BHP Iron Ore Pty Ltd
Marillana Creek (Yandi) Closure Plan

Appendices

Navigating this document

The pdf of this document has been saved with bookmarks that can be used to quickly navigate between appendices (Figure 1). To access these bookmarks, the navigation pane will need to be opened. The location of this pane is dependent on the browser used, but typically can be identified from a bookmark icon similar to that shown circled in red in Figure 1.

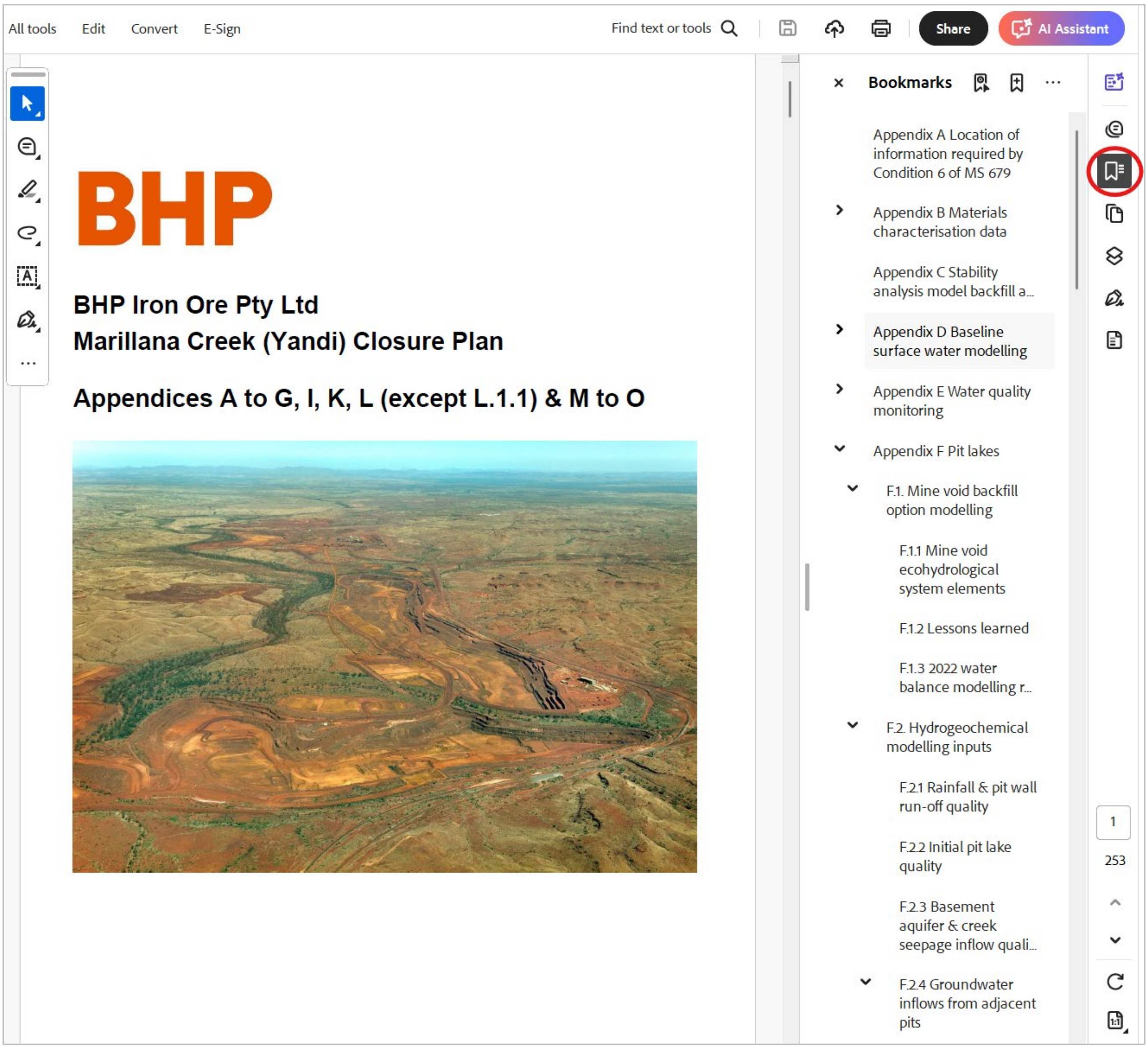


Figure 1 **Snapshot of pdf browser navigation pane with bookmarks**

Appendix A Location of information required by Condition 6 of MS 679

Insert from main document

Appendix B Materials characterisation data

B.1. Statistical summary of total sulphur data (GHD, 2014)

Sulphur concentrations by deposit

Resource definition area	Total number of samples	Number of total S samples	Mean total S (%)	Median total S (%)	Minimum total S (%)	Maximum total S (%)	Number samples <0.2 %S	% samples <0.2 %S
Global database	8,991,133	8,653,463	-	-	-	-	8,649,423	99.95%
C1	1,026,039	1,026,039	0.01	0.01	0.00	1.08	1,025,925	99.99%
C2	222,943	222,943	0.01	0.01	0.00	0.08	222,943	100.00%
C3	136,346	136,346	0.01	0.01	0.00	0.03	136,346	100.00%
C4	107,854	107,854	0.01	0.01	0.00	0.14	107,854	100.00%
C5	596,328	596,328	0.01	0.01	0.00	1.30	595,700	99.89%
E1	185,379	185,379	0.01	0.01	0.00	0.44	185,262	99.94%
E2	419,457	419,457	0.01	0.01	0.00	0.06	419,457	100.00%
E356	950,183	950,183	0.01	0.01	0.00	0.29	950,129	99.99%
E4	257,237	257,237	0.01	0.01	0.00	0.13	257,237	100.00%
E7	45,857	29,741	0.01	0.01	0.00	0.05	29,741	100.00%
W1N	937,545	937,545	0.01	0.01	0.00	0.65	937,451	99.99%
W1S	934,043	911,809	0.01	0.01	0.00	0.18	911,809	100.00%
W2	528,846	499,358	0.01	0.01	0.00	0.46	499,247	99.98%
W3	255,811	0	0.00	0.00	0.00	0.00	0	0.00%
W4	926,872	912,851	0.01	0.01	0.00	0.11	912,851	100.00%
W5N	519,562	519,562	0.01	0.01	0.00	2.36	516,672	99.44%
W5S	626,348	626,348	0.01	0.01	0.00	0.43	626,316	99.99%
W6	314,483	314,483	0.01	0.00	0.00	0.12	314,483	100.00%

Source: GHD (2014)

Sulphur concentrations by lithology

Lithology	Central (%S)					Eastern (%S)					Western (%S)				
	Mean	Median	Minimum	Maximum	No Samples	Mean	Median	Minimum	Maximum	No Samples	Mean	Median	Minimum	Maximum	No Samples
Iowa Eastern Member Eastern CID	-	-	-	-	-	0.01	0.01	0.00	0.18	140,748	0.02	0.02	0.01	0.14	29,715
Barimunya Member Upper CID	0.01	0.01	0.00	0.23	718,717	0.01	0.01	0.00	0.13	622,181	0.01	0.01	0.00	0.17	1,361,518
Barimunya Member Lower CID	0.01	0.01	0.00	0.06	117,992	0.01	0.01	0.00	0.03	140,344	0.01	0.01	0.00	0.05	672,531
Munjina Member Basal Conglomerate	0.01	0.01	0.00	1.30	482,612	0.01	0.01	0.00	0.29	443,502	0.01	0.01	0.00	0.66	1,072,238
Weeli Wolli Formation	0.01	0.01	0.00	0.27	734,106	0.01	0.01	0.00	0.44	437,531	0.01	0.01	0.00	2.36	1,673,191
Unknown	0.01	0.01	0.01	0.05	36,083	0.01	0.01	0.00	0.06	73,807	0.02	0.01	0.00	0.65	162,393

Source: GHD (2014)

B.2. Summary of samples within the Yandi environmental geochemistry dataset analysed by MWM (2022)

Description	Strat.	No. of samples Tested	ABA	ELEMENTAL ANALYSIS	QXRD	SHORT-TERM LEACH	MULTI-STAGE LEACH	SATURATED LEACH
Alluvials	A	1	1					
Surface Scree	SZ	6	6	6	3	8	1	
Dykes/Sills	K	4	4	4	2	6	1	
Marillana Formation:								
Iowa Member - Eastern CID Weathered	M4W	1	1					
Iowa Member - Eastern Clay	EK	5	5					
Barimunya Member - Upper CID	M3	7	7	6	3	9	1	1
Barimunya Member, Upper CID High SiO_2/AlO_3	M3SA	1	1					
Barimunya Member, Northern Marginal Zone	M3MN	1	1					
Barimunya Member, Southern Marginal zone	M3MS	9	9					
Barimunya Member, Ochreous Clay	OK	3	3					
Barimunya Member – Lower CID	M2	12	12	8	4	11	1	1
Munjina Member - Basal Clay	BK	9	9					
Munjina Member - Basal Conglomerate	BG	11	11	3	1	5	1	
Weeli Wolli Formation:								
Undifferentiated	WW	8	8	2				
Weeli Wolli Iron Formation	HJ	17	17	7	1	9	1	

Description	Strat.	No. of samples Tested	ABA	ELEMENTAL ANALYSIS	QXRD	SHORT-TERM LEACH	MULTI-STAGE LEACH	SATURATED LEACH
Weeli Wolli Dolerite	HE	13	13	2		2		
Unknown	UN	4	4	4		2		
OSA Composite Samples								
Barimunya Member – Lower CID	M2	10	10	10	5	10		
Barimunya Member, Upper CID High SiO_2/AlO_3	M3/M3SA	4	4	4	2	4		
TOTAL NUMBER OF SAMPLES		**126**	**126**	**52**	**21**	**38**	**6**	**2**

Source: Mine Waste Management (2022)

B.3. Yandi ABA data by stratigraphy

Summary of ABA data for Yandi samples by stratigraphy

Strat Code	Formation	*n*	Paste pH			Paste EC (µs/cm)			Total S (%)			ANC (kg H_2SO_4/t)			MPA (kg H_2SO_4/t)			NAPP (kg H_2SO_4/t)*			NPR*			NAG pH			
			Min	MED.	Max	Min	MED.	Max	Min	MED.	Max	Min	MED.	Max	Min	MED.	Max	Min	MED.	Max	Min	MED.	Max	*n*	Min	MED.	Max
A	Alluvials	1	7.2	-	7.2	144	144	144	<0.01	-	<0.01	4.8	-	4.8	<0.3	-	<0.3	-4.6	-	-4.6	31	-	31	1	6.8	-	6.8
SZ	Surface scree	6	6.5	6.9	7.9	61	140	257	<0.01	<0.01	0.01	0.8	1.7	4.9	<0.3	<0.3	0.4	-4.8	-1.5	-0.7	5.3	8.6	32	2	6.8	8.0	9.1
K	Dykes/Sills	4	7.2	7.3	7.4	108	127	168	<0.01	<0.01	<0.01	0.5	1.6	2.8	<0.3	<0.3	<0.3	-2.7	-1.4	-0.3	3.2	10	18	2	6.3	6.3	6.4
M4W	Eastern CID Weathered	1	7.3		7.3	322	-	322	<0.01		<0.01	2.4	-	2.4	<0.3		<0.3	-2.2		-2.2	16	-	16	1	7.7	-	7.7
EK	Iowa Member - Eastern Clay	5	5.9	6.3	6.8	93	138	744	<0.01	<0.01	0.05	1.8	4	7.9	<0.3	<0.3	<0.3	-7.7	-3.8	-1.6	12	52	52	5	5.9	6.3	8.2
M3	Barimunya Member - Upper CID	7	6.4	7.1	7.3	62	111	261	<0.01	<0.01	<0.01	1.3	2	2.9	<0.3	<0.3	<0.3	-2.8	-1.9	-1.1	8.5	13	19	4	6.4	7.1	8.1
M3SA	Barimunya Member, Upper CID High Silica High Alumina	1	6.8	-	6.8	104	-	104	<0.01	-	<0.01	2.7	-	2.7	<0.3	-	<0.3	-2.5	-	-2.5	18	-	18	1	6.9	-	6.9
M3/M3SA	OSA Composite Samples: Barimunya Member - Upper CID	4	7.2	7.5	7.6	92	190	200	<0.01	<0.01	<0.01	2.6	3.6	3.7	0.2	0.2	0.2	-3.5	-3.4	-2.4	17	23	24	4	7.1	7.5	7.7
M3MN	Barimunya Member, Northern Marginal Zone	1	6.9		6.9	61	-	61	<0.01	<0.01	<0.01	2.4	-	2.4	<0.3	-	<0.3	-2.2	-	-2.2	16	-	16	1	6.6	-	6.6
M3MS	Barimunya Member, Southern Marginal zone	9	6.3	6.9	7.2	42	74	165	<0.01	<0.01	<0.01	1.4	2.9	4.2	<0.3	<0.3	<0.3	-4	-2.7	-1.2	9.2	19	27	9	5.7	7.2	7.6
OK	Barimunya Member, Ochreous Clay	3	6.8	-	7.1	81	-	417	<0.01	-	<0.01	1.8	-	4.1	<0.3	<0.3	<0.3	-3.9	-	-1.6	12		27	3	6.4	-	7.0
M2	Barimunya Member - Lower CID	12	7.0	7.2	7.4	70	124	246	<0.01	<0.01	<0.01	0.9	2.1	4.7	<0.3	<0.3	<0.3	-4.5	-2	-0.7	5.6	14	31	7	5.9	6.9	7.7
M2	OSA Composite Samples: Barimunya Member - Lower CID	10	7.2	7.5	7.9	83	175	360	<0.01	<0.01	<0.01	2.2	3.7	17	0.2	0.2	0.2	-17	-3.5	-2	14	24	111	10	7.1	7.7	9.3
BK	Munjina Member - Basal Clay	9	7.1	7.2	7.4	59	96	188	<0.01	<0.01	<0.01	1.1	2.9	5.2	<0.3	<0.3	<0.3	-5	-2.7	-0.9	7.2	19	34	9	6.4	6.7	7.9
BG	Munjina Member - Basal Conglomerate	11	6.4	7.1	7.5	49	77	181	<0.01	<0.01	0.01	0.6	3.3	6.4	<0.3	<0.3	<0.3	-6.2	3.1	-0.4	3.9	22	42	10	6.2	6.6	8.1
WW	Weeli Wolli Formation (Undiff.)	8	6.4	8.2	9.5	81	267	463	<0.01	<0.01	0.03	1	2.3	84	<0.3	<0.3	0.9	-83	-2.2	-0.7	2.1	15	546	2	6.6	6.7	6.7
HE	Weeli Wolli Dolerite	13	7.7	8.6	9.0	85	247	765	<0.01	<0.01	0.13	1.4	18	326	<0.3	<0.3	4	-323	-18	-0.5	1.5	119	712	6	6.7	8.1	9.7
HJ	Weeli Wolli Iron Formation	17	6.4	7.9	9.7	39	120	492	<0.01	<0.01	0.03	<0.5	5.5	121	<0.3	<0.3	0.9	-120*	-5.3	-0.5	0*	36	132	10	5.9	6.8	10.9
UN	Unknown	4	7.7	8.9	9.8	95	243	309	<0.01	0.02	0.16	9.2	14	208	<0.3	0.9	4.9	-203	-13	-9	8.3	53	111	4	7.3	8.0	10.4
	TOTAL	**112**																						**77**			

Min: Minimum; Max: Maximum; Med: Median (n>3); n: number of data; *NAPP and NPR values excluded where both total sulphur (MPA) and ANC were below reporting limits (samples classified as NAF / AMD0).
Source: Mine Waste Management (2022)

B.4. Yandi ABA data by deposit from regional geochemistry database

PARAMETER	DEPOSIT										TOTAL
	C5	E1	E356	E4	E7	E8	W1S	W4	W5	UNK	
Paste pH	1	2	1	1	45	2	3	2	6	15	81
Paste EC	1	2	1	1	45	2	3	2	6	15	81
Total S	1	2	1	1	45	2	3	2	6	15	81
Sulphate S	1		1		45	2	3	2		6	63
ANC	1	2	1	1	45	2	3	2	6	15	81
NAG	1		1		45	2	3	2		6	63

Source: Mine Waste Management (2020)

B.5. Multi-stage leach testing results

E8 deposit samples selected for multi-stage leach testing

STRAT	UNITS	SAMPLE ID / COMPOSITE
M3	7350 - Upper CID High Silica High Alumina	Composite (Y851963, Y851103, Y851915)
	7370 - Upper CID Weathered	
	7300 - Barimunya Member - Upper CID	
	7320 - Southern Marginal zone	
	7330 - Northern Marginal Zone	
M2	7120 - Barimunya Member - Lower CID	Composite (Y851035, Y851921)
BG	7030 – Munjina Member - Basal Conglomerate	Y851051
K	Dykes/Sills	Composite (Y851123 and Y851925)
SZ	8150 – Surface Scree	Y851895
HJ	6110 – Weeli Wolli Iron Formation	Y851141

Source: Mine Waste Management (2022)

Y851051 leachate results

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION					LEACHATES EXCEEDING LOR	MINIMUM LEACHATE CONCENTRATION	MAXIMUM LEACHATE CONCENTRATION	% LEACHED FROM SOLID
			S1	S2	S3	S4	S5				
Liquid: Solid Ratio (L/kg)			0.4	0.4	0.4	0.4	0.4				
Cumulative Liquid: Solid Ratio (L/kg)			0.4	0.8	1.2	1.6	2.0				
pH	SU	-	7.14	7.69	7.42	7.62	7.78	5	7.14	7.78	N.D
EC	µS/cm	10	773	203	161	145	123	5	123.4	773	N.D
Total alkalinity	mg/L as CaCO3	1	72	81	85	78	65	5	64.87	84.81	N.D
Fluoride	mg/L	0.01	10.8	2.54	1	1.33	1.03	5	1.03	10.8	N.D
Chloride	mg/L	0.01	137	8.73	2	0.68	0.5	5	0.53	137	N.D
Bromide	mg/L	0.01	0.13	0.01	0.03	< 0.01	0.01	4	0.01	0.13	N.D
Nitrate	mg/L	0.01	0.8	0.02	< 0.01	< 0.01	< 0.01	2	0.02	0.81	N.D
Phosphate	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	<LOR	<LOR	N.D
Sulphate	mg/L	0.01	44	12.70	2	0.97	1	5	0.74	44.4	N.D
Si	mg/L	0.01	6	6.15	6.3	6.73	6.4	5	5.88	6.73	N.D
Al	mg/L	0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	<LOR	<LOR	<0.1
Ca	mg/L	0.01	24.9	5.11	3.4	4.17	4.76	5	3.37	24.9	1.8
Mg	mg/L	0.01	29.8	6.01	4.7	5.02	5.67	5	4.74	29.8	0.9
Fe	mg/L	0.001	0.003	0.008	0.007	0.004	0.007	5	0.003	0.008	<0.1
Na	mg/L	0.01	49	20	16	13	8	5	7.78	49.2	35.1
K	mg/L	0.01	6	2.85	2.4	2.37	2.3	5	2.33	6.48	17.3
B	mg/L	0.01	0.1	0.071	0.068	0.062	0.039	5	0.039	0.072	Total <LOR
P	mg/L	0.001	0.063	0.013	0.008	<0.001	0.013	4	0.008	0.063	<0.1
S	mg/L	0.01	15.8	3.94	1	0.332	0.235	5	0.235	15.8	Total <LOR
As	mg/L	0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	1	0.002	0.002	<0.1
Ba	mg/L	0.001	1.10	0.212	0.175	0.188	0.21	5	0.175	1.103	0.5
Be	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Bi	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cd	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ce	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Co	mg/L	0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	1	0.002	0.002	<0.1
Cr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cs	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cu	mg/L	0.001	0.003	0.002	< 0.001	< 0.001	< 0.001	2	0.002	0.003	<0.1
Ga	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ge	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hf	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hg	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
La	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Li	mg/L	0.001	0.329	0.157	0.129	0.124	0.109	5	0.109	0.329	63.6
Mo	mg/L	0.001	0.006	0.014	0.015	0.015	0.013	5	0.006	0.015	1.5
Nb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ni	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Pb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Rb	mg/L	0.001	0.006	0.003	0.002	0.003	0.002	5	0.002	0.006	0.8
Sb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sc	mg/L	0.001	0.002	0.002	0.002	0.002	0.002	5	0.002	0.002	<0.1
Se	mg/L	0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	1	0.002	0.002	<0.1
Sn	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sr	mg/L	0.001	0.16	0.03	0.02	0.025	0.029	5	0.024	0.159	1.3
Ta	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Th	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Tl	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	Total <LOR
U	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
V	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
W	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Y	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Zn	mg/L	0.001	0.021	0.001	< 0.001	< 0.001	< 0.001	2	0.001	0.021	<0.1
Zr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1

Source: Mine Waste Management (2022)

Notes: N.D : Not determined; LOR : Laboratory Limit of Reporting

Cumulative leached concentration - Y851051

Source: Mine Waste Management (2022)

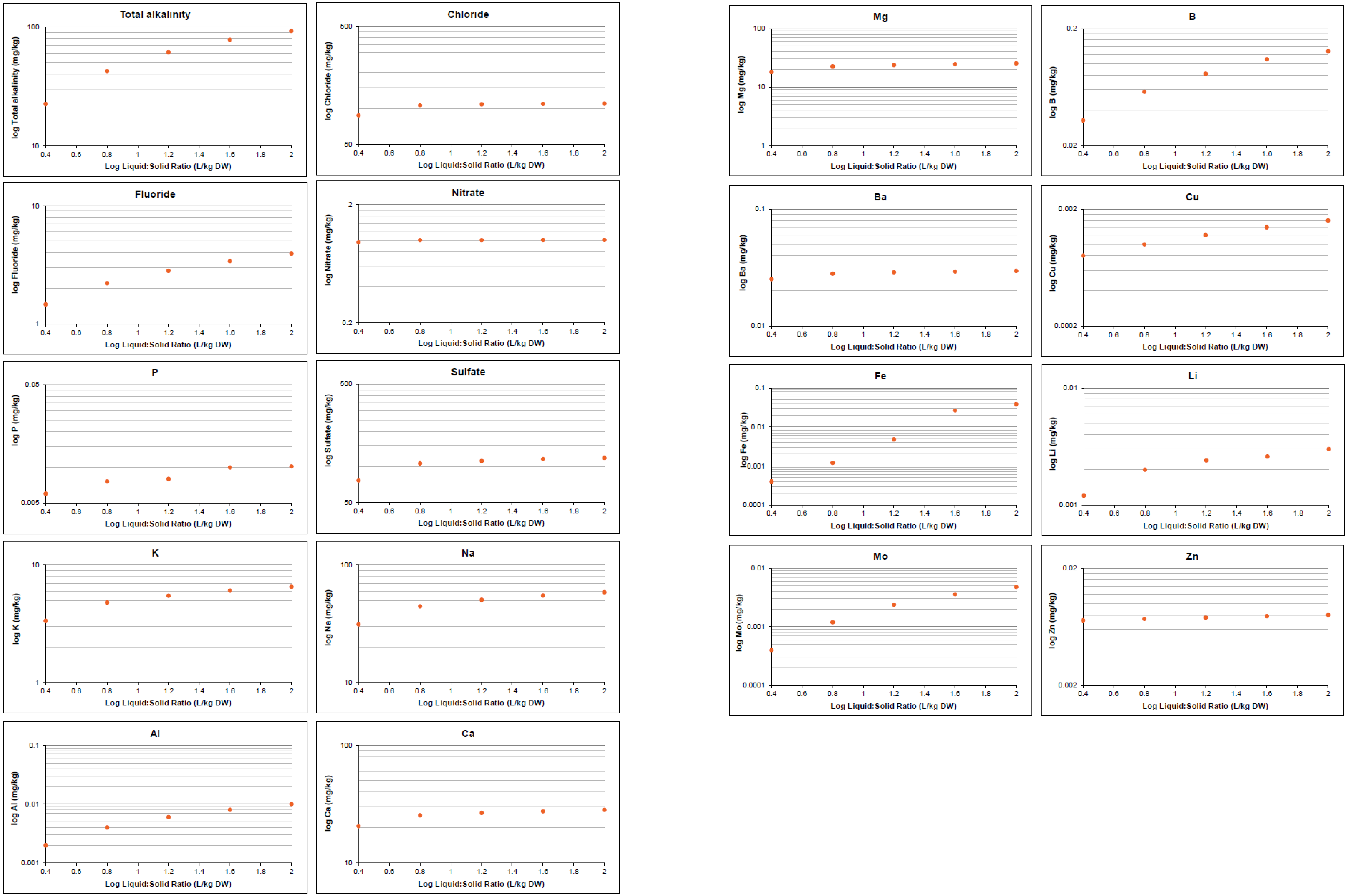
Y851123 / Y851925 leachate results

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION					LEACHATES EXCEEDING LOR	MINIMUM LEACHATE CONCENTRATION	MAXIMUM LEACHATE CONCENTRATION	% LEACHED FROM SOLID
			S1	S2	S3	S4	S5				
Liquid: Solid Ratio (L/kg)			0.4	0.4	0.4	0.4	0.4				
Cumulative Liquid: Solid Ratio (L/kg)			0.4	0.8	1.2	1.6	2.0				
pH	SU	-	7.54	7.63	7.62	7.53	7.6	5	7.53	7.63	N.D
EC	µS/cm	10	1,289	418	158	117	83	5	83	1,289	N.D
Total alkalinity	mg/L as CaCO3	1	56	50	47	42	35	5	35	56	N.D
Fluoride	mg/L	0.01	3.7	1.86	2	1.44	1.34	5	1.3	3.7	N.D
Chloride	mg/L	0.01	220	47	5.9	2.2	1.4	5	1.4	220	N.D
Bromide	mg/L	0.01	0.26	0.04	0.01	0.01	0.01	5	0.01	0.26	N.D
Nitrate	mg/L	0.01	2.4	0.1	< 0.01	< 0.01	< 0.01	2	0.1	2.4	N.D
Phosphate	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	<LOR	<LOR	N.D
Sulphate	mg/L	0.01	192	76	14	9.5	6.2	5	6.2	192	N.D
Si	mg/L	0.01	7.6	5	4.8	5	4.9	5	4.8	7.6	N.D
Al	mg/L	0.01	< 0.01	< 0.01	< 0.01	<0.01	< 0.01	0	<LOR	<LOR	<0.1
Ca	mg/L	0.01	51	12	3	2.3	2	5	2	51	4.5
Mg	mg/L	0.01	45	11	2.8	2.2	1.9	5	1.9	45	1.8
Fe	mg/L	0.001	0.001	0.002	0.009	0.054	0.03	5	0.001	0.054	<0.1
Na	mg/L	0.01	78	33	15	11	8.8	5	8.8	78	32.9
K	mg/L	0.01	8.4	3.7	1.7	1.4	1.2	5	1.2	8.4	6.0
B	mg/L	0.01	0.08	0.06	0.06	0.07	0.05	5	0.048	0.082	1.5
P	mg/L	0.001	0.015	0.004	0.001	0.005	<0.001	4	0.001	0.015	<0.1
S	mg/L	0.01	74	26	5.7	2.9	2	5	2	74	Total <LOR
As	mg/L	0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	1	0.002	0.002	<0.1
Ba	mg/L	0.001	0.063	0.007	0.002	0.001	0.001	5	0.001	0.063	0.5
Be	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Bi	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cd	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ce	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Co	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cs	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cu	mg/L	0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	1	0.002	0.002	<0.1
Ga	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ge	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hf	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hg	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
La	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Li	mg/L	0.001	0.003	0.002	0.001	< 0.001	0.001	4	0.001	0.003	<0.1
Mo	mg/L	0.001	0.001	0.002	0.003	0.003	0.003	5	0.001	0.003	0.2
Nb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ni	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Pb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Rb	mg/L	0.001	0.007	0.003	0.002	0.001	0.001	5	0.001	0.007	4.2
Sb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sc	mg/L	0.001	0.002	0.001	0.001	0.001	0.001	5	0.001	0.002	<0.1
Se	mg/L	0.001	0.005	0.001	< 0.001	< 0.001	< 0.001	2	0.001	0.005	0.1
Sn	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sr	mg/L	0.001	0.21	0.047	0.012	0.009	0.007	5	0.007	0.21	0.8
Ta	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Th	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Tl	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	Total <LOR
U	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
V	mg/L	0.001	< 0.001	< 0.001	0.001	0.001	< 0.001	2	0.001	0.001	<0.1
W	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Y	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Zn	mg/L	0.001	0.018	< 0.001	< 0.001	< 0.001	< 0.001	1	0.018	0.018	<0.1
Zr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1

Source: Mine Waste Management (2022)

Notes: N.D : Not determined; LOR : Laboratory Limit of Reporting

Cumulative leached concentration - Y851123 / Y851925



Source: Mine Waste Management (2022)

Y851895 leachate results

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION					LEACHATES EXCEEDING LOR	MINIMUM LEACHATE CONCENTRATION	MAXIMUM LEACHATE CONCENTRATION	% LEACHED FROM SOLID
			S1	S2	S3	S4	S5				
Liquid: Solid Ratio (L/kg)			0.4	0.4	0.4	0.4	0.4				
Cumulative Liquid: Solid Ratio (L/kg)			0.4	0.8	1.2	1.6	2.0				
pH	SU	-	6.8	6.57	6.73	6.53	6.71	5	6.53	6.8	N.D
EC	µS/cm	10	353	106	60	50	45	5	45	353	N.D
Total alkalinity	mg/L as CaCO3	1	19	11	10	8.5	7.5	5	7.5	19	N.D
Fluoride	mg/L	0.01	4.8	2.2	0.46	0.24	0.16	5	0.16	4.8	N.D
Chloride	mg/L	0.01	69	8.4	0.47	0.37	0.27	5	0.27	69	N.D
Bromide	mg/L	0.01	0.16	0.01	< 0.01	< 0.01	< 0.01	2	0.01	0.16	N.D
Nitrate	mg/L	0.01	0.33	0.02	< 0.01	< 0.01	< 0.01	2	0.02	0.33	N.D
Phosphate	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	<LOR	<LOR	N.D
Sulphate	mg/L	0.01	12	16	14	11	9.6	5	9.6	16	N.D
Si	mg/L	0.01	5.2	5.5	5.6	6.0	5.6	5	5.2	6	N.D
Al	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	<LOR	<LOR	<0.1
Ca	mg/L	0.01	5.2	2.4	2.2	2.1	2	5	2	5.2	4.2
Mg	mg/L	0.01	4.9	2.9	2.7	2.9	2.8	5	2.7	4.9	3.4
Fe	mg/L	0.001	0.002	0.002	0.001	0.001	0.017	5	0.001	0.017	<0.1
Na	mg/L	0.01	30	7.3	1.5	0.51	0.26	5	0.26	30	41.6
K	mg/L	0.01	7.7	4.2	2.7	1.4	0.48	5	0.48	7.7	31.2
B	mg/L	0.01	0.022	0.014	0.018	0.017	0.014	5	0.014	0.022	Total <LOR
P	mg/L	0.001	0.013	0.006	0.008	0.002	<0.001	4	0.002	0.013	<0.1
S	mg/L	0.01	6	6.1	4.7	4	3.7	5	3.7	6.1	Total <LOR
As	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ba	mg/L	0.001	0.074	0.014	0.013	0.014	0.014	5	0.013	0.074	0.5
Be	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Bi	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	Total <LOR
Cd	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	Total <LOR
Ce	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Co	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cs	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	Total <LOR
Cu	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ga	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ge	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hf	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hg	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
La	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Li	mg/L	0.001	0.003	0.002	0.001	0.001	< 0.001	4	0.001	0.003	6.7
Mo	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Nb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ni	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Pb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Rb	mg/L	0.001	0.003	0.002	0.002	0.001	< 0.001	4	0.001	0.003	0.5
Sb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sc	mg/L	0.001	0.002	0.002	0.001	0.001	0.001	5	0.001	0.002	0.1
Se	mg/L	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	0.001	0.001	Total <LOR
Sn	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sr	mg/L	0.001	0.025	0.012	0.01	0.012	0.012	5	0.01	0.025	1.5
Ta	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Th	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Tl	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	Total <LOR
U	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
V	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
W	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Y	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Zn	mg/L	0.001	0.029	< 0.001	< 0.001	< 0.001	< 0.001	1	0.029	0.029	Total <LOR
Zr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1

Source: Mine Waste Management (2022)

Notes: N.D : Not determined; LOR : Laboratory Limit of Reporting

Cumulative leached concentration - Y851895

Source: Mine Waste Management (2022)

Y851141 leachate results

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION S1	S2	S3	S4	S5	LEACHATES EXCEEDING LOR	MINIMUM LEACHATE CONCENTRATION	MAXIMUM LEACHATE CONCENTRATION	% LEACHED FROM SOLID
Liquid: Solid Ratio (L/kg)			0.4	0.4	0.4	0.4	0.4				
Cumulative Liquid: Solid Ratio (L/kg)			0.4	0.8	1.2	1.6	2.0				
pH	SU	-	7.81	7.79	8.06	7.95	7.89	5	7.79	8.06	N.D
EC	µS/cm	10	1,012	255	189	140	115	5	115	1,012	N.D
Total alkalinity	mg/L as CaCO3	1	62	93	86	63	56	5	56	93	N.D
Fluoride	mg/L	0.01	7.1	1.5	1.7	1.2	0.88	5	0.88	7.1	N.D
Chloride	mg/L	0.01	214	9.9	2.4	0.98	0.51	5	0.51	214	N.D
Bromide	mg/L	0.01	0.2	0.01	< 0.01	0.01	< 0.01	3	0.01	0.2	N.D
Nitrate	mg/L	0.01	1.4	0.01	< 0.01	0.01	< 0.01	3	0.01	1.4	N.D
Phosphate	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	<LOR	<LOR	N.D
Sulphate	mg/L	0.01	50	18	7.7	4.1	2.7	5	2.7	50	N.D
Si	mg/L	0.01	7.1	6.4	5.7	5.2	0.04	5	0.04	7.1	N.D
Al	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.06	1	0.06	0.06	<0.1
Ca	mg/L	0.01	28	5	5.1	4.6	0.09	5	0.09	28	1.2
Mg	mg/L	0.01	30	5.7	5.9	5.3	<0.01	4	5.3	30	1.0
Fe	mg/L	0.001	0.002	0.007	0.001	0.001	0.017	5	0.001	0.017	<0.1
Na	mg/L	0.01	30	23	15	15	0.08	5	0.08	30	7.6
K	mg/L	0.01	8.3	3.7	3.6	3.1	0.01	5	0.01	8.3	0.5
B	mg/L	0.01	0.15	0.11	0.062	0.035	<0.01	4	0.035	0.15	4.1
P	mg/L	0.001	0.081	0.008	0.02	0.029	0.004	5	0.004	0.08	<0.1
S	mg/L	0.01	20	5.9	2.4	1.3	0.013	5	0.013	20	Total <LOR
As	mg/L	0.001	0.002	< 0.001	< 0.001	< 0.002	< 0.002	1	0.002	0.002	<0.1
Ba	mg/L	0.001	0.85	0.18	0.23	0.23	< 0.001	4	0.18	0.85	<0.1
Be	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Bi	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cd	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ce	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Co	mg/L	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	0.001	0.001	<0.1
Cr	mg/L	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	0.001	0.001	<0.1
Cs	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cu	mg/L	0.001	0.009	0.003	0.001	< 0.001	< 0.001	3	0.001	0.009	<0.1
Ga	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ge	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hf	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hg	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
La	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Li	mg/L	0.001	0.66	0.25	0.16	0.12	< 0.001	4	0.12	0.66	30.6
Mo	mg/L	0.001	0.007	0.016	0.03	0.03	< 0.001	4	0.007	0.03	2.4
Nb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ni	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Pb	mg/L	0.001	< 0.001	0.03	< 0.001	< 0.001	< 0.001	1	0.0	0.0	0.2
Rb	mg/L	0.001	0.003	0.001	0.001	< 0.001	< 0.001	3	0.001	0.003	<0.1
Sb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sc	mg/L	0.001	0.002	0.002	0.002	0.002	< 0.001	4	0.002	0.002	<0.1
Se	mg/L	0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	1	0.003	0.003	<0.1
Sn	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sr	mg/L	0.001	0.17	0.033	0.034	0.029	0.001	5	0.001	0.17	0.8
Ta	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Th	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Tl	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
U	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
V	mg/L	0.001	< 0.001	0.002	0.002	0.001	< 0.001	3	0.001	0.002	<0.1
W	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	1	0.002	0.002	<0.1
Y	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Zn	mg/L	0.001	0.001	< 0.001	< 0.001	0.005	< 0.001	2	0.001	0.005	<0.1
Zr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1

Source: Mine Waste Management (2022)

Notes: N.D : Not determined; LOR : Laboratory Limit of Reporting

Cumulative leached concentration - Y851141

Source: Mine Waste Management (2022)

M2 Composite (Y851035 / Y851921) leachate results

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION					LEACHATES EXCEEDING LOR	MINIMUM LEACHATE CONCENTRATION	MAXIMUM LEACHATE CONCENTRATION	% LEACHED FROM SOLID
			S1	S2	S3	S4	S5				
Liquid: Solid Ratio (L/kg)			0.4	0.4	0.4	0.4	0.4				
Cumulative Liquid: Solid Ratio (L/kg)			0.4	0.8	1.2	1.6	2.0				
pH	SU	-	7.41	7.67	7.83	7.24	7.4	5	7.24	7.83	N.D
EC	µS/cm	10	820	211	126	106	82	5	82	820	N.D
Total alkalinity	mg/L as CaCO3	1	62	56	50	46	35	5	35	62	N.D
Fluoride	mg/L	0.01	7.1	1.6	1.4	1	1.1	5	1	7.1	N.D
Chloride	mg/L	0.01	165	12	2	1.1	0.87	5	0.87	165	N.D
Bromide	mg/L	0.01	0.34	0.01	< 0.01	< 0.01	< 0.01	2	0.01	0.34	N.D
Nitrate	mg/L	0.01	9.8	0.28	< 0.01	< 0.01	< 0.01	2	0.28	9.8	N.D
Phosphate	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	<LOR	<LOR	N.D
Sulphate	mg/L	0.01	28	22	8.8	5	3.9	5	3.9	28	N.D
Si	mg/L	0.01	4.5	4.2	3.9	4.3	3.9	5	3.9	4.5	N.D
Al	mg/L	0.01	< 0.01	< 0.01	<0.01	< 0.01	0.02	1	0.02	0.02	<0.1
Ca	mg/L	0.01	25	3.4	2.2	1.8	1.5	5	1.5	25	1.4
Mg	mg/L	0.01	2.2	4.4	2.3	2.1	1.7	5	1.7	4.4	0.4
Fe	mg/L	0.001	0.001	0.001	0.016	0.035	0.06	5	0.001	0.06	<0.1
Na	mg/L	0.01	55	21	14	11	8.5	5	8.5	55	13.8
K	mg/L	0.01	5.3	2	1.2	1.1	1.1	5	1.1	5.3	2.9
B	mg/L	0.01	0.08	0.08	0.08	0.08	0.07	5	0.07	0.08	<0.1
P	mg/L	0.001	0.023	0.007	0.003	0.006	0.003	5	0.003	0.023	<0.1
S	mg/L	0.01	15	8.1	3.1	1.7	1.3	5	1.3	15	Total <LOR
As	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ba	mg/L	0.001	0.037	0.005	0.21	0.002	0.002	5	0.002	0.21	0.3
Be	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Bi	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cd	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ce	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Co	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cs	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cu	mg/L	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	0.001	0.001	<0.1
Ga	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ge	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hf	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hg	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
La	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Li	mg/L	0.001	0.003	0.001	< 0.001	< 0.001	< 0.001	2	0.001	0.003	<0.1
Mo	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Nb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ni	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Pb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Rb	mg/L	0.001	0.006	0.002	< 0.001	0.001	0.001	4	0.001	0.006	<0.1
Sb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sc	mg/L	0.001	0.002	0.001	0.001	< 0.001	< 0.001	3	0.001	0.002	<0.1
Se	mg/L	0.001	0.005	0.001	< 0.001	< 0.001	< 0.001	2	0.001	0.005	<0.1
Sn	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sr	mg/L	0.001	0.11	0.017	0.013	0.007	0.006	5	0.006	0.11	0.2
Ta	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Th	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Tl	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	Total <LOR
U	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
V	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
W	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Y	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Zn	mg/L	0.001	0.001	< 0.001	0.033	< 0.001	< 0.001	2	0.001	0.033	0.2
Zr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1

Source: Mine Waste Management (2022)

Notes: N.D : Not determined; LOR : Laboratory Limit of Reporting

Cumulative leached concentration - M2 Composite (Y851035 / Y851921)

Source: Mine Waste Management (2022)

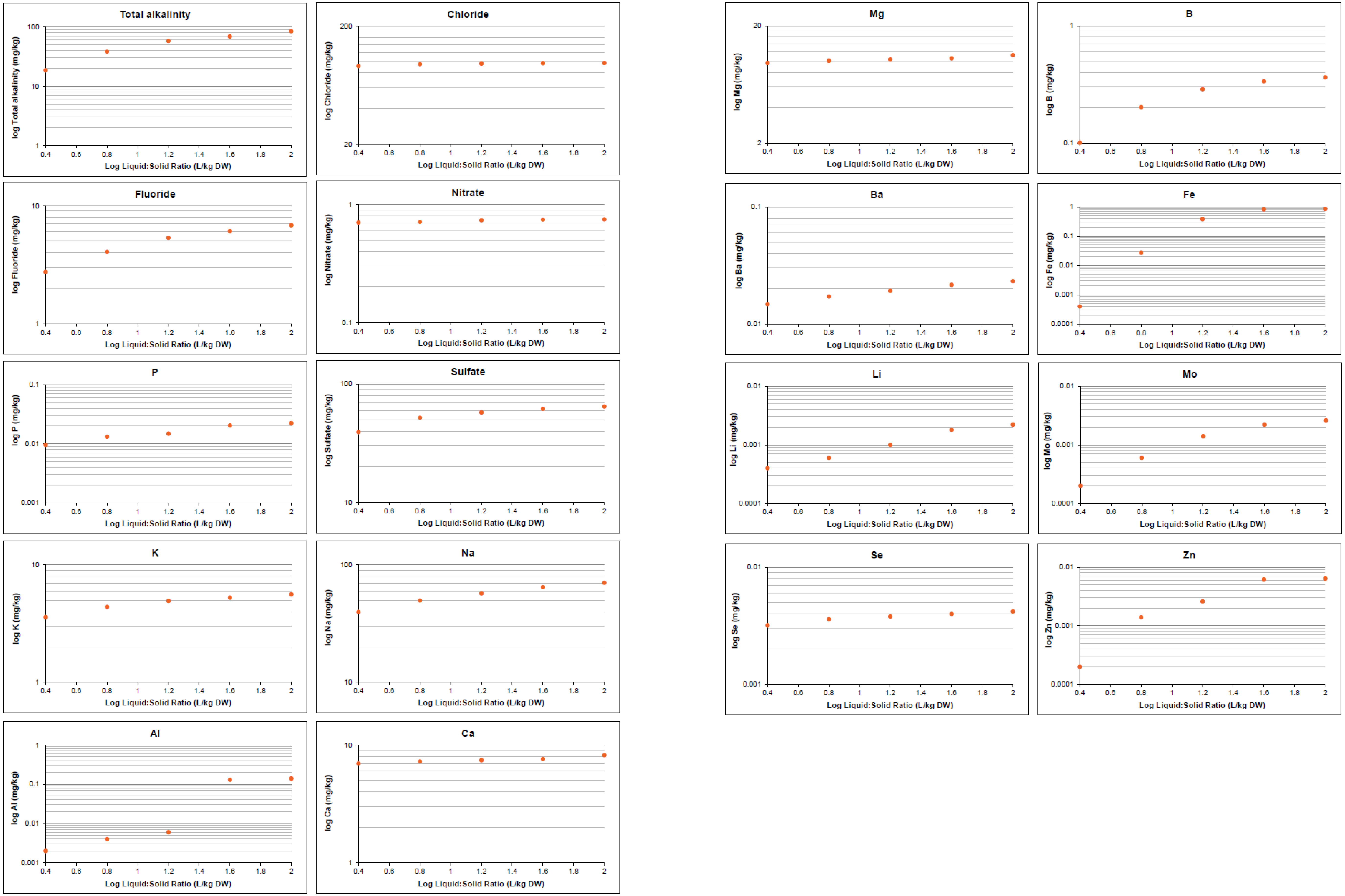
M3 Composite (Y851963 / Y851103 / Y851915) leachate results

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION					LEACHATES EXCEEDING LOR	MINIMUM LEACHATE CONCENTRATION	MAXIMUM LEACHATE CONCENTRATION	% LEACHED FROM SOLID
			S1	S2	S3	S4	S5				
Liquid: Solid Ratio (L/kg)			0.4	0.4	0.4	0.4	0.4				
Cumulative Liquid: Solid Ratio (L/kg)			0.4	0.8	1.2	1.6	2.0				
pH	SU	-	7.57	7.56	7.68	7.32	7.57	5	7.32	7.68	N.D
EC	µS/cm	10	1,139	215	161	139	100	5	100	1,139	N.D
Total alkalinity	mg/L as CaCO3	1	46	50	49	27	38	5	27	50	N.D
Fluoride	mg/L	0.01	6.9	3.3	3.2	1.9	1.8	5	1.8	6.9	N.D
Chloride	mg/L	0.01	230	8.2	2.6	1.4	1.3	5	1.3	230	N.D
Bromide	mg/L	0.01	0.46	0.02	< 0.01	< 0.01	< 0.01	2	0.02	0.46	N.D
Nitrate	mg/L	0.01	1.8	0.02	0.06	0.02	0.01	5	0.01	1.8	N.D
Phosphate	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	<LOR	<LOR	N.D
Sulphate	mg/L	0.01	98	32	14	10	7.3	5	7.3	98	N.D
Si	mg/L	0.01	12	12	12	11	4.1	5	4.1	12	N.D
Al	mg/L	0.01	< 0.01	< 0.01	<0.01	0.31	0.03	2	0.03	0.31	<0.1
Ca	mg/L	0.01	17	0.75	0.42	0.42	1.5	5	0.42	17	1.4
Mg	mg/L	0.01	24	1.1	0.65	0.59	1.7	5	0.59	24	0.7
Fe	mg/L	0.001	0.001	0.067	0.89	1.1	0.06	5	0.001	1.1	<0.1
Na	mg/L	0.01	99	25	19	19	15	5	15	99	15.7
K	mg/L	0.01	9	2	1.4	0.79	0.9	5	0.79	9	2.4
B	mg/L	0.01	0.25	0.25	0.21	0.12	0.067	5	0.067	0.25	0.7
P	mg/L	0.001	0.024	0.009	0.004	0.014	0.005	5	0.004	0.024	<0.1
S	mg/L	0.01	37	10	4.7	3.4	1.4	5	1.4	37	Total <LOR
As	mg/L	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	0.001	0.001	<0.1
Ba	mg/L	0.001	0.037	0.006	0.005	0.006	0.004	5	0.004	0.037	<0.1
Be	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Bi	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cd	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ce	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Co	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cs	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Cu	mg/L	0.001	0.001	< 0.001	< 0.001	0.001	< 0.001	2	0.001	0.001	<0.1
Ga	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ge	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hf	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Hg	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
La	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Li	mg/L	0.001	0.001	< 0.001	0.001	0.002	0.001	4	0.001	0.002	<0.1
Mo	mg/L	0.001	< 0.001	0.001	0.002	0.002	0.001	4	0.001	0.002	0.1
Nb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Ni	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Pb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Rb	mg/L	0.001	0.008	0.002	0.001	< 0.001	< 0.001	3	0.001	0.008	0.6
Sb	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sc	mg/L	0.001	0.002	0.003	0.003	0.003	0.003	5	0.002	0.003	<0.1
Se	mg/L	0.001	0.008	0.001	< 0.001	< 0.001	< 0.001	2	0.001	0.008	0.4
Sn	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Sr	mg/L	0.001	0.15	0.006	0.004	0.003	0.002	5	0.002	0.15	0.3
Ta	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Th	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Tl	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
U	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
V	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
W	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Y	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1
Zn	mg/L	0.001	< 0.001	0.003	0.003	0.009	< 0.001	3	0.003	0.009	<0.1
Zr	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	<LOR	<LOR	<0.1

Source: Mine Waste Management (2022)

Notes: N.D : Not determined; LOR : Laboratory Limit of Reporting

Cumulative leached concentration - M3 Composite (Y851963 / Y851103 / Y851915)



Source: Mine Waste Management (2022)

B.6. Saturated leach testing results

E Deposit composite samples selected for saturated leach testing

Strat	Units
M3	7350 - Upper CID High Silica High Alumina
	7370 - Upper CID Weathered
	7300 - Barimunya Member - Upper CID
	7320 - Southern Marginal zone
	7330 - Northern Marginal Zone
M2	7120 - Barimunya Member - Lower CID

Source: Mine Waste Management (2022)

Saturated water leach results - M2 Composite

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION - WEEKS											
			1	2	3	4	5	6	7	8	9	10	11	12
pH	pH Units		8	9.00	9.10	8.90	9.00	9.10	9.30	9.00	9.10	8.90	9.10	8.90
EC	µS/cm	1	600	290	210	220	210	220	210	180	190	150	130	80
Redox Potential	mV		40	43	57	62	100	95	89	122	128	106	119	112
Dissolved Oxygen	mg/L	0.1	0	0.66	0.64	0.63	0.68	1	1.1	0.94	0.9	0.91	0.94	1.2
Alkalinity as CaCO3	mg/L	5	43	61.0	74.0	140	160	120	110	96	80	69	68	43
Bromide	mg/L	0.5	2	1	<0.5	4.2	1	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloride	mg/L	1	120	36	20	8	4	16	3	1	11	5	2	<1
Fluoride	mg/L	0.1	0	1	1	0.7	0.6	0.8	0.6	0.4	0.6	0.6	0.7	0.6
2-Sulfate as SO4	mg/L	1	25	13	3	<1	1	<1	<1	<1	3	2	3	2
Sulphur as S	mg/L	0.5	10	5	1	<0.5	<0.5	<0.5	<0.5	<0.5	1	0.8	1	0.9
Nitrate as N	mg/L	0.005	0	<0.005	<0.005	0.03	0.01	<0.005	<0.005	<0.005	0.054	0.01	<0.005	<0.005
Phosphate as P	mg/L	0.005	0	0.32	0.03	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Phosphorus as P	mg/L	0.05	1	0.6	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ca	mg/L	0.5	16	5	3	8.1	11	9.2	8.2	7	5.7	6.1	5.9	4
K	mg/L	0.5	13	6.3	6.6	7.9	7	5.6	5.4	3	5	5.6	3	3
Mg	mg/L	0.5	10	6	4	9.3	14	11	9.5	8.7	6.7	7.1	6.9	4
Na	mg/L	0.5	65	39	27	32	31	23	17	15	17	11	10	5.7
Ag	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Al	µg/L	50	70	60	4200	<50	<50	<50	<50	<50	<50	<50	<50	80
As	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
B	µg/L	20	100	200	100	100	100	100	100	100	100	90	90	50
Ba	µg/L	5	8	<5	<5	8	10	10	10	8	9	8	7	<5
Be	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bi	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cd	µg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ce	µg/L	1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Co	µg/L	1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cr	µg/L	1	<1	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cs	µg/L	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cu	µg/L	1	8	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Fe	µg/L	50	<50	<50	11,000	<50	<50	70	100	110	100	<50	90	240
Fe(II)	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Hg	µg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
La	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Li	µg/L	1	6	1	3	3	2	2	<1	2	2	2	1	<1
Mn	µg/L	5	14	<5	14	5	30	19	10	10	10	7	7	<5
Mo	µg/L	1	<1	<1	1	<1	1	<1	<1	<1	<1	<1	<1	<1
Nb	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ni	µg/L	1	1	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	µg/L	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Rb	µg/L	1	21	3	3	4	4	4	4	3	3	3	3	2
Sb	µg/L	1	<1	<1	<1	<1	2	<1	<1	<1	<1	<1	<1	<1
Se	µg/L	1	3	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1
Si	mg/L	0.2	7	7	13	9.3	11	10	9.7	9.5	8.9	9.4	9.3	6.7

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION - WEEKS											
			1	2	3	4	5	6	7	8	9	10	11	12
Sn	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sr	µg/L	1	82	23	14	36	45	38	38	34	30	25	24	14
Ta	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Te	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	1.9	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5
Th	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ti	µg/L	1	<1	1	170	<1	1.6	1.5	2	2.2	3.3	1.3	2.5	5.8
Tl	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
U	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
V	µg/L	1	<1	<1	11	<1	<1	<1	<1	1	<1	<1	<1	<1
W	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Zn	µg/L	1	5	2	2	3	2	4	3	<1	<1	<1	<1	1

Source: Mine Waste Management (2022)

Notes: N.D : Not determined; LOR : Laboratory Limit of Reporting

Saturated water leach results - M3 Composite

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION - WEEKS											
			1	2	3	4	5	6	7	8	9	10	11	12
pH	pH Units		9	9.3	9	9	9	9.1	9	9.2	8.9	8.7	8.9	8.8
EC	µS/cm	1	750	410	380	260	230	250	220	140	140	120	110	99
Redox Potential	mV		77	103	95	92	110	107	87	93	125	119	116	120
Dissolved Oxygen	mg/L	0.1	2	1	1	0.76	0.77	1	1.1	1.1	1	0.81	1.1	0.93
Alkalinity as CaCO3	mg/L	5	110	180	180	180	230	130	110	96	74	67	54	50
Bromide	mg/L	0.5	2	11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloride	mg/L	1	110	6	4	1	<1	4	<1	3	<1	<1	<1	<1
Fluoride	mg/L	0.1	1	1	1	0.9	0.8	0.6	0.9	0.6	0.8	0.7	0.7	0.8
2- Sulphate as SO4	mg/L	1	75	18	12	8	5	22	3	3	2	2	2	2
Sulphur as S	mg/L	0.5	27	7	4	2.7	2.2	1.9	1.2	1	0.7	0.9	0.7	0.9
Nitrate as N	mg/L	0.005	0	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.02	0.008	0.01	0.02
Phosphate as P	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Phosphorus as P	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ca	mg/L	0.5	8	3	3	4	4	3	2	2	2	2	2	2
K	mg/L	0.5	8	5.4	5.9	5.6	5.4	5	4	6.1	3	3	3	3
Mg	mg/L	0.5	11	4	5	5.4	5.6	5	4	4	3	3	3	3
Na	mg/L	0.5	120	72	61	54	50	47	35	30	20	19	16	14
Ag	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Al	µg/L	50	<50	<50	60	<50	60	110	220	100	110	280	80	290
As	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
B	µg/L	20	270	300	290	290	260	230	200	200	100	100	100	100
Ba	µg/L	5	10	<5	9	20	30	30	30	30	30	30	20	20
Be	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bi	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cd	µg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ce	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Co	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cr	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cs	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cu	µg/L	1	10	<1	<1	6	<1	<1	<1	<1	<1	<1	<1	<1
Total Fe	µg/L	50	<50	<50	60	<50	70	110	250	190	120	370	90	290
Fe(II)	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Hg	µg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
La	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Li	µg/L	1	1	<1	<1	<1	1	1	<1	<1	<1	1	1	<1
Mn	µg/L	5	51	13	8	6	<5	<5	<5	<5	<5	<5	<5	<5
Mo	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Nb	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ni	µg/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	µg/L	1	<1	<1	<1	2	<1	<1	<1	<1	<1	<1	<1	<1
Rb	µg/L	1	5	4	5	5	5	4	4	4	3	3	3	2
Sb	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Se	µg/L	1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Si	mg/L	0.2	15	17	17	16	17	17	17	17	16	17	16	16
Sn	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sr	µg/L	1	63	25	30	33	34	30	27	25	20	20	18	17

PARAMETER	UNITS	LOR	LEACHATE CONCENTRATION - WEEKS											
			1	2	3	4	5	6	7	8	9	10	11	12
Ta	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Te	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Th	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ti	µg/L	1	<1	<1	3	<1	1.4	3.4	4.5	2.5	1.7	6	1.8	4.5
Tl	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
U	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
V	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Zn	µg/L	1	13	2	2	3	4	3	3	1	<1	<1	<1	1

Source: Mine Waste Management (2022)

Notes: N.D : Not determined; LOR : Laboratory Limit of Reporting

B.7. Pit wall stratigraphies

This appendix provides the pit wall stratigraphy images from the Mine Waste Management (2022) report. Stratigraphic units which have been greyed out in the keys are not present within the respective pit. Grey areas at the pit crest indicate blocks from the mining model that have not been assigned a stratigraphy as they are above the surface topography.

B.8. NAG leachate results for E1 wall rock

Parameter	Units	LOR	#1	#2	#3	#4	#5	#6	#7
Net Acid Generation									
pH (OX)	pH Unit	0.1	8.1	7.6	2.5	3.6	1.9	6.7	7.9
NAG (pH 4.5)	kg H_2SO_4/t	0.1	<0.1	<0.1	18	2.6	193	<0.1	<0.1
NAG (pH 7.0)	kg H_2SO_4/t	0.1	<0.1	<0.1	21.4	6.1	219	0.6	<0.1
Physical Parameters									
pH Value	pH Unit	0.01	7.70	6.04	2.50	3.27	1.88	6.95	7.90
Major Ions & Ligands									
Sulphate as SO_4	mg/L	1	10	<1	308	324	1790	44	34
Dissolved Metals									
Aluminium	mg/L	0.01	0.02	0.02	0.59	1.09	3.01	0.13	0.20
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	0.003	0.002	<0.001	<0.001	0.013	<0.001	<0.001
Bismuth	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	<0.0001	<0.0001
Chromium	mg/L	0.001	0.005	0.005	0.002	0.002	0.013	0.003	0.004
Cobalt	mg/L	0.001	<0.001	<0.001	0.008	0.003	0.039	<0.001	<0.001
Copper	mg/L	0.001	<0.001	<0.001	0.009	<0.001	0.161	<0.001	<0.001
Lead	mg/L	0.001	<0.001	<0.001	0.014	0.001	0.205	<0.001	<0.001
Manganese	mg/L	0.001	0.002	0.029	0.046	0.276	0.429	<0.001	0.001
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	<0.001	<0.001	0.016	0.013	0.095	<0.001	<0.001
Selenium	mg/L	0.01	<0.01	<0.01	0.03	0.02	0.13	<0.01	<0.01
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tellurium	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005
Thallium	mg/L	0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	<0.001
Tin	mg/L	0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Uranium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	<0.005	<0.005	0.010	0.016	0.021	<0.005	<0.005
Boron	mg/L	0.05	0.08	0.09	0.11	0.14	0.11	0.07	0.07
Iron	mg/L	0.05	<0.05	0.21	1.47	0.26	219	0.05	0.11

Source: Earth Systems (2019a)

B.9. Geochemical test work results for Marillana Creek diversion samples

This appendix provides the geochemical test work results collated in WAIO (2020g).

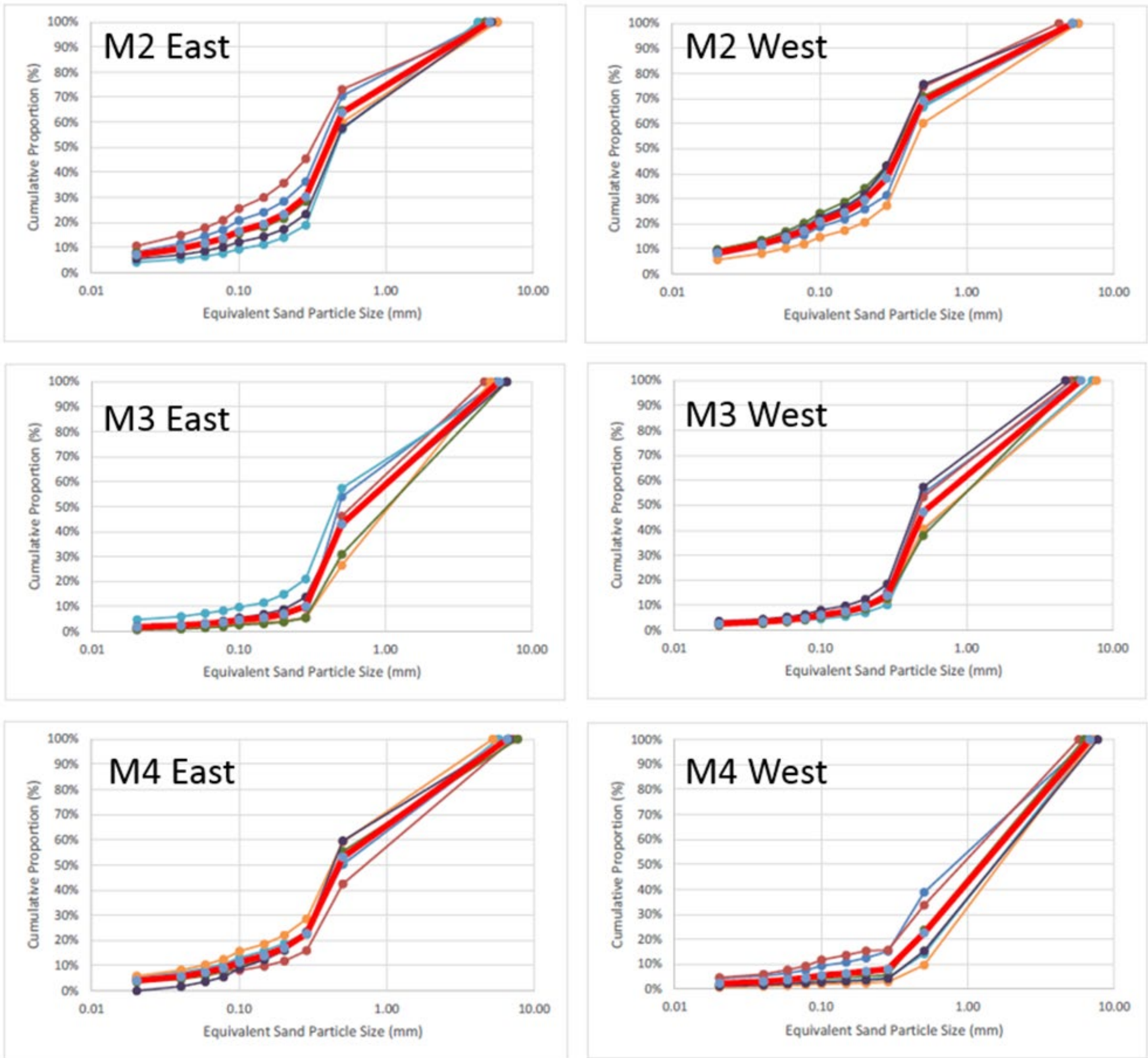
B.10. Landloch 2016 characterisation of selected Yandi waste materials

Analyses		Unit	M2 East	M2 West	M3 East	M3 West	M4 East	M4 West
Particle Size Distribution of Fine Fraction	Coarse Sand 0.2-2.0mm	%	43.8	40.8	63.3	67.0	52.0	48.4
	Fine Sand 0.02-0.2mm	%	23.3	27.9	25.2	22.5	32.0	27.7
	Silt 0.002-0.02mm	%	11.1	11.3	4.6	8.4	6.4	4.6
	Clay <0.002mm	%	21.9	20.1	6.9	2.1	9.7	19.3
Particle Size Distribution of All Sizes	Rock >45mm	%	8.6	9.3	16.3	5.7	28.6	3.5
	Pebbles 25-45mm	%	11.3	10.1	20.3	22.5	14.9	8.7
	Coarse gravel 5-25mm	%	25.2	27.1	29.3	28.7	23.8	55.5
	Fine gravel 2-5mm	%	14.5	16.4	13.6	14.9	11.9	16.4
	Fines >2mm	%	40.3	37.1	20.5	28.2	20.8	16.0
Dispersion Potential		Class	8	5	3	5	5	5
Rock Particle Density		g/cm³	2.7	2.8	2.8	3.1	2.7	3.4
Effective Cation Exchange Capacity		meq/100g	4.90	3.31	2.54	3.27	3.11	3.75
Exchangeable Sodium Percentage		%	8.5	9.6	12.0	12.5	6.5	4.9
Rock Water Absorption		%	19.6	8.9	7.9	4.7	9.1	3.9
pH		pH units	7.3	7.4	8.0	7.9	6.5	7.4
Electrical Conductivity		dS/m	0.10	0.16	0.07	0.30	0.08	0.02
Total Nitrogen		mg/kg	134	154	113	109	227	214
Total Phosphorus		mg/kg	386	366	377	24	197	85
Organic Carbon		%	0.29	0.21	0.36	0.37	0.26	0.18
Plant Available Nutrients	Phosphorus - Colwell	mg/kg	16.2	22.4	38.2	18.9	4.41	13.2
	Potassium - Colwell	mg/kg	74	71	45	73	93	112
	Sulphur - KCl	mg/kg	15.1	14.5	10.4	91.9	11.6	15.9
	Copper – DTPA	mg/kg	0.17	0.17	0.18	0.16	<0.20	0.39
	Iron – DTPA	mg/kg	2.81	2.83	8.48	5.15	72.5	2.73
	Manganese – DTPA	mg/kg	0.18	0.12	0.19	0.16	1.21	0.95
	Zinc – DTPA	mg/kg	0.20	0.36	0.95	0.18	<0.20	0.37

Analyses		Unit	M2 East	M2 West	M3 East	M3 West	M4 East	M4 West
Exchangeable Cations	Calcium	meq/100g	1.93	1.85	1.60	1.50	1.91	2.50
	Magnesium	meq/100g	2.39	1.06	0.59	1.32	0.84	0.95
	Potassium	meq/100g	0.15	0.08	0.04	0.04	0.15	0.12
	Sodium	meq/100g	0.42	0.32	0.31	0.41	0.20	0.18
	Aluminium	meq/100g	0.01	0.01	0.01	0.01	0.01	0.01
Plant Available Water Content		%	8	8	5	6	3	7

Source: Landloch (2016)

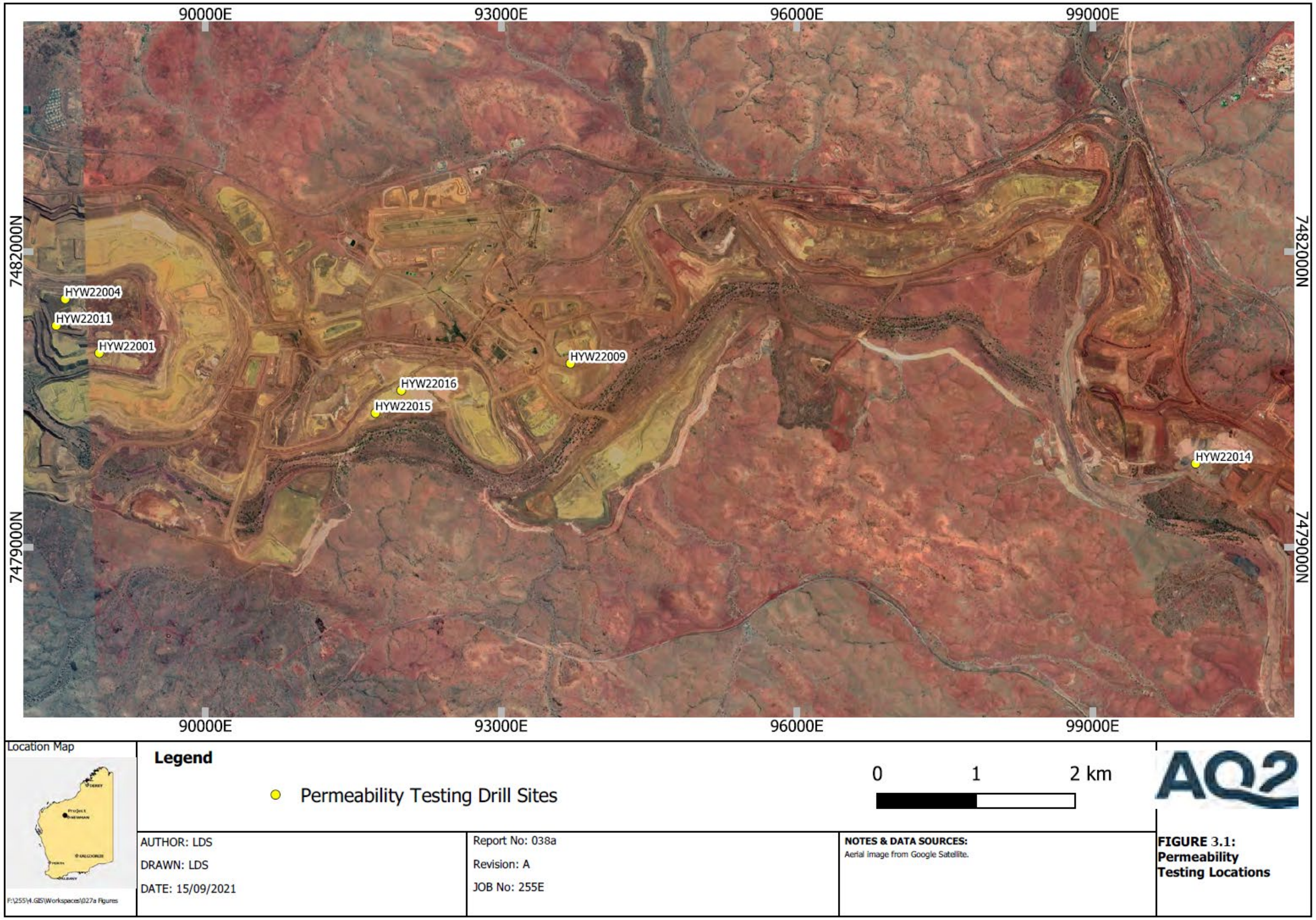
B.11. Landloch 2016 particle size distribution



Note: Thin coloured lines within each chart represent the different replicates, and the thick red line is the average of the replicates.

B.12. Backfill hydraulic properties assessment

Spatial location of drill holes



Source: AQ2 (2022a)

B.13. Outback Ecology 2005 characterisation for use in rehabilitation

Analysis of material chemistry

Sample		Material name	NO_3 (mg/kg)	NH_4 (mg/kg)	Extractable P (mg/kg)	Extractable K (mg/kg)	Extractable S (mg/kg)	Organic C (%)	EC mS/m)	Ph (CaCl2)	pH (H_2O)	Exchangeable Ca (meq/100g)	Exchangeable K (meq/100g)	Exchangeable Mg (meq/100g)	Exchangeable Na (meq/100 g)	CEC (sum of bases) (meq/100g)	ESP (%)
ID	Location																
MC1	Southern End C5 A	Siliceous Hard Cap	1	2	2	81	23.2	0.09	8.0	6.5	7.4	0.62	0.14	3.35	0.12	4.23	2.8
MC2	Southern End C5 B	Siliceous Hard Cap	2	4	2	74	25	0.05	7.1	6.2	6.8	0.25	0.11	3.60	0.12	4.08	2.9
MC3	C1 546 A	Poddy Clay	2	4	10	48	55.1	0.09	2.3	5.5	5.9	2.25	0.09	2.23	0.17	4.73	3.6
MC4	C1 546 B	Poddy Clay	1	1	6	41	64.8	0.06	2.2	5.6	5.9	1.77	0.08	1.80	0.01	3.65	0.3
MC5	C5 510 Bench A	Ochreous Geothitic Clay	4	1	8	40	22.7	0.07	10.0	6.5	6.8	1.87	0.04	2.59	0.04	4.53	0.9
MC6	C5 510 Bench B	Ochreous Geothitic Clay	12	20	9	132	18	0.11	9.5	6.7	7.4	7.08	0.27	10.32	0.13	17.79	0.7
MC7	C1 546 A	Wet Basal Clay	1	2	5	37	57.4	0.14	10.2	6.3	6.6	1.52	0.06	1.73	0.02	3.33	0.7
MC8	C1 546 B	Wet Basal Clay	1	1	4	21	69.8	0.1	6.4	6.2	6.6	0.80	0.03	0.86	0.16	1.85	8.6
MC9	C5 West Wall A	Basal Clay	1	1	4	33	10.8	0.22	5.4	6.3	6.8	1.08	0.05	1.71	0.03	2.88	1.1
MC10	C5 West Wall B	Basal Clay	1	1	5	40	9.8	0.06	4.2	6.3	7.0	1.46	0.08	2.44	0.05	4.03	1.2

Analysis of material physical properties

Sample		Material name	Maunsell colour	% coarse fraction (>2mm)	Slaking/Dispersion	Texture	Crust strength (kPa)
ID	Location						
MC1	Southern End C5 A	Siliceous Hard Cap	Dark yellowish brown 10YR 4/2 - Light brown 5YR 5/6	70	n.a	sand	21.3
MC2	Southern End C5 B	Siliceous Hard Cap	Moderate brown 5YR 4/4 - Dark yellowish brown 10YR 4/2 - Dark yellowish orange 1OYR 6/6	90	n.a	sand	N/A
MC3	C1 546 A	Poddy Clay	Mottled: dark yellowish orange 10YR 6/6 – dark reddish brown 1OR 3 /4	35	slaked but no disp.	light medium clay	48.5
MC4	C1 546 B	Poddy Clay	Mottled: dark yellowish orange 10YR 6/6 – dark reddish brown 1OR 3 /4	55	slaked but no disp.	light medium clay	39.8
MC5	C5 510 Bench A	Ochreous Geothitic Clay	Dark yellowish orange 10YR 6/6	40	slaked but no disp.	clay loam, sandy	N/A
MC6	C5 510 Bench B	Ochreous Geothitic Clay	Dark yellowish orange 10YR 6/6	50	slaked but no disp.	light medium clay	N/A
MC?	C1 546 A	Wet Basal Clay	Light brown 5YR 5/6	38	slaked but no disp.	medium clay	138.8

Sample		Material name	Maunsell colour	% coarse fraction (>2mm)	Slaking/Dispersion	Texture	Crust strength (kPa)
ID	Location						
MC8	C1 546 B	Wet Basal Clay	Light brown 5YR 5/6	13	slaked but no disp.	clay loam, sandy	75.1
MC9	C5 West Wall A	Basal Clay	Dark yellowish orange 10YR 6/6	30	slaked but no disp.	light medium clay	141.5
MC10	C5 West Wall B	Basal Clay	Dark yellowish orange 10YR 6/6	55	slaked but no disp.	light medium clay	80.8

n.a = no aggregates in the sample, therefore, could not be assessed

Appendix C Stability analysis model backfill assumptions

Modelled pit backfill assumptions for end wall & land bridge backfill design scenario analysis.

Pit	Backfill (Mm3)
W1	69.4
W2	8.9
W3	5.6
W4	33.2
W5	9.3
W6	3.2
C12	8.0
C4/5	1.1
E1	3.7
E2/3/5/6	32.9
E4	1.4
E7	0.0

Source: Golder (2020e)

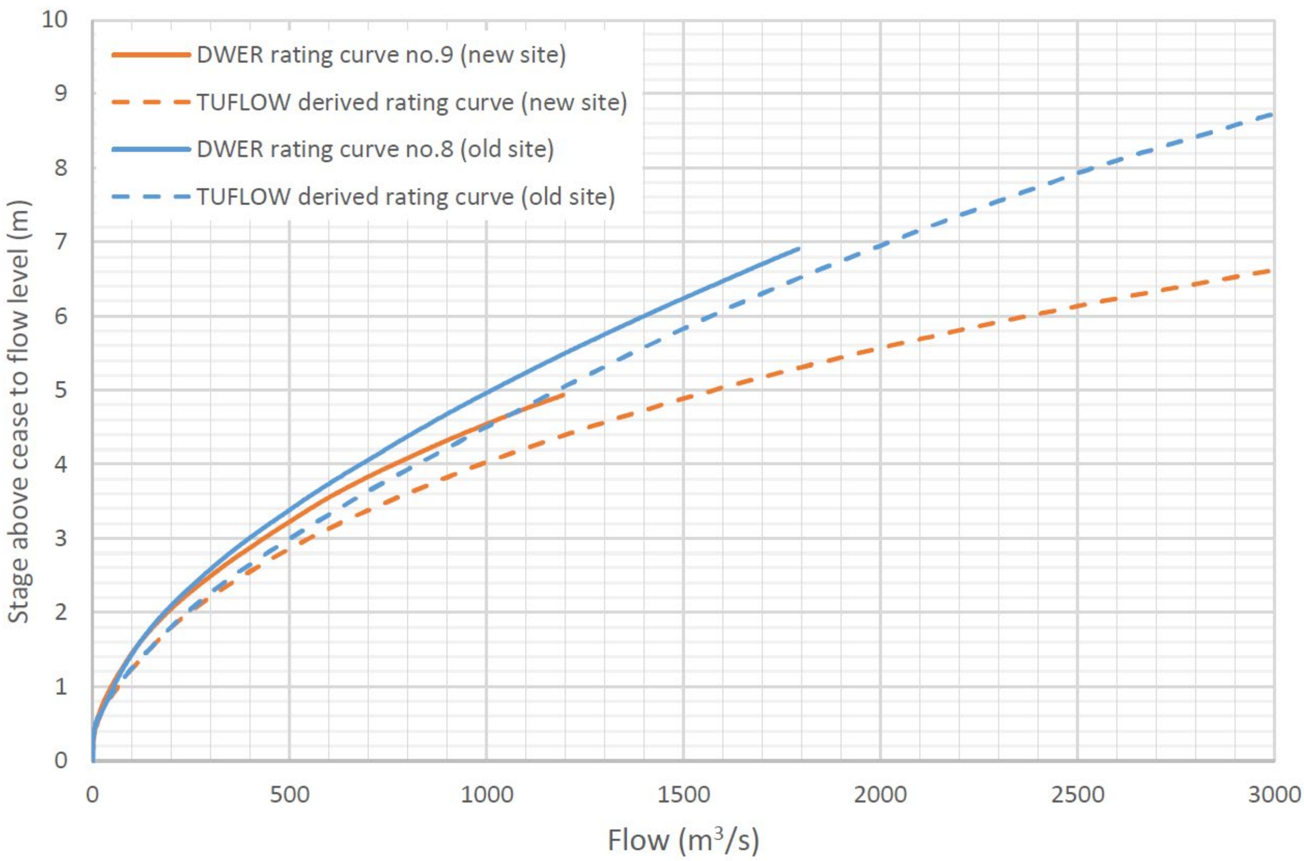
Appendix D Baseline surface water modelling

D.1. Rainfall Intensity Frequency Duration (IFD) data

D.2. Review of the suitability of the Flat Rocks gauging station data

The Flat Rocks gauging station was established in 1967, but its location was changed in 1983 due to the poor location of the orifice which meant that hydraulic behaviours at this location were particularly intense (high flow velocities and depths) and complex (flow recirculation and eddies). The new gauging station was installed nearby, but the pre-1983 and post-1983 data are not directly comparable as a tributary enters the mainstream between the two gauging sites. Furthermore, as gauging stations record stream levels rather than flow, manual gauging is undertaken by hydrographers at varying streamflow levels to develop a flow estimate rating table. The largest manually gauged flows at the original site (1967 to 1983) and current site (1983 onwards) were 18.1 m^3/s and 0.2 m^3/s respectively. This means that there is significant extrapolation from manually gauged flows up to the rare events assessed by Advisian (2023c), based on a DWER derived rating curve (typically derived from DWER one-dimensional (1D) modelling). To improve the accuracy of peak flows for use in the flood frequency analysis, high-resolution 2D modelling was conducted for each gauge site and compared to a cross sectionally averaged result associated with 1D modelling. A detailed 2D model of the gauge location was developed by Advisian using TUFLOW HPC hydraulic modelling software. TUFLOW HPC is an explicit solver for the full 2D shallow water equations, including a sub-grid scale eddy viscosity model (Advisian, 2023c).

The comparisons of the DWER derived, and Advisian derived rating curves for the original and new gauge sites are presented in Figure D-1. The shape of the DWER-derived and Advisian-derived rating curves is generally consistent, but the Advisian curves show an increase in flow across the range of modelled flows at both gauging sites. The Advisian rating curves for each gauge site (and relevant period of record) have, therefore, been used to update flow estimates based on a revised translation of the recorded stream gauge levels.



Source: Advisian (2023c)

Figure D-1. Advisian versus DWER flow rating curves for Flat Rocks

D.3. Approach to estimating PMP in a climate change scenario

D.4. Comparison of PMF with a 1 in 10,000 year flood

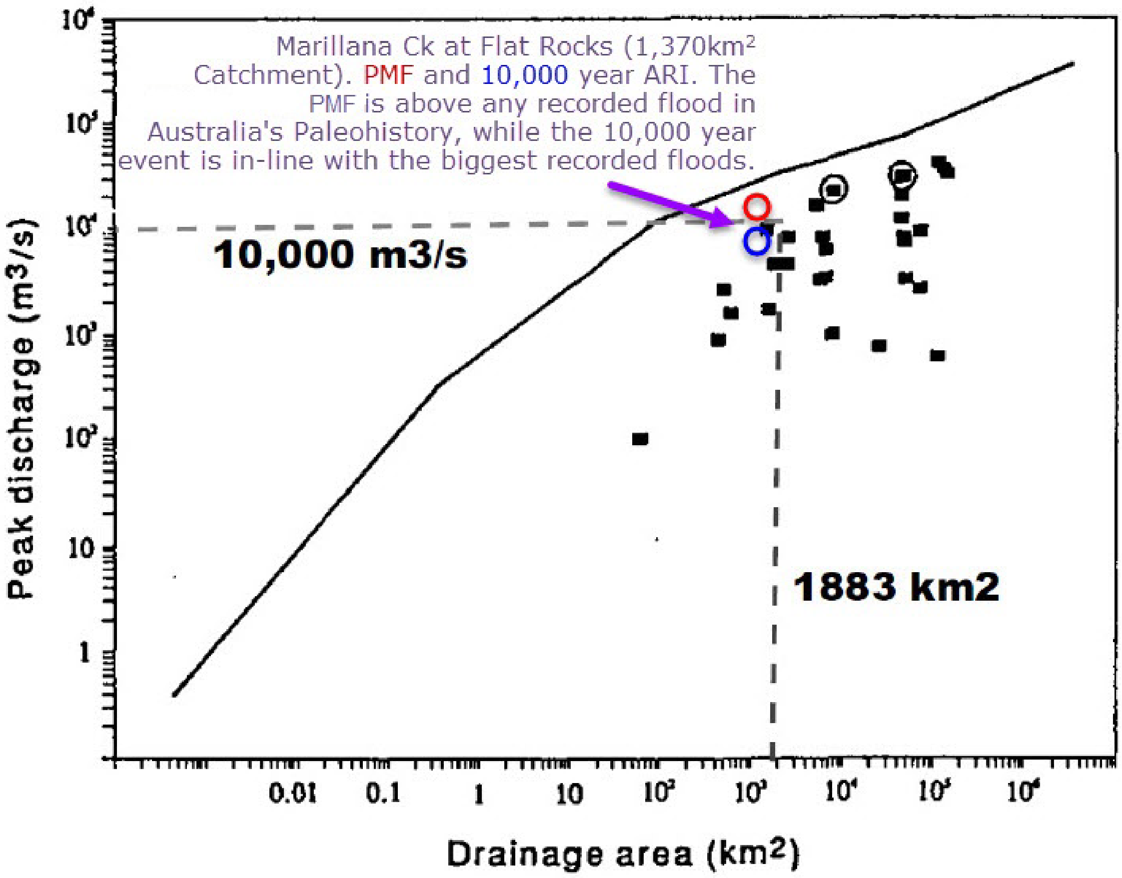


Figure 2.5: Plot of maximum rainfall-runoff floods measured world-wide and in Australia (reproduced from Fig. 5 Wohl et.al 1994). Envelope curve for world floods, shown as solid line, based on data from Costa (1987). Australian data points from Rodier and Roche (1984) and Finlayson and McMahon (1988) represent maximum floods measured in Australia north of 25° South. The largest palaeo-floods in the Fitzroy and Margaret River are circled. The peak discharge for the catchment area of Marillana Creek (1883 km^2) is estimated.

D.5. Comparison of Advisian design flows with previous studies

Marillana Creek flows

Location		AEP event								
		10% (m^3/s)	5% (m^3/s)	2% (m^3/s)	1% (m^3/s)	1 in 200 (m^3/s)	1 in 500 (m^3/s)	1 in 1,000 (m^3/s)	1 in 2,000 (m^3/s)	1 in 10,000 (m^3/s)
Flat Rocks	Advisian	493	849	1,398	1,898	2,457	3,345	4,055	4,825	7,244
	2020 MCP	549	853	1,370	2,020	-	3,390	-	-	7,080
	GHD 2014	550	850	1,370	2,020	-	-	-	-	-
Lamb Creek confluence	Advisian	508	929	1,573	2,129	2,736	3,698	4,469	5,296	7,978
Herberts Creek confluence	Advisian	513	956	1,634	2,209	2,833	3,820	4,612	5,459	8,232
Iowa Creek confluence	Advisian	523	1,016	1,769	2,387	3,046	4,087	4,925	5,813	8,785
Unnamed Creek confluence	Advisian	528	1,047	1,840	2,480	3,158	4,227	5,088	5,998	9,074
BHP Rail	Advisian	532	1,071	1,895	2,553	3,245	4,335	5,214	6,140	9,297
	GHD 2014	620	970	1,640	2,570	-	-	-	-	-

Source: Advisian (2023c)

Tributary flows

Location		AEP event						
		10% (m^3/s)	5% (m^3/s)	2% (m^3/s)	1% (m^3/s)	1 in 200 (m^3/s)	1 in 500 (m^3/s)	1 in 1,000 (m^3/s)
Lamb Creek outlet	Advisian	156	265	384	484	616	776	893
Herberts Creek outlet	Advisian	92	138	205	248	276	332	375
	MWH 2014	66	104	193	297			431
Iowa Creek outlet	Advisian	244	374	534	646	811	981	1,109
	GHD 201	125	193	278	405			N/A

Source: Advisian (2023c)

D.6. Design flows climate change sensitivity analysis

Marillana Creek flows

Location	Method	AEP	Design Flow (m^3/s)	
			Current Climate	Future Climate (2075)
Flat Rocks	RORB Peak Flow Quartile	10%	493	668 (+35%)
		5%	849	1,096 (+29%)
		2%	1,398	1,773 (+27%)
		1%	1,898	2,364 (+25%)
	RORB Ensemble Mean Peak Flow	1 in 200	2,457	3,023 (+23%)
		1 in 500	3,345	4,030 (+20%)
		1 in 1,000	4055	4,829 (+19%)
		1 in 2,000	4,825	5,698 (+18%)
		1 in 10,000	7244	7,943 (+10%)

Location	Method	AEP	Design Flow (m³/s)	
			Current Climate	Future Climate (2075)
BHP Rail	RORB Peak Flow Quartile	10%	532	779 (+46%)
		5%	1,071	1,451 (+35%)
		2%	1,895	2,384 (+26%)
		1%	2,553	3,147 (+23%)
	RORB Ensemble Mean Peak Flow	1 in 200	3,245	3,961 (+22%)
		1 in 500	4,335	5,217 (+20%)
		1 in 1,000	5,214	6,233 (+20%)
		1 in 2,000	6,140	7,252 (+18%)
		1 in 10,000	9297	10,305 (+11%)

Source: Advisian (2023c)

Tributary flows

Location	Climate scenario	AEP event						
		10% (m³/s)	5% (m³/s)	2% (m³/s)	1% (m³/s)	1 in 200 (m³/s)	1 in 500 (m³/s)	1 in 1,000 (m³/s)
Lamb Creek	Current climate	156	265	384	484	616	776	893
	2075 future climate	205 (+31%)	319 (+20%)	473 (+23%)	586 (+21%)	710 (+15%)	885 (+14%)	1,014 (+14%)
Herberts Creek	Current climate	92	138	205	248	273	332	375
	2075 future climate	111 (+20%)	171 (+23%)	241 (+17%)	290 (+17%)	315 (+15%)	377 (+14%)	425 (+13%)
Iowa Creek	Current climate	244	374	534	646	766	965	1,109
	2075 future climate	326 (+34%)	465 (+24%)	633 (+19%)	757 (+17%)	882 (+15%)	1,098 (+14%)	1,256 (+13%)

Source: Advisian (2023c)

Appendix E Water quality monitoring

E.1. Baseline water quality (Flat Rocks gauging station)

Parameter	Minimum	Maximum	Australian Drinking Water Guidelines Criteria (NHMRC, 2011)
pH	6.10	8.70*	6.5 - 8.5 (aesthetic value)
EC (uncompensated) (µS/cm)	136	1805	-
Total Dissolved Solids (calc @180°C-by cond) (mg/L)	100	722*	600 (aesthetic value)
Al (mg/L)	0.18	0.66	0.2 (aesthetic value)
$CaCO_3$ (mg/L)	54	420.34	-
Ca (mg/L)	20	54	-
Cl (mg/L)	4.85	237	250 (aesthetic value)
K (mg/L)	8	15	-
Mg (mg/L)	44	76	-
Na (mg/L)	75	136	180 (aesthetic value)
SO_4 (mg/L)	44	84	500 (250 - aesthetic value)

*Parameter exceeds Guideline Value

Source: DoW (2010) Water Information (WIN) database - discrete sample data. [8/12/2010]. Department of Water, Water Information Provision section, Perth Western Australia. Hydstra database - time-series data. [8/12/2010]. Department of Water, Water Information Provision section, Perth Western Australia as cited in BHP Billiton Iron Ore (2014).

E.2. Yandi surface water quality analyses

The surface water quality data collated by Hydro Geochem Group (2022) and screened against water quality criteria follow.

E.3. Marillana Creek pool water quality

Wet and dry season 2014

	Internal Trigger Values	Marillana Creek (Within Lease Area)												Marillana Creek Reference				Weeli Wolli Reference					
		MC1		MC2		MC4		MC5		MC6		MC7		FR		FRDS		WMU		MW		UWWCS	
Parameter		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Temp (°C)		21.1	–	23.7	–	20.1	DRY	27.1	DRY	30.8	DRY	NOT SAMPLED	30.9	27.2	24.5	NOT SAMPLED	26.2	19.9	18.9	22.8	15.6	25.3	NOT SAMPLED
pH	6.8 - 8.5	8.62	9.34	8.62	8.67	7.48		7.82		7.89			7.08	8.68	8.86		8.42	8.67	7.87	7.8	7.94	7.66	
EC (µS/cm)	4458	1120	1280	1470	5030	1320		1310		1070			977	1300	2020		1220	255	872	3260	23000	954	
DO (%)		87.1	–	98.4	–	48.4		143.3		143.8			78.1	116.4	91.2		95.4	93.6	51.7	75.3	28.1	98.4	
Max depth (m)		2	1.4	1.4	0.7	0.4		1.2		0.4			2.5	0.8	0.4		4	1.1	0.4	0.85	0.4	1.1	
Ca (mg/L)	1000	18.5	7.3	27.2	16.3	57.7		59.1		54.4			40.9	23.9	30		27.1	21.7	61.7	158	749	68.1	
Mg (mg/L)	2000	59.7	88.6	73.9	331	57.2		62.2		55.1			39.1	73.9	114		70.1	12.2	45.6	165	1640	59.4	
Na (mg/L)	409	99	124	130	566	104		99.9		81.7			66.1	122	206		115	7.1	35.2	308	3390	23.7	
K (mg/L)	15	10.4	10.6	12.6	41.2	9.4		10.9		10.9			6.3	14.4	20.1		13.6	4.1	19.8	9.1	42	3.5	
HCO_3 (mg/L)	476	273	180	221	432	416		426		346			348	249	347		279	118	451	517	158	496	
Cl (mg/L)	403	187	234	298	1150	172		159		131			49	235	404		205	15	61	485	4740	57	
SO_4 (mg/L)	1000	48.8	38.6	91.8	359	90		86.3		60.8			56.9	63.9	92		46.9	7.2	8.8	774	8640	36.6	
CO_3 (mg/L)	5	15	89	19	122	<1		<1		<1			<1	27	46		22	3	<1	<1	<1	<1	
Hardness		290	380	370	1400	380		400		360			260	360	540		360	100	340	1100	8600	410	
Alkalinity		249	297	213	558	342		350		284			286	250	361		265	102	370	425	130	407	
NH_3 (mg/L)		<0.01	<0.01	<0.01	<0.01	0.09		<0.01		<0.01			<0.01	<0.01	<0.01		<0.01	<0.01	2.6	<0.01	0.1	<0.01	
Nitrate (mg/L)	400	0.07	0.38	0.07	0.29	3.8		0.21		0.15			2.5	1.5	0.16		0.14	0.15	0.01	0.1	<0.01	0.11	
Total N (mg/L)		0.36	0.8	0.42	1.3	4.2		0.27		0.24			2.6	2.2	0.91		0.54	0.39	5.8	0.28	2.5	0.17	
Total P (mg/L)		<0.010	0.015	<0.010	<0.010	<0.010		<0.010		<0.010			0.021	<0.010	<0.010		<0.010	<0.010	0.14	<0.010	0.02	<0.010	
Al (mg/L)	5.5	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005		<0.005			<0.005	<0.005	0.007		0.014	0.01	<0.005	<0.005	<0.005	<0.005	
As (mg/L)	0.02	<0.001	<0.001	<0.001	<0.002	<0.001		<0.001		<0.001			<0.001	<0.001	<0.001		<0.001	<0.001	0.002	<0.001	<0.005	<0.001	
B (mg/L)	0.55	0.39	0.36	0.38	1.1	0.42		0.47		0.41			0.35	0.46	0.68		0.39	0.06	0.09	0.22	0.39	0.13	
Ba (mg/L)		0.028	0.011	0.049	0.028	0.11		0.066		0.058			0.038	0.033	0.046		0.048	0.005	0.15	0.12	0.092	0.03	
Cd (mg/L)	0.001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001		<0.0001		<0.0001			<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0001	
Co (mg/L)		0.0001	0.0001	0.0001	0.0003	0.0001		<0.0001		<0.0001			<0.0001	0.0001	0.0003		<0.0001	0.0001	0.0014	0.001	0.011	0.0002	
Cr (mg/L)	0.01	<0.0005	<0.0005	<0.0005	<0.0010	<0.0005		<0.0005		<0.0005			<0.0005	<0.0005	<0.0005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0025	<0.0005	
Cu (mg/L)	0.01	0.0002	0.0002	0.0007	0.0007	0.0001		<0.0001		<0.0001			<0.0001	0.0008	0.0014		0.0005	0.0017	0.0007	0.0005	0.0017	<0.0001	
Fe (mg/L)	0.01	0.035	0.012	0.006	0.01	0.021		0.032		0.02			<0.005	0.008	0.016		0.01	0.028	0.78	0.04	0.12	0.04	
Mn (mg/L)	0.01	0.004	0.023	0.004	0.014	0.042		0.008		0.019			<0.001	0.004	0.02		0.002	0.009	0.34	0.33	5.3	0.097	
Mo (mg/L)		<0.001	<0.001	<0.001	<0.002	<0.001		<0.001		<0.001			<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	
Ni (mg/L)	0.01	<0.001	<0.001	<0.001	<0.002	<0.001		<0.001		<0.001			<0.001	<0.001	<0.001		<0.001	<0.001	0.002	0.001	0.006	<0.001	
Pb (mg/L)		<0.0001	<0.0001	<0.0001	<0.0002	<0.0001		<0.0001		<0.0001			<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0001	
S (mg/L)		16	15	31	130	30		29		23			19	25	35		17	2.4	3.2	260	1900	12	
Se (mg/L)	0.01	<0.001	<0.001	<0.001	<0.002	0.001		<0.001		0.001			0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	
U (mg/L)		0.001	0.001	0.001	0.002	0.002		0.002		0.002			0.001	0.001	0.001		0.001	<0.001	0.001	0.003	0.001	0.001	
V (mg/L)		0.0027	0.001	0.0036	0.004	0.0065		0.0073		0.012			0.001	0.0048	0.002		0.001	0.0033	0.004	0.0017	0.001	0.0007	
Zn (mg/L)	0.08	0.001	0.002	0.001	0.008	0.001		0.001		0.001			0.003	0.001	0.006		0.002	0.003	0.006	0.002	0.008	0.002	

Note: Grey shading indicates values outside internal trigger values.
Source: BHP Billiton (2016)

Wet and dry season 2017

Parameter	LOR	Internal Trigger Values	Units	Yandi Lease Area Sites Upstream of Mine Dewater Discharge									Yandi Lease Area Sites Downstream of Mine Dewater Discharge						Reference						
				MC1		MC1-B	MC2		MC3	MC4	MC5	MC6	MC7		MC8		MC9		FU	WM		WMU		WMC	
				Wet	Dry	Dry	Wet	Dry	Wet	Wet	Wet	Wet	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Wet	Dry	Wet	Dry	Wet	Dry
Temperature	0.1		°C	18.7	16.3	20.6	19	26	25.7	21.5	17.9	17.4	28.8	31	26.2	28.3	25.5	25.5	20.7	18.9	20.6	18.9	26.9	19.9	16.2
pH	0.1	6.8 - 8.5	pH	8.6	8.1	8.5	8.6	8.4	8.1	7.9	7.9	8	7.6	7.8	7.7	7.9	7.8	7.9	7.7	8	7.9	7.8	8.1	7.5	8.1
Econd_Lab	0.2	4458	µS/cm	785	1870	1380	688	2420	536	617	631	536	875	947	897	947	900	935	311	627	2520	206	645	120	208
DO	0.1		%	71.7	30.8	77.7	100.7	124.2	132.2	97.9	71.1	74.2	91.8	80	93.4	73.1	85.7	65.2	77.8	60.1	55.5	84.6	103.2	92.2	89.5
Ca	0.1	1000	mg/L	21.4	25.6	20	20.5	34.5	28.8	35.7	34.8	31	42.4	48.2	45.8	47.9	46.2	46.8	28.4	45.8	102	19.6	53.8	10	19.6
Mg	0.1	2000	mg/L	43.4	108	85.5	36.6	157	26.1	30.9	31.8	27.6	42.2	49.5	44.7	48.6	46.4	46.6	8.5	33.4	187	8.8	32.5	4.3	8.2
Na	0.1	409	mg/L	79.9	222	152	66.6	274	39.1	46.4	45	37.3	73.5	84.8	75.9	84	78.2	81.1	17.9	36	238	5.7	24	5.9	9.4
K	0.1	15	mg/L	8.8	17.9	12.7	7.6	17.6	5.7	6.4	6.9	6.4	7.1	8.3	7.8	8	7.7	7.7	3.7	4.4	8.2	2.8	9.1	2.5	4
HCO3	1	476	mg/L	217	607	372	185	464	188	291	270	234	317	349	312	345	310	338	99	199	750	76	238	40	91
Cl	1	403	mg/L	112	392	272	99	564	64	44	56	45	97	120	102	111	98	120	38	49	325	22	96	8	13
SO4_S	0.1	1000	mg/L	34	12.7	41.6	28.8	191	21.9	23.7	28.2	21.4	50.6	55.5	50.3	54.3	51.6	52.3	14.8	86.7	483	6.9	9.9	13.4	18.2
CO3	1	5	mg/L	17	<1	22	16	13	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hardness	1		mg/L	230	510	400	200	730	180	220	220	190	280	320	300	320	310	310	110	250	1000	85	270	43	83
Alkalinity	1		mg/L	205	498	342	179	403	154	239	222	192	260	286	256	283	255	278	81	163	616	62	195	33	74
NH3	0.01		mg/L	<0.01	0.03	0.03	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.02	<0.01	0.03	<0.01	<0.01	0.49	<0.01	0.09	<0.01	0.02
Nitrate	0.01	400	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	3.3	3	3.7	2.7	3.5	1.8	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total N	0.01		mg/L	0.18	1	0.51	0.17	0.56	0.09	0.07	0.04	0.06	3.7	3.4	3.8	3.1	3.6	3.1	0.1	0.23	1.3	0.09	1	0.12	0.27
Total P	0.005		mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	0.014	0.01	<0.010	<0.010	<0.010	0.035	0.011	0.032	0.011	<0.010	<0.010	0.026	<0.010	0.016	<0.010	<0.010
Al	0.005	5.5	mg/L	0.007	0.015	<0.005	0.014	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	0.007	0.017	0.011	0.008
As	0.001	0.02	mg/L	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
B	0.02	0.55	mg/L	0.3	0.59	0.37	0.23	0.56	0.15	0.24	0.23	0.19	0.35	0.39	0.35	0.39	0.38	0.36	0.03	0.07	0.34	0.03	0.06	0.03	0.03
Ba	0.002		mg/L	0.031	0.073	0.03	0.029	0.041	0.05	0.045	0.039	0.039	0.038	0.045	0.042	0.044	0.042	0.042	0.066	0.036	0.092	0.02	0.073	0.01	0.021
Cd	0.0001	0.001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Co	0.0001		mg/L	<0.0001	0.0003	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	0.0001	0.0013	<0.0001	0.0005	<0.0001	0.0002
Cr	0.0005	0.01	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Cu	0.0001	0.01	mg/L	0.0003	<0.0001	0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0019	0.0004	0.0008	0.0017	0.0015	0.0014
Fe	0.005	1	mg/L	0.021	0.29	0.031	0.036	0.086	0.056	0.011	0.016	0.033	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.14	0.01	0.06	0.019	0.077	0.018	0.011
Mn	0.001	0.01	mg/L	0.002	0.33	0.009	0.002	0.009	0.003	0.005	0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	0.003	0.86	0.003	0.074	0.001	0.001
Mo	0.001		mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.002
Ni	0.001	0.01	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.001	<0.001	<0.001
Pb	0.0001		mg/L	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0007	<0.0001	<0.0001	<0.0001		<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
S	0.1		mg/L	11	4.3	14	9.6	64	7.3	7.9	9.4	7.2	17	19	17	18	17	17	4.9	29	160	2.3	3.3	4.5	6.1
Se	0.001	0.01	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	0.002	0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
TDS_calc	5	1500	mg/L	430	1000	760	380	1300	290	340	350	290	480	520	490	520	490	510	170	350	1400	110	350	66	110
TSS	1	80	mg/L	3	39	4	4	4	1	<1	<1	13	<1	<1	<1	<1	<1	2	9	5	17	3	23	3	10
U	0.0001		mg/L	0.0007	0.0008	0.001	0.0005	0.0018	0.0003	0.0006	0.0008	0.0004	0.0007	0.0008	0.0007	0.0008	0.0008	0.0008	0.0002	0.0003	0.0009	<0.0001	0.0004	<0.0001	<0.0001
V	0.0001		mg/L	0.0038	0.0018	0.0013	0.0024	0.0016	0.0016	0.0034	0.0049	0.0039	0.0009	0.0011	0.0011	0.0013	0.0012	0.0013	0.001	0.0016	0.0032	0.0007	0.001	0.0013	0.0007
Zn	0.001	0.08	mg/L	0.004	<0.001	<0.001	0.003	<0.001	0.002	0.004	0.006	0.003	0.003	<0.001	0.004	<0.001	0.004	<0.001	0.003	0.003	<0.001	0.004	<0.001	0.007	<0.001

Note: Grey shading indicates values outside internal trigger values.
Source: WRM (2018)

E.4. Yandicoogina creek water quality

Surface water quality sampling results are provided in Table E-1 and Table E-2, and the locations of sampling points in Figure E-1.

Table E-1. Dry Season Sampling 2019

		ANZECC default GV		Yandicoogina Creek				Reference Sites			
	Units	99% GV	95%	YC1	YC2	YC3	YC4	WWS	BENS	MUNJS	SS
Temp	°C			23.6	24.5	26.4	23.3	27.5	20.6	25.6	26.41
pH	pH units		6-8	7.22	6.8	7.23	7.45	7.25	7.84	8.08	7.74
Redox	mV			-46.8	-43.7	-43	-41.1	-56.2	-62	-29.7	-90.5
EC	µS/cm		250	598	571	664	621	1030	890	922	729
DO	%		85-120	53.8	27.0	55.6	70.3	83.6	52.0	108.8	58.1
Turbidity	NTU		15	3.6	3.8	0.3	2.4	0.5	<0.1	2.0	2.2
TSS	mg/L			8	23	36	11	1	<1	5	5
Alkalinity	mg/L			266	251	295	267	256	395	426	328
Hardness	mg/L			228	202	238	209	284	382	443	259
Na	mg/L			35.2	31.6	42.9	39.5	84.8	42.5	28.2	53.6
Ca	mg/L			47.1	42.3	48	41.9	37.5	67.3	68.4	47.7
Mg	mg/L			26.8	23.4	28.8	25.4	46.3	52.1	66.2	33.9
K	mg/L			9.8	9.5	11	10	12.2	9.6	7.6	4.9
HCO3	mg/L			266	251	295	267	246	395	426	328
Cl	mg/L			38	38	44	45	201	71	54	51
S_SO4	mg/L			9.17	8.37	8.83	9.13	4.27	17.9	11.1	6.63
CO3	mg/L			<1	<1	<1	<1	11	<1	<1	<1
dAl	mg/L	0.027	0.055	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
dAs	mg/L	0.001	0.024	<0.0002	<0.0002	<0.0002	<0.0002	0.0002	0.0004	0.0006	0.0002
dB	mg/L	0.09	0.37	0.144	0.126	0.172	0.157	0.252	0.376	0.157	0.144
dBa	mg/L			0.0166	0.0165	0.028	0.0185	0.0618	0.0103	0.0698	0.472
dCd	mg/L	0.00006	0.0002	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
dCo	mg/L			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	0.0004
dCr	mg/L	0.00001	0.001	0.0004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
dCu	mg/L	0.001	0.0014	<0.00005	0.00009	<0.00005	<0.00005	0.00011	0.00008	0.00048	0.00013
dFe	mg/L			0.054	0.02	0.032	0.038	0.025	<0.002	0.004	0.046
dMn	mg/L	1.2	1.9	0.0406	0.0022	0.0039	0.0014	0.0019	<0.0005	0.0741	0.553
dMo	mg/L			0.0002	0.0002	0.0002	0.0002	<0.0001	0.0003	0.0005	0.0005
dNi	mg/L	0.008	0.011	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0008	<0.0005
dPb	mg/L	0.001	0.0034	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
dS	mg/L			9.9	8.8	9.5	8.9	4.9	18.1	11.6	7.2
dSe	mg/L	0.005	0.011	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
dU	mg/L			0.00011	0.0001	0.00019	0.00017	<0.00005	0.00065	0.00046	0.00048
dV	mg/L			<0.0001	0.0007	0.0011	0.0014	0.0002	0.0029	0.0012	0.0007
dZn	mg/L	0.0024	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
N_NH_3	mg/L	0.32	0.90	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
N_NO_3	mg/L	1.00	2.40	0.02	0.04	<0.01	0.01	<0.01	<0.01	0.02	0.01
N_NOx	mg/L		0.01	0.02	0.04	<0.01	0.01	<0.01	<0.01	0.02	0.01
TN	mg/L		0.30	0.17	2.20	0.06	0.27	0.25	0.02	0.71	0.12
TP	mg/L		0.01	0.04	0.09	0.03	0.06	0.04	0.03	0.09	0.04

Source: Biologic (2020b)

Notes:

WWS - Weeli Wolli Spring; BENS - Ben's Oasis; MUNJS - Munjina Spring; SS - Skull Spring

Highlighted cells refer to values which are in excess of: > ANZECC Guideline Value for 99% Protection of Ecosystems; > ANZECC Guideline Value for 95% Protection of Ecosystems > low reliability ANZECC Guideline Value.

Table E-2. Wet Season Sampling 2020

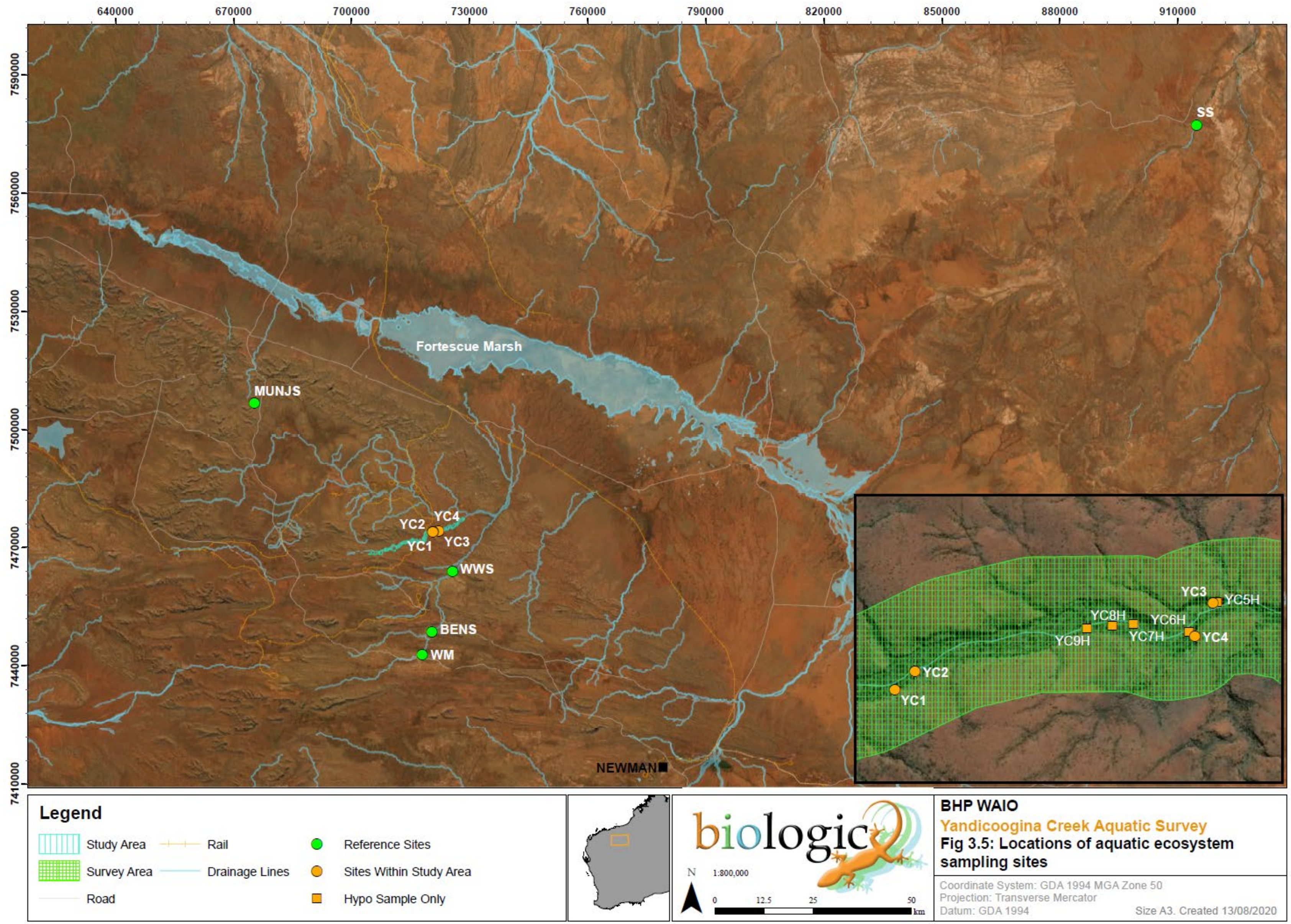
		ANZECC default GV		Yandicoogina Creek				Reference Sites			
	Units	99% GV	95%	YC1	YC2	YC3	YC4	WWS	WM	MUNJS	SS
Temp	°C			25.8	25.7	27.8	24.5	29.1	25.3	23.3	27.2
pH	pH units		6-8	7.36	7.39	7.45	7.68	7.94	8.22	7.96	8.09
Redox	mV			45.8	-63.7	105.9	53.7	138	92	92.6	37.9
EC	µS/cm		250	620	554	639	641	883	525	833	581
DO	%		85-120	38.2	25.5	39.5	23.3	53.2	92.4	73.1	76.5
Turbidity	NTU		15	7.6	10.9	2.0	1.5	0.4	3.2	1.1	0.4
TSS	mg/L			3	4	5	4	2	5	<1	<1
Alkalinity	mg/L			241	218	261	254	324	81	162	294
Hardness	mg/L			263	240	274	262	413	193	294	248
Na	mg/L			36.2	32.7	39.6	43.4	42.3	36.9	63.5	37.5
Ca	mg/L			54.4	49.7	55.3	52.7	72.8	41.6	44.2	49.1
Mg	mg/L			30.9	28.2	32.9	31.7	56.2	21.6	44.6	30.5
K	mg/L			11	10.8	12.2	12	10	6	13	5.5
HCO3	mg/L			241	218	261	254	324	81	162	292
Cl	mg/L			39	37	40	45	71	58	150	43
S_SO_4	mg/L			11.1	8.3	10.3	9.67	19.8	31.5	22.8	6.47
CO_3	mg/L			<1	<1	<1	<1	<1	<1	<1	2
dAl	mg/L	0.027	0.055	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
dAs	mg/L	0.001	0.024	0.0003	0.0002	<0.0002	<0.0002	0.0005	0.0004	0.0004	0.0002
dB	mg/L	0.09	0.37	0.18	0.15	0.18	0.17	0.34	0.06	0.25	0.13
dBa	mg/L			0.020	0.020	0.029	0.022	0.012	0.031	0.062	0.243
dCd	mg/L	0.00006	0.0002	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
dCo	mg/L			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
dCr	mg/L	0.00001	0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
dCu	mg/L	0.001	0.0014	<0.00005	0.00005	0.00008	<0.00005	0.00009	0.00164	0.00009	0.00010
dFe	mg/L			0.030	0.468	0.014	0.038	<0.002	0.009	0.080	0.021
dMn	mg/L	1.2	1.9	0.0393	0.0344	0.0083	0.0049	<0.0005	0.0016	0.0041	0.111
dMo	mg/L			0.0002	0.0002	0.0004	0.0001	0.0003	0.0001	0.0001	0.0003
dNi	mg/L	0.008	0.011	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0006	<0.0005	<0.0005
dPb	mg/L	0.001	0.0034	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
dS	mg/L			9.6	7.3	9.9	7.6	17.0	28.9	20.6	5.6
dSe	mg/L	0.005	0.011	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
dU	mg/L			0.00011	0.00006	0.00017	0.00015	0.00069	0.00006	<0.00005	0.00044
dV	mg/L			<0.0001	0.0002	0.0007	0.0006	0.0032	0.0019	0.0002	0.0016
dZn	mg/L	0.0024	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
N_NH_3	mg/L	0.26	0.73	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
N_NO_3	mg/L	1.00	2.40	0.01	<0.01	0.01	0.01	0.04	<0.01	0.02	0.08
N_NOx	mg/L		0.01	0.01	<0.01	0.01	0.01	0.04	<0.01	0.02	0.08
TN	mg/L		0.30	0.21	0.11	0.40	0.12	0.06	0.34	0.22	0.12
TP	mg/L		0.01	0.04	0.05	0.06	0.03	0.03	0.03	0.04	0.02

Source: Biologic (2020b)

Notes:

WWS - Weeli Wolli Spring; BENS - Ben's Oasis; MUNJS - Munjina Spring; SS - Skull Spring

Highlighted cells refer to values which are in excess of: > ANZECC Guideline Value for 99% Protection of Ecosystems; > ANZECC Guideline Value for 95% Protection of Ecosystems >low reliability ANZECC Guideline Value.



Source: Biologic (2020b)

Figure E-1. Yandicoogina Creek sampling locations

E.5. Yandi groundwater quality analyses

The groundwater quality data collated by Hydro Geochem Group (2022) and screened against water quality criteria follow.

Appendix F Pit lakes

F.1. Mine void backfill option modelling

F.1.1 Mine void ecohydrological system elements

A number of element configurations have the potential to influence the ecohydrological values of mine voids post-closure (AQ2 & Equinox, 2016):

- Surface water body (fresh or hyper-saline lake).
- Aquifer (subterranean water body).
- Engineered fill (porous substrate, providing a growth medium for vegetation).
- Vegetation (aquatic / fringing terrestrial / xerophytic).
- Habitat for fauna (terrestrial / aquatic / stygobitic).

Key system operating parameters include the frequency of significant inundation events, depth to groundwater (where engineered fill is incorporated) and salinity development in the pit lakes. Conceptual examples of the progressive inclusion of different elements into the void landforms are shown in Figure F-1 (void base above the water table) and Figure F-2 (void includes freshwater and hyper-saline permanent water body).

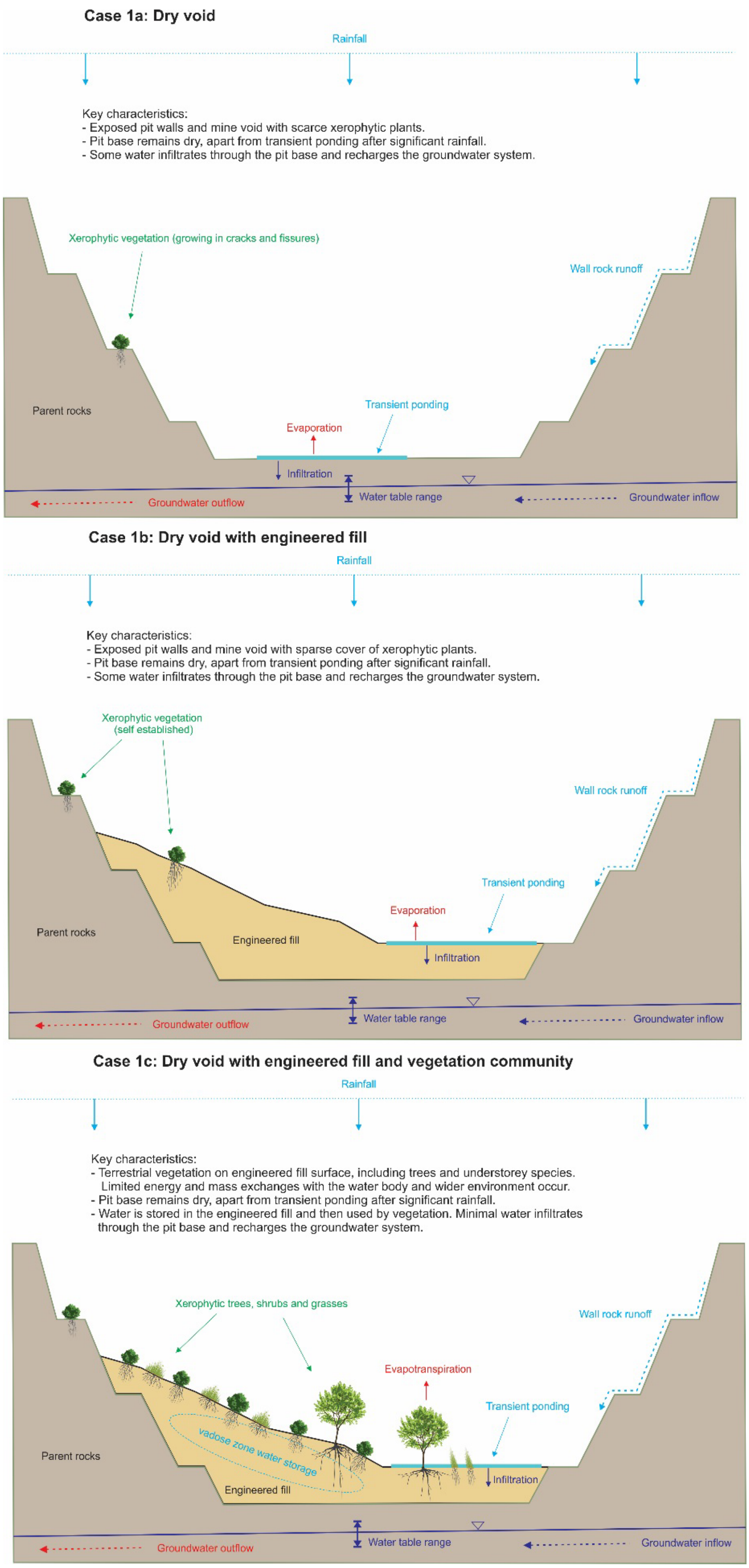


Figure F-1. Conceptual mine void closure option – Case 1 void base above the water table

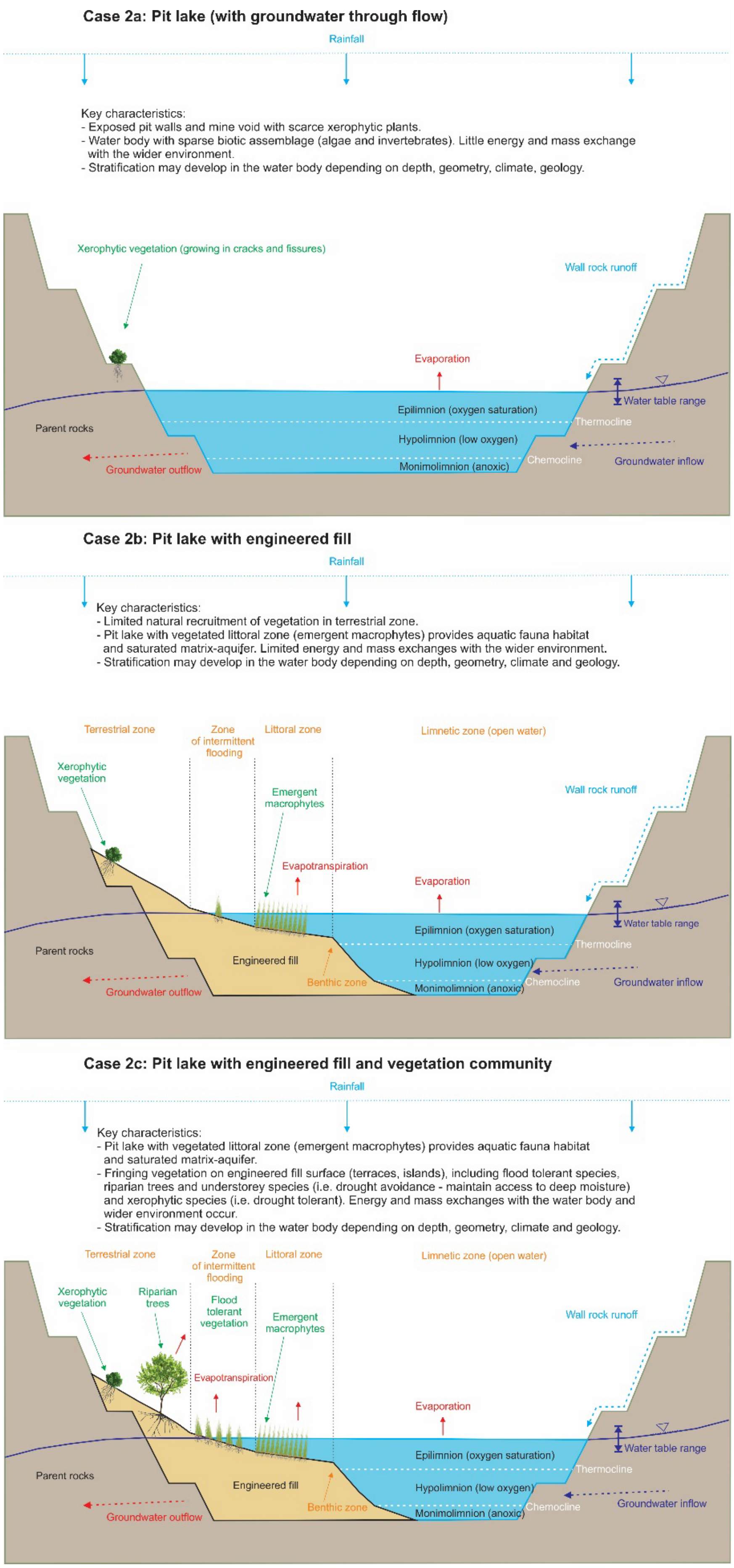


Figure F-2. Conceptual mine void closure option - Case 2 void includes a throughflow pit lake

F.1.2 Lessons learned

AQ2 (2020c) summarised the previous work that has been conducted to model pit water balances. The key learnings from these studies are as follows:

- If there is no pit backfill, water within pits exceeds the stock water guideline (ANZECC & ARMCANZ, 2000) for salinity, and groundwater throughflow conditions within the CID are not established.
- If only the eastern pits are backfilled, a groundwater sink develops at W5. C4/5 becomes a groundwater divide towards W5 and E7. E7 generally outflows to downstream to RTIO's Mungadoo West Pit Lake. W4 and W5 salinity exceeds the stock water guideline limit.
- If pits are backfilled with material closest to where the backfill is placed, there will be outflow from E7 to RTIO's Mungadoo West Pit Lake. Pit lakes will form resulting in salinity at C4/5, E1, E2/3/5/6 and E4 which exceeds the stock water guideline limit.
- If backfill is distributed evenly throughout the pits, there will be outflow from E7 to RTIO's Mungadoo West Pit Lake. Pit lakes will form resulting in salinity at C4/5, E1, E2/3/5/6 and E4 which exceeds the stock water guideline limit.
- If E7 is selected as a sink, it isolates the Yandi closure outcomes from closure outcomes at RTIO's Yandicoogina mine downstream. However, there is the potential that water levels in RTIO's pits at closure are below the base of E7 Pit which would negate this advantage. With E7 as a sink, the secondary sink is required to be located at C4/5.
- If there is select backfill, small lakes could be created within each of the mine voids to increase the ecohydrological benefit of the rehabilitation of the mine, without increasing the salinity of the throughflow pits above the non-saline water quality criteria.
- It is likely to be possible to create seasonal pools within the backfill (a preference stated by Traditional Owners) by selectively contouring an area of the pit to develop a low-point that will be inundated during seasonal water-level highs in the pits. Typical water level fluctuations are between 0 m and 1 m, however there will be periods of prolonged inundation and dry spells.
- Irrigation is likely to be required to support the vadose zone moisture content until roots are sufficiently deep and groundwater levels sufficiently high to support vegetation evapotranspiration requirements.
- Water levels and salinity are likely to be higher in a non-vegetated scenario as opposed one with vegetation. The difference in salinity between the vegetated and non-vegetated models is low after 100-years, but the difference increases such that the impact of vegetation on salinity may prove to be more significant if the model were run over a longer period.
- Predicted water levels vary in response to the magnitude and frequency of creek overflow and seepage events.
- Model results in Scenario B (sinks in W1, W2, W3 and E7) are sensitive to the aquifer characteristics simulated between pits W2 and W3. W2 and W3 are separated by approximately 3 km of remnant CID aquifer with unknown geometry and aquifer properties. A nominal flow area perpendicular to the flow direction within the remnant CID was used in the 2022 and 2024 water balance models to estimate the hydraulic connection between W2 and W3. When a greater connection was simulated between these two pits, the backfill required through pits W4-C12 to keep the pits non-saline increased.

F.1.3 2022 water balance modelling results

AQ2 (2022a) revised the water balance modelling for Yandi based on the scenarios outlined in Table F-1.

Table F-1. 2022 water balance modelling scenarios

Scenario	Nominated saline sinks	Sub-variant salinity target*	
		4,000 mg/L	8,000 mg/L
B.1	W2, W3, C4/5 and E7	✓	
B.2			✓
C.1	W1, C4/5 and E7	✓	
C.2			✓
D	Reference case - backfill to stabilize W1 and W5 land bridge and existing ISAs only		
E.1	C4/5 and E7	✓	
E.2			✓

Source: AQ2 (2022a)

*Notes: salinity target refers to the salinity of all pits other than the designated saline sinks

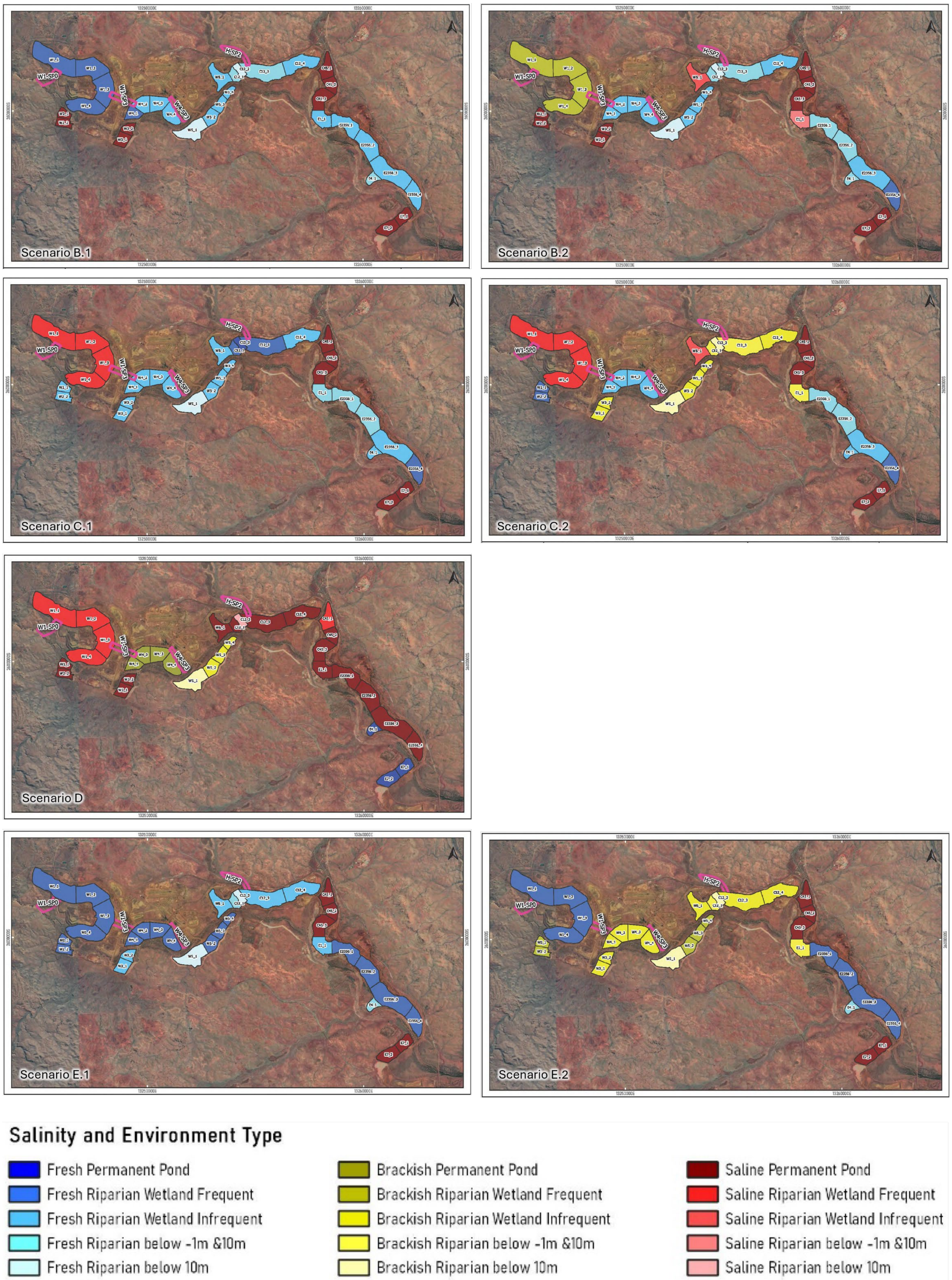
The backfill elevations required to achieve the salinity outcomes for each scenario are provided in Table F-2. The analysis concluded that there is a high risk that there will be insufficient backfill for Scenario E to be pursued.

The pit classifications for each modelled scenario are provided in Figure F-3. For Scenarios B.1 and C.1, the model predicted the salinity to be generally <4,000 mg/L in all pits not designated as saline sinks, with a short-term increase in groundwater salinity throughout the mine path following a large rainfall event. For Scenario E.1 salinity within the W2 to C1/2 pits fluctuated more than the other model scenarios, and depending on the pit, the fluctuations pushed the salinity classification out of the non-saline designation and temporarily into either the brackish or saline designation for short periods.

Table F-2. Predicted backfill elevations to achieve scenario outcomes

Pit	Cell	Cell Base	Scenario B.1	Scenario B.2	Scenario C.1	Scenario C.2	Scenario D	Scenario E.1	Scenario E.2
W1	1	534	570	562	555	555	555	580	577
	2	534	567	559	551	551	551	577	574
	3	528	563	558	542.5	542.5	542.5	574.5	572
	4	528	557	557	534	534	534	571.5	569
W2	1	522	522	522	559	550	522	569.75	567.5
	2	516	516	516	560	551	516	569	567
W3	1	510	510	510	558	553	510	563	561
	2	510	510	510	557	552	510	561.5	560
W4	1	516	536	536	556	550	516	559	558
	2	516	537	537	554	548	516	558.25	557
	3	510	538	538	553	546	510	556.5	555
	4	510	540.5	541	551	544	510	554.75	553
W5	1	516	542	537	547	540	529	552	550
	2	510	544	536.5	544	538	529	549.5	547
	3	510	542	536	541.5	536	529	547	544
	4	510	539	535	539	534	529	544	541
W6	1	510	538	530	536.25	530	510	539	536
C12	1	522	535	528	534	528	522	535.25	528
	2	522	530	527	530	525	522	530	530
	3	498	525	522.5	525	522	498	528	525
	4	492	518.75	518.75	518.75	518.75	492	520	518
C45	1	504.6	504.6	504.6	504.6	504.6	504.6	504.6	504.6
	2	504	504	504	504	504	504	504	504
	3	498	498	498	498	498	498	498	498
E1	1	498	514	513	514	513	498	514	513
E2356	1	500	519	517	519	517	500	519	517
	2	488	523	518	523	518	488	523	518
	3	492	519	517	519	517	492	519	517
	4	492	515	513	515	513	492	515	513
E4	1	498	520	518	520	518	498	520	518
E7	1	474	474	474	474	474	474	474	474
	2	474	474	474	474	474	474	474	474

Source: AQ2 (2022a)



Source: AQ2 (2022a)

Figure F-3. 2022 water balance modelling pit classifications

F.2. Hydrogeochemical modelling inputs

F.2.1 Rainfall & pit wall run-off quality

PARAMETER	UNITS	DIRECT RAINFALL*	PIT WALL RUNOFF#
pH	pH unit	5.6^	7.5
Alkalinity	mg $CaCO_3$/L	2	49
Al	mg/L	<LOR	0.13
B	mg/L	<LOR	<LOR
Ba	mg/L	<LOR	0.06
Ca	mg/L	0.95	6.8
Cl	mg/L	2.4	19
F	mg/L	<LOR	1.2
K	mg/L	0.2	3
Li	mg/L	<LOR	0.01
Mg	mg/L	0.4	4.7
Mn	mg/L	<LOR	0.27
Na	mg/L	1.9	18
NO_3	mg/L	0.48	1.1
Ni	mg/L	<LOR	0.01
Se	mg/L	<LOR	<LOR
SO_4	mg/L	1.6	13
Si	mg/L	<LOR	7
Sr	mg/L	<LOR	0.04
Zn	mg/L	<LOR	0.02

Source: Mine Waste Management (2023a)

Notes: *average values derived from a rainfall composition monitoring network established by CSIRO (Crosbie, et al., 2012) and 27 samples collected at the Meekatharra station in Western Australia from May 2007 to Jun 2011

#average values from the de-ionised water leachate tests conducted on Yandi stratigraphies

^indicated as amount weighted average in Crosbie et al. (2012)

<LOR indicates all measurements below the analytical limit of reporting (LOR) and not included in the source term

F.2.2 Initial pit lake quality

PARAMETER	UNIT	INITIAL PIT LAKE QUALITY*
pH	pH unit	7.5
Alkalinity	mg $CaCO_3$/L	113
Al	mg/L	0.29
B	mg/L	0.18
Ba	mg/L	0.14
Br	mg/L	0.13
Ca	mg/L	16
Cl	mg/L	43
F	mg/L	2.7
Fe	mg/L	0.25
K	mg/L	7
Li	mg/L	0.03
Mg	mg/L	11

PARAMETER	UNIT	INITIAL PIT LAKE QUALITY*
Mn	mg/L	1
Na	mg/L	41
NO_3	mg/L	2.6
Ni	mg/L	0.02
Rb	mg/L	0.01
SO_4	mg/L	31
Si	mg/L	16
Sr	mg/L	0.08
Zn	mg/L	0.05

Source: Mine Waste Management (2023a)

Notes: *Based on pit wall run-off source term and adjusted to account for evapo-concentration (comprising concentration of solutes by a factor of ~2.3 which corresponds to an estimation that the initial pit lakes will lose approximately 55% of their volume to evaporation).

F.2.3 Basement aquifer & creek seepage inflow quality

PARAMETER	UNITS	BASEMENT AQUIFER INFLOW*	CREEK SEEPAGE#
pH	pH unit	8.1	8.2
Alkalinity	mg $CaCO_3$/L	291	208
Al	mg/L	<LOR	0.013
B	mg/L	0.04	0.24
Ba	mg/L	0.04	0.1
Ca	mg/L	50	36
Cl	mg/L	126	117
F	mg/L	0.54	0.5
Fe	mg/L	<LOR^	0.144
K	mg/L	7	8.3
Mg	mg/L	50	34
Mn	mg/L	<LOR	0.053
Na	mg/L	81	91
Nitrate as NO_3	mg/L	14+	0.78
Ni	mg/L	<LOR	0.004
Sulphate as SO_4	mg/L	58	56
Zn	mg/L	<LOR	0.035

Source: Mine Waste Management (2023a)

Notes: <LOR indicates all measurements below the analytical limit of reporting (LOR) and not included in the source term.

*Average composition of 32 samples from bores near E1 & E2, W1, W2, W4, W5, W6, C1/C2, C4/5 and E3/E5/E6, collected between September 2019 and May 2020.

#Median composition of 15 samples from alluvium-screened bores at Yandi from December 2012 to October 2015.

^Most measurements below detection limit and not included in source term

+Median nitrate is 11 mg/L with range from 4-42 mg/L.

F.2.4 Groundwater inflows from adjacent pits

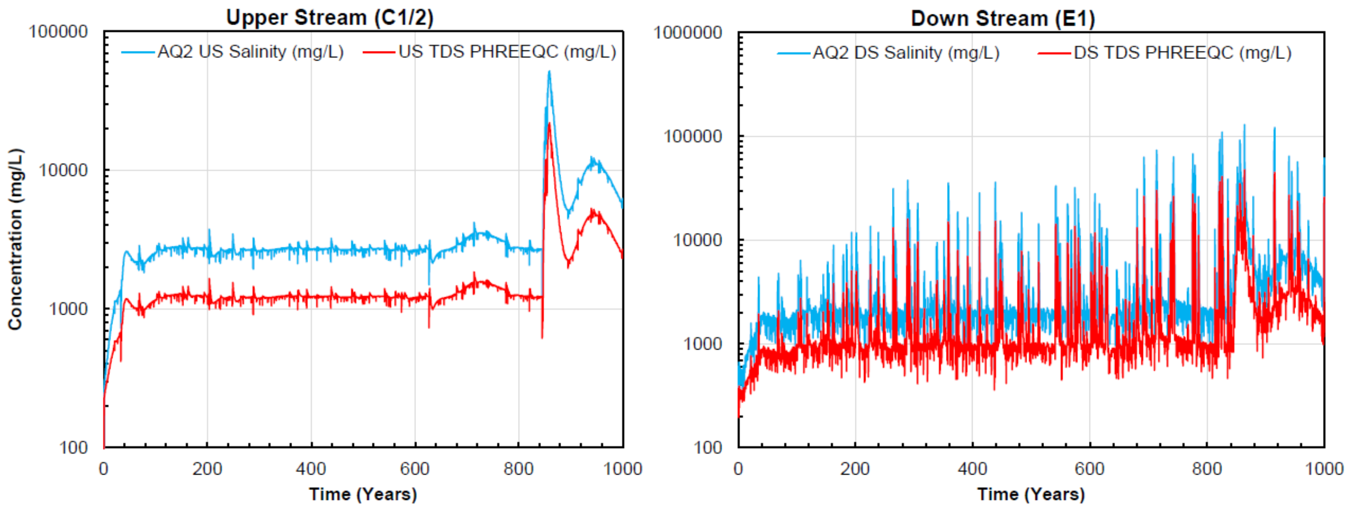
Modification of basement groundwater

To account for evapo-concentration and geochemical reactivity over the 1,000 year projection period, solute concentrations for the basement groundwater inflow source term were normalised to salinity (TDS) values predicted by the solute balances developed by AQ2 (2022a) (Figure F-4) (Mine Waste Management, 2023a).

An evaporation model was developed using PHREEQC to:

- derive groundwater inflow composition normalised to the solute balance TDS predictions for each pit lake; and
- account for influences of secondary mineral precipitation and atmospheric gas exchange on the inflow composition.

The evaporation model considers precipitation of calcite ($CaCO_3$) and other minor carbonates, gypsum ($CaSO_4{:}2H_2O$) and other minor sulphate minerals, and equilibrium of the water with average levels of atmospheric oxygen and CO_2. For the pit lake mixing model, the composition of groundwater inflows from upstream and downstream was indexed to outputs from the evaporation model at each timestep. Figure F-4 shows the difference between TDS predicted using the PHREEQC model and the simple solute balance used by AQ2 (Mine Waste Management, 2022b).

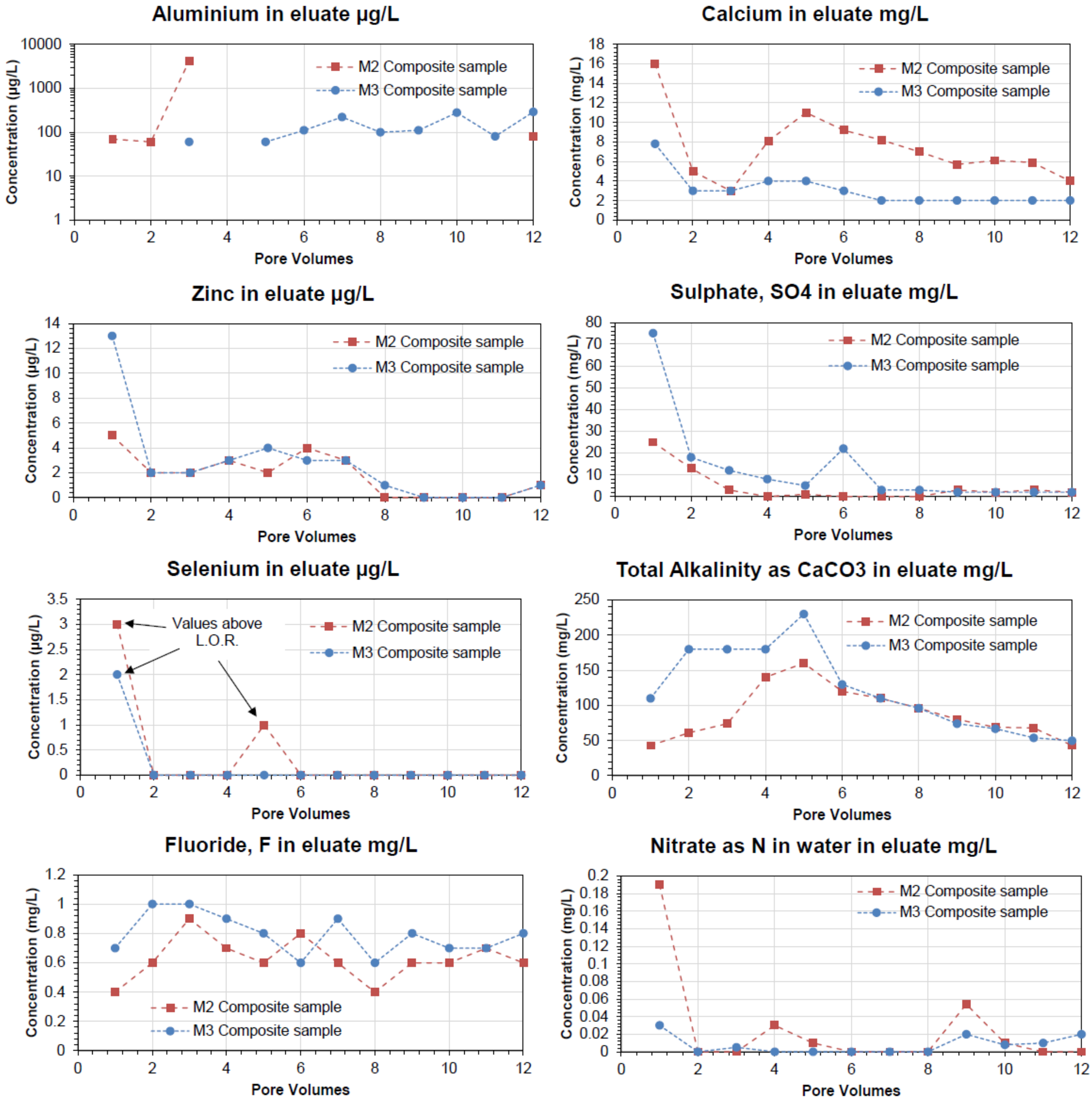


Source: Mine Waste Management (2022b)

Figure F-4. Estimated TDS concentrations for the C1/2 and E1 source terms predicted by a simple solute balance (AQ2) and adjusted to account for secondary mineral precipitation and atmospheric gas exchange (PHREEQC).

Solute load from backfill

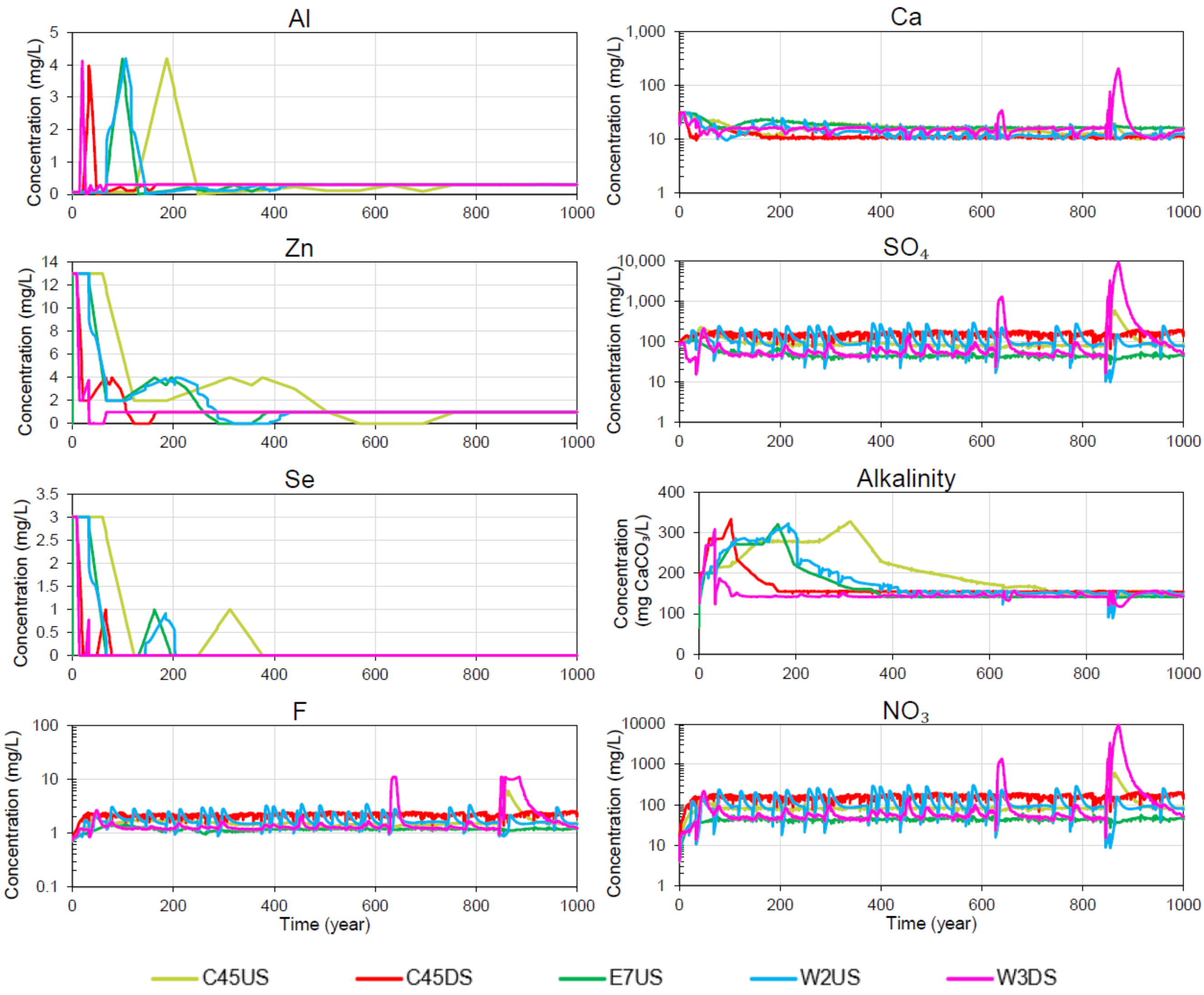
Figure F-5 shows the saturated column leach test results plotted against the number of pore volumes of de-ionised water moving through the column.



Source: Mine Waste Management (2023a)

Figure F-5. Saturated column leach test results vs pore volumes for selected parameters

Figure F-6 shows the calculated groundwater inflow concentrations for each of the relevant groundwater inflow components of each modelled pit lake, which includes the combined solute load from backfill and modified basement groundwater. Note that only Al, Zn, and Se are associated with the solute load from the backfill, whilst the other elements reflect a combination of the solute load from the backfill and the modified basement groundwater. The modified groundwater TDS values are calculated using the water balance and AQ2 model, which show some peaks in TDS like those observed in year ~850. Concentration 'spikes' as noted W3DS are attributed to significant rainfall events (e.g., year ~850) reflecting the synthetic rainfall record used in the water balance (AQ2, 2022a). The nitrate column leach test results are likely to be less than waste rock exposed to nitrogen blast residue. However, nitrate concentrations more representative of blasted rock inputs are incorporated in the basement groundwater source term and conservatively subjected to evapo-concentration in the model (but not biochemical cycling) (Mine Waste Management, 2023a).



Source: Mine Waste Management (2023a)

Notes: Solute concentrations represent the combination of solute release from backfill and solutes present in influent groundwater.

Figure F-6. Upstream (US) and downstream (DS) source terms for groundwater inflow from upgradient backfilled pits to permanent pit lakes for selected elements vs projection duration (years)

F.2.5 Model inputs - composition of precipitated salts

Table F-3. Input water qualities used for evaporation simulations

PARAMETER	MAXIMUM GROUNDWATER	MEDIAN GROUNDWATER
pH	8.2	7.9
TDS (mg/L)	840	570
Alkalinity (mg/L as $CaCO_3$)	440	300
Al (mg/L)	2.3	0.006
B (mg/L)	0.91	0.35
Ba (mg/L)	0.7	0.044
Ca (mg/L)	54	52
Cl (mg/L)	180	120
Cu (mg/L)	0.13	0.002
F (mg/L)	0.6	0.5
Fe (mg/L)	0.67	0.02

PARAMETER	MAXIMUM GROUNDWATER	MEDIAN GROUNDWATER
K (mg/L)	3.7	7.8
Mg (mg/L)	64	45
Mn (mg/L)	1.4	0.009
Na (mg/L)	160	80
Nitrate (mg/L as NO_3)	48	8.9
Ni (mg/L)	0.54	0.002
Pb (mg/L)	0.007	0.002
Sulphate (mg/L as SO_4)	65	55
Si (mg/L)	57	25
Zn (mg/L)	1.9	0.012

Source: Mine Waste Management (2023b)

Table F-4. Precipitated salt mass after >99.5% evaporation

MINERAL PHASE	FORMULA	RELATIVE PERCENTAGE PRECIPITATED FROM: MAX YANDI GROUNDWATER	RELATIVE PERCENTAGE PRECIPITATED FROM: MEDIAN YANDI GROUNDWATER
Barite	$BaSO_4$	0.1%	<0.1%
Calcite	$CaCO_3$	17.6%	29.7%
Ferrihydrite	$Fe(OH)_3$	0.2%	<0.1%
Fluorite	CaF_2	0.1%	0.3%
Gibbsite	$Al(OH)_3$	1.1%	<0.1%
Gypsum	$CaSO_4$	8.2%	3.5%
Halite	NaCl	33.3%	7.6%
Magnesite	$MgCO_3$	34.7%	48%
Rhodochrosite	$MnCO_3$	0.3%	<0.1%
Silica (amorphous)	SiO_2	12.5%	10.8%
Totals		**100%**	**100%**

Source: Mine Waste Management (2023b)

F.2.6 Pit lake overtopping water quality inputs

Table F-5. Marillana Creek surface water quality source term

Parameter	Units	Surface Water (YNSWPC002 Jan-18)
pH	pH unit	7.4
Alkalinity	mg $CaCO_3$/L	67
Al	mg/L	0.006
Ba	mg/L	-
Ca	mg/L	11
Cl	mg/L	23
F	mg/L	-
K	mg/L	4.4
Li	mg/L	-
Mg	mg/L	6.4
Mn	mg/L	0.005
Na	mg/L	8.8

Parameter	Units	Surface Water (YNSWPC002 Jan-18)
Nitrate	mg/L NO_3	1.8
Ni	mg/L	0.005
SO_4	mg/L	11
Si	mg/L	-
Sr	mg/L	-
Zn	mg/L	0.003

Source: Mine Waste Management (2023c)

Notes: Dashes indicate no data were available.

Analytical data were available for nine samples collected from March 2017 to March 2021

Table F-6. Extrapolated W1 / W4 pit lake water quality

PARAMETER	Units	W1 (2,023 mg/L TDS)	W1 (3,003 mg/L TDS)	W4 (2,023 mg/L TDS)	W4 (26k mg/L TDS)
pH (pH units)		8.06	8.00	8.06	7.46
TDS	mg/L	2,023	3,003	2,023	25,704
Alkalinity as $CaCO_3$	mg/L	96	88	96	59
Al	mg/L	0.01	0.009	0.01	0.005
B	mg/L	0.039	0.042	0.039	0.047
Ba	mg/L	0.030	0.027	0.030	0.021
Br	mg/L	0.028	0.03	0.028	0.034
Ca	mg/L	78	115	78	1,015
Cl	mg/L	765	1,157	765	10,209
F	mg/L	4.4	4.4	4.4	4.2
Fe	mg/L	0.0014	0.0014	0.0014	0.0014
K	mg/L	43	64	43	554
Li	mg/L	0.011	0.014	0.011	0.042
Mg	mg/L	135	197	135	1,640
Mn	mg/L	0.2	0.27	0.2	0.8
Na	mg/L	481	726	481	6,370
Nitrate (as NO_3)	mg/L	74	112	74	989
Ni	mg/L	0.0083	0.011	0.008	0.035
Rb	mg/L	0.0019	0.002	0.0019	0.0023
SO_4	mg/L	367	555	367	4,868
Si	mg/L	2.96	2.94	2.96	2.59
Sr	mg/L	0.027	0.035	0.027	0.11
Zn	mg/L	0.018	0.024	0.018	0.077

Source: Mine Waste Management (2023c)

F.2.7 Pit lake overtopping flow contributions

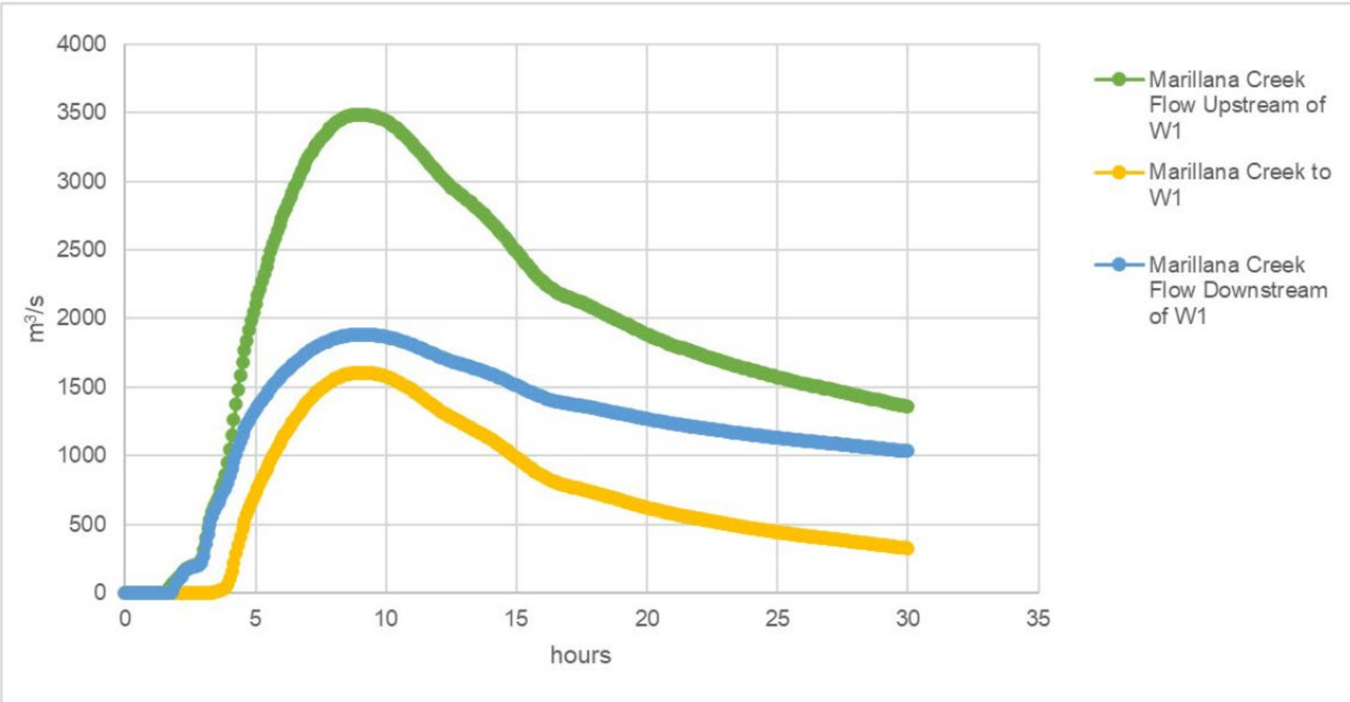
Table F-7 summarises key volumes in the mixing zone (i.e., downstream of the W4 outflow) extracted from the 1:10,000 AEP hydrological model results for (1) both pits full, and (2) W1 full and W4 part full. The part full volume has been calculated from a pit backfill elevation of 538 m, a pond water level of 545 m and the estimated area of W4 (1.2×10^6 m^2).

Table F-7. Flow volumes in the W1 / W4 / Marillana Creek system (1:10,000 AEP event)

FLOW COMPONENT	VOLUME (m^3)	SCENARIO 1 RELATIVE PROPORTIONS IF W1 & W4 ARE FULL	VOLUME (m^3)	SCENARIO 2 RELATIVE PROPORTIONS IF W1 IS FULL & W4 PART FULL	MARILLANA CREEK FLOW SCENARIO
W1	5.6×10^7	16.4%	5.6×10^7	18.4%	1:10,000 AEP
W4	4.6×10^7	13.3%	8.2×10^6	2.7%	1:10,000 AEP
Marillana Creek upstream of W1	5.2×10^8	70.3%	5.2×10^8	78.9%	1:10,000 AEP
Totals	**6.2×10^8**	**100%**	**5.8×10^8**	**100%**	

Source: Mine Waste Management (2023c)

Figure F-7 shows modelled flows over 30 hours for the 1:500 AEP event, assuming W1 and W4 pits are empty at the beginning of the event. There are no flows between W1 and W4, or overflow from W4, because there is insufficient volume from upstream in Marillana Creek.



Source: Advisian (2022) as cited in Mine Waste Management (2023c)

Figure F-7. 1 in 500 AEP hydrograph

F.3. Pit lake risk assessment

F.3.1 Key pit lake risk assessment assumptions and SRK commentary

Assumption	Comment	Materiality
Negative water balances exist for the lakes and they will be permanent sinks in landscape	Given the dry Pilbara climate this is a reasonable assumption and appears borne out by water balance modelling (GoldSim) undertaken to date. Water harvesting or overflow during high runoff events could raise water levels to above the groundwater table resulting in temporary groundwater outflows which has implications on the assumption and could impact closure requirements (e.g. raising diversions to prevent inflow).	High
Water quality predictions at hundreds of years (500 years) will be an adequate measure of long-term water quality	Influence from landforms located ex-pit, but within the pit zone of influence (e.g. waste rock dumps) may take longer to eventuate. It is however understood that risk of AMD from such landforms is low.	Low
Density-driven flows are unlikely	Even if such flows were to occur, it would be reasonable to assume that the zone of influence would be small.	Low
Water quality impacts can be considered on the basis of direct contact and / or ingestion of constituents of potential concern	A reasonable assumption given that, for a permanent sink scenario, solute transport away from pits (in either surface or groundwater) is unlikely; more distal water quality impacts to, for example, downstream vegetation, would therefore be unlikely.	Low (for permanent sink scenario)
Dominant (long-term) salt source is groundwater	This may be true of salinity in general, but sources of constituents of potential concern should be investigated in more detail. [Geochemical source terms had not been developed at the time of the study].	Low (for permanent sink scenario)
Available geochemical characterisation data are adequate for assessing AMD risk from sources	The following points are made with respect to the geochemical characterisation data: • The [recent] datasets focus on material from E7 and E8 and, therefore, do not capture spatial variability that might exist laterally across the different pits • Tertiary Sediments are not represented; these sediments often contain greater leachable solute content than other rock types in the area. • The leach testing dataset includes de-ionised water and saline water static leach testing, and multi-stage leach tests. Maximum leachate concentrations from the multi-stage tests are used as a screening tool to identify constituents of potential concern. SRK would caution that such an approach, without considering how test conditions differ from those in the pit lake, may not identify all constituents of potential concern robustly. • Neutral metalliferous drainage rather than AMD is likely to be of greater concern.	Low (for permanent sink scenario)
Lake is well-mixed (seasonal lake turnover, wind action)	Chemical heterogeneity was considered mainly from a vertical stratification perspective (e.g. temperature, dissolved oxygen and carbon dioxide). For pits that contain in-pit waste rock (backfill), it is possible that the quality of water within backfill pore space differs significantly from that of the open pit lake – mixing across the submerged backfill surface may introduce lateral heterogeneity to pit lake quality. Notwithstanding how chemical heterogeneity develops, the assumption of effective mixing due to seasonal turnover needs to be verified since the wind direction and fetch dictates the wind action (considering pit wall heights the lakes are likely to be protected against such action), and temperature changes may not be sufficient to induce complete lake turnover.	Low, for permanent sink scenario
Decant from the lakes will be rare	Whilst dependent on the volume of water that may enter the lakes due to local runoff, the assumption is reasonable given the dry Pilbara climate, and considerable free board suggested by current estimates of final lake elevations. Given expected deterioration of lake water quality over time, the potential for consequence would increase with time, but remain low due to the high dilution expected during any storm event resulting in decant.	Low
Limited connectivity between the pit lakes and other water bodies in the area	One of several limitations on development of a diverse ecosystem within the lakes, which would attract wildlife, and increase the potential for exposure to detrimental water quality impacts.	Low
Unless of special conservation or functional significance, fauna species can be treated as communities (e.g. waterfowl) and emphasis can be placed on overall ecosystem functionality rather than individual species	A reasonable assumption given the high-level nature of the assessment at this stage of study.	Low

Source: SRK (2022b)

F.3.2 Pit lake risk assessment matrices

Likelihood	Consequence	Extent	Duration	Confidence	Risk	Classification
1	1	Immediate	Days	Case studies	5-120	Very Low
2	2	Surrounds	Months	Direct published literature	121-600	Low
3	3	Local	Years	Indirect published literature	601-1,500	Moderate
4	4	Catchment	Decades	Unpublished reports	1,501-2,500	High
5	5	Regional	Centuries	Anecdote	2,501-3,125	Extreme

Table 23. Likelihood descriptions.

Weighting	Likelihood*
1	Rare (very unlikely to occur in the decade following closure)
2	Unlikely (unlikely to occur in the decade following closure)
3	Possible (possibly may occur in the decade following closure)
4	Likely (likely to occur in the decade following closure)
5	Almost certain (almost certain to occur in the decade following closure)

*Defined by SPR model.

Table 24. Consequence descriptions for environmental (DIIS, 2016a) and livestock and human health receptors.

Weighting	Environmental	Livestock	Human health
1	Limited damage to minimal area of low significance	Reversible short-term health effects in weakened and young individuals	Minor reversible health effects of little concern
2	Short-term impact not affecting ecosystem function	Reversible long-term health effects in weakened and young individuals	Minor, reversible health effects requiring medical intervention
3	Significant medium-term impact on valued species but not ecosystem function	Fatality of some weakened or young individuals only, minor chronic health effects for multiple individuals	Serious, reversible health effects requiring medical intervention and time
4	Significant long-term impairment of ecosystem function or valued species	Fatality of an individual, serious chronic health effects for multiple individuals	Single fatality or multiple chronic health effects
5	Very significant impacts on highly valued ecosystems or components.	Fatality of multiple individuals, chronic long-term health effects at herd level	Multiple fatalities or serious disabling health effects

Source: Mine Lakes Consulting (2022)

F.3.3 Pit lake attributes

#	Attribute	Definition
1	Location	Location on Yandi project area, -1 as Western, 0 as Central and 1 as Eastern.
2	Orientation	Clockwise from 0°N.
3	Residual mineralized materials (RMM)	Remaining mineralised material exposed at void completion. Normalised data. 0.07 represents E3 / E4.
4	Total catchment	Total catchment areas (including pit footprints) as km^2.
5	Local catchment	Local catchment areas as km^2.
6	Groundwater inflow	Groundwater flow from Weeli Wolli Formation. Constant total seepage rate of 6,000 kL/d nominally split across the pits.
7	Marillana Creek inflow	Marillana Creek seepage losses through the CID and into the pit voids. Split of total creek seepage as GL.
8	Marillana Creek seepage	Proportion of total creek seepage to each pit.
9	Alluvial inflow	% proportion of total alluvials inflow into pits.
10	Backfill %total	Estimated % of waste placed in pit to-date relative to the total 'pit volume'. Where pit volume is defined as Max Pit Design up to the full backfill level provided by Advisian in IPS Phase 1. As of January 2022, instead of as of end of FY22.
11	Backfill COPC	Invariant data entered due to backfill geochemistry data paucity.
12	Roads	Closest distance to Flat Rocks Rd (main bitumen road running across Yandi [west-east]) as this is the most likely road that human receptors will be more frequently travelling on.
13	Heritage	Shortest distances (m) from pit void perimeter estimated from gazetted Aboriginal heritage zones (red polygons, not already impacted by ops).
14	Heritage (Moderate)	Number of business risk sites (within 1 km envelope).
15	Heritage (High)	Number of business risk sites (within 1 km envelope).
16	Heritage (Very high)	Number of business risk sites (within 1 km envelope).
17	Neighbour distance	Distance from pit edge to nearest neighbour, centre of Yandicoogina Mine.
18	Vertebrate habitat	Major drainage lines (which indicate significant vertebrate habitat area on IOMaps) intersect all pits except W4 and C12, assessed as the proportion (%) of pit that intersects the drainage line. Have only considered significant fauna as recorded on IOMaps (priority 4 onwards) and have not considered all fauna / flora observed on the site. Utilised (where possible) significant fauna habitats as opposed to observations.
19	Flora number	Number of significant flora observations within 500 m envelop of pit void.
20	Flora length	Shortest distance (km) between pit perimeter and nearest significant flora observation.
21	Riparian	Measured using the shortest distance (km) between the pit edge and receptor (edge of pit to closest habitat area).
22	SREs	Shortest distance (km) between pit perimeter and observation.
23	Stygofauna	Where stygofauna have been observed in pit, value is 0. Used observation points as the reference point as there were no habitats recorded to stygofauna, only points where stygofauna have been observed. Measured using the shortest distance between pit perimeter (km) and receptor (edge of pit to closest habitat area).
24	Ponding	Permanent ponding in some part of the pit as binary scale with 0 as none and 1 as some ponding.
25	Permanent water	Distance from pit edge to centre of Flat Rocks permanent spring.
26	Depth	Likert scale with pit void average across cells where >10 m below surface = 0; <1 m above surface = 1; >1 m at >100 yr = 2; >1 m at <100 yr = 3. If depth data missing then permanent water = 3.
27	Salinity	TDS (mg/L) <4,000 = 1; 4,000 to 8,000 = 2; and >8,000 = 3. W4 salinity manually from 3 to 2 due to some backfill post report (SME-CW,DS).
28	Decant to Creek	per 1,000 yr ARI. Note: W1 decants to W4 only. Only W4 decants to Creek.
29	Decant to pit	per 1,000 yr ARI. Note: W1 decants to W4 only. Only W4 decants to Creek.
30	Creek decant salinity	1,000 yr ARI. Note: W1 decants to W4 only. Only W4 decants to Creek. TDS as mg/L.
31	Pit decant salinity .	1,000 yr ARI. Note: W1 decants to W4 only. Only W4 decants to Creek. TDS as mg/L
32	A	Alluvials stratigraphy present on final pit surface (presence / absence as binary).
33	SZ	Surface scree stratigraphy present on final pit surface (presence / absence as binary).
34	T	Tertiary sediments stratigraphy present on final pit surface (presence / absence as binary).
35	TO	Oakover formation stratigraphy present on final pit surface (presence / absence as binary).
36	M4W	Eastern clay (weathered) stratigraphy present on final pit surface (presence / absence as binary).
37	EK	Eastern clay stratigraphy present on final pit surface (presence / absence as binary).
38	M3W	Upper CID (weathered) stratigraphy present on final pit surface (presence / absence as binary).

#	Attribute	Definition
39	M3SA	Upper CID (high silica/alumina) stratigraphy present on final pit surface (presence / absence as binary).
40	M3MN	Upper CID (Northern marginal zone) stratigraphy present on final pit surface (presence / absence as binary).
41	M3MS	Upper CID (Southern marginal zone) stratigraphy present on final pit surface (presence / absence as binary).
42	M3	Upper CID stratigraphy present on final pit surface (presence / absence as binary).
43	OK	Ochreous stratigraphy present on final pit surface (presence / absence as binary).
44	M2	Lower CID stratigraphy present on final pit surface (presence / absence as binary).
45	M1	Lower CID stratigraphy present on final pit surface (presence / absence as binary).
46	BK	Basal clay stratigraphy present on final pit surface (presence / absence as binary).
47	BG	Basal stratigraphy present on final pit surface (presence / absence as binary).
48	HE	Weeli Wolli dolerite stratigraphy present on final pit surface (presence / absence as binary).
49	HJ	Weeli Wolli iron formation stratigraphy present on final pit surface (presence / absence as binary).

Source: Mine Lakes Consulting (Mine Lakes Consulting, 2022)

Notes: The attributes shaded in orange were defined as primary attributes and used in the SWOT analysis

F.3.4 Pit lake SWOT analysis

Attribute	Strength				Weakness				Opportunity				Threat			
	W1	E2356	W4	Remaining	W1	E2356	W4	Remaining	W1	E2356	W4	Remaining	W1	E2356	W4	Remaining
RMM	5	4	1	4	1	1	3	1	4	2	1	2	1	1	1	1
Permanent water	1	1	1	1	5	3	4	3	4	2	3	3	5	4	4	4
Pit decant salinity	1	3	2	3	4	3	5	3	1	3	1	3	4	3	5	3
Decant to pit	2	3	2	3	4	3	4	3	2	3	1	3	4	2	4	2
Total catchment	1	2	2	3	5	4	3	2	4	2	3	3	5	5	4	4
MC seepage	1	1	1	1	4	5	4	5	1	1	1	1	4	5	4	5
Alluvial inflow	1	1	1	1	4	5	4	5	1	1	1	1	4	5	4	5
Heritage (Moderate)	3	3	3	3	5	4	4	4	3	3	3	3	5	4	4	4
Neighbour distance	4	2	4	1	2	4	2	5	4	4	4	4	3	3	3	3
Eastern clay (weathered)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Eastern clay	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Ochreous	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Weeli Wolli dolerite	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

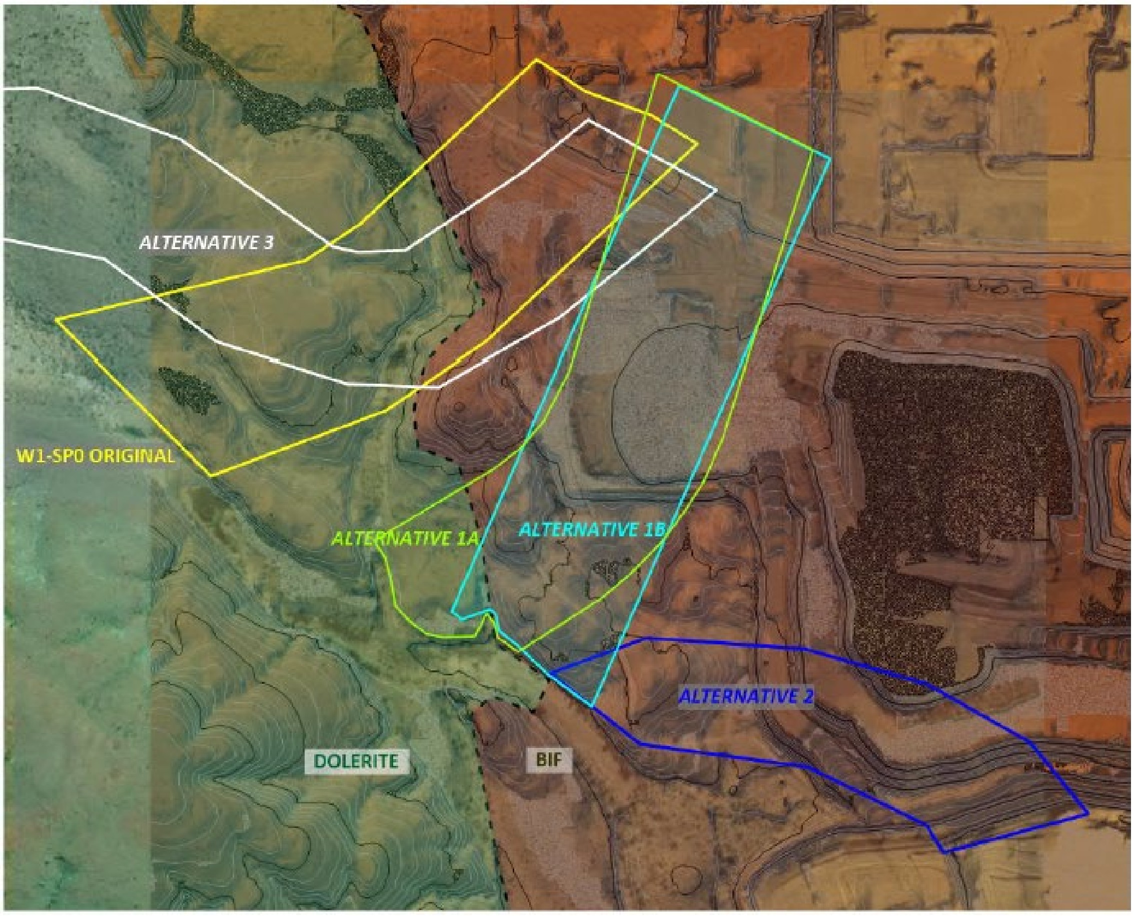
Appendix G Surface water management infrastructure

G.1. W1-SP0 alignment selection

The original location for W1-SP0 was conceived to take advantage of the fresh and high strength dolerite sill (Weeli Wolli Dolerite) exposed at the creek southwest of W1 pit (Figure G-1). Based on a site walkover and understanding of the Yandi geology, the initial location for the main W1-SP0 spillway would have been expected to be located in fresh dolerite, which would significantly reduce the risk of scour and creek capture. A site walkover along the area between the pit shell and Marillana Creek identified a persistent slightly weathered to fresh Dolerite visible in numerous outcrops. The Dolerite exposure continues to the east up to approximately 600 m from the western end of W2, where outcrops of BIF are visible at the creek banks, likely covering the Dolerite sill. Most of the outcrops seen along the proposed spillway alignment showed joint spacing varying from 200 mm to more than 4,000 mm. Joints were commonly sub-vertical, planar to undulating, slightly rough and clean (Advisian, 2019).

To address heritage constraints four alternative locations for the W1-SP0 spillway have been considered (Figure G-1). Based on the initial drilling program (limited to 5 boreholes in the original W1-SP0 spillway location), the extent of the Dolerite sill in the area and the upper and lower contacts with BIF, are uncertain. The bedrock exposures are limited to the creek bed, part of the flood plain near the entrance of W1-SP0 spillway and localised areas along the tributaries, with most of the area covered by tertiary sediments (colluvium) and duricrusts. A geological interpretation combining the drilling data, records of Advisian's (2019) site walkover and aerial imagery suggests the contact between Dolerite and BIF runs north-south along the tributary that crosses W1- SP0, with the Dolerite gently plunging to the east underneath the BIF (Figure G-1). Based on this interpretation the following assessment was made of the alternative W1-SP0 spillway locations (Advisian, 2020b):

- Alternatives 1A and 1B are likely to cross similar geological conditions encountered in the original spillway route, particularly nearer the pit, where the greater excavation volume is expected. These alternatives do not cross the northern tributary, eliminating additional structures to divert its flow and are considered the best options within the existing constraints, and warrant further consideration.
- Alternative 2 runs west-east discharging into the southern end of W1 pit where there is little information about ground conditions. BIF outcrops found at the entrance of Alternative 2 spillway and downstream of Marillana Creek are at a significantly lower elevation than the upper limit of the Dolerite encountered in the drillholes, suggesting that the Dolerite sill tapers towards W1 pit. Alternative 2 is considered less attractive due to:
  - Unknown geological conditions, with greater chance to encounter less Dolerite to the East.
  - A shorter route with higher gradient, resulting in a steeper channel and / or more drop structures (steps), both requiring better rock quality.
  - Thinner Dolerite sills usually present more joints, increasing the erodibility risk and issues with the cut slope stability.
  - Closure stability assessment recommendations for flattening or buttressing the pit wall where the spillway reaches the pit due to inferior rock mass quality present at that location. Although the spillway would cut through that wall, the slopes on both sides of the channel near the pit would still present significant long-term stability challenges.
- Alternative 3 presents greater geological uncertainties and significant excavation volumes and does not warrant further consideration.

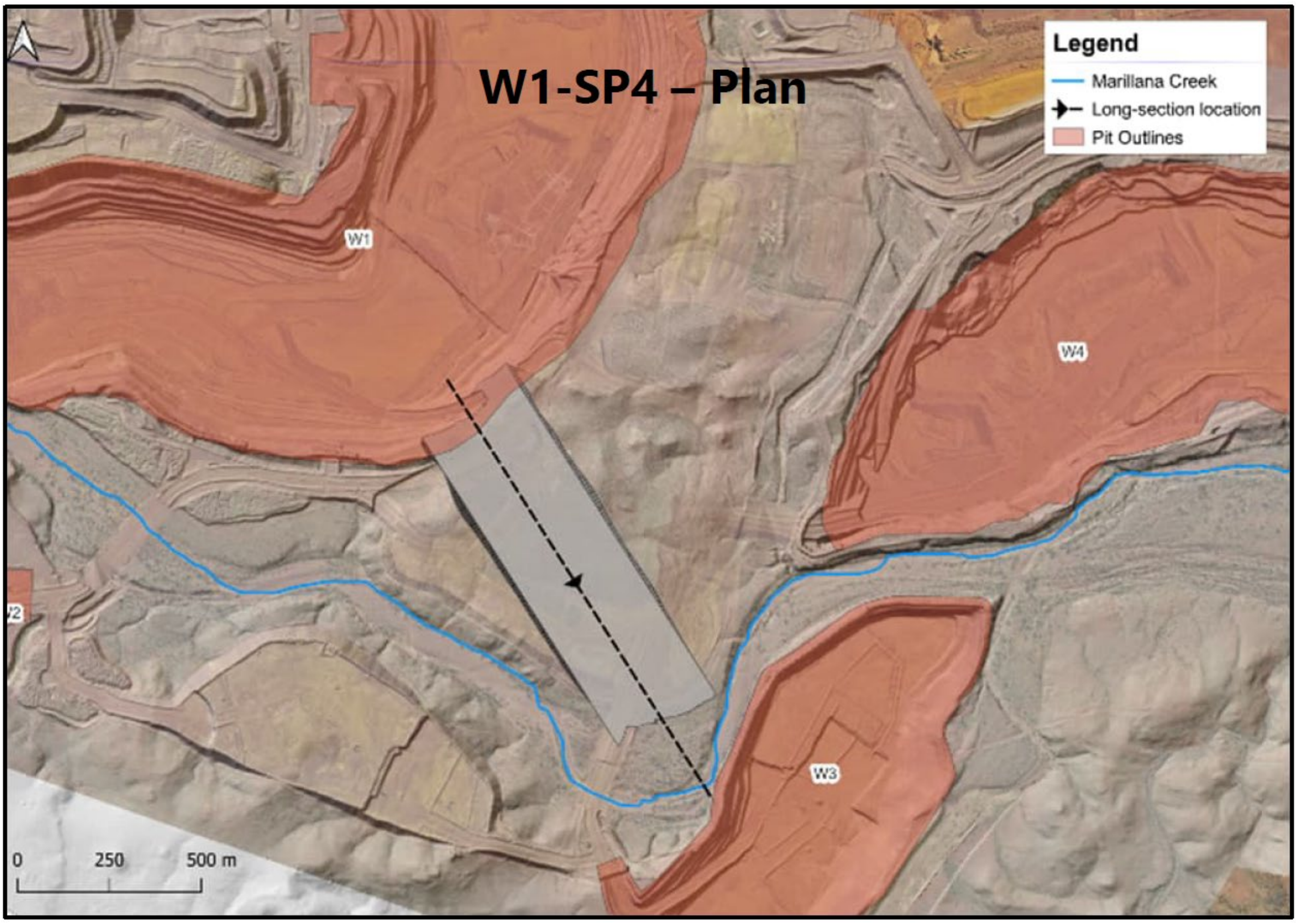


Source: Advisian (2020b)

Figure G-1. Interpreted surface contact between dolerite and BIF in area of W1-SP01

G.2. W1-SP3 / W1-SP4 trade-off study

The W1-SP3 spillway directs water from W1 pit to W4 pit in the event that W1 pit reaches capacity. This would only be expected to occur infrequently. Once the W4 pit reaches capacity, the W4-SP3 spillway would discharge water back to Marillana Creek from the W4 pit. This spillway would not be expected to be activated until the 1 in 10,000 AEP event. However, prior to the geotechnical investigation, there was limited information on the geology of the W1-SP3 and W4-SP3 spillway locations and unfavourable geology would increase the risk of erosion. Given these unknowns, an alternate spillway configuration was reviewed which uses only W1 pit for flood attenuation and passes overflow from the W1 pit back to Marillana Creek from an outlet location in W1 via a new spillway (W1-SP4) (Figure G-2) (Advisian, 2023f).

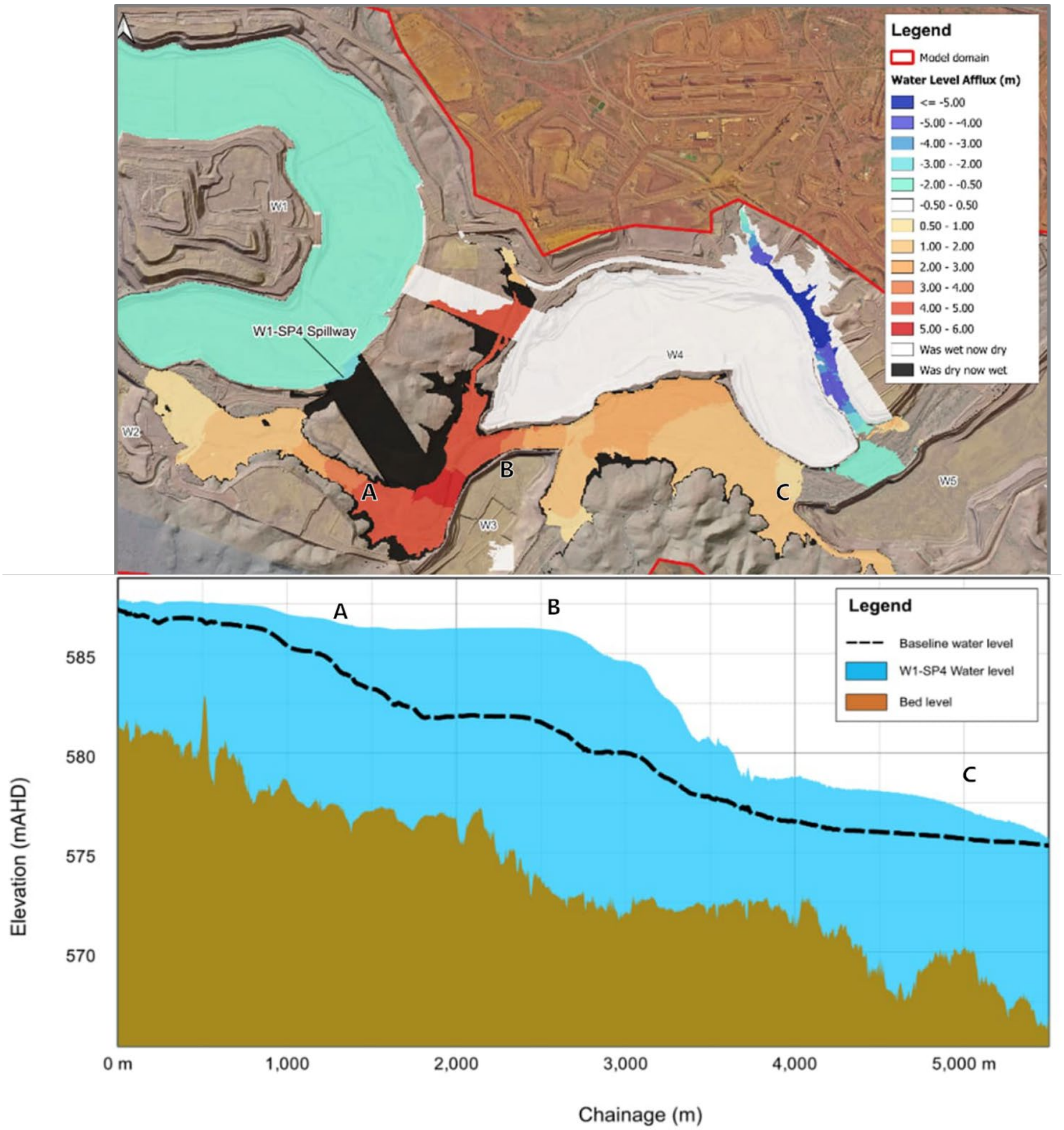


Source: Advisian (2023f)

Figure G-2. Location of W1-SP4 spillway

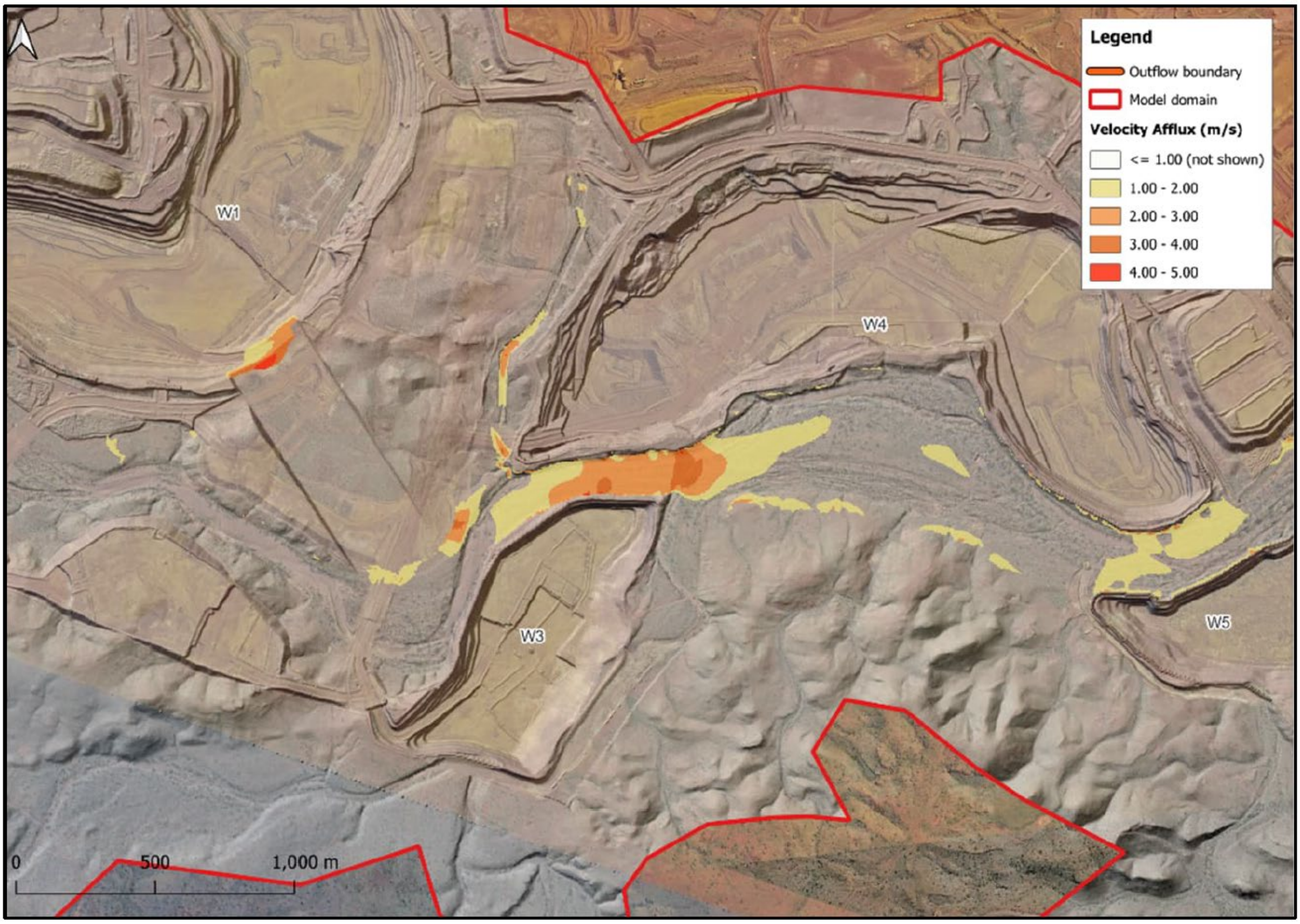
2 D hydraulic TUFLOW modelling was used to compare the W1-SP3 and W1-SP4 design options. The modelling results showed that (Advisian, 2023f):

- Neither the W1-SP3 or W1-SP4 flood channel is activated in a 1 in 100 AEP event, with water levels in W1 Pit not reaching the outlet level of 582.5 mAHD.
- The W1-SP4 spillway is activated in a 1:500 AEP event and discharges to Marillana Creek, but with the W1-SP3 spillway in place, the W4 pit does not fill to overflowing and therefore does not discharge to Marillana Creek. The flows in Marillana Creek following discharge from the W1-SP4 spillway do not exceed the peak flows without the discharge.
- In a 1 in 10,000 AEP event, the W1-SP4 scenario results in:
  - Increased peak flows through the section of Marillana Creek from W3 Pit to W5 Pit (~8,000 m^3/s for the W1-SP4 scenario compared to ~4,000 m^3/s with the W1-SP3 spillway).
  - An estimated increase in flood levels of 5 - 6 m at the flood channel outlet, with increases extending upstream to the natural land bridge between W1 and W2 Pits and downstream to W5 Pit. The long-section in Figure G-3 illustrates the backwater caused by the constriction in the creek between W4 and W3 Pits (location B). A flood bund ~1.3 m high will be required at the crest of the western edge of W3 pit to prevent ingress of flood waters. The section of CID between the creek and the pit crest is ~12 m above ground level and has a width of ~20 m at the crest which poses challenges for construction.
  - Velocity increases of between 2 m/s to 4 m/s in the constrained section of creek between W3 and W4 Pits which will not require additional rock armouring, and estimated velocity increases of 1 to 2 m/s at the flood bund at W5 Pit (Figure G-4), which will require increasing the size of the proposed flood bund rock protection from ¼ Tonne Class 1 Tonne Class.
- The W1-SP3 flood channel chute experiences very high velocity flows (up to 11 m/s for ~4,000 m^3/s in the 1:10,000 AEP) which could lead to erosion of the flood channel if the energy dissipator cannot be located in a zone of suitable rock. Erosion could result in head cutting of the structure with the 582.5 mAHD crest level reducing to the level of the W1 Pit backfill (562 mAHD).
- While W1-SP4 has a direct connection with Marillana Creek which increases the potential risk of head cutting erosion from the creek back to the flood channel crest leading to permanent pit capture of Marillana Creek, the risk of this is low as backwater in the 1:10,000 AEP event is not expected to pass from the flood channel chute into the pit.



Source: Advisian (2023f)

Figure G-3. Difference in water level with W1-SP4 spillway design compared to W1-SP3 spillway



Source: Advisian (2023f)

Figure G-4. Difference in flow velocities with W1-SP4 spillway design compared to W1-SP3 spillway

The review concluded that the W1-SP3 flood channel be adopted for the SPS landform design, given the following risks associated with the W1-SP4 design (Advisian, 2023f):

- Increased scour risk where the water flows out of the spillway and makes a hard left turn at W3 Pit.
- Flood bund at W3 pit which would be challenging to construct.
- Increased velocity at the W3-W4 natural land bridge.

However, the W1-SP4 option could potentially be reconsidered if drilling at either the W1-SP3 or W4-SP3 sites reveals unfavourable geological conditions (Advisian, 2023f).

G.3. Design used for ‘no spillway’ scenario modelling

G.4. Flood bund foundation conditions

Flood Protection Bund	Location	Total Length (m)	Maximum Height (m)	Chainage	Geological Conditions Underlying Flood Protection Bund
W4-1	W4 Pit to W4-SP4 Inlet	345	11.9	CH0 – CH75	Engineered Fill (Haul Road) over CID
				CH75 – CH140	Engineered Fill (Haul Road) over Colluvium over CID
				CH140 – CH160	Engineered Fill (Haul Road) over Alluvium over CID
				CH160 – CH275	Engineered Fill (Haul Road) over Colluvium over CID
W5-1	W5 Pit	1,365	8.1	CH0 – CH725	Engineered Fill (Haul Road) over Alluvium (~10m thick) over BIF
				CH725 – CH800	Non – Engineered Fill (Waste Stockpiles) over Alluvium over CID over BIF
				CH800 – CH1025	Non – Engineered Fill (Waste Stockpiles) over CID over BIF
				CH1025 – CH1230	Non – Engineered Fill (Waste Stockpiles) over Alluvium over CID over BIF
				CH1230 – CH1350	Non – Engineered Fill (Waste Stockpiles) over CID
W5-2	W 5 Pit	530	6.4	CH0 – CH425	Non – Engineered Fill (Waste Stockpiles) over Colluvium over Basal Conglomerate over BIF
W6-1	W4-SP4/W6 Pit	610	10.6	CH0 – CH325	Non – Engineered Fill (Waste Stockpiles) over Colluvium over BIF
				CH325 – CH500	Colluvium over Oakover Formation over BIF
				CH500 – CH575	CID over BIF
C12	C12 Pit	3,090	7.3	CH0 – CH130	Engineered Fill (Haul Road) over Basal Conglomerate over BIF
				CH130 – CH250	Engineered Fill (Haul Road) over Colluvium over CID
				CH250– CH325	Engineered Fill (Haul Road) over Alluvium over CID
				CH325– CH375	Engineered Fill (Haul Road) over BIF
				CH375 – CH525	Engineered Fill (Haul Road) over Alluvium over CID
				CH525 – CH1975	Engineered Fill (Haul Road) over Colluvium over CID over BIF/Dolerite
				CH1975 – CH2650	Engineered Fill (Haul Road) over Alluvium over CID over BIF/Dolerite
				CH2650 – CH2750	Engineered Fill (Haul Road) over CID over Basal Clay over Basal Conglomerate
				CH2750 – CH3050	Alluvium/Colluvium over CID
C5-1	C45 Pit	305	2.9	CH0 – CH275	Engineered Fill (Haul Road) over Non-Engineered Fill (Waste Stockpile) over CID
E1-1	E1 Pit	965	1.2	CH0 – CH100	Engineered Fill (Existing Bund) over Colluvium over BIF
				CH100 – CH875	Engineered Fill (Existing Bund) over Alluvium over BIF
E1-2	E1 Pit	120	4.6	CH0 – CH75	Colluvium over BIF
				CH75 – CH100	Colluvium/Alluvium (Veneer) over BIF
E1-3	E1 Pit	140	6.6	CH0 – CH125	Colluvium/Alluvium (Veneer) over BIF
E1-4	E1 Pit	495	13.6	CH0 – CH90	Engineered Fill (Access Road) over BIF

Flood Protection Bund	Location	Total Length (m)	Maximum Height (m)	Chainage	Geological Conditions Underlying Flood Protection Bund
				CH90 – CH425	Engineered Fill (Existing Bund) over Alluvium over BIF
				CH425 – CH475	Engineered Fill (Access Road) over CID
E4-1	E4 Pit	1,275	11.1	CH0 – CH75	Engineered Fill (Existing Bund) over Colluvium over CID
				C75 – CH750	Engineered Fill (Existing Bund) over Alluvium over BIF
				CH950 – 1250	Non-Engineered Fill (Waste Stockpile) over Colluvium over BIF
E4-2	E4 Pit	2,510	5.6	CH0 – CH250	Non-Engineered Fill (Waste Stockpile) over Colluvium over BIF
				CH250 – CH900	Non-Engineered Fill (Waste Stockpile) over Alluvium over BIF
				CH900 – CH1075	Non-Engineered Fill (Waste Stockpile) over BIF
				CH1075 – CH1375	Non-Engineered Fill (Waste Stockpile) over Alluvium over BIF
				CH1375 – CH2475	Engineered Fill (Existing Bund) over Alluvium over BIF
E7	E7 Pit	510	9.1	CH0 – CH175	Non-Engineered Fill (Pit Berm) over Alluvium (discontinuous veneer) over CID
				CH175 – CH450	Non-Engineered Fill (Pit Berm) over CID

Source: Advisian (2023j)

G.5. Minor bund register

ID	Easting	Northing	ID	Easting	Northing
W2			**Herbert's Creek**		
W2-4	4630	83583	HCB	11535	86176
W3			**C12**		
W3:1	6789	82793	C1-4	13555	85412
W3:2	7200	82918	C1-42	13252	85312
W5			C1-63	14323	85660
W5:W1	9806	83596	C3-1	15601	86300
W5:W2	9279	83335	C45-2	15336	85112
W5:W2	9679	83004	C45-51	15908	86311
W5-1	10187	83970	C6-1	15557	87544
W5-10	9965	83804	C6-3	15347	86066
W5-11	10756	83570	**E2356**		
W5-12	11080	83991	E1-O	15502	83362
W5-2	10811	84549	E1-1	14985	84619
W5-21	11259	84232	E1-2	14999	84044
W5-53	11390	84576	E1-4	15756	83258
W6			E3-1	18709	80816
W6-1	10597	86257	E4	15502	83362
W6-11	11106	86401	E7	19246	79748
W6-12	11500	8544			
W6-31	11955	85417			
W6-32	12044	85424			
W6-4	12473	85501			

Source: Advisian (2024a)

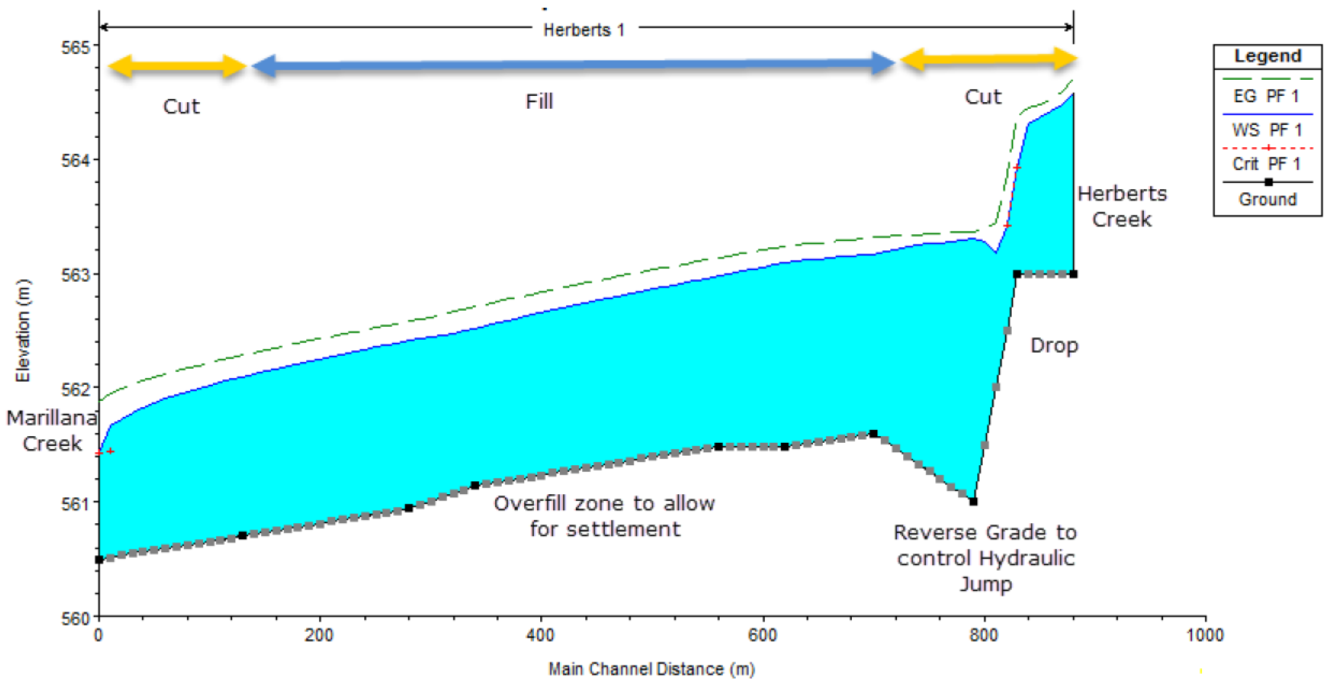
G.6. Herbert's Creek land bridge

The land bridge has a fill depth of 38 m placed by end tipping. The northern 80 m length of fill was placed in 2006, the central 380 m in 2015 / 2016, and the southern 150 m in 2004.

The land bridge diversion comprises (BHP Billiton Iron Ore, 2016a):

- An overfill section to accommodate differential settlement in the central areas (Figure G-6) compared to the northern and southern sections, where settlement would have largely taken place by the time of construction.
- A bed slope of 0.15% which was selected to result in velocities ranging between 1.8 and 2.3 m/s.
- A drop structure (dropping 2 m at a 1:20 slope from the invert of Herbert's creek) which accommodates the excess elevation along the diversion route due to the erosion resistant CID upstream of the diversion. A reverse grade section 90 m long was incorporated to control the hydraulic jump and result in sub-critical flow prior to reaching the land bridge (Figure G-6). The reverse grade section contains 0.5 tonne (0.7 m diameter) rock boulders at 5 m spacing on a staggered grid to increase roughness and ensure the hydraulic jump.
- Bunds 2.5 m high with a 5 m crest width on both sides of the land bridge (Figure G-7). These bunds provide a minimum 0.7 m freeboard above the 100-year ARI flow. The toes are constructed 1 m below the final diversion elevation to prevent the scour zone from undermining the bund.
- A Geosynthetic Clay Liner (GCL) to ensure that the majority of water which enters the land bridge also exits it (Figure G-7). Failure to do this would starve downstream environments of water as well as place the land bridge at risk of failure. The seepage barrier is also designed to limit subsoil moisture and the potential for tree growth. The growth of trees on the land bridge is not desirable due to the risk that they will topple during storms and potentially compromise the liner / bunds, or that their roots will create preferential flow paths leading to piping failure. The GCL was installed with some slack to allow for differential settlement.
- A 1.0 m cover over the GCL to maintain the mobile bed zone away from the GCL (Figure G-7). The velocity across the land bridge is relatively low; typically 1.8 m/s, which is below the 2 m/s threshold often cited for requiring rock armouring. However, during large flow events, a mobile bed would occur. The depth of the active bed layer during a 100-year ARI event was calculated to be 0.6 m. Coarser material (minimum D_{50} of 100 mm) was placed in the base of the low flow channel to constrain the mobile bed depth to 0.1 m.
- A low flow channel with a shallow meander sequence was designed such that the meander will push towards the widest part of the land bridge (east) which contains the light vehicle track. If meanders were not built into the channel, they would form at uncontrolled locations. Creeks in this area, including Herbert's Creek tend to form meanders with a wavelength of around 500 m. The low flow channel (0.5 m deep, 10 m wide) was designed to accommodate a 2-year ARI flow of 21m^3/s. The low flow channel dimensions replicate the low flow channels seen naturally in Herbert's Creek.
- Small areas of the diversion have been provided with rip rap protection (minimum D_{50} of 0.3 m and a minimum thickness of 0.5 m):
  - Upstream bund (150 m long and typical height 2 m).
  - Transition from cut to fill at the top of the land bridge (a length of 20 m across the 60 m channel). This transition was designed to be smooth, however, settlement may result in localised steeper slopes.
  - Outside of low flow meander. The meander has a single outside bend within the land bridge which is armoured over a 100 m length on the outside slope.
  - Transition from fill to cut at the base of the land bridge (a length of 20m across the 60m channel). This transition was designed to be smooth, however settlement may result in localised steeper slopes.

Photographs of the diversion post-construction are provided in Figure G-6.



Source: BHP Billiton Iron Ore (2016a)

Figure G-5. Herbert's Creek land bridge ground and water profile

Figure G-6. Herbert's Creek land bridge post construction (2019)

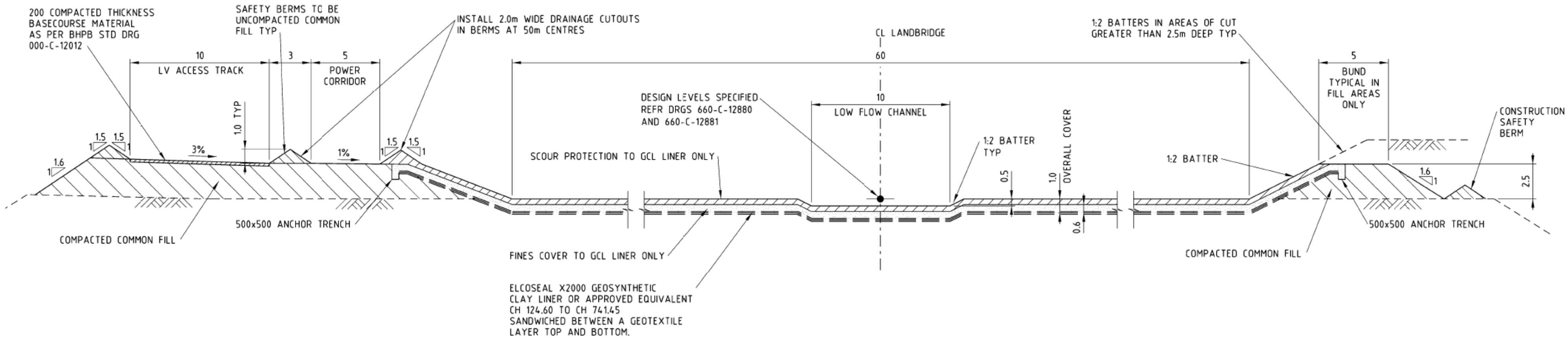


Figure G-7. Herbert's Creek land bridge - typical section

Appendix H BHP procedures

H.1. WAIO AMD Management Standard

H.2. WAIO rehabilitation monitoring procedure

H.3. WAIO borrow pit management & rehabilitation procedure

Appendix I Rehabilitation species list

I.1. Current rehabilitation seed mix for Yandi

This appendix provides the current rehabilitation seed mix for Yandi which has been based on baseline vegetation surveys and rehabilitation experience across BHP’s Pilbara operations.

I.2. Plants of cultural significance to Banjima people

Banjima name	Common name	Latin name	Source
Bajirla	Coastal Caper	*Capparis spinosa subsp. Nummularia*	BHP's ethnobotanical database
Barlgarringu	Bloodwood	*Corymbia hamersleyana*	BHP's ethnobotanical database
Birrungu	-	-	Banjima Yurlubajagu Strategic Plan
Blackart, Gurrabi-unn or Malygan	Snappy Gum	*Eucalyptus leucophloia*	BHP's ethnobotanical database
Burdardu	Northern Sandalwood	*Santalum lanceolatum*	BHP's ethnobotanical database
Burdardu	Sandalwood	*Santalum spicatum*	BHP's ethnobotanical database
Bunga	Type of berry	-	Banjima Yurlubajagu Strategic Plan
Cuggla-leara	Silky Pear	*Marsdenia australis*	BHP's ethnobotanical database
Dam-bar-lee Murruru	Two Nerved Wattle	*Acacia bivenosa*	BHP's ethnobotanical database
Djidda; Djitha; Marla	Native Carrot	*Rhynchosia minima*	BHP's ethnobotanical database
Gawiwarnda	Fish Poison	*Tribulus suberosus*	BHP's ethnobotanical database
Gajawari	Wild orange	-	Banjima Yurlubajagu Strategic Plan
Ganyji	White gum	*Acacia pyrifolia*	BHP's ethnobotanical database
Garlumbu	Wild tomato	-	Banjima Yurlubajagu Strategic Plan
Garlburla	Wild banana	-	Banjima Yurlubajagu Strategic Plan
Garrany	Camel Bush	*Acacia inaequilatera*	BHP's ethnobotanical database
Garrayin	Corkwood Tree	*Hakea lorea subsp. lorea*	BHP's ethnobotanical database
Gudja-wari; Jirrwirliny	Native Orange	*Capparis lasiantha*	BHP's ethnobotanical database
Gurlibirn	Desert honey-myrtle	*Melaleuca glomerata*	BHP's ethnobotanical database
Jami; Jummy Bush	Vicks Bush	*Stemodia grossa*	BHP's ethnobotanical database
Jandaru	Wild honey	-	Banjima Yurlubajagu Strategic Plan
Jarrawayi	River Jam	*Acacia citrinoviridis*	BHP's ethnobotanical database
Jibburra	Rock Melon	*Cucumis melo*	BHP's ethnobotanical database
Jitha; Jidda; Gulyu	Bush Potato	*Ipomoea muelleri*	BHP's ethnobotanical database
Jilgurra or Gurarra	Snakewood	*Acacia tetragonophylla*	BHP's ethnobotanical database
Jilybugarri	Wild passionfruit	-	Banjima Yurlubajagu Strategic Plan
Jummy	Tupentine Bush	*Eremophila fraseri subsp. fraseri*	BHP's ethnobotanical database
Malha	Honeycomb	-	Banjima Yurlubajagu Strategic Plan
Marduwari	Bulrush	*Typha domingensis*	BHP's ethnobotanical database
Marruwa; Bugardi	Snakewood	*Acacia xiphophylla*	BHP's ethnobotanical database
Mathangura	Scent grass	*Cymbopogon ambiguus*	BHP's ethnobotanical database
Mina	Soft Spinifex	*Triodia pungens*	BHP's ethnobotanical database
Mirli	Black tea-tree	*Melaleuca bracteata*	BHP's ethnobotanical database
Mugarli, Jun-Gin/Junjin	Pilbara Pindan Wattle	*Acacia tumida var. pilbarensis*	BHP's ethnobotanical database
Mulumulu	Mulla mulla flowers	-	Banjima Yurlubajagu Strategic Plan
Ngarlgu	Wild onion	*Cyperus bulbosus*	BHP's ethnobotanical database
Nyinarri	Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*	BHP's ethnobotanical database
Thalgu; Tharlgu	Paperbark	*Melaleuca argentea*	BHP's ethnobotanical database
Thambarli	Gundabluey Wattle	*Acacia victoriae subsp. victoriae*	BHP's ethnobotanical database
Weenyarr	White Fig	*Ficus virens*	BHP's ethnobotanical database
Wiranggura	River Red Gum	*Eucalyptus camaldulensis*	BHP's ethnobotanical database
Wiranggura	River Red Gum	*Eucalyptus camaldulensis var. obtusa*	BHP's ethnobotanical database
Wirndamarra	Broad-Leaf Mulga	*Acacia aneura*	BHP's ethnobotanical database
Winyarrangu; Wingga	Desert Fig	*Ficus brachypoda*	BHP's ethnobotanical database
Yaliri	Stiffleaf Sedge	*Cyperus vaginatus*	BHP's ethnobotanical database

Source: BNTAC (2019)

I.3. Species lists for rehabilitation of C1 OSA

I.3.1 2011 rehabilitation areas

Species	Total kgs for Yandi mix	Yandi batch 1 (kgs)	Yandi batch 2 (kgs)	kg/ha
Acacia ancistrocarpa	1.10	0.57	0.53	0.08
Acacia aneura	1.23	0.64	0.59	0.08
Acacia bivenosa	0.83	0.43	0.40	0.06
Acacia citrinoviridus*	0.57	0.30	0.27	0.04
Acacia dictyophleba	1.23	0.64	0.59	0.08
Acacia hamersleyensis	0.11	0.06	0.05	0.01
Acacia hilliana	1.12	0.59	0.54	0.08
Acacia inaequilatera	0.91	0.47	0.44	0.06
Acacia maitlandii	0.68	0.35	0.32	0.05
Acacia monticola	0.77	0.40	0.37	0.05
Acacia pruniocarpa*	0.85	0.44	0.41	0.06
Acacia pyrifolia	1.40	0.73	0.67	0.10
Acacia tenuissima	1.39	0.72	0.67	0.10
Acacia tetragonophylla	1.40	0.73	0.67	0.10
Acacia tumida	0.86	0.45	0.41	0.06
Atalaya hemiglauca	0.41	0.21	0.20	0.03
Calytrix carinata*	0.06	0.03	0.03	0.00
Corymbia hamersleyana	0.61	0.32	0.29	0.04
Cymbopogon ambiguus	4.09	2.13	1.96	0.28
Cymbopogon obtectus	1.64	0.85	0.78	0.11
Eucalyptus gamophylla	1.31	0.68	0.63	0.09
Eucalyptus leucophloia	2.02	1.05	0.97	0.14
Gossypium robinsonii	0.41	0.21	0.20	0.03
Grevillia wickhamii	2.62	1.36	1.26	0.18
Indigofera rugosa	0.41	0.21	0.20	0.03
Petalostylis labicheoides	0.03	0.01	0.01	0.00
Senna artemisioides	2.13	1.11	1.02	0.15
Senna glutinosa subsp. x luerssenii	0.75	0.39	0.36	0.05
Senna hamersleyensis (artemisioides ssp)	1.23	0.64	0.59	0.08
Solanum lasiophyllum	0.57	0.30	0.27	0.04
Trachymene oleracea	1.08	0.56	0.52	0.07
Tribulus hirsutus	0.71	0.37	0.34	0.05
Triodia pungens	71.57	37.24	34.33	4.93
Triodia wiseana	20.45	10.64	9.81	1.41
Legume	**18.57**	**9.66**	**8.91**	**1.28**
Tree	**6.97**	**3.62**	**3.34**	**0.48**
Grass	**97.74**	**50.85**	**46.89**	**6.73**
Other	**3.27**	**1.70**	**1.57**	**0.22**
Total	**126.55**	**65.84**	**60.70**	**8.71**

I.3.2 East face

Species
Acacia adoxa
Acacia ancistrocarpa
Acacia aneura
Acacia arida
Acacia atkinsiana
Acacia bivenosa
Acacia bivenosa
Acacia dictyophleba
Acacia inaequilatera
Acacia inaequilatera
Acacia maitlandii
Acacia maitlandii
Acacia pruinocarpa
Aristida contorta
Cleome viscosa
Corchorus lasiocarpus
Cymbopogon obtectus
Gompholobium sp. Pilbara
Gompholobium oreophilum
Goodenia stobbsiana
Oldenlandia crouchiana
Ptilotus calostachyus
Ptilotus exaltatus
Ptilotus obovatus
Sida echinocarpa
Solanum lasiophyllum
Tribulus platypterus
Corymbia deserticola
Corymbia hamersleyana
Corymbia hamersleyana
Eucalyptus gamophylla
Eucalyptus leucophloia
Grevillea wickhamii hispidula
Grevillea wickhamii hispidula
Indigofera monophylla
Indigofera rugosa
Senna artemisiodes subs oligophylla
Senna glutinosa subs glutinosa
Senna notabilis

I.4. Species list for rehabilitation of E2 OSA 2004

Acacia adoxa 27g/ha

Acacia ancistrocarpa 242g/ha

Acacia grasbyi 46g/ha

Acacia pruinocarpa 333g/ha

Acacia pyrifolia 303g/ha

Maireana triptera 30g/ha

Senna glutinosa 242g/ha

Triodia pungens (Fruit) 400g/ha

Triodia basidowii (Fruit) 760g/ha

Triodia basidowii (Pure Seed) 55g/ha

Eucalyptus leucophloia (Seed and Chaff) 140g/ha

Appendix J Memos provided to BNTAC

J.1. Post-mining land use studies

J.2. Option evaluation summary

J.3. BNTAC comments on draft MCP and BHP responses

Appendix K WAIO closure & rehabilitation research & trials

Summary of findings - rehabilitation performance at BHP's Pilbara operations

Site	Description of Findings from Rehabilitation Performance
General	Scalloping has been demonstrated to be effective on competent overburden materials on slopes below 20°, at slopes higher than 20° or where materials are not competent, erosion tends to be more pronounced. When using scalloping as a rehabilitation technique, the scallops must be 'interlocked' to minimise erosion and optimise the success of revegetation. The construction of bunds on the top of OSAs around the perimeter is essential as it prevents water from flowing down the slopes and minimises erosion potential. Material that has a higher sulphidic content can impact on the success of revegetation. It has been found that using inert overburden material as a cover can minimise the impact of sulphidic material. When applying topsoil, it is preferable that it be incorporated (keyed-in) into the subsurface material to minimise surface erosion. Contour ripping has been effective at slopes below 20°; however, the contours must be surveyed accurately to minimise failure of rip lines. Backfilling pits with overburden material minimises visual impacts of the operations and reduces the need to disturb land for new out-of-pit OSA areas. Increased revegetation success has been observed when seeding has occurred prior to the main wet season (i.e. before January).
Mt Whaleback and Orebody 29/30/35	Previous trials have found that revegetation performance generally increases with greater depth of topsoil application (i.e. there would be an ideal topsoil depth which would be dependent on the species).
Jimblebar - Wheelarra Hill, OB18	Prior to 2004, qualitative rehabilitation monitoring at the Wheelarra Hill mine showed some areas encountered problems due to plants being of the same age. By adjusting the rehabilitation method used, WAIO has demonstrated that this issue can be overcome by undertaking additional seeding (or planting) in subsequent years. Operational experience has indicated that due to the unpredictable rainfall in the Newman area, seed application should, where practicable, be timed to coincide with major rainfall events. Preliminary rehabilitation monitoring results indicate that rehabilitated stockpiled fines are capable of supporting local native species and are exhibiting growth on a trajectory that would suggest that a sustainable ecosystem will develop over time. The batters of the rehabilitated stockpiled fines have not performed well in terms of stability. These batters were generally profiled to a final slope of 20̊, and were directly seeded and contour ripped. High litter development appears to be associated with higher densities of *Triodia* spp. on the rehabilitated stockpiled fines. Higher infiltration and nutrient cycling values recorded in the Landscape Function Analysis monitoring program also appear to be correlated with the high litter content of topsoil.
Marillana Creek (Yandi)	Monitoring of OSA surfaces confirmed significantly advanced rates of recovery in rehabilitated areas with topsoil (i.e. greater than 25% foliar cover) when compared with rehabilitated areas without topsoil (i.e. less than 10% foliar cover). It was also determined that topsoil should be spread at a depth of 50 mm to 60 mm to achieve optimum use of available topsoil resources. Promotion of soil harvesting and progressive rehabilitation has led to high success rates for rehabilitation. As a result of Yandi's soil harvesting, it has been possible for all rehabilitation areas to date to have topsoil applied. Operator ability has been identified as a key factor in successful rehabilitation. Rehabilitation operators where possible are preferentially selected based on their understanding and interest in environmental requirements to generate optimal rehabilitation results.
Yarrie/Nimingarra	Operational experience has indicated that due to the unpredictable rainfall in the Goldsworthy area, seed application should, where practicable, be timed to coincide with major rainfall events. Surface treatment trials are being undertaken to assess stability and revegetation success using no rip and minimal rip treatments, and are incorporated into progressive rehabilitation works.
Mt Goldsworthy	Due to a lack of rehabilitation planning in the early stages of mine development, Mount Goldsworthy has a topsoil deficit. This highlights the need for life of mine planning for rehabilitation, in particular soil recovery and storage. Scalloping has been used effectively on rehabilitated slopes at Goldsworthy. Due to the coarse blocky overburden material scalloping has been able to be used effectively on slopes up to 25°.
Mt Whaleback	Erosion plots established at Mt Whaleback in 2015 continued to be monitored and maintained. The plots at Mt Whaleback represent both analogue and rehabilitated slope conditions. The plots here represent the oldest erosion plots installed on concave surfaces anywhere within the WAIO project area.

Site	Description of Findings from Rehabilitation Performance
Mining Area C	Nine ongoing long-term rock armour trials established in 2012 to assess the effects of varying surface and armour treatments on surface erosion. The treatments assessed comprised: • Detrital material no rip, ripped, scarified; • 1:1 detrital/rock mix no rip, ripped, scarified; and • 1:2 detrital/rock mix no rip, ripped, scarified; Findings: • Detrital material on its own had the highest mean annual erosion rates outside of acceptable design criteria. • Erosion rates for the other rock mixes recorded rates that were within acceptable design criteria ranges. • There was no functional difference between the 1:1 and 1:2 detrital/rock mixes. • The no rip treatment produced slightly more sediment movement in these material types, but well within acceptable design criteria ranges.

Summary of active rehabilitation research

Subject	Research Summary
Seed Management	Pilbara Seed Atlas: a five-year research project involved with the development of practical recommendations for the collection, processing, storage, germination, and efficient use of seeds in mine-site restoration in collaboration with researchers from the Botanic Gardens and Parks Authority. Restoration Seed Bank: initiative is a five-year partnership between BHP Iron Ore, the University of Western Australia, and the Botanic Gardens and Parks Authority to improve the existing 'restoration supply chain' from seed collection, cleaning, drying, storage, treatment, distribution, germination, establishment and monitoring, verification and reporting.
Seed Treatments	Trails commenced at Whaleback to: • Evaluate pelleted seed using local topsoil as a filler rather than inert clay. • Assess flame treated *Triodia* seed compared to non-flamed seed. • Monitor the effect of various ripping depths and scarification to improve surface erosion control. • Observe the position of seed placement using optimised seeding equipment. • Assess the influence of soil amendments on germination • Observe the influence of first summer rain on germination.
Growth Media	Yarrie/Nimingarra: Topsoil deficit has been identified as an issue for future rehabilitation works. As a result, WAIO is conducting a trial to use shallow lateritic material as future growth media on rehabilitated landforms. Yarrie/Nimingarra: Growth media trails utilising in-situ overburden materials are being incorporated into progressive rehabilitation works Growth Media Atlas: to enable successful establishment of vegetation in rehabilitated areas by assessing existing topsoil stockpiles for the chemical, physical and plant growth properties; and identify suitable alternative growth media materials that could be made available for rehabilitation.
Fire Ecology	Jimblebar, Wheelarra Hill, OB18, Marillana Creek (Yandi): WAIO is investigating fire ecology (i.e. response of ecosystems following fire) by monitoring areas which have been burnt. Findings from this investigation will be used to determine the possibility of using fire as a rehabilitation tool and to better manage fire affected areas.
Surface Treatments	Yarrie/Nimingarra: Trial to assess the stability and revegetation success using alternative surface treatments to 'moonscaping', such as contour ripping, and the creation of contour banks. Yarrie/Nimingarra: Surface treatment trials are being undertaken to assess stability and revegetation success using no rip and minimal rip treatments, and are incorporated into progressive rehabilitation works.
Erosion Guidelines	Collaboration with Pilbara Rehabilitation Group Members, Western Australian Biodiversity Institute and Pilbara Mining Industry Funding Partners to develop Acceptable Rates of Erosion Guidelines.
Erosion Trials	Six erosion trial plots at OB18 were installed FY2019, to collect erosion & runoff data from six different surface configurations. Findings from this investigation will be used to determine suitability of each configuration for future rehabilitation applications across OB18. The six different surface treatments comprise: • 500mm rock armour, no growth media; • 250mm of rock armour, no growth media; • 150mm of rock armour, no growth media; • 250mm rock armour, 150mm of growth media; • 500mm rock armour, 150mm growth media; and • 1000mm, rock armour, 150mm growth media.
Remote sensing	Since 2016, BHP have used remote sensing data capture and cross referenced this information with key plant species data. This investigation provides the opportunity to quantitatively assess rehabilitation development across large areas. The project aims to improve vegetation discrimination, (including weed identification), investigate additional data types for vegetation detection; and to develop an integrated remote sensing methodology for rehabilitation monitoring.

Subject	Research Summary
Ecosystem re-establishment	With the use of ants as a biological indicator (bioindicators) of ecological succession in rehabilitation areas, BHP is investigating options to establish a simple invertebrate monitoring procedure that can be used to help assess ecosystem re-establishment. In May 2018, BHP undertook the first phase of survey work to begin establishing a baseline trajectory for ant succession in rehabilitated areas at Goldsworthy Northern Areas. The program sampled 20 sites consisting of 14 rehabilitation areas and six analogue areas. BHP has now completed its third round of monitoring throughout the GNA provenance. Initial results show a favourable correlation between species richness and the age of rehabilitated areas.
Completion criteria	Detailed analysis of rehabilitation monitoring program data has occurred and has been used in the development of draft rehabilitation completion criteria metrics for two post-mining land uses, Pastoral Grazing and Native Habitat. The ongoing review of rehabilitation monitoring data will continue to inform completion criteria development. It is proposed to use the same approach for the assessment of the success of historical rehabilitation. BHP will update predictions of future rehabilitation success as it undertakes progressive rehabilitation and updates its assessment of the success of historical rehabilitation as a hub approaches closure. BHP may also refine criteria/targets over time as new information becomes available.
Vegetative cover	Previous works conducted at Mt Whaleback have identified that vegetation can substantially reduce net percolation, and thus potential acid mobilisation, through plant transpiration. Therefore, the aim of future work will be undertaken to investigate and quantify the role of evapotranspiration on store-and-release cover systems designed to minimise net percolation.

Summary of findings – overburden management at WAIO's Pilbara operations

Subject	Research Summary
Neutralising Mineral Reactions for Control of Acid Completed 2004	Investigation of ARD control including mineral reaction control and hydrogeologic control through cover design, assessment and prediction of short and long-term mineral reactivity in overburden, measurement of the reactivity of minerals with long-term neutralising capacity. Included a case study of Mt Whaleback. Research partners: AMIRA International, University of South Australia, Env. Geochemistry International, Levay & Co. Env. Services Findings: Identified ARD passivation mechanisms and methods for assessing the reactivity of minerals.
Evaluation of ARD Passivation Treatments Completed 2013	Confirmation and definition of ARD passivation mechanisms leading to a methodology for implementation at mining sites using readily available materials. Included a case study of Mt Whaleback. Research partners: AMIRA International, University of South Australia, Env. Geochemistry International, Levay & Co. Env. Services Findings: Improved understanding of pyrite oxidation control and test methods. Identified alternative treatment options for long term ARD control. Extension of the project is planned for long-term acid rock and tailings drainage mitigation through source control.
Acid generating characterisation of stored overburden and current impact upon the surface environment, Mt Goldsworthy Iron Ore Mine Completed 2009	Masters research project investigated OSA overburden material and AMD release at Mt Goldsworthy. Research Partner: Environmental Inorganic Geochemistry Group (EIGG) at Curtin University Findings: Identified the occurrence and characteristics of acid generating overburden on the surface of OSAs and their effects on vegetation. The work is being extended in a PhD research project.
Environmental impact of the storage of lignite overburden from the Jimblebar iron ore mine, Newman, Western Australia 2013	Study of Tertiary lignites (young, immature, low grade coal deposits) that may pose risks of combustion and AMD formation if they contain pyrite or other metal sulphide minerals. Research partner: EIGG at Curtin University Findings: Identified the geochemical and mineralogical nature of the rock types, their sulphide contents, and capacity to release acidic, metal laden drainage. Informs proper management and storage of the overburden material
Investigation into the Rapid Oxidation Potential for Pyrite Containing Mt McRae Shales from Mt Whaleback Completed 2013	Investigation and recommendation of options for treatment of PAF overburden to remove long term liabilities. Research Partners: Umwelt Australia, University of Western Australia, ChemCentre Findings: A desktop study has been completed that reviewed chemical, biological and physical treatment options. Identified possible laboratory and pilot scale trials that could be conducted.
Pit Lake Disposal of Pyritic Shale Completed 2013	Conducted a desktop study of potential subaqueous disposal of shale. Included review of several case studies and examples that have been described in the literature where pit lakes have been used for the pit lake storage of sulphidic overburden material, including overburden and mine tailings. Considered implications for pit lake overburden disposal at Mt Whaleback. Research Partners: Umwelt Australia, ChemCentre Findings: A key finding from the literature review is that pit lakes are considered to be an effective location for the long-term storage of acid generating materials. This information will inform long-term management of Mt Whaleback pyritic overburden and other potentially problematic overburden.

Summary of active overburden research

Subject	Research Summary
Acid Rock Drainage Cover Research Program at Mt. Whaleback and Yarrie mine sites	Cover system field trials have been monitored at the Mt Whaleback site and Yarrie site since 1997. The trials evaluate performance of cover systems of varying thickness that primarily utilise the moisture store-and-release concept. Research partners: O'Kane Consultants.
Mechanisms of acid release from overburden piles containing pyritic carbonaceous shale, Mt Goldsworthy Mine	PhD research project. Detailed study with the overall goal of elucidating not only the full extent of acid-generating potential but also comprehending the kinetics of the geochemical alteration and AMD production. Comparisons will be drawn with other iron ore mine sites across the Pilbara region where shale is encountered to assess implications for overburden management and closure. Research partner: (EIGG) at Curtin University
Analysis for selenium content of iron mining overburden in the Pilbara	Investigation of the difficulties in producing accurate and reliable analysis for Se in geological materials and application of the optimised procedures to environmental samples encountered in WAIO's operations. Research partner: EIGG at Curtin University
Investigation into PAF Overburden and Shale Reactivity Iron Ore Mines in the Pilbara	Isothermal reactor and ARD testing of reactive pyritic shale samples to investigate spontaneous combustion reactivity and ARD potential. Evaluation of the associated management strategies. Research Partner: University of Western Australia

Appendix L Risk assessment supporting information

L.1. Yandi closure risk assessment matrices

Severity matrix

Severity Level	Descriptor
5	6 or more fatalities or 6 or more life shortening illnesses; or Severe impact to the environment and where recovery of ecosystem function takes 10 years or more; or Severe impact on community lasting more than 12 months or a substantiated human rights violation impacting 6 or more people.
4	1-5 fatalities or 1-5 life shortening illnesses; or Serious impact to the environment, where recovery of ecosystem function takes between 3 and up to 10 years; or Serious impact on community lasting 6-12 months or a substantiated human rights violation impacting 1-5 persons.
3	Life altering or long term/permanent disabling injury or illness to one or more persons; or Substantial impact to the environment, where recovery of ecosystem function takes between 1 and up to 3 years; or Substantial impact on community lasting 2-6 months
2	Non-life altering or short-term disabling injury or illness to one or more persons; or Measurable but limited impact to the environment, where recovery of ecosystem function takes less than 1 year; or Measurable but limited community impact lasting less than one month.
1	Low level impact resulting in first aid only; or Minor, temporary impact to the environment, where the ecosystem recovers with little intervention; or Minor, temporary community impact that recovers with little intervention.

Likelihood matrix

Uncertainty	Frequency	Likelihood Factor
Highly Likely	Likely to occur within a 1-year period.	3
Likely	Likely to occur within a 1 - 5-year period.	1
Possible	Likely to occur within a 5 - 20-year period.	0.3
Unlikely	Likely to occur within a 20 - 50-year period.	0.1
Highly Unlikely	Not likely to occur within a 50-year period.	0.03

Risk matrix

L.1.1 Severity level guidance

Environment

Note for some environmental events, other impact types may be more severe or endure longer than environmental ecosystem impacts and therefore also need to be considered - e.g., there may be instances where strict environmental recovery is possible or occurs within a certain timeframe, however the reputational impacts or perceived impacts exceed / outlast the actual environmental impact.

Level	Descriptor	Guidance	Examples include but not limited to:
5	Severe impacts to the environment and where recovery of ecosystem function takes ≥10 years	Activity or event where the environmental status or ecosystem function is altered to such an extent that it is beyond its natural resilience and capacity to recover. Severe impact(s) may be to land, biodiversity, ecosystem services, water resources or air. Extensive remedial action required, however due to loss of environment / ecosystem resilience, full recovery to pre activity/ event condition is not expected within a 10-year period, that is, impairment is expected to be semi-permanent or permanent. Compensation claims likely.	• Water extraction rates above natural recharge levels for an extended timeframe, causing long term or permanent impacts to the resource and its dependent ecosystems. • Causing a species or community to become extinct in the wild or to change IUCN risk status category due to habitat destruction from single or cumulative impacts. • Uncontrolled release / loss of containment of hydrocarbons, minerals / metals or chemicals in a marine or land environment (e.g., significant tailings dam collapse or significant breach of offshore well or pipeline) where recovery or ongoing containment of the contaminant and full rehabilitation is not possible.
4	Serious impacts to the environment, where recovery of ecosystem function takes 3 to < 10 years	Activity or event where the environmental status or ecosystem function is seriously impacted and intervention is required to prevent permanent impacts, however it is still possible for environment / ecosystem resilience to be restored. Activity / event that results in serious impact(s) to land, biodiversity, ecosystem services, water resources or air. Significant remedial action required to restore environment / ecosystem resilience. Recovery to pre activity/ event condition is expected to be possible within a 10-year period. Compensation could be required.	• Uncontrolled release / loss of containment of hydrocarbons, minerals / metals or chemicals in a marine or land environment, which could be a single impact or a cumulative impact over time (e.g., loss of tailings dam containment or loss of containment of concentrate during ship loading impacting water column, sediments and species), but where removal of a significant proportion of the contaminant and rehabilitation is possible, although ecosystem recovery could take a period of up to 10 years. • Uncontrolled release of substances to air (e.g., chlorine gas) resulting in vegetation dieback and / or fauna death, for which a multi-year management program is required to achieve ecosystem recovery. • Unauthorised impact to significant habitat, for which a multi-year management program is required to achieve ecosystem recovery. • Extensive land clearing or significant spread of invasive species, impacting local / regional population function, for which a multi-year management program is required to achieve ecosystem recovery.

Level	Descriptor	Guidance	Examples include but not limited to:
3	Substantial impacts to the environment, where recovery of ecosystem function takes 1 to < 3 years	Activity or event where the environmental status or ecosystem function is substantially impacted or modified, and intervention is required to prevent restore environment / ecosystem resilience within 1 to < 3 years. Activity / event that results in substantial impact(s) to land, biodiversity, ecosystem services, water resources or air. Remediation required. Environment / ecosystem resilience not significantly compromised and recovery to pre activity/ event condition is expected within a 3-year period or small number of growing cycles / seasons.	• Unauthorised impact to significant habitat, however there is sufficient natural resilience to recover within a small number of growing cycles / seasons. • Uncontrolled spread of invasive species which requires a multi-year effort to control spread. • Unauthorised release of mine affected water/ sediments which impacts water quality or ecosystem health. • Uncontrolled release of substances to air resulting in vegetation dieback and / or fauna death, however there is sufficient natural resilience to recover within a small number of growing cycles / seasons. • Short term impacts to water quality and availability that may cause some fluctuations in that natural environment, however there is sufficient natural resilience to recover within a small number of growing cycles / seasons.
2	Measurable but limited impacts to the environment, where recovery of ecosystem function takes <1 year	Activity / event that results in measurable impact(s) to land, biodiversity, ecosystem services, water resources or air. Although measurable, severity of impacts is limited in scope and extent. Some remediation generally required, but the environment / ecosystem is expected to recover to pre activity / event conditions within 1 year.	• Spills of hazardous materials (e.g., radioactive process material, hydrocarbon, chemical, sewage) that cannot be cleaned up immediately and persists in the environment for up to 1 year, or where once the contaminant has been removed, little additional remediation is required. • Moderate unauthorised land clearance or unauthorised vegetation removal impacting on a listed species; but where there is sufficient ecosystem resilience to substantially recover within a growing cycle / season. • Invasive species identified outside known extent, spread needs to be controlled; but where there is sufficient ecosystem resilience to substantially recover within a growing cycle / season. • Unauthorised release of mine affected water / sediments which impacts water quality or ecosystem health, but where there is sufficient ecosystem resilience to substantially recover within a growing cycle / season.
1	Minor, temporary impacts to the environment, ecosystem recovers with little or no intervention.	Activity / event that impacts the environment in a way that is of limited duration and does not change the receiving environment from baseline conditions. No remediation generally required or limited to immediate response activities such removal of released contaminants where appropriate.	• Unauthorised release of mine affected water but compliant with downstream water quality limits. • Unauthorised release of sediments to waterways but no material build-up of sediment. • Minor unauthorised land clearance or unauthorised vegetation removal. • Incorrect waste storage / transport / disposal / minor spill of hazardous materials / liquids. • Invasive species identified outside known extent, spread prevented. • Vehicle strike to fauna. • Topsoil not recovered during clearing activity. • Exceedance of dust limit recorded at township monitor, determined to be due to BHP activity. • Unauthorised discharge of water with low level of hydrocarbon contamination.

Community

Level	Descriptor	Level
5	Severe impact on community lasting more than 12 months or a substantiated human rights violation impacting 6 or more people	• Environmental disaster leaves people without a source of income. Long term this can lead to welfare dependency and uncertainty about future livelihood options. • Spiritual disconnection from Country / places of cultural significance can impact mental health and ability to function productively as a member of the community. • Irreparable damage to places of spiritual / cultural significance. • Multiple community fatalities. • Loss of access to community water supply resulting from BHP activities. • Impacts to economic viability of entire township or village (e.g., change to workforce model removes residential population).
4	Serious impact on community lasting 6-12 months or a substantiated human rights violation impacting 1-5 persons	• Health concerns, triggered by perception of dust, or caused by dust from mining operations. • Significant damage to community infrastructure caused by mining operations (e.g., subsidence to roads, blast impacts). • Loss of agriculture / fisheries or wild fauna (previously used for hunting) due to mining operations. • Repairable damage to places of spiritual / cultural significance. • Community opposition resulting in regulatory or legal action and / or intervention.
3	Substantial impact on community lasting 2-6 months	• Damage to an Indigenous cultural site. • Damage to community infrastructure i.e., cracks in houses due to subsidence or blasting. • Sustained Community protest activities outside our office or mine site with ongoing disruption to work. • Multiple community complaints such as dust, noise, vibration, increased heavy vehicle traffic requiring strategic action.
2	Measurable but limited community impacts lasting less than one month	• Multiple community complaints such as dust, noise, vibration, increased heavy vehicle traffic requiring strategic action. • Community protest activities outside our office or mine site with minimal disruption to work. • Environmental impact restricts community access to land / water / infrastructure (e.g., Water releases increase flows and cut off road access).
1	Minor, temporary community impacts that require little or no intervention	• Community protest activities outside our office or mine site with no disruption to work. • Individual community complaints relating to operational activities, including noise, dust, vibration, heavy vehicle traffic.

L.2. Risk framing

See pages embedded in main MCP document

Appendix M Completion criteria

M.1. Syrinx review of completion criteria