sulfides (such as covellite, chalcocite, sphalerite and galena) which yield less acidity than iron pyrite or, in some cases, are non-acid-generating.

The above information indicates the ABA methodology is likely to significantly over-estimate MPA because it assumes all sulfur is in a form that will readily react with oxygen and water to produce sulfuric acid. For the Abra deposit, this is not the case.

- **Table 21** identifies significant quantities of barite ($BaSO_4$) in a number of material types through the orebody. In one type, ZBZ, it represents the dominant mineral.
- **Figure 1** shows the zone of high sulfur is mostly located above the orebody. The bulk of this material will not be mined. **Figure 2** shows a high correlation between barium (Ba) and sulphur (S), indicating most of the sulphur is likely to be in barite, a highly stable, non-reactive sulphate form that is unlikely to form sulphuric acid.
- Tailings characterisation (Section 4.3.4) states that enrichment of residual minerals in tailings indicates that barite will comprise almost one third of the total-tailings mass. The TSF design report (L&MGSPL 2018) provides design details on the facility designed to store 8.48 million tonnes of tailings over a 15 year life. On the above information there will be approximately 2.544 million tonnes of barite in the TSF. Sulfur represents 13.7% of barite and therefore approximately 350,000 tonnes by mass in the tailings. Using the ABA methodology, all this sulfur would report as MPA where in reality it is locked in a stable, unreactive sulphate form.
- A similar situation to the tailings characterisation also exists for waste rock that reports to the WRD. Barite would also represent some proportion of this waste, further overestimating MPA using the ABA methodology



1. **Figure 1: Mine design with sulphur overlay**



2. **Figure 2: Barium vs Sulphur correlation**

The Net Acid Generation (NAG) test is used, in association with the acid–base calculations, to provide greater certainty on the net acid generating potential of a material. The NAG test involves reaction with hydrogen peroxide to rapidly oxidise any reactive sulphide minerals. Both acid generation and acid neutralisation reactions occur simultaneously and the result represents a direct measure of the net acid generation (= net acid producing potential (NAPP)). The amount of acid produced is determined by titration and expressed in units of (kg H2SO4/t). A pH after reaction (NAG pH) of < 4.5 indicates the material is acid-generating. A pH after reaction (NAG pH) of ≥ 4.5 indicates the sample is not acid-generating.

Individually, the acid–base calculation and NAG test have limitations, but in combination the reliability of acid generation prediction is greatly enhanced. The risk of misclassifying NAF material as Potentially Acid Forming (PAF), and vice versa, is substantially reduced by conducting both acid–base and NAG tests.

Table 7 shows the results of acid and metalliferous drainage (AMD) laboratory analysis conducted on two samples of each of the nine material types described in Table 21. The samples were selected to be representative of material that would present as mine waste to the WRD. In addition, a number of samples were identified with lead grade between 2.5 – 5.5%. This material would be classified as Low Grade ore. The site layout (Figure 3) shows low grade ore will be deposited as an extension to the ROM. Initial characterisation is required to determine the potential acid generation of this material and therefore whether specific drainage containment design is required.

The results of the ABA and NAG test work confirms a discrepancy between the two methodologies, likely due to the ABA overestimation of MPA because of the complicating factor of barite. The following summary of information in **Table 7** is provided:

i. The presence of significant amounts of barite in a number of material types makes acid generating capacity using the acid base accounting (ABA) methodology unreliable. For this reason, the net acid generation (NAG) test has been used to categorise mine waste material.
ii. All samples tested contain significant acid neutralising capacity (ANC), even samples classified as PAF.
iii. Only one material type, ZBZ, is classified as PAF-HC. This material is very restricted in the orebody. The mine plan only removes a small quantity of this material.
iv. Most of the mine waste material types are NAF, with final NAG pH >8. One material type is acid consuming.
v. Low Grade ore samples tested as NAF, with all samples having a final NAG pH between 6-7.

Considering the above information, Galena has adopted the following indicators of potential acid formation from mine waste for the Abra project (**Table 6**). These categories have been colour coded to be consistent with **Table 7**.

3. **Table 6: Mine waste acid producing potential**

Material	NAG (pH)	NAG pH 4.5 (H_2SO_4/t)
Potential Acid Forming -High Capacity (PAF-HC)	<4	>5
Potential Acid Forming (PAF)	4-5	1-5
Potential Acid Forming -Low Capacity (PAF-LC)	5 - 5.5	0.5 – 1.0
Non Acid Forming (NAF).	5.6-9	<0.5
Acid Consuming (AC)	>9	<0.5

4. **Table 7: Acid generation results**

						Acid Base Accounting					Net Acid generation (NAG)					
Rock code	Description	Zone	Sample No.	Pb (%)		Total S (%)	MPA[1] (H_2SO_4/t)	ANC (H_2SO_4/t)	NAPP (H_2SO_4/t))		NAG (pH)	NAG pH 4.5 (H_2SO_4/t)	NAG pH 7 (H_2SO_4/t)		NAG EC (uS/cm)	TDS[2] (ppm)
SCO	Conglomerate, quart dominant	Apron	G14635	0.05		1.68	51.4	4.2	47.2		8.5	<0.5	<0.5		150	96
		Apron	G14636	0.06		1.43	43.8	3.9	39.9		8.3	<0.5	<0.5		150	96
SCOZRB	Conglomerate with intensively altered jaspilite, with subordinate barite, dolomite and silica alteration	Apron	G14047	0.0035		3.46	105.9	140	-34.1		9.2	<0.5	<0.5		220	141
		Apron	G14048	0.0075		2.3	70.4	200	-129.6		9.1	<0.5	<0.5		220	141
ZRR	Intense jaspilite, silica and haematite alteration with variable barite and dolomite alteration intensity	Apron	G16287	0.03		4.61	141.1	150	-8.9		8.5	<0.5	<0.5		150	96
		Apron	G16288	0.12		4.57	139.8	160	-20.2		8.2	<0.5	<0.5		150	96
ZBZ	intense concentration of barite, where barite is more than 60% of the total mass of the interval.	Apron	G13947	0.02		10.8	330.5	13	317.5		2.8	10	12		1300	832
		Apron	G13948	0.01		10.6	324.4	9.3	315.1		2.9	7.5	10		960	614
ADB	Dolomite zone - intense dolomite alteration zones. This rock group is characterised by colloform banded dolomite units with local stromatolitic texture. Locally, this unit occurs as a very fine-grained dolomitic mudstone (micrite)	Apron	G16298	0.01		3.47	106.2	380	-273.8		8.3	<0.5	<0.5		170	109
		Apron	G16307	0.36		3.6	110.2	440	-329.8		8.3	<0.5	<0.5		230	147
MIC	Micrite (microcrystalline calcite present in some types of limestone)	Apron	G17157	1.1		1.78	54.5	2.6	51.9		4.8	<0.5	3.5		240	154
		Apron	G17158	0.23		0.864	26.4	2.0	24.4		4.0	0.8	3.5		260	166
ZBB	Intense magnetite, hematite and silica alteration. This zone is also enriched in barite and dolomite in places.	Apron	G14991	5.11		4.55	139.2	91	48.2		6.5	<0.5	<0.5		230	147
		Apron	G14992	4.06		6.01	183.9	95	88.9		6.8	<0.5	<0.5		310	198
HYZ	Hydothermal alteration zone - intense silica, barite alteration, which appears to be parallel to the overall banding plane direction.	Apron	G16609	0.87		4.49	137.4	120	17.4		6.2	<0.5	<0.5		200	128
		Apron	G16610	2.75		6.56	200.7	95	105.7		6.2	<0.5	<0.5		380	243
HYV	Hydrothermal vein zone - intense veining (typically silica, barite, galena, sphalerite, etc). This is the major style of Pb-Ag mineralisation within the Core.	Core/Apron	G17429	0.82		1.95	59.7	23	36.7		5.9	<0.5	<0.5		270	173
		Core/Apron	G17430	4.23		4.04	123.6	28	95.6		6.6	<0.5	<0.5		320	205

1. (MPA = %S x 30.6 [to convert units to kg H2SO4/ t]).
2. TDS =0.64 x NAG EC

(ii) Soils: Adequate characterisation of the soils has not been presented clearly in the MP, including information on the chemical/physical properties that will affect stability of successful rehabilitation. Please refer to section 3.8.3 of the MP Guidelines which outlines the required information.

No specific laboratory test work has been undertaken on the topsoil and Galena considers this is not necessary. The topsoil hosts healthy native vegetation and excavations show healthy plant root development. The existing gravel and stone content of the surface soil provides a functioning “rock mulch” matrix that partially armours the finer soil from erosion. There is no empirical evidence that the topsoil contains any deleterious properties that would inhibit plant establishment in rehabilitation programmes.

In addition, groundwater analysis confirms low TDS, further supporting that the immediate area is unlikely to contain salts that may inhibit rehabilitation.

(iii) Hydrology: This section does not include any baseline data regarding surface water within the project area, however the risk assessment and environmental outcomes table refers to sediment basins, drainage basins and stormwater systems. It is unknown whether these proposed surface water management measures are adequate. Please refer to section 3.8.5 of the MP Guidelines which outlines the required information.

The Hydrogeology section has been re-titled **Water Resources**, and now includes both hydrogeology and hydrology components. See below for hydrology.

Rockwater (2018) undertook an assessment of local surface hydrology resources. The complete report is attached in Appendix H. Salient extracts from the report are provided below.

The Abra project is elevated well above the surrounding major drainage lines. However, the project’s planned infrastructure intersects or lies close to two minor creeks.

There are two major catchments with the potential for peak flows to impact the project area and underground mine, and three smaller catchments that could impact the project’s surface infrastructure. The characteristics of the catchments which could impact the Abra project are listed in **Table 8**.

Table 8: Catchment Characteristics

Type	Catchment	Area (km^2)	Length (km)
Major	A	40.5	7.6
	B	5.5	4.0
Minor	C	0.12	0.7
	D	0.74	1.5
	E	1.17	2.1

Figure 3 and **Figure 4** reproduce Figure 1 and Figure 3 respectively from the Rockwater (2018) report.

Flows in major catchments were analysed to assess whether the 1 in 100 year ARI peak flows and Probable Maximum Flood (PMF) could reach the project area and underground mines. Hydraulic analyses were conducted at four cross-sections to assess whether the peak flows would reach the project's boundaries. The analysis showed no impact to mine infrastructure.

Flows in the minor catchments which could impact the infrastructure area were also analysed to assess the impact of the 1 in 100 year ARI peak flows and Probable Maximum Flood (PMF) on the surface infrastructure to determine the protective measures required. The planned infrastructure intersects or is very close to two small natural drainage lines that could impact the project during high rainfall events. Hydraulic analyses were conducted at three critical locations to assess the impact of the peak flows. The peak flows from these catchments could result in scouring and damage to infrastructure. The report recommends slightly change to the footprint of the tailings storage facility (TSF) and to construct diversion channels and drainage structures to either eliminate the interaction or reduce the extent of the peak floods.

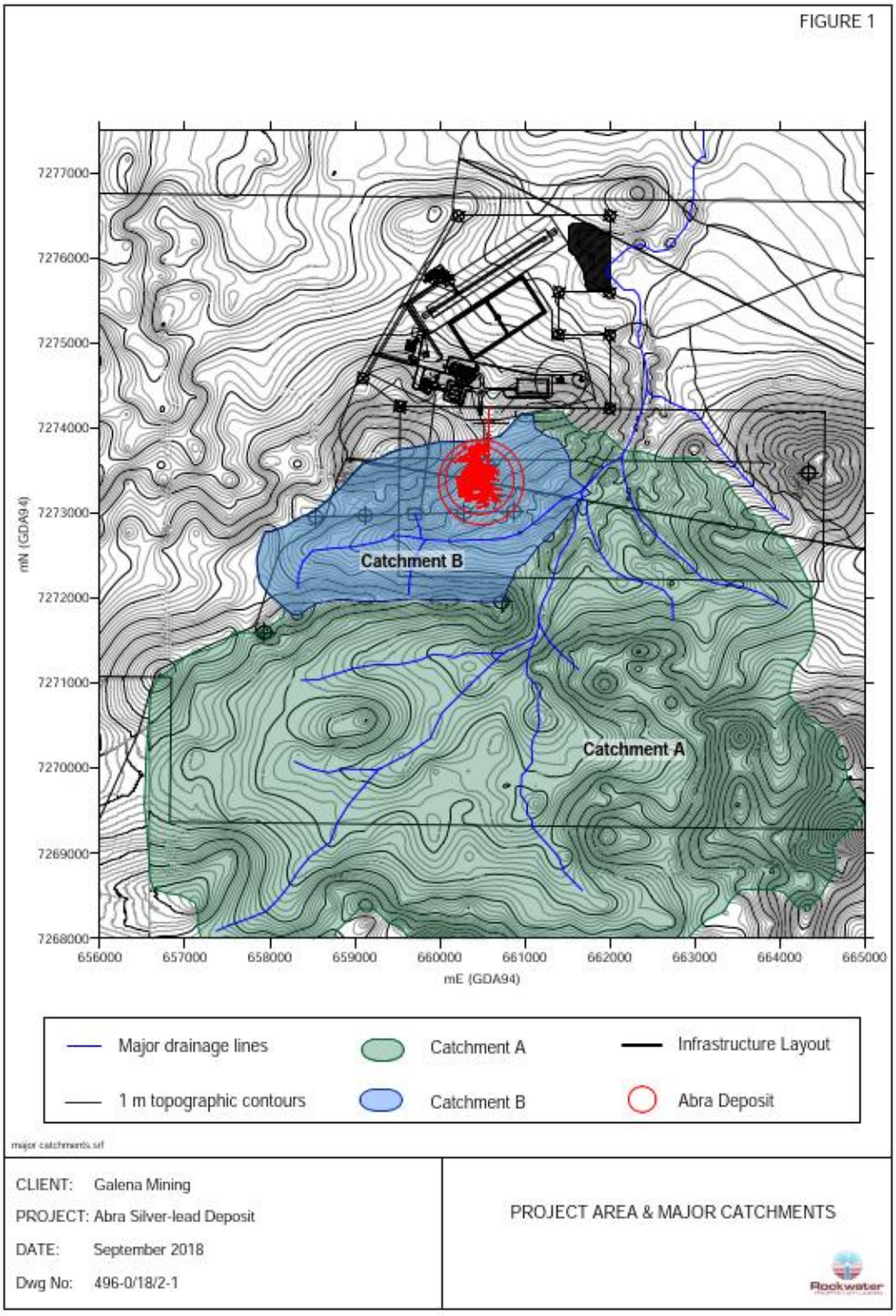


Figure 3: Major catchments

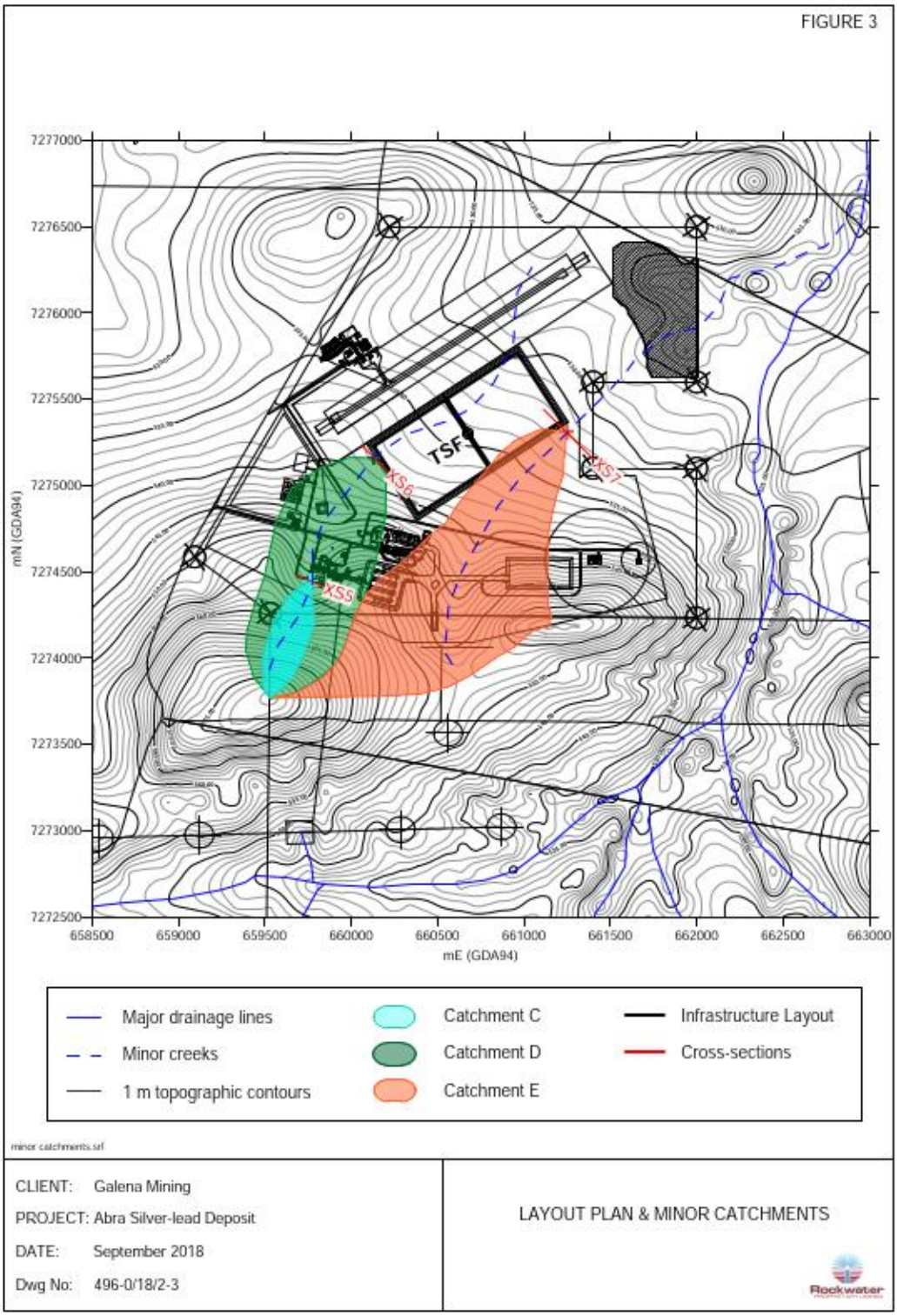


Figure 4: Minor catchments

1.1.1 Analysis and Interpretation of water resources data

The following analysis and interpretation of the above information is provided:

i. Only two regional bores, wells and springs are recorded in the DWER Water Information Reporting (WIR) database within 15km of the Abra project - Bedford bore and Chalk Spring in the Ethel River. Rockwater conclude there is no possibility that pumping from bores at Abra would have any impact on these features. This indicates a negligible risk to other existing water resources beyond the project boundary
ii. Groundwater quality is regarded as fresh, with salinities in a range around 500 mg/L Total Dissolved Solids (TDS). This information, in combination with the similar value for TSF slurry water (Section 4.3.4)

indicates a low risk of significant contamination and deterioration of local or regional groundwater quality from project infrastructure.

iii. Only minor surface catchments occur through the mine infrastructure area. The TSF has been located to reduce interaction with natural drainage lines and diversions drains are included in the design to direct surface water around the facility. In addition, process plant design includes diversion drains where required that direct all surface water flow to the raw water dam. This dam collects all stormwater from the process plant area. This eliminates the risk of contaminated surface water exiting the project area.

9. Please note that in Section 4.2 Landscape, it refers to Figure 1. However, Figure 1 is the regional view of the general site location. Please confirm whether this should have referred to a new figure.

Yes. The text should state **Figure 2**. The complete sentence states *Figure 1 shows the southern portion of the project site is located on the ridgeline and upper slope of a ridgeline.* The correct figure (Figure 2) shows contour information that shows these features.

Given that further baseline data is required for the Project, a complete review of the risk assessment and proposed environmental outcomes could not be undertaken. However, please see below the general comments for the current risk assessment and proposed environmental outcomes. Please be advised that DMIRS may request further for information or have additional comments, dependent on the update/changes to the baseline data in the revision.

Risk Assessment

10. Overall, the risk assessment for the Abra Project does not meet the MP Guidelines and will require an update. Please be reminded that the risk assessment required in the MP is an environmental risk assessment. The environmental consequence criteria is generic, and therefore may be skewing the consequence level applied to the risk to be lower than what DMIRS would expect. This criteria should be updated to be specific for each environmental factor/aspect. Please refer to Appendix J (Table J2) of the MP Guidelines for examples. DMIRS invites Galena Mining (or Jacobs on behalf of Galena) to submit the revised consequence criteria prior to undertaking the full risk assessment again. It is further recommended that the revised risk assessment be submitted to DMIRS prior to the submission of the revised MP.

Galena submitted a revised consequence table via email on 12/3/2019.

For Table 32: Risk Assessment, the column titled *Aspect (activity that impacts Factor)* in Revision 1 has been renamed *Risk Pathway* in Revision 2, to remove confusion and provide textual consistency with the MP guidelines

The revised risk assessment text is provided below:

Galena considers the overall level of risk is consistent with the nature and scale of the project and is informed by the results of the baseline environmental data as follows:

1. Located in an isolated area of the State with the nearest residential premise (sensitive receptor) approximately 40 kilometres from the mine and the nearest regional town 180 kilometres from the mine.
2. Relatively small scale of overall disturbance. Approximately 130 hectares in a region mostly uncleared.
3. No populations of flora or fauna unique to the project area, eliminating the risk of catastrophic or major consequences to specific significant environmental factors.
4. Vegetation communities impacted by the project are widely represented in the region.
5. Located in an arid environment (less than 300 millimetres of rainfall per year), with no permanent surface water bodies in the vicinity. This results in reduced risk of surface water contamination and no risk to wetlands.
6. No other users of shallow groundwater resources (up to 100mbgl) nearby (within 10 kilometres) of the project site.
7. No other users of deep groundwater resources (300 – 500mbgl [depth of the orebody]).
8. Mining operations are restricted to underground mining. No large open pit void, large mine waste landform or residual pit void lake will be produced.
9. A significant level of mine waste re-use. Approximately one third of the total tailings produced during the life of mine will be processed in a paste plant and returned underground to backfill completed stopes. Waste

rock from the boxcut and UG development will be assessed for its suitability for use as TSF embankment and capping material. This may reduce or possibly eliminate the WRD at closure.

The above points indicate most potential impacts have only a localised affect, confined to the mine boundary. In most cases these can be readily controlled or remediated.

i. Table 9: Risk likelihood

Determine the likelihood of the event occurring using the table below.

Likelihood Rating	Probability (%)	Description
Certain	>75	Is expected to occur in most circumstances - Evidence of common or repeated occurrence. Occurs more than once a year.
Likely	40-75	Will occur in most circumstances. Historical evidence of occurrence – 'It has happened'. Occurs at least once in a year
Possible	5-40	Might occur at some time. Anecdotal evidence of an occurrence – 'Remember it happening before'. May occur every 1-2 years
Unlikely	1-5	Could occur at some time, although no evidence of an occurrence – 'Heard of it happening'. May occur once in 10 years.
Rare	<1	May occur only in exceptional circumstances. Practically impossible. May occur in 25 years

ii. Table 10: Risk consequence

Identify the credible consequence for each unwanted event using the table below.

Consequence Rating	Insignificant	Minor	Moderate	High	Extreme
Biodiversity /Ecosystem (General)	Minor localised impact. Limited damage with no long term effects.	On site impact to area of low significance – immediately contained.	Off site impact to area of high significance with longer term detrimental effects.	Off site impact with longer term detrimental effects.	Serious, long-term environmental damage – widespread effects
Flora or Fauna (Specific)	Very small number of individuals (1%) in local population of species may be affected	Small number (<10%) of individuals in the local population of species may be affected	A significant species is affected. Reversible, short term impact to <50% of individuals in the local population.	Major loss to significant species at the local level. Disturbance with long term impact to >50% of individuals at the local level.	Loss of species at a local or regional level
Water resources	Low impact to isolated area without affecting any other use of the water.	On site low impact with negligible effect on other use of the water.	Off site impact that will materially affect the immediate use of the water, but able to be rectified in the short-term.	Extensive hazardous impact requiring long-term rectification.	Extensive hazardous impact with residual effect
Landforms	Negligible impact to isolated area.	On site low impact, not impacting on any significant environmental value.	Off site impact, able to be rectified in short-term without causing pollution or contamination.	Extensive hazardous impact requiring long-term rectification.	Extensive hazardous impact with residual effect
Mine closure	Site is safe, stable a non-polluting and post mining land use is not adversely affected.	The site is safe. Major landforms have stability or pollution issues that are contained and require no residual management. Post-mining land use is not adversely affected.	The site is safe. Any stability or pollution issues require minor, ongoing maintenance by end land-user	The site cannot be considered safe, stable or non-polluting without long-term management or intervention. Agreed end land-use cannot proceed without ongoing management.	The site is unsafe, unstable and/or causing pollution or contamination that will cause an ongoing residual affect. The post-mining land use cannot be achieved.

iii. Table 11: Risk matrix

Risk priority - the lower the number, the higher the risk priority. eg; 9-H has a higher priority that 13-H

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**High**	**Extreme**
Certain	18	13	4	2	1
Likely	19	16	10	5	3
Possible	22	17	12	8	6
Unlikely	23	21	15	11	7
Rare	25	24	20	14	9

iv. Table 12:Risk ranking

Extreme	Unacceptable. Major modification of proposed action required. Department manager accountability
High	Modification and / or mitigation of proposed action required. Supervisor accountability
Moderate	Some mitigation required. Documented processes in the EMS. Team leader accountability
Low	Minor mitigation required. Managed by routing procedures in the EMS. Operator accountability

v. **Table 13: Risk Assessment**

No.	Factor	Risk Pathway	Potential impacts (What)	Cause (How)	L	C	Inherent Risk	P	Control Measures (mitigation)	L	C	Residual risk	P
Construction phase													
1	Aboriginal heritage,	Over clearing and/or vehicle movement in unauthorised area	Interference to Aboriginal heritage sites	Vehicle/machine disturbance.	L	Min	Mod	16	Undertake heritage survey. Mark sites on constraints map. Implement clearing procedure. Induction.	U	Min	Low	21
2	Biodiversity, flora, fauna	Over clearing for mine activities	Vegetation loss / Loss of fauna habitat	Clearing	L	Min	Mod	16	Implement clearing procedure	U	Min	Low	21
3	Biodiversity, flora, fauna	Access /haul roads	Drainage shadow causing vegetation loss in areas where vegetation is reliant on sheet flow	Alter natural drainage lines and divert surface water flow.	P	Mod	High	12	Install culverts under road to maintain natural flow path	U	Mod	Mod	15
4	Flora, fauna	Vehicle movement on access/haul roads	Dust smothering adjacent native vegetation	Dust from dry roads	L	Min	Mod	16	Dust suppression (water carts) used to control dust emissions	U	Min	Low	21
5	Landforms, water resources	Hydrocarbon spillages	Localised contamination of soil and surface water.	Refuelling / transferring spills. Machinery breakdown-burst hoses Pipeline joint leaks.	L	Min	Mod	16	Inspection, maintenance of equipment. Implement spill clean-up procedure Supply of bioremediation agent on site Bunding of bulk hydrocarbon storage areas compliant with AS 1940:2004.	U	Min	Low	21
6	Soil, surface water	Vehicle accident	Spillage of hydrocarbons (diesel / oil)	Ruptured fuel tank / lines Overturned truck	U	Mod	Mod	15	Induction Speed limits on site Emergency response procedure	R	Mod	Low	20
7	Surface water	Storm water contaminated with sediment running off site.	Sedimentation of surface water channels.	Ineffective containment of materials Inefficient drainage structures	L	Mod	High	10	Designed drainage system to capture runoff from process plant	P	Min	Mod	17

No.	Factor	Risk Pathway	Potential impacts (What)	Cause (How)	L	C	Inherent Risk	P	Control Measures (mitigation)	L	C	Residual risk	P
Operation phase													
General – whole of site													
8	Biodiversity, flora, fauna	Over clearing for mine activities	Vegetation loss / Loss of fauna habitat	Clearing	L	Min	Mod	16	Implement clearing procedure	U	Min	Low	21
9	Biodiversity, flora, fauna	Fires from exhausts and hot work activities.	Bush fires	Hot work activities Hot exhausts of equipment and vehicles setting dry bush alight.	P	Min	Mod	17	Hot work permit Vehicle maintenance & inspections Emergency response	U	Min	Low	21
10	Soil, surface water	Hydrocarbon spillages	Spillage of hydrocarbons (diesel / oil)	Refuelling / transferring spills. Machinery breakdown-burst hoses Pipeline joint leaks.	L	Min	Mod	16	Inspection, maintenance of equipment. Implement spill clean-up procedure Supply of bioremediation agent on site Bunding of bulk hydrocarbon storage areas compliant with AS 1940:2004.	U	Min	Low	21
Underground Mining													
11	Subterranean fauna	Dewatering	Loss of subterranean fauna	Change in groundwater levels and quality impacting subterranean fauna habitat	Un	Min	Low	21	Baseline surveys confirm the low significance of this factor. Monitor groundwater levels. Surveys show species exist beyond the project footprint	Un	I	Low	23
12	Groundwater	Dewatering and UG mining	Groundwater quantity (level) and quality changes.	Mine dewatering and change in metals, pH, TDS, etc. in groundwater from UG mining activities	C	Min	High	13	Monitor GWL and quality in shallow aquifers (<100m) to confirm parameters are within set values for sequential use.	P	Min	Mod	17
Processing – crushing, ROM stockpiles, conveyor transfer points													
13	Landform (dust), flora	Dust from crushing and stockpiles	Dust to and adjacent vegetation. Dust impacts from physical (particle size) and chemical (metals) aspects	Exposed areas, dry ROM stockpiles, transfer between conveyor belts, crusher dust	C	Min	High	13	Water sprays on active works areas. Dust extraction on conveyor systems and transfer points. Inspection and maintenance of dust extraction equipment	P	Min	Mod	17
14	Landform, water resources	Drainage off ROM entering surrounding environment	sediment impacting surrounding areas	Incorrect drainage systems causing discharge to the environment	L	Min	Mod	16	Drainage system and detention basins installed	U	I	Low	21
15	Landform, water resources	Contamination from spills of process liquor	Metals, acidity, sediment impacting surrounding areas	Incorrect drainage systems causing discharge to the environment	P	Mod	Mod	17	Drainage system and detention basins. Bunds around tanks in process area.	U	Min	Low	21
Waste Rock Dump (WRD)													
16	Landform, biodiversity, water resources	sediment from WRD	Sediment in surrounding vegetation, soil and surface water systems. Visual impact	Runoff from WRD entering surrounding environment	U	Mod	Mod	16	Baseline materials characterisation studies quantify the risk of PAF material in mine waste. Install toe bund to contain water off WRD.	U	Min	Low	21
17	Visual amenity	Visual impact of WRD on the surrounding landscape.	Aesthetics	Inappropriate sighting and design of WRD	P	I	Low	22	Isolated project location, no close sensitive receptors. Revegetate WRD.	U	I	Low	23
Tailings Storage Facility													
18	Landform, biodiversity	Dry tailings blowing off the TSF	Contamination of surrounding land and vegetation	Dust from dry tailings containing metals, acidity etc deposited on area surrounding the TSF	C	Mod	Extreme	4	Cover tailings and revegetate at mine closure	U	Min	Low	21

No.	Factor	Risk Pathway	Potential impacts (What)	Cause (How)	L	C	Inherent Risk	P	Control Measures (mitigation)	L	C	Residual risk	P
19	Water resources	Groundwater level	Inundation of surrounding vegetation and fauna from surface expression	Seepage from TSF causing a localised groundwater mound and rising water table.	L	Mod	High	10	Install toe drains and interception bores during mine life and after closure to reduce GWL to agreed level.	U	Min	Low	21
20	Water resources	Groundwater quality	Quality (metals, TDS, pH) impacting groundwater for sequential beneficial uses.	Seepage from TSF (metals, pH, TDS)	P	Mod	High	12	Baseline information indicates low risk of AMD. Tailings water within stock drinking water guidelines. Water monitoring around TSF	U	Min	Low	21
21	Fauna (livestock)	Drowning / entrapment in TSF	Death or injury to stock	Access to TSF surface	L	Min	Mod	16	Fence TSF to exclude stock	U	I	Low	23
Powerhouse													
22	Landform, water resources	Hydrocarbon spillage during fuel transfer	Contamination of soil and surface water	Leaking valve, hoses, pipelines. Spillage	L	Min	Mod	16	Concrete apron and sump on loading area to contain spills Fuel suppliers have trained operators and procedures.	U	Min	Low	21
23	Landform, water resources	Hydrocarbon leakage from storage areas, pipelines	Contamination of soil and surface water.	Leaking pipelines, flanges, valves.	P	Mod	High	12	Bunding of bulk hydrocarbon storage areas compliant with AS 1940:2004.	U	Min	Low	21
Workshop Facilities													
24	Landform, water resources	Hydrocarbon contamination from fuel, oil storage and work areas	Contamination of soil and surface water	Ruptured or damaged containers Spills and leaks	P	Min	Mod	17	Self bunded (double lined) storage tanks or bunded areas compliant with AS 1940:2004 Floor drainage in the workshop and other bunded areas are drained to a pit which is transferred by pump to an oil separator.	U	Min	Low	21
25	Landform, water resources	Contamination from wash down bay	Contamination of soil and surface water	Overflow of system	P	Min	Mod	17	Inspection and maintenance of system	U	Min	Low	21
Explosive Facilities													
26	Landform, water resources	Spillage of ANFO	Contamination of soil and surface water.	Transferring product to magazine and from magazine to truck.	P	Min	Mod	17	Appropriate SDS information. prompt clean-up of spills.	U	Min	Low	21
Waste Management													
27	Landform	Landfill site.	Windblown litter Odour Attract fauna	Inappropriate sighting and operation of landfill site. Disposal of inappropriate waste into landfill site. Not covering waste disposed to landfill	L	Min	Mod	16	Fencing around landfill site Monitoring of landfill capacity Covering of waste disposed to landfill site Pickup windblown litter	P	I	Low	22
28	Landform	Tyre disposal	Hazard in fire situation	Inappropriate disposal process for tyres	U	Mod	Mod	15	Regularly bury tyres Fire management plan to minimise the impact of a fire	R	Min	Low	24
29	Landform	Disposal of contaminated soil.	Contamination of soil and surface water.	Disposal in inappropriate area.	L	Mod	High	10	Small areas of soil contamination to be remediated in situ Large volumes of contaminated soil to be removed to a dedicated bioremediation facility (if required)	U	Min	Low	21
Waste Water Treatment Plant													
30	Flora, fauna	WWTP irrigation field	weed growth	High water and nutrient levels	P	Min	Mod	17	Implement site inspection checklist and weed procedure, if required.	U	I	Low	23

No.	Factor	Risk Pathway	Potential impacts (What)	Cause (How)	L	C	Inherent Risk	P	Control Measures (mitigation)	L	C	Residual risk	P
Rehabilitation													
31	Landform, biodiversity	Ineffectual rehabilitation	Poor revegetation success Slow growth rates	Lack of rain Poor timing of rehabilitation Cyclone Use of inappropriate species.	P	Min	Mod	17	Research into appropriate species and times of the year for optimum rehabilitation results Comparison of baseline studies and similar mine site locations in the area on vegetation that has resulted in successful rehabilitation	U	Min	Low	21
32	Landform, biodiversity	Erosion on final landforms	Sediment in surface water. Inability to stabilise landform	Lack of stormwater control systems. Lack of vegetation on slopes	P	Min	Mod	17	Interim (during construction) and final stormwater design on the waste landform Implement appropriate stormwater control design Monitoring of erosion and stability of landforms Appropriate vegetation on slope of landforms to minimise excess erosion	U	Min	Low	21
33	Landform, biodiversity	Grazing of rehabilitation by animals	Native and feral animals grazing young rehabilitation and trampling slopes,	Inability of plants to establish. erosion on slopes	P	Min	Mod	17	Monitor extent of grazing on waste landforms Fence landforms to prevent degradation of vegetation from grazing, if required.	U	Min	Low	21

vi. Table 14: Risk Assessment Summary

No.	Risk Pathway	Inherent Risk	Control Measures	Residual Risk	Control Documents
18	Dry tailings blowing off the TSF	Extreme	Cover tailings and revegetate at mine closure	Low	MCP - Implementation
3	Access /haul roads	High	Install culverts under road to maintain natural flow path	Mod	Vegetation management procedure
7	Storm water contaminated with sediment running off site.	High	Designed drainage system to capture runoff from process plant	Mod	Monthly inspection of mine area Monthly inspection of contractors area
12	Dewatering and UG mining	High	Monitor GWL and quality in shallow aquifers (<100m) to confirm parameters are within set values for sequential use.	Mod	MCP - Monitoring
13	Dust from crushing and stockpiles	High	Water sprays on active works areas. Dust extraction on conveyor systems and transfer points. Inspection and maintenance of dust extraction equipment	Mod	Monthly inspection of mine area Monthly inspection of contractors area
19	Groundwater level	High	Install toe drains and interception bores during mine life and after closure to reduce GWL to agreed level	Low	Water monitoring procedure
20	Groundwater quality	High	Baseline information indicates low risk of AMD. Tailings water within stock drinking water guidelines. Water monitoring around TSF	Low	Water monitoring procedure
23	Hydrocarbon leakage from storage areas, pipelines	High	Bunding of bulk hydrocarbon storage areas compliant with AS 1940:2004.	Low	Hydrocarbon and chemical procedure
29	Disposal of contaminated soil.	High	Small areas of soil contamination to be remediated in situ Large volumes of contaminated soil to be removed to a dedicated bioremediation facility (if required)	Low	Hydrocarbon and chemical procedure
1	Over clearing and/or vehicle movement in unauthorised area	Mod	Undertake heritage survey. Mark sites on constraints map.	Low	Aboriginal heritage procedure Constraints map

No.	Risk Pathway	Inherent Risk	Control Measures	Residual Risk	Control Documents
			Implement clearing procedure. Induction.		
2	Over clearing for mine activities	Mod	Implement clearing procedure	Low	Vegetation management procedure
4	Vehicle movement on access/haul roads	Mod	Dust suppression (water carts) used to control dust emissions	Low	Monthly inspection of mine area Monthly inspection of contractors area
5	Hydrocarbon spillages	Mod	Inspection, maintenance of equipment. Implement spill clean-up procedure Supply of bioremediation agent on site Bunding of bulk hydrocarbon storage areas compliant with AS 1940:2004.	Low	Monthly inspection of mine area Monthly inspection of contractors area Hydrocarbon and chemical procedure
6	Vehicle accident	Mod	Induction Speed limits on site Emergency response procedure	Low	Induction. Accident/Incident Form
8	Over clearing for mine activities	Mod	Implement clearing procedure	Low	Vegetation management procedure
9	Fires from exhausts and hot work activities.	Mod	Hot work permit Vehicle maintenance & inspections Emergency response	Low	Hot work permit.
10	Hydrocarbon spillages	Mod	Inspection, maintenance of equipment. Implement spill clean-up procedure Supply of bioremediation agent on site Bunding of bulk hydrocarbon storage areas compliant with AS 1940:2004.	Low	Hydrocarbon and chemical procedure
14	Drainage off ROM entering surrounding environment	Mod	Drainage system and detention basins installed	Low	Monthly inspection of mine area Monthly inspection of contractors area
15	Contamination from spills of process liquor	Mod	Drainage system and detention basins. Bunds around tanks in process area.	Low	Monthly inspection of mine area

No.	Risk Pathway	Inherent Risk	Control Measures	Residual Risk	Control Documents
					Monthly inspection of contractors area
16	sediment from WRD	Mod	Baseline materials characterisation studies quantify the risk of PAF material in mine waste. Install toe bund to contain water off WRD.	Low	MCP - Implementation
21	Drowning / entrapment in TSF	Mod	Fence TSF to exclude stock	Low	Monthly inspection of mine area Accident/Incident Form
22	Hydrocarbon spillage during fuel transfer	Mod	Concrete apron and sump on loading area to contain spills Fuel suppliers have trained operators and procedures.	Low	Hydrocarbon and chemical procedure
24	Hydrocarbon contamination from fuel, oil storage and work areas	Mod	Self bunded (double lined) storage tanks or bunded areas compliant with AS 1940:2004 Floor drainage in the workshop and other bunded areas are drained to a pit which is transferred by pump to an oil separator.	Low	Monthly inspection of mine area Monthly inspection of contractors area Hydrocarbon and chemical procedure
25	Contamination from wash down bay	Mod	Inspection and maintenance of system	Low	Monthly inspection of mine area Monthly inspection of contractors area
26	Spillage of ANFO	Mod	Appropriate SDS information. prompt clean-up of spills.	Low	Hydrocarbon and chemical procedure
27	Landfill site.	Mod	Fencing around landfill site Monitoring of landfill capacity Covering of waste disposed to landfill site Pickup windblown litter	Low	Waste management procedure.
28	Tyre disposal	Mod	Regularly bury tyres Fire management plan to minimise the impact of a fire	Low	Waste management procedure.
30	WWTP irrigation field	Mod	Implement site inspection checklist and weed procedure, if required.	Low	Monthly inspection of mine area
31	Ineffectual rehabilitation	Mod	Research into appropriate species and times of the year for optimum rehabilitation results Comparison of baseline studies and similar mine site	Low	MCP - Rehabilitation

No.	Risk Pathway	Inherent Risk	Control Measures	Residual Risk	Control Documents
			locations in the area on vegetation that has resulted in successful rehabilitation		
32	Erosion on final landforms	Mod	Interim (during construction) and final stormwater design on the waste landform Implement appropriate stormwater control design Monitoring of erosion and stability of landforms Appropriate vegetation on slope of landforms to minimise excess erosion	Low	MCP - Implementation
33	Grazing of rehabilitation by animals	Mod	Monitor extent of grazing on waste landforms Fence landforms to prevent degradation of vegetation from grazing, if required.	Low	MCP – Implementation and Monitoring
11	Dewatering	Low	Baseline surveys confirm the low significance of this factor. Monitor groundwater levels. Surveys show species exist beyond the project footprint	Low	NA
17	Visual impact of WRD on the surrounding landscape.	Low	Isolated project location, no close sensitive receptors. Revegetate WRD.	Low	NA

11. All residual risk except for risk No.13 have been dropped to Low. When assessing the risk of an unwanted event (i.e. potential impacts), the consequence can only change where an activity has been eliminated or avoided. Therefore, internal procedures typically would not warrant a drop in consequence. The likelihood is the factor which changes, and then only usually by one degree, unless the controls are exceptional and are demonstrated across the industry to result in a greater change to likelihood. Majority of the likelihood and consequences in this risk assessment have been dropped without the elimination or avoidance of the risk pathway. Therefore, DMIRS considers the drop in likelihood and consequence (and therefore risk) is unjustified in many cases. An example is provided below, however please review the risk assessment in its entirety.

 Waste Rock Dump: The risk of 'sediment in surrounding vegetation and surface water systems' is Moderate, then with the control measure of 'conduct planning to see if WRD can be used for TSF capping', the risk drops to Low. The control measure in this case is to 'conduct planning', which does not eliminate or avoid the unwanted activity. Therefore, the drop in likelihood or consequence is not warranted in this case. Once the studies are completed and conclude that the WRD is suitable for TSF capping, then can the risk be dropped.

The risk assessment has been revised based on the additional information in the baseline data section and the revised consequence table.

Consequence level has dropped in cases where actions remove or eliminate the risk pathway. As an example:

> No.18 – dry tailings blowing off the TSF - reduces from an inherent consequence of Moderate to residual consequence of Minor as the control measure of *cover tailings and revegetate at mine closure* functions to remove (eliminate) tailings on the TSF surface that are subject to dust lift-off.

12. Risk No.2 and No.8 (which are the same) has the risk of 'Vegetation loss / Loss of fauna habitat'. Regardless of whether there is a clearing procedure in place or not, vegetation and fauna habitat will be lost within the process of clearing native vegetation when developing the mine. If this risk refers to the unwanted event of clearing of vegetation and loss of habitat outside the permitted area, then it should be reworded to clearly state this.

Risk No. 2 is in the section titled Construction phase. Risk No.8 is in the section titled Operation phase. It should be noted that the majority of clearing required for the project's mine life will be undertaken during the initial construction phase. However, Cell B of the TSF will not be required for 2 or 3 years, so some clearing will also be required during the operational phase of the mine.

The risk refers to clearing beyond the boundary or extent of the approved clearing area. Clearing authorised under an approved CPS is not considered a risk. Text has been amended to clarify this.

13. There are numerous other documents that can assist when reviewing the risk assessment;

 DMIRS has published a guidance on Risk Assessment and Environmental Outcomes that can be find here: http://www.dmp.wa.gov.au/News/DMIRS-guidance-on-Risk-23499.aspx

 AS/NZS ISO 3100:2009 Risk Management – Principles and Guidelines

 Australian Standard HB 203:2006 Environmental Risk Management

Noted.

Environmental Outcomes, Performance Criteria and Monitoring

14. Once the baseline data and risk assessment has been updated, the revised information should facilitate the development of the revised environmental outcomes table. However, please see below some additional comments in relation to the requirements of the environmental outcomes table as outlined in the MP Guidelines.

(i) The risk pathways should be clearly described for all environmental factors without reference to the risk assessment. Please see Appendix L for an example.

This sentence is incorrect. The third column in the table in Appendix L is titled Risk Pathways, the same as the third column in Appendix K titled Example risk assessment.

(ii) The performance criteria should be specific, measurable, achievable, realistic and time bound (SMART). However, being overly prescriptive can also be unrealistic. For example, the environmental outcome of 'no escape of hazardous materials to the environment' would mean that if Galena had one minor hydrocarbon spill, then this outcome cannot be met. Furthermore, this outcome is contradictive to the outcome of 'all spills are quickly and effectively cleaned up', which assumes that a spill may occur.

Please also note that 'quickly and effectively' is also an example of an outcome that is not measurable (e.g. what is considered to be quick and effective? 1 hour? 24 hours? This needs to be refined).

Performance measures in MP Rev 2 Table 31 have been revised, as has the respective text in each of the procedures in the EMS control documents.

MP Rev 2 Table 31 integrates:

- DMP factors and objectives stated in the guidelines (column 1 and 2)
- Risk pathways from the risk assessment (column 3)
- The relevant EMS control documents (column 4)
- Outcomes and Performance Measures included in the control documents (column 5 and 6)
- Includes a time-bound element of the SMART principle (column 7).

Factor (DMP 2016)	DMP Objective (DMP 2016)	Risk Pathway (from Table 14)	EMS Control Document	Outcomes	Performance Measure	Schedule
Biodiversity/Flora/Fauna/ Ecosystem	To maintain representation, diversity, viability and ecological function at the species, population and community level.	3 Access /haul roads 2 Over clearing for mine activities 8 Over clearing for mine activities	Vegetation Management Procedure	All site activities are undertaken within approved project disturbance boundaries.	Extent of site clearing is within approved limit and boundaries.	Quarterly
				All personnel aware of the need to minimise clearing.	Record of personnel completing site induction	Quarterly
				Required diversion structures discharges to existing drainage pathways as soon as possible	No vegetation death attributable to drought caused by altered surface drainage	Quarterly
				Salvage seed from cleared vegetation where practicable	Document weight of seed and species collected from cleared areas	As required
				Topsoil salvaged and stored for use in rehabilitation	Map topsoil and vegetation stockpiles in the constraints map	As required
				No environmental incidents of unplanned clearing	Number of incidents of unplanned clearing recorded	Quarterly
Water resources	To maintain the hydrological regimes, quality and quantity of groundwater and surface water to the extent that existing and potential uses, including ecosystem maintenance, are protected.	19 Groundwater level 20 Groundwater quality	Water Monitoring Procedure	Comply with all licence water monitoring requirements.	All licence requirements met.	Annual
				Record all monitoring results and assess against standards / limits set.	All results within licence limits.	Annual
				Review monitoring results and provide quarterly internal reports to site managers.	Number of internal water monitoring reports circulated per year.	Annual
Landforms	Mining will not result in appreciable land degradation or the contamination or pollution of the land.	23 Hydrocarbon leakage from storage areas, pipelines 29 Disposal of contaminated soil. 10 Hydrocarbon spillages 22 Hydrocarbon spillage during fuel transfer 26 Spillage of ANFO 27 Landfill site. 28 Tyre disposal 7 Storm water contaminated with sediment running off site. 13 Dust from crushing and stockpiles 1 Over clearing and/or vehicle movement in unauthorised area 4 Vehicle movement on access/haul roads 5 Hydrocarbon spillages	Hydrocarbon and Chemical Procedure	Integrity of hydrocarbon and chemical storage bunds and containment measures is maintained.	Number of completed inspection records.	Monthly
				Compliance with licence conditions, Regulations and Standards	Number of environmental incidents arising from non-compliance with statutory requirements	Quarterly
				All spills are categorised as per the spill procedure and actioned accordingly within 24 hours	Environmental incidents reports arising from spills.	Monthly
			Waste Management Procedure	Maximise quantity of material reused or /recycled.	Register of reused / recycled materials recording quantities of materials	Monthly
				All waste disposed in an acceptable manner	Annual report on landfill management including the number of waste management incidents.	Annual
				All spills are categorised as per the spill procedure and actioned accordingly within 24 hours	Number of incident reports.	Quarterly
			Aboriginal heritage procedure	No damage to Aboriginal heritage sites located in or adjacent to active areas.	Number of environmental incidents of disturbance to Aboriginal heritage site	Quarterly
			Monthly inspection of mine area	Facilities and infrastructure are maintained in good working order	Record of action to close out inspection items	Monthly

Factor (DMP 2016)	DMP Objective (DMP 2016)	Risk Pathway (from Table 14)	EMS Control Document	Outcomes	Performance Measure	Schedule
		14 Drainage off ROM entering surrounding environment 15 Contamination from spills of process liquor 21 Drowning / entrapment in TSF 24 Hydrocarbon contamination from fuel, oil storage and work areas 25 Contamination from wash down bay 30 WWTP irrigation field 6 Vehicle accident	Monthly inspection of contractors area			
		9 Fires from exhausts and hot work activities.	Hot work permit.	No fires started from hot work activities that impact surrounding environment	Number of incidence of fires started by hot work activities	Quarterly
Mine closure	Mines are closed in a manner to make them (physically) safe to humans and animals, (geo-technically) stable, (geo-chemically) non-polluting/non-contaminating, and capable of sustaining an agreed post-mining land use, and without unacceptable liability to the State.	18 Dry tailings blowing off the TSF 12 Dewatering and UG mining 16 sediment from WRD 31 Ineffectual rehabilitation 32 Erosion on final landforms 33 Grazing of rehabilitation by animals	Closure aspects are not covered in Revision 1 of the EMS. See EMS document Section 1.1	To be determined	To be determined	To be determined

(iii) An environmental outcome of 'Above targets are met' is not considered to be an environmental outcome and should be removed.

The outcome referred to the annual audit and review process of procedures within the EMS. These have now been removed as an outcome in the MP table.

(iv) Performance criteria should wherever possible refer to key actions from a management plan/procedure and not just the plan/procedure itself. Please refer to addition guidance on writing outcomes and criteria available from the DMIRS website: http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-023.pdf.

This is not always practical. The spill procedure documents separate actions for different categories of spills. All this text can not practically be inserted into a single cell within the outcomes table.

Appendices

15. Please ensure that the appendices provided in the MP are correct. It does not appear that Appendix D, Vegetation Clearing Application has been included, and there is a duplication of Appendix E, Environmental Management System.

MP Rev 2 will be checked to ensure all appendices are included.

It should be noted that the vegetation clearing application has now been approved (CPS8234/1), so there is now no "application" pending.

16. The groundwater report and materials characterisation should also be appended to the MP, not just within the Mine Closure Plan.

These will be included in MP Rev 2, as will the surface water report.

Geotechnical Review

A review by a DMIRS Inspector of Mines – Geotechnical was undertaken of the TSF design, and further information is required on the following items:

17. Provide a PMP assessment to demonstrate impact to mine site designed final infrastructure (i.e. impact on TSF Embankments, remaining diversion channels if applicable).

Galena considers action (and response to this question) is more appropriately addressed in the PMP. There appears to be an overlap between DMIRS environmental branch, who assess the Mining Proposal (MP) and DMIRS safety branch, who assess the Project Management Plan (PMP).

Galena staff attended a meeting with the safety branch on 7/12/2018 to discuss the PMP. This is a separate document to the MP and is still in preparation. The current design work on the TSF includes a geotechnical assessment report by CMW Geosciences (Oct 2018). This will be included in the package of information attached to the PMP.

18. The Third Party Independent Technical Reviewer declaration for the TSF has not been endorsed by Galena Mining Limited. Provide a completed declaration (page 467).

MP Rev 2 will include signature by Galena Mining representative.

19. Based on the nature of the tailings (i.e. dispersive, high settling density etc.) describe any implications to the use of tailings in the backfill paste (i.e. describe the work completed to confirm the tailings will be acceptable to use underground).

As above, Galena considers response to this question is more appropriately addressed in the PMP. The status to date is that a bulk tailings sample was generated under optimised flotation conditions using ore sourced mainly from the apron zone. A scope of work was developed in consultation with a paste backfill expert and a testwork program will commence shortly. The laboratory testwork program includes the following.

- Tailing characterisation including assay, particle size distribution and mineralogy.
- Rheology testing on full stream tailings paste including conical slump and vane rheometer testing to define the relationship between yield stress and the mix solids concentration.
- Strength testing including a range of hydration periods up to 240 days and a binder optimisation program to assess the suitability of the two most commonly used binders in paste backfill applications.
- Shear viscosity testing.

MINE CLOSURE PLAN (MCP)

Identification of Closure Obligations and Commitments

20. The current Compliance Register does not provide information on what the actual closure obligations and commitments are, but a list of the source of the obligations/commitments (e.g. Tenement Condition, MP Commitments, Works Approval, etc.). Therefore, the current Compliance Register may be a useful internal register to keep, but it does not meet the requirements of the MCP Guidelines. It is noted that non-legal obligations or commitments under the Heritage Agreement are not included in this register. This section will need to be updated to include all closure related obligations and commitments. Please refer to Section 4.6 and Appendix E of the MCP Guidelines.

At the time of preparing MP Rev 1 (October 2018), most of the other approval processes were also occurring in parallel. The clearing permit, works approvals and water licences had not yet been issued so no conditions had been set.

The purpose of presenting the compliance register in its current state is to demonstrate Galena has an adaptive EMS and that it will be regularly updated as approvals and permits are issued.

The compliance register will only contain legal requirements. ‘Commitments’ included in statutory documents (eg Mining Proposal) or a legal agreement – become legal obligations. These will be included in the compliance register.

Between October 2018 and the present (March 2019), Galena has received some permits and approvals. These have been incorporated into the compliance register and the updated register is included in Rev 2 of the EMS.

Government of Western Australia
Department of Mines, Industry Regulation and Safety

Our ref Registration ID : 76773
Enquiries Lawson Brandis
(08) 9222 3718
Lawson.brandis@dmirs.wa.gov.au

The Registered Manager
Galena Mining Limited
PO BOX 8187
SUBIACO EAST WA 6008

Attention: Paul Rokich

Dear Sir

APPROVAL FOR MINING PROPOSAL WITH A MINE CLOSURE PLAN- ABRA BASE METALS PROJECT MINING PROPOSAL AND MINE CLOSURE PLAN REVISION 3 ON G 52/292, L 52/194 and M 52/776.

ENVIRONMENTAL GROUP SITE NAME: Abra Environmental Group (S0237582)
ENVIRONMENTAL GROUP SITE: Abra-Mulgul (J00545)
REGISTRATION ID: 76773

I refer to your Mining Proposal and Mine Closure Plan dated 24 May 2019. The Mining Proposal and Mine Closure Plan have been assessed by the Department of Mines, Industry Regulation and Safety (DMIRS) and determined to provide the information required in the guidelines approved under section 70O of the *Mining Act 1978* (WA) (the Mining Act).

I hereby approve the Mining Proposal and Mine Closure Plan.

Approval is restricted to undertaking the mining activities detailed in the activity details Tables 5, 6 & 7 and key mine activities Tables 8 - 13 of the Mining Proposal**.** These activities must be undertaken within the approved disturbance envelope, as specified by the spatial data provided with the approved Mining Proposal, which is represented in Schedule 1.

The site will be required to achieve the environmental outcomes detailed in Table 39 of the Mining Proposal. Any changes to these outcomes must be assessed and approved via resubmission of a Mining Proposal and Mine Closure Plan.

Please note the comments in Schedule 2 which must be addressed in the next version of the Mine Closure Plan. The Mine Closure Plan must be revised and re-submitted with the Department in May 2022, in accordance with the revised tenement conditions (see Schedule 3).

I advise that I intend to recommend the Minister for Mines and Petroleum's delegate impose further conditions on G52/292, L52/194 and M52/776, as outlined in Schedule 3. Further correspondence will be sent from DMIRS once the conditions are imposed.

Important – please note that you must submit a revised Mining Proposal and Mine Closure Plan for assessment and approval in the following circumstances:

- When any disturbance is proposed outside the approved disturbance envelope;
- The characteristics of any 'Key Mine Activities' detailed in the Mining Proposal need to be altered; or
- A new activity, or change to an activity type, beyond that listed in the Mining Proposal is proposed.

This approval does not supersede any other applicable provisions of the Mining Act, or remove the need for any necessary approvals from other authorities.

You are reminded that you are required to report disturbance data on an annual basis and pay any corresponding levy in accordance with the *Mining Rehabilitation Fund Act 2012* and associated Regulations.

Please be reminded of your obligation to carry out the mining operation in accordance with the provisions of the *Mines Safety and Inspection Act 1994* and Regulations 1995. You must have an approved Project Management Plan (PMP) in place prior to commencing construction or mining operations.

Further to this, if your proposal is clearing native vegetation a clearing permit under Part V Division 2 of the *Environmental Protection Act 1986* for clearing of native vegetation will be required.

Should you have any queries regarding this letter, please contact Environmental Officer - Lawson Brandis on (08) 9222 3718.

Yours faithfully

Karen Caple

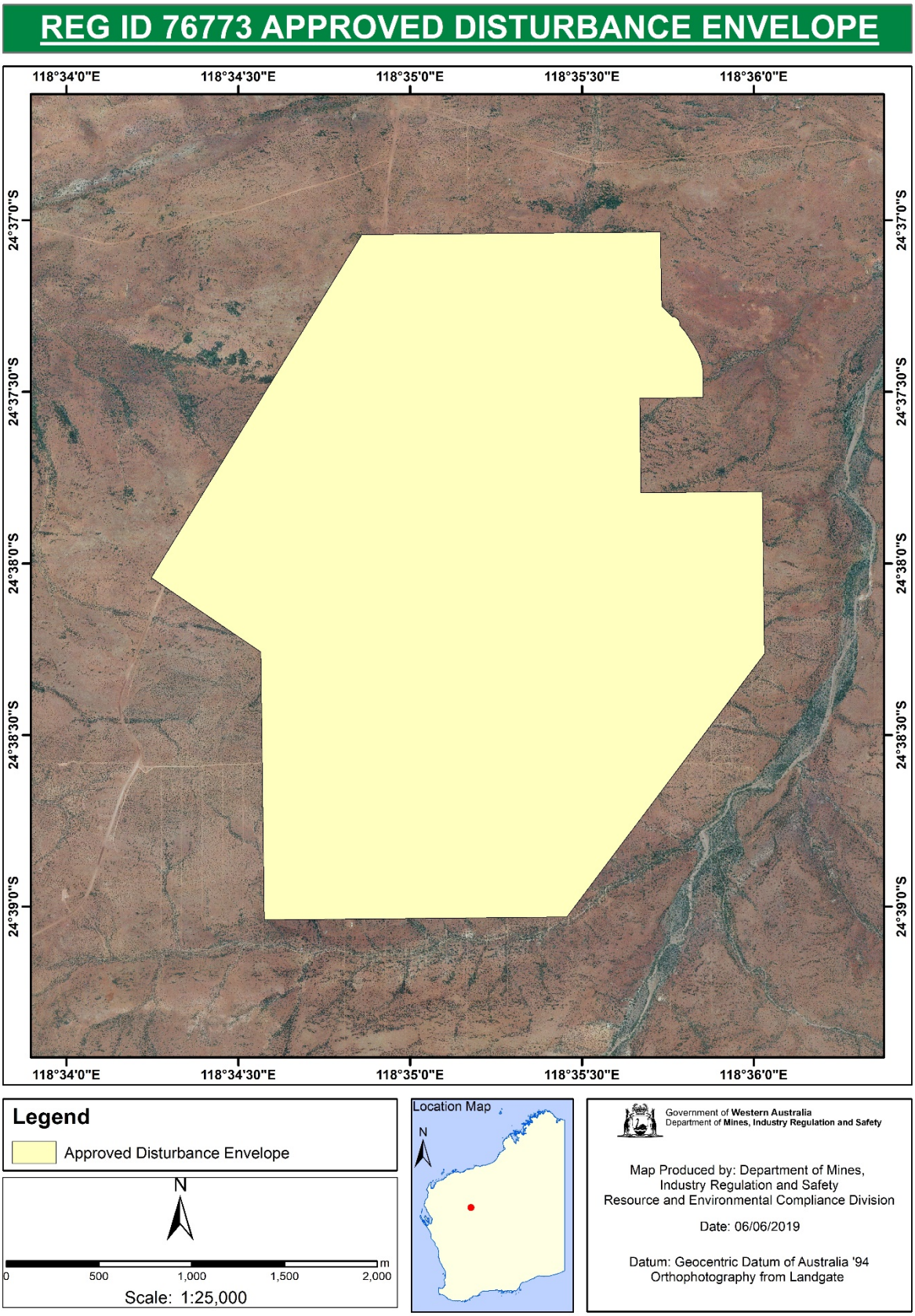
Acting Executive Director Resource and Environmental Compliance

Resource and Environmental Compliance Division

10 June 2019

Attach: *Schedule 1; Approved Disturbance Envelope*
Schedule 2: Areas of the Mine Closure Plan that require further development in the next revision
Schedule 3: Recommended further conditions

SCHEDULE 1: Approved Disturbance Envelope



SCHEDULE 2: Areas of the Mine Closure Plan that require further development in the next revision

Section of the Mine Closure Plan	Comments
General comments	Throughout the MCP reference is made to the "final MCP". Please note that the "final MCP" is simply the most recently approved MCP, thus this MCP is currently the "final MCP". In future iterations it should simply be referred to as 'the MCP'.
Post mining land use	The current proposed PMLU is to return the site for pastoral activities, however it is noted that this has not been proposed to, or agreed with key stakeholders. Future iterations of the MCP should be developed to the proposed PLMU.
	Provide conceptual landform design diagrams in the next iteration of the MCP.
Development of completion criteria	As no post mining land use has been discussed with key stakeholders (pastoralist), completion criteria have not been informed by stakeholder consultation. In the next iteration of the MCP completion criteria should be discussed with key stakeholders and be documented in the MCP.
Identification and management of closure issues	Control measures for the various potential impacts should be reviewed and made clearer in the next MCP.
Closure implementation	While general closure requirements are described in section 8.4 of the MCP, the MCP refers to a 'Task Register' numerous times however, the task register provided as Appendix B is completely empty. It is noted that Galena will add to this register as mine features are constructed. In the next version of the MCP the task register must be more detailed otherwise it shouldn't be included.
	Include a decommissioning section in the next iteration of the MCP. It is noted that in the early stages of a mine's life this section may contain limited detail.
Closure monitoring and maintenance	In the next MCP provide more detail on the following: • Monitoring methodologies to be utilised; • How monitoring takes into account the wider receiving environments, receptors and exposure pathways; • Quality control systems and procedures for monitoring; • Any trends that are developing; and • Contingency strategies for if monitoring data indicates environmental indicators move outside closure criteria.
Financial provisioning for closure	The next MCP needs to include more detail regarding financial provisioning for closure, particularly cost estimate methodology, as per section 4.14 of the Guideline.
Management of Information and Data	Please provide additional details regarding internal record keeping systems in the next iteration of the MCP.

SCHEDULE 3: Recommended further conditions

RECOMMENDED FURTHER CONDITIONS
FOR GENERAL PURPOSE LEASE 52/292

Please impose the following new conditions:

6. All mining operations to meet the environmental outcomes as measured by the performance criteria stated in Table 39 of the mining proposal (Reg ID: 76773) "Abra Base Metals Project - Mining Proposal – Version 3" dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767. **[MTSD: Standard Condition 661]**

7. All ground disturbance to be undertaken within the disturbance envelope as represented by the spatial data provided on 30 October 2018 and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6116799.
[MTSD: Standard Condition 669]

8. No alteration or expansion of mining operations beyond the activities detailed in Table 5 - 7 and Tables 8 – 13 of the mining proposal (Reg ID: 76773) "Abra Base Metals Project - Mining Proposal – Version 3" dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767.
[MTSD: Standard Condition 670]

9. Management of mine closure is to be undertaken in accordance with the Mine Closure Plan (Reg ID: 76773) "Abra Base Metals Project – Mine Closure Plan – Version 3" dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767.**[MTSD: Standard Condition 662]**

10. Report any incident arising from mining activities that has caused, or has the potential to cause environmental harm or injury to land, to the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety, within 24 hours of becoming aware of the occurrence of the incident. **[MTSD: Standard Condition 671]**

11. Report any breach of environmental outcome or performance criteria stated in table 39 of the mining proposal (Reg ID: 76773) "Abra Base Metals Project - Mining Proposal – Version 3" dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767, to the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety within 24 hours of becoming aware of the occurrence of the breach. **[MTSD: Standard Condition 672]**

12. The development and operation of the project being carried out in such a manner so as to create the minimum practicable disturbance to the existing vegetation and natural landform. **[MTSD: Standard Condition 384]**

13. All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. **[MTSD: Standard Condition 385]**

14. All rubbish and scrap is to be progressively disposed of in a suitable manner. **[MTSD: Standard Condition 387]**

15. Take all reasonable measures to prevent or minimise the generation of dust from all materials handling operations, stockpiles, open areas and transport activities. **[MTSD: Standard Condition 659]**

16. Where saline water is used for dust suppression, all reasonable measures being taken to avoid any detrimental effects to surrounding vegetation and topsoil stockpiles. **[MTSD: Standard Condition 401]**

17. Placement of waste material must be such that the final footprint after rehabilitation will not be impacted upon by pit wall subsidence or be within the zone of pit instability to the satisfaction of the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 573]**

18. On the completion of operations or progressively when possible, all waste dumps, tailings storage facilities, stockpiles or other mining related landforms must be rehabilitated to form safe, stable, non-polluting structures which are integrated with the surrounding landscape and support self-sustaining, functional ecosystems comprising suitable, local provenance species or an alternative agreed outcome to the satisfaction of the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 388]**

19. An annual environmental report is to be submitted to the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety, outlining the project operations, minesite environmental management and rehabilitation work undertaken in the previous 12 months and the proposed operations, environmental management plans and rehabilitation programs for the next 12 months. This report to be submitted each year in: **[MTSD: Standard Condition 392]**
    - May

20. The construction of any tailings storage embankment shall be supervised by an engineering or geotechnical specialist. **[MTSD: Non-Standard Condition]**

21. The construction details of any tailings storage embankment shall be documented by an engineering or geotechnical specialist and confirm that the construction satisfies the design intent. The construction document shall include the records of all construction quality control testing, the basis of any method specification adopted, and any significant modifications to the original design together with the reasons why the modifications were necessary. The construction document shall also present as-built drawings for the embankment earthworks and pipework. A copy of the construction document shall be submitted to DMIRS for its records. **[MTSD: Non-Standard Condition]**

22. The tailings storage facility shall be checked on a routine daily basis by site personnel during periods of deposition to ensure that the facility is functioning as per the design intent. **[MTSD: Non-Standard Condition]**

23. An engineering or geotechnical specialist shall audit and review the active tailings storage facility on an annual basis. The specialist shall review past performance, validate the design, examine tailings management, and review the results of monitoring. Any deficiencies noted in the audit and review report shall be suitably addressed and improved. The audit and review report shall be submitted to DMIRS and should be accompanied by a recent survey pick-up of the facility and an updated tailings storage data sheet. **[MTSD: Non-Standard Condition]**

24. At the time of decommissioning of the tailings storage facility and prior to rehabilitation, a further review report by a geotechnical or engineering specialist shall be submitted to DMIRS. This report should review the status of the structure and its contained tailings, examine and address the implications of the physical and chemical characteristics of the materials, and present and review the results of all monitoring. The rehabilitation stabilisation works proposed and any on-going remedial requirements should also be addressed. **[MTSD: Non-Standard Condition]**

25. All activities being carried out in such a manner so as to not have a detrimental effect on the natural water flow through the lease and surrounding areas to the satisfaction of the Environmental Officer, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 657]**

26. A Mine Closure Plan is to be submitted in the annual environmental reporting month specified in tenement conditions in the year specified below, unless otherwise directed by the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. The Mine Closure Plan is to be prepared in accordance with the "Guidelines for Preparing Mine Closure Plans" available on the Department of Mines, Industry Regulation and Safety website: **[MTSD: Standard Condition 578]**
    - 2022

RECOMMENDED FURTHER CONDITIONS
FOR MISCELLANEOUS LICENCE 52/194

Please impose the following new conditions:

15. All mining operations to meet the environmental outcomes as measured by the performance criteria stated in Table 39 of the mining proposal (Reg ID: 76773) "Abra Base Metals Project - Mining Proposal – Version 3" dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767. **[MTSD: Standard Condition 661]**

16. All ground disturbance to be undertaken within the disturbance envelope as represented by the spatial data provided on 30 October 2018 and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6116799.
[MTSD: Standard Condition 669]

17. No alteration or expansion of mining operations beyond the activities detailed in Table 5 - 7 and Tables 8 – 13 of the mining proposal (Reg ID: 76773) "Abra Base Metals Project - Mining Proposal – Version 3" dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767.
[MTSD: Standard Condition 670]

18. Management of mine closure is to be undertaken in accordance with the Mine Closure Plan (Reg ID: 76773) "Abra Base Metals Project – Mine Closure Plan – Version 3" dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767.
[MTSD: Standard Condition 662]

19. Report any incident arising from mining activities that has caused, or has the potential to cause environmental harm or injury to land, to the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety, within 24 hours of becoming aware of the occurrence of the incident.
[MTSD: Standard Condition 671]

20. Report any breach of environmental outcome or performance criteria stated in table 39 of the mining proposal (Reg ID: 76773) "Abra Base Metals Project - Mining Proposal – Version 3" dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767, to the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety within 24 hours of becoming aware of the occurrence of the breach.
[MTSD: Standard Condition 672]

21. The development and operation of the project being carried out in such a manner so as to create the minimum practicable disturbance to the existing vegetation and natural landform. **[MTSD: Standard Condition 384]**

22. All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. **[MTSD: Standard Condition 385]**

23. All rubbish and scrap is to be progressively disposed of in a suitable manner. **[MTSD: Standard Condition 387]**

24. Take all reasonable measures to prevent or minimise the generation of dust from all materials handling operations, stockpiles, open areas and transport activities. **[MTSD: Standard Condition 659]**

25. Where saline water is used for dust suppression, all reasonable measures being taken to avoid any detrimental effects to surrounding vegetation and topsoil stockpiles. **[MTSD: Standard Condition 401]**

26. Placement of waste material must be such that the final footprint after rehabilitation will not be impacted upon by pit wall subsidence or be within the zone of pit instability to the satisfaction of the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 573]**

27. On the completion of operations or progressively when possible, all waste dumps, tailings storage facilities, stockpiles or other mining related landforms must be rehabilitated to form safe, stable, non-polluting structures which are integrated with the surrounding landscape and support self-sustaining, functional ecosystems comprising suitable, local provenance species or an alternative agreed outcome to the satisfaction of the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 388]**

28. An annual environmental report is to be submitted to the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety, outlining the project operations, minesite environmental management and rehabilitation work undertaken in the previous 12 months and the proposed operations, environmental management plans and rehabilitation programs for the next 12 months. This report to be submitted each year in: **[MTSD: Standard Condition 392]**
    - May

29. All activities being carried out in such a manner so as to not have a detrimental effect on the natural water flow through the lease and surrounding areas to the satisfaction of the Environmental Officer, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 657]**

30. A Mine Closure Plan is to be submitted in the annual environmental reporting month specified in tenement conditions in the year specified below, unless otherwise directed by the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. The Mine Closure Plan is to be prepared in accordance with the "Guidelines for Preparing Mine Closure Plans" available on the Department of Mines, Industry Regulation and Safety website:
    - 2022

[MTSD: Standard Condition 578]

RECOMMENDED FURTHER CONDITIONS
FOR MINING LEASE 52/776

Please revise the following existing conditions to read:

3. All disturbances to the surface of the land made as a result of exploration, including costeans, drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, Department of Mines, Industry Regulation and Safety. Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 4]**

5. Unless the written approval of the Environmental Officer, Department of Mines, Industry Regulation and Safety is first obtained, the use of drilling rigs, scrapers, graders, bulldozers, backhoes or other mechanised equipment for surface disturbance or the excavation of costeans is prohibited. Following approval, all topsoil being removed ahead of mining operations and separately stockpiled for replacement after backfilling and/or completion of operations. **[MTSD: Standard Condition 6]**

8. The lessee submitting a plan of proposed operations and measures to safeguard the environment to the Executive Director, Resource and Environmental Compliance, Department of Mines, Industry Regulation and Safety for their assessment and written approval prior to commencing any developmental or productive mining or construction activity. **[MTSD: Standard Condition 9]**

Please impose the following new conditions:

9. All mining operations to meet the environmental outcomes as measured by the performance criteria stated in Table 39 of the mining proposal (Reg ID: 76773) “Abra Base Metals Project - Mining Proposal – Version 3” dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767. **[MTSD: Standard Condition 661]**

10. All ground disturbance to be undertaken within the disturbance envelope as represented by the spatial data provided on 30 October 2018 and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6116799. **[MTSD: Standard Condition 669]**

11. No alteration or expansion of mining operations beyond the activities detailed in Table 5 - 7 and Tables 8 – 13 of the mining proposal (Reg ID: 76773) “Abra Base Metals Project - Mining Proposal – Version 3” dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767. **[MTSD: Standard Condition 670]**

12. Management of mine closure is to be undertaken in accordance with the Mine Closure Plan (Reg ID: 76773) “Abra Base Metals Project – Mine Closure Plan – Version 3” dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767. **[MTSD: Standard Condition 662]**

13. Report any incident arising from mining activities that has caused, or has the potential to cause environmental harm or injury to land, to the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety, within 24 hours of becoming aware of the occurrence of the incident. **[MTSD: Standard Condition 671]**

14. Report any breach of environmental outcome or performance criteria stated in table 39 of the mining proposal (Reg ID: 76773) "Abra Base Metals Project - Mining Proposal – Version 3" dated 24 May 2019 signed by Troy Flannery, and retained on Department of Mines, Industry Regulation and Safety file no. EARS-MPMCP-76773 as Doc ID 6554767, to the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety within 24 hours of becoming aware of the occurrence of the breach. **[MTSD: Standard Condition 672]**

15. The development and operation of the project being carried out in such a manner so as to create the minimum practicable disturbance to the existing vegetation and natural landform. **[MTSD: Standard Condition 384]**

16. All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. **[MTSD: Standard Condition 385]**

17. All rubbish and scrap is to be progressively disposed of in a suitable manner. **[MTSD: Standard Condition 387]**

18. Take all reasonable measures to prevent or minimise the generation of dust from all materials handling operations, stockpiles, open areas and transport activities. **[MTSD: Standard Condition 659]**

19. Where saline water is used for dust suppression, all reasonable measures being taken to avoid any detrimental effects to surrounding vegetation and topsoil stockpiles. **[MTSD: Standard Condition 401]**

20. Placement of waste material must be such that the final footprint after rehabilitation will not be impacted upon by pit wall subsidence or be within the zone of pit instability to the satisfaction of the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 573]**

21. On the completion of operations or progressively when possible, all waste dumps, tailings storage facilities, stockpiles or other mining related landforms must be rehabilitated to form safe, stable, non-polluting structures which are integrated with the surrounding landscape and support self-sustaining, functional ecosystems comprising suitable, local provenance species or an alternative agreed outcome to the satisfaction of the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 388]**

22. An annual environmental report is to be submitted to the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety, outlining the project operations, minesite environmental management and rehabilitation work undertaken in the previous 12 months and the proposed operations, environmental management plans and rehabilitation programs for the next 12 months. This report to be submitted each year in: **[MTSD: Standard Condition 392]**
    - May

23. All activities being carried out in such a manner so as to not have a detrimental effect on the natural water flow through the lease and surrounding areas to the satisfaction of the Environmental Officer, Department of Mines, Industry Regulation and Safety. **[MTSD: Standard Condition 657]**

24. A Mine Closure Plan is to be submitted in the annual environmental reporting month specified in tenement conditions in the year specified below, unless otherwise directed by the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. The Mine Closure Plan is to be prepared in accordance with the "Guidelines for Preparing Mine Closure Plans" available on the Department of Mines, Industry Regulation and Safety website: **[MTSD: Standard Condition 578]**
    - 2022

Appendix K. Confidential Information

Not to be made publicly available