



Vimy Resources Limited

Tailings Storage Facility Monitoring and Management Plan

(Outcome-Based Condition Environmental Management Plan)

Mulga Rock Uranium Project

EMP-EHS-008

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Summary

Title of the proposal	Mulga Rock Uranium Project
Proponent	Vimy Resources Limited
Ministerial Statement Number	1046
Purpose of this Condition EMP	The Tailings Storage Facility Monitoring and Management Plan is submitted to fulfil the requirements of Conditions 6 and 15 of the above Statement.
EPA's environmental objective for the key environmental factor/s	Inland Waters Environmental Quality To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.
Condition environmental outcome or proposed measurable outcome	<ol style="list-style-type: none"> (1) Ensure that the tailings plume is within background groundwater concentrations at the M39/1080 lease boundary as shown in Figure 4 of Schedule 1 and defined by the geographic coordinates in Schedule 2; (2) Ensure that the in-pit TSFs are designed to have at least 2 metres of carbonaceous material beneath them and they are covered with a minimum of 1 metre of appropriate material to act as a capillary break at closure; and (3) Ensure that the above-ground Tailings Storage Facility is designed to have at least a 1 metre clay liner beneath it and is covered with a minimum of 1 metre of appropriate material to act as a capillary break at closure.
Key provisions	<p>Trigger Criterion 1a: Groundwater quality (as measured by pH and TDS) ≥ 1.65 standard deviations different from background groundwater concentrations at the location of the Trigger Monitoring Bores for three or more consecutive monitoring periods (a monitoring period is three months). Data will be adjusted for skew and kurtosis or whatever transformation is required to create a standard normal distribution.</p> <p>Trigger Criterion 1b: Water sampling for metal ions (Zn, Ni, Cu, Co, U – in mg/L) ≥ 1.65 standard deviations above baseline data for the same bore when tested as a result of Trigger Criterion 1a being exceeded. Data will be adjusted for skew and kurtosis or whatever transformation is required to create a standard normal distribution.</p> <p>Threshold Criterion 1: Groundwater quality ≥ 2 standard deviations above background groundwater concentrations at the 'geographic co-ordinates in Schedule 2 of MS1046 that relate to the ML39/1080 lease boundary' for three or more consecutive monitoring periods (a monitoring period is three months). Data will be adjusted for skew and kurtosis or whatever transformation is required to create a standard normal distribution.</p> <p>Trigger Criterion 2: Carbonaceous layer beneath the in-pit TSFs ≤ 2.5m.</p> <p>Threshold Criterion 2: Carbonaceous layer beneath the in-pit TSFs ≤ 2m.</p>



	Trigger Criterion 3: Clay liner beneath above ground TSF \leq 1.2m.
	Threshold Criterion 3: Clay liner beneath above ground TSF \leq 1m.
	Trigger Criterion 4: Capillary break above the dried / consolidated tailings surface is \leq 1.2m.
	Threshold Criterion 4: Capillary break above the dried / consolidated tailings surface is \leq 1m.

1. Context, Scope and Rationale

1.1 Proposal

Vimy Resources Limited (Vimy) proposes to develop the Mulga Rock Uranium Project (MRUP or the Project) which lies approximately 240km east-north-east of Kalgoorlie-Boulder in the Shire of Menzies. The area is remote, located on the western flank of the Great Victoria Desert (GVD), comprising of a series of large, generally parallel sand dunes, with inter-dunal swales and broad flat plains.

The MRUP covers approximately 102,000 hectares on granted mining tenure (primarily M39/1104 and M39/1105) within Unallocated Crown Land (UCL). It includes two distinct mining centres, Mulga Rock East (MRE) comprising the Princess and Ambassador resources and Mulga Rock West (MRW) comprising the Emperor and Shogun resources, which are approximately 20km apart. The deposits will be mined using large-scale open pits to produce an annualised peak capacity of 2,180 t/a (4.8 Mlbs) U₃O₈.

The anticipated Life-of-Mine (LOM) is up to 16 years, based on the currently identified resource.

This Condition Environment Management Plan (CEMP) has been written in accordance with the *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans* (EPA, 2016).

1.2 Key Environmental Factor/s

This Tailings Storage Facility Monitoring and Management Plan specifically addresses the Inland Waters Environmental Quality Environmental factor, which is part of the overall Water Theme.

The MRUP will result in the generation of a tailings product which will be stored in in-pit tailings storage facilities (TSFs). These TSFs will be operated, decommissioned, rehabilitated, and closed in accordance with the following standards to ensure their long-term safety and stability, and that they are geochemically non-polluting and can support sustainable rehabilitation:

- DME (1998). Guidelines on the Development of an Operating Manual for Tailings Storage.
- DME (1999). Guidelines on the Safe Design and Operating Standards for Tailings Storage.
- DMP (2013) Tailings Storage Facilities in Western Australia: Code of Practice.
- ANCOLD (2012). Guidelines on tailings dams - Planning, design, construction, operation and closure.
- ICOLD (2013). Bulletin 153 – Sustainable design and post-closure performance of tailings dams.
- ICOLD (2011). Bulletin 139 – Improving tailings dam safety - Critical aspects of management, design, operation and closure.
- ICOLD (1996). Bulletin 106 – A guide to tailings dams and impoundments - Design, construction, use and rehabilitation.

Whilst the in-pit TSFs will adhere to the above standards and best practice, the following risks have been identified based on a source-pathway-receptor model:

Impact Group	Risk
Groundwater quality	Impact on background groundwater quality in response to seepage of tailings liquor into the groundwater and / or soil

It is important to note that risks associated with tailings production and storage at the MRUP to members of the public, non-human biota and Terrestrial Environmental Quality are covered by Condition 16 and the corresponding Above Ground Tailings Storage Facility Monitoring and Management Plan. Furthermore, impacts on groundwater quality from Acid and Metalliferous Drainage (AMD) and reinjection of surplus water into the aquifer are covered by Condition 12 and the corresponding Groundwater Monitoring and Management Plan.

This CEMP provides specific Environmental Criteria (Trigger and Threshold Criteria) and Response Actions (Trigger Level and Threshold Contingency Actions) to provide long-term protection for the above impact group against the identified risks.

1.3 Condition requirements

Condition	Section in Condition EMP
<p>15-1 The proponent shall manage the design and maintenance of all TSFs to meet the following environmental outcomes:</p> <ul style="list-style-type: none"> (1) Ensure that the tailings plume is within background groundwater concentrations at the M39/1080 lease boundary as shown in Figure 4 of Schedule 1 and defined by the geographic coordinates in Schedule 2; (2) Ensure that the in-pit TSFs are designed to have at least 2 metres of carbonaceous material beneath them and they are covered with a minimum of 1 metre of appropriate material to act as a capillary break at closure; and (3) Ensure that the above-ground Tailings Storage Facility is designed to have at least a 1 metre clay liner beneath it and is covered with a minimum of 1 metre of appropriate material to act as a capillary break at closure. 	Whole document
<p>15-2 The proponent shall consult with the Department of Mines and Petroleum and prepare a Tailing Storage Facility Monitoring and Management Plan required by condition 6-1 that satisfies the requirements of condition 6-2, to meet the outcomes of condition 15-1.</p>	Section 4
<p>15-3 The Tailings Storage Facility Monitoring and Management Plan required by condition 6-1 shall include provisions required by condition 6-2 to manage impacts on groundwater quality including from, but not limited to seepage of contaminants into the groundwater and/or soil.</p>	Section 2
<p>15-4 The proponent shall continue to implement the version of the Tailing Storage Facility Monitoring and Management Plan most recently approved by the CEO until the CEO has confirmed by notice in writing the Tailings Storage Facility Monitoring and Management Plan required by condition 6-1 satisfied the requirements of condition 6-2 to meet the outcomes required by condition 15-1.</p>	Whole document

As mentioned above, the key aspects of safety, and geotechnical and geomorphological stability are explicitly addressed in Condition 16-1 and the associated outcome-based Above Ground Tailings Storage Facility Monitoring and Management Plan, whilst impacts on groundwater quality from AMD and reinjection of surplus water are covered by Condition 12-1 and the management-based Groundwater Monitoring and Management Plan. This CEMP therefore covers the geochemical stability (i.e. non-polluting) risks associated with the TSFs.

1.4 Rationale and approach

1.4.1 Survey and study findings

Tailings will be generated as a by-product from the processing of the carbonaceous-material-hosted uranium-bearing ore. Processing will involve the following stages:

- Beneficiation of the ore to remove sand (quartz) particles using conventional gravity / screening techniques;
- Milling (to 150µm);
- Extraction of the uranium from the ore using H₂SO₄;
- Capturing the released uranium using Resin-In-Pulp;
- Stripping of uranium from the loaded resin; and
- Uranium conditioning (nano-filtration, precipitation, drying, packaging).

Extensive tailings geochemical characterisation, including seepage quality, has been completed as part of the PER (Vimy, 2015) and for the Definitive Feasibility Study (DFS) piloting program for the processing plant. The results from this test work are summarised below.

Parameter	Unit	Value
Physical properties		
Particle size distribution		
Passing 300µm	%	100
Passing 200µm	%	98.6
Passing 150µm	%	92.8
Passing 75µm	%	82.6
Passing 20µm (Silt + Clay)	%	35.5
Passing 2µm (Clay)	%	29.6
Specific gravity	t/m ³	2.19
Water retention properties		
0kPa	% v/v	63.1
10kPa	% v/v	42.6
33kPa	% v/v	38.3
100kPa	% v/v	30.7
1,500kPa	% v/v	21.1
Geochemical properties		
Inherent pH	-	1.67
Inherent electrical conductivity (EC; salinity)	mS/m	> 2,500
pH _{FOX} (peroxide oxidation)	-	1.62
Acid Rock Drainage Properties		
Total Sulphur (including sulphate)	% w/w	3.73
Sulphide Sulphur	%w/w	2.25
Chromium Reducible Sulphur	% w/w	0.45
Net Acid Generation (NAG) - pH 4.5	kg H ₂ SO ₄ /t	47.15
Net Acid Generation (NAG) - pH 7.0	kg H ₂ SO ₄ /t	107.50
Acid Neutralisation Capacity (ANC)	kg H ₂ SO ₄ equiv./t	<0.5
Acid Neutralisation Capacity (ANC)	% CaCO ₃	<0.25
Total Carbon	% w/w	20.45
Base cations		
Calcium	% w/w	0.03
Magnesium	% w/w	0.02
Sodium	% w/w	0.10
Potassium	% w/w	0.10
Base anions		
Chloride	% w/w	0.51
Silica	% w/w	22.00
Metals / Metalloids		

Aluminium	% w/w	6.65
Arsenic	ppm	16.5
Barium	ppm	234
Cadmium	ppm	7
Chromium	ppm	444
Cobalt	% w/w	0.0605
Copper	% w/w	0.24
Iron	% w/w	1.105
Lead	% w/w	0.05
Manganese	ppm	<100
Mercury	ppm	39.05
Molybdenum	ppm	15
Nickel	% w/w	0.125
Selenium	ppm	297
Thorium	ppm	62.5
Tin	ppm	1.2
Titanium	ppm	57.5
Uranium	ppm	201
Vanadium	ppm	89.5
Zinc	% w/w	0.053
<u>Rare Earths</u>		
Lanthanum	ppm	85.5
Neodymium	ppm	87.5
Praseodymium	ppm	23.5
Zirconium	ppm	30.75

Actual (i.e. entrained tailings liquor) and potential seepage (i.e. determined using Australian Standard Leach Procedure – ASLP) quality are provided below. Bold values exceed the Department of Health (DoH, 2006) Domestic non-potable groundwater use criteria, emphasising their elevated status.

Parameter	Units	ASLP Acetic Acid Leach (mg/L)	ASLP Water Leach (mg/L)	Seepage Quality from Free-Draining Columns (mg/L)	Extracted tailings liquor (mg/L)
Basic properties					
pH	-	2.9	5.0	1.74	1.20
Electrical conductivity	µS/cm	-	-	>25,000	43,633
TDS	mg/L	-	-	>15,000	66,800

Parameter	Units	ASLP Acetic Acid Leach (mg/L)	ASLP Water Leach (mg/L)	Seepage Quality from Free-Draining Columns (mg/L)	Extracted tailings liquor (mg/L)
Base cations					
Calcium	mg/L	373	237	623	592
Magnesium	mg/L	239	231	503	483
Sodium	mg/L	3,950	2,175	6,840	7,150
Potassium	mg/L	80	81	149	31
Base anions					
Chloride	mg/L	5,562	3,965	11,700	10,500
Silicon	mg/L	98	17	143	131
Sulphate (as SO ₄ ²⁻)	mg/L	16,050	3,590	12,250	26,167
Metals and Metalloids					
Aluminium	mg/L	126	114	1,530	1,353.33
Antimony	mg/L	<0.01	<0.01	<0.01	<0.01
Arsenic	mg/L	1.1	0.2	1.6	0.78
Barium	mg/L	<0.1	0.2	0.02	0.12
Cadmium	mg/L	4.0	1.6	7.4	14.00
Cobalt	mg/L	89	<0.01	179	216.33
Chromium	mg/L	5.5	4.7	20	25.07
Copper	mg/L	610	48	699	836.67
Caesium	mg/L	18	102	0.02	-
Iron	mg/L	651	124	3,620	3,603.33
Lead	mg/L	4.4	4.8	6.6	8.74
Manganese	mg/L	4.1	4.0	11.2	19.03
Mercury	mg/L	0.0001	0.0001	0.00025	0.00043
Nickel	mg/L	159	70	363	360.67
Selenium	mg/L	4.7	2.5	10.3	3.02
Thorium	mg/L	6.5	0.9	2.5	3.19
Tin	mg/L	0.1	0.2	<0.01	<0.01
Titanium	mg/L	<0.01	<0.01	<0.01	0.187
Uranium	mg/L	9.2	2.2	14.2	51.23
Vanadium	mg/L	<0.10	1.7	20	15.03
Zinc	mg/L	342	144	1,111	774.33
Rare Earths					
Lanthanum	mg/L	2.6	2.2	15	7.11

Parameter	Units	ASLP Acetic Acid Leach (mg/L)	ASLP Water Leach (mg/L)	Seepage Quality from Free- Draining Columns (mg/L)	Extracted tailings liquor (mg/L)
Neodymium	mg/L	13.3	6.3	40	33.20
Praseodymium	mg/L	2.6	1.5	9.6	6.42
Zirconium	mg/L	<0.05	<0.05	0.07	< 0.05

Baseline groundwater quality data for the palaeodrainage channel is summarised below.

Parameter	Units	Ambassador/Princess			Shogun			Emperor			Reinjection Borefield		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Basic Properties													
pH	-	3.50	7.23	5.24	2.91	5.47	3.71	2.89	7.90	4.35	3.93	6.90	4.96
TDS	mg/L	7,200	75,200	22,047	26,600	113,400	58,289	6,067	146,900	64,860	6,400	73,900	47,951
Conductivity	uS/cm	1,300	122,000	35,928	23,600	177,200	96,540	11,689	229,600	101,605	9,500	121,000	74,246
ORP	mV	-364	335	19	151	167	157	108	108	108	-57	295	159
Redox	mV	-9	181	59	157	157	157	-	-	-	37.60	181	114
Alkalinity	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Base Cations and Anions													
Cl	mg/L	330	38000	12410	7029	56090	36145	17470	75620	38578	2900	41000	27151
Na	mg/L	190	24000	7194	4150	34500	21443	10500	45000	22778	1500	24000	16022
K	mg/L	8	740	229	93	675	428	220	935	521	110	610	433
Ca	mg/L	15	1185	488	438	790	587	220	710	480	150	540	440
Mg	mg/L	19	2400	716	358	3195	1957	550	3995	2097	270	2400	1650
Fe	mg/L	0.1	51.0	5.5	2.1	55.0	24.7	0.3	190.0	29.9	0.6	10.0	7.2
HCO3	mg/L	4.9	2100.0	183.0	0.6	15.0	4.3	0.6	165.9	53.6	6.0	99.0	45.4
CaCO3	mg/L	3.9	1700.0	200.5	-	-	-	-	-	-	29.0	81.0	45.5
SO4	mg/L	8	5600	2489	3900	11500	8482	2460	13600	7033	880	8000	5257
Cl/SO4	mg/L	3.3	5.9	4.8	1.0	18.0	4.6	0.1	20.0	3.4	3.3	5.1	5.2
NO3	mg/L	0.10	11.00	3.75	0.10	2.00	1.05	0.70	0.80	0.75	-	-	-
Trace Metals and Metalloids													
Al	mg/L	-	-	-	0.1	2	1.05	0.7	0.8	0.75	-	-	-

Parameter	Units	Ambassador/Princess			Shogun			Emperor			Reinjection Borefield		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
As	mg/L	0.030	0.030	0.030	0.009	0.009	0.009	0.002	0.004	0.003	0.026	0.026	0.026
Au	mg/L	0.005	0.021	0.011	-	-	-	-	-	-	-	-	-
B	mg/L	0.85	2.70	1.57	0.03	0.03	0.03	0.03	0.03	0.03	3.00	7.20	5.17
Ba	mg/L	0.02	0.16	0.05	-	-	-	-	-	-	0.02	0.08	0.04
Be	mg/L	0.01	0.02	0.01	22.50	46.40	34.45	30.90	71.40	51.15	-	-	-
Br	mg/L	3.30	23.30	15.67	0.01	0.01	0.01	0.00	0.01	0.01	-	-	-
C	mg/L	0.001	0.377	0.054	-	-	-	-	-	-	-	-	-
Cd	mg/L	0.001	0.319	0.037	0.002	0.077	0.040	0.012	0.012	0.012	0.004	0.004	0.004
Cr	mg/L	0.002	0.065	0.010	-	-	-	-	-	-	0.025	0.027	0.026
Cs	mg/L	0.001	0.022	0.012	-	-	-	-	-	-	-	-	-
Cu	mg/L	0.005	2.800	0.433	0.011	0.011	0.011	-	-	-	0.022	0.980	0.240
Co	mg/L	0.005	4.000	0.581	0.400	0.700	0.550	0.200	0.800	0.467	0.015	0.024	0.020
F	mg/L	0.600	0.600	0.600	-	-	-	-	-	-	0.400	0.600	0.500
Hg	mg/L	0.000	0.000	0.000	0.300	0.520	0.410	0.630	0.940	0.785	0.000	0.001	0.001
I	mg/L	0.010	0.770	0.334	0.004	0.022	0.013	0.008	0.017	0.013	-	-	-
Pb	mg/L	0.001	3.100	0.200	-	-	-	-	-	-	0.005	0.110	0.045
PO4	mg/L	0.010	4.890	1.233	-	-	-	-	-	-	-	-	-
Mo	mg/L	0.008	0.035	0.018	1.450	1.640	1.545	0.950	1.800	1.375	-	-	-
Mn	mg/L	0.050	3.100	0.921	-	-	-	-	-	-	0.094	1.600	0.802
N	mg/L	-	-	-	0.010	0.070	0.043	0.020	0.070	0.045	-	-	-
Ni	mg/L	0.006	3.800	0.406	-	-	-	-	-	-	0.023	0.180	0.066

Parameter	Units	Ambassador/Princess			Shogun			Emperor			Reinjection Borefield		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Sb	mg/L	0.005	0.015	0.010	4.400	14.700	8.033	3.300	40.000	23.167	-	-	-
Si	mg/L	0.3	34.0	11.0	-	-	-	-	-	-	12.0	53.0	26.8
Se	mg/L	0.007	0.100	0.039	9.700	10.100	9.900	7.700	8.800	8.250	-	-	-
Sr	mg/L	1.700	11.800	5.960	0.005	0.005	0.005	0.006	0.009	0.007	-	-	-
Th	mg/L	0.005	10.000	1.574	-	-	-	-	-	-	-	-	-
Tl	mg/L	0.000	0.001	0.000	0.007	0.007	0.007	0.007	0.030	0.018	-	-	-
U	mg/L	0.002	0.068	0.021	-	-	-	-	-	-	-	-	-
V	mg/L	0.002	0.009	0.005	-	-	-	-	-	-	-	-	-
W	mg/L	0.003	0.005	0.004	-	-	-	-	-	-	-	-	-
Y	mg/L	0.002	0.008	0.004	0.035	0.180	0.128	0.015	0.155	0.085	-	-	-
Zn	mg/L	0.005	13.000	1.259	-	-	-	-	-	-	0.150	2.400	0.484

Vimy is required to manage the design and maintenance of all TSF facilities so as to ensure that were there to be a tailings plume that reached lease boundary M39/1104, that plume would be no worse than normal background concentrations within the groundwater at what is now lease boundary M39/1104.

Vimy has not undertaken baseline groundwater surveys at what is the lease boundary of M39/1104 and proposes that such groundwater surveys to establish baseline groundwater quality data will be undertaken once mining activity commences.

Three monitoring bores will be established along the southern edge of lease boundary for M39/1104 (**Threshold Monitoring Bores**) as shown in Figure 1, and a further three monitoring bores (**Trigger Monitoring Bores**) will be established in the area between the Threshold Monitoring Bores and the southern edge of the mine pit area. The Trigger Monitoring Bores will be located approximately 2 kilometres north of the lease boundary within the area that hosts the paleochannel through which any tailings plume would necessarily flow.

During the development of the monitoring bores (3 Threshold Monitoring Bores and 3 Trigger Monitoring bores), each bore will be pumped until water quality stability has been achieved and then pumped for sufficient duration (at least 1 hour) to establish at least three separate water quality samples (each separated by 30 minutes of pumping) from each bore. In total at least 18 samples. Thereafter the process will be repeated at 6 monthly intervals over the first two years making a total of at least 80 samples. The samples will be tested for salinity (TDS), acidity (pH) and for key metal ions in solution (mg/L for Zinc, Nickel, Copper, Cobalt and Uranium). The data will be analysed for skew and kurtosis and its distribution transformed into a standard normal distribution with an adjusted mean and an adjusted deviation around that mean. All subsequent observations will undergo the same transformation so that transformed observations are being compared to what has become a standard normal distribution. This will remove any bias related to potentially large variations.

The Monitoring Bores (Threshold and Trigger) will be continuously monitored (for pH and TDS) using an appropriate data logger located in the groundwater inside the Monitoring Bores at an appropriate depth. A record of the pH and TDS will be made each quarter at each bore. These observations will be added to the baseline data (established during the first two years) and re-analysed to establish a cumulative adjusted mean and an associated distribution.

Metal ions concentrations will not be measured (after the initial two year period when baseline data is being established) unless acidity increases (pH falls) to a level above 1.65 adjusted standard deviations from the established cumulative adjusted mean for three consecutive periods (a monitoring period is three months) at any one of the three Trigger Monitoring Bores. Note that due to logarithmic nature of pH calculations the level of acidity will be converted from pH back into underlying hydrogen ion activity when calculating mean values and standard deviations.

For the purposes of complying with Condition 15-1(1), background groundwater concentrations are deemed to be a range of '3 standard deviations' about the mean value (both suitably adjusted). However, it should be noted that natural variation would still be expected to sometimes take samples outside this range. Note that if a plume from the TSF was able to travel to the lease boundary without the metals being dissipated or absorbed during the process the concentration of the contaminants would be expected to be considerably more than '3 standard deviations' above the mean. Threshold Criterion 1, where groundwater quality has been outside a range of '2 standard deviations' different from a mean for '3 consecutive periods' indicates a high possibility that groundwater was potentially being impacted by something that was taking it beyond normal background variation. For monitoring purposes acidity is used as an indicator that metal ion concentrations could be being altered and only when high readings are observed (low pH) would metal sampling be undertaken and the results incorporated into the cumulative average and associated standard deviation (appropriately adjusted).

1.4.2 Key Assumptions and uncertainties

It is assumed that the baseline data collected for the MRUP, and which has been used to assess the risks associated with the Project, have sufficiently captured and characterised the heterogeneity of materials to be disturbed and their handling and utilisation risks. However, given the large spatial extent of the MRUP, it is possible that some materials and processes may not have been identified and quantified sufficiently to accurately assess risk. It is important to note that the characterisation of materials and understanding of processes will continue throughout the LoM of the Project and thus the risks will be continually updated and reviewed, as part of the Adaptive Management Approach (Section 3).

1.4.3 Management approach

The management approach to be applied is based on sound scientific and technical understanding of the geochemical risks to groundwater quality, and of the processes that may adversely impact on Inland Waters Environmental Quality of the region. Management targets and actions have therefore been developed on these principles to ensure that they are realistic, attainable, and effectively reduce the identified risks.

In addition, the management approach will rely on:

- Environmental Inductions – to ensure that all new personnel entering the MRUP are aware of the environmental qualities within the MRUP and how their actions may impact on these qualities.
- Environmental Training – this will ensure that all personnel undertaking works on the proposed TSFs are properly trained, are competent to perform the task, and that fit-for-purpose equipment is used to minimise the existing and future risks to baseline groundwater quality and the Inland Waters Environmental Quality of the region.
- Contributing Factors – identification and implementation of management actions to minimise and prevent the contributing factors that may increase the risks to baseline groundwater quality and may lead to adverse impacts on the surrounding environmental qualities.

If monitoring shows that the TSF's represent an existing or developing geochemical / contamination issue, then investigations will be undertaken to determine the contributing factors and re-evaluate the appropriateness of existing response actions, establishing new response actions if required, to achieve the performance indicators and overall environmental outcome.

1.4.4 Rationale for choice of provisions

A performance indicator has been established for each contributing factor listed in Section 1.2 that may influence the geochemical stability of the TSFs and the potential impact on groundwater quality. It is expected that by implementing the identified performance indicators, and response actions where required, then the environmental outcome will be met.

Further protection of Terrestrial Environmental Quality and Inland Waters Environmental Quality will be achieved by Condition 16-1 which requires that the TSFs are safe to members of the public and non-human biota and are geo-technically and geomorphologically stable. Similarly, protection of groundwater quality from AMD and reinjection of surplus water will be achieved by Condition 12-1 which requires that impacts to groundwater quality are minimised as far as practicable.

2. Condition EMP Provisions

This section of the EMP identifies the legal provisions that Vimy proposes to implement to ensure that the TSFs are geochemically stable, and that the risks to baseline groundwater quality are minimised as far as practicable. It identifies the performance indicators that Vimy will implement and how they will be

monitored and reported, to achieve the environmental outcomes of Condition 15-1. Table 1 provides a detailed list of these provisions.

This section also identifies how Vimy will review and revise the performance indicators and the corresponding response actions if the performance indicators are exceeded.

2.1 Outcome

As specified in Ministerial Statement No. 1046 the environmental outcomes for Condition 15-1 are:

- Condition 15-1(1): Ensure that the tailings plume is within background groundwater concentrations at the M39/1080 lease boundary as shown in Figure 4 of Schedule 1 and defined by the geographic coordinates in Schedule 2; and
- Condition 15-1(2): Ensure that the in-pit TSFs are designed to have at least 2 metres of carbonaceous material beneath them and they are covered with a minimum of 1 metre of appropriate material to act as a capillary break at closure; and
- Condition 15-1(3): Ensure that the above-ground Tailings Storage Facility is designed to have at least a 1 metre clay liner beneath it and is covered with a minimum of 1 metre of appropriate material to act as a capillary break at closure.

2.2 Performance indicators (environmental criteria)

The following performance indicators (Trigger and Threshold Criteria) have been identified to ensure that the above environmental outcome is achieved:

Trigger Criterion 1a:	Groundwater quality (as measured by pH and TDS) ≥ 1.65 standard deviations different from background groundwater concentrations when measured at the Trigger Monitoring Bores (located between the lease boundary and the southernmost area of the mining pit – approximately 2km north of the lease boundary). Data will be adjusted for skew and kurtosis or whatever transformation is required to create a standard normal distribution.
Trigger Criterion 1b:	Water sampling for metal ions (Zn, Ni, Cu, Co, U – in mg/L) ≥ 1.65 standard deviations above baseline data for the same bore when tested as a result of Trigger Criterion 1a being exceeded. Data will be adjusted for skew and kurtosis or whatever transformation is required to create a standard normal distribution.
Threshold Criterion 1:	Groundwater quality ≥ 2 standard deviations above background groundwater concentrations at the 'geographic co-ordinates in Schedule 2 of MS1046 that relate to the ML39/1080 lease boundary' for three or more consecutive monitoring periods (a monitoring period is three months). Data will be adjusted for skew and kurtosis or whatever transformation is required to create a standard normal distribution.
Trigger Criterion 2:	Carbonaceous layer beneath the in-pit TSFs ≤ 2.5 m.
Threshold Criterion 2:	Carbonaceous layer beneath the in-pit TSFs ≤ 2 m.
Trigger Criterion 3:	Clay liner beneath above ground TSF ≤ 1.2 m.
Threshold Criterion 3:	Clay liner beneath above ground TSF ≤ 1 m.
Trigger Criterion 4:	Capillary break above the dried / consolidated tailings surface is ≤ 1.2 m.
Threshold Criterion 4:	Capillary break above the dried / consolidated tailings surface is ≤ 1 m.

Background groundwater concentrations will be calculated from measurements taken from Trigger Monitoring Bores and Threshold Monitoring Bores, and will be updated each monitoring period to give a cumulative mean and a calculated standard deviation around that cumulative mean.

Since the pH is the decimal logarithm of the reciprocal of the hydrogen ion activity in a solution, using the mean value of pH readings may marginally skew the estimate of background water quality away from the true mean of the hydrogen ion activity. In calculating background groundwater pH values and the associated standard deviation values, the pH values will be converted back into the underlying hydrogen ion activity in order to calculate the mean and standard deviations and then reconverted back into pH values to express the limits of the parameters so calculated.

All data will be analysed for skew and kurtosis and, if necessary, adjusted by an algorithm that transforms the data into a distribution that approximates a standard normal distribution. Samples will then be transformed by the same algorithm which effectively enables monitoring to avoid the effects of large variations in the data when baselines are established.

2.3 Response actions

The following specific response actions will be implemented if monitoring identifies that the above performance indicators are exceeded.

Trigger Criteria 1a and then 1b:

Trigger Level Actions

- Investigate potential sources and contributing factors for the Trigger Criteria exceedance – initially this would involve extended pumping from the Trigger Monitoring Bores to check whether the levels being recorded are stable under extended pumping and sampling of monitoring bores both upstream and downstream from the Trigger Monitoring Bores (i.e. at the lease boundary and monitoring bores in close proximity to the active mining area) to establish whether this systematic increase in concentration levels at the Trigger Monitoring Bores is coming from the mining area.
- Undertake a risk assessment to determine whether the Trigger Criteria exceedance combined with upstream sampling suggested that there was a possibility that Condition 15-1(1) could be exceeded in future.
- Implement mitigation measures to ensure that the assessed tailings plume would not subsequently be able to result in background groundwater concentrations at lease boundary M39/1140 exceeding normal levels of variation.
 - Regardless of the parameter (TDS, pH, or particular metal ion) that was expected in future to exceed background groundwater concentrations at the lease boundary, the most likely mitigation measure would be to use the Trigger Monitoring Bores as intercept bores and pump some of the groundwater containing plume liquid back to the mining area for disposal back into tailings facilities. However there are other options such as injecting mine dewatering water or even the relatively fresh water from Kakarook North into the plume to dilute it back to groundwater levels or simply use it to slow the flow of the plume (by injecting water in advance of the plume) to allow more time for dilution, dispersion and sequestration to have an impact. Exact mitigation measures would be determined after establishing why the tailings were releasing more liquid than expected, why the plume was travelling much faster than expected and why carbonaceous material was not sequestering the metals in the plume.

- Mitigation measures would be implemented until water quality in the plume was brought back within background levels and therefore wouldn't have the potential to exceed background levels when it reached the lease boundary.
- Continue monitoring to confirm efficacy of mitigation strategies.
- Cease mitigation works when the Trigger Criteria are met and / or Trigger Level Actions are no longer required.
- Identify additional measures to prevent the Trigger Criteria being exceeded in the future.

Threshold Criterion 1: *Threshold Contingency Actions*

- Investigate potential sources and contributing factors for the Threshold Criterion exceedance – initially this would involve sampling of monitoring bores upstream from the lease boundary (both Trigger Monitoring Bores and bores used to monitor activity around active mining areas) to establish whether this systematic increase in concentration levels at the lease boundary was the result of a plume from the tailings facility – in which case there would also be consistently high readings upstream.
- Undertake a risk assessment to determine whether the threshold exceedance combined with upstream sampling suggested that Condition 15-1(1) was not being complied with, and to what extent that might require mitigation measures in excess of those necessary to bring groundwater quality in the plume back to normal groundwater levels at the lease boundary.
- Implement mitigation measures to ensure that the tailings plume is intercepted or diluted or retarded in a manner that would bring the plume at the lease boundary back into compliance with Condition 15-1(1) and that if there were any further impacts to groundwater (such as the plume having already passed the lease boundary) this material was also similarly intercepted or diluted or retarded.
- Continue monitoring to confirm efficacy of mitigation measures.
- Cease mitigation works when the established extent of the plume has been sufficiently intercepted and pumped back to disposal in tailings or diluted or retarded such that at the lease boundary it will all be 'at' or 'below' background groundwater concentrations.
- Identify additional measures to prevent the Threshold Criterion being exceeded in the future.
- Note – there are no sensitive environmental receptors along the path that any plume from the tailings' facilities will travel (being confined to the paleochannel) and therefore no possibility of there being an adverse impact upon the environment.

Trigger Criterion 2: *Trigger Level Actions*

- The in-pit tailings facilities will be located in areas where the carbonaceous material beneath the pit floor was already known to be deep enough to ensure compliance with condition 15-1(2); if a survey of the pit floor found that the estimated layer of carbonaceous material remaining after mining, was in places as little as 2.5 metres that would be a surprise as the minimum layer remaining after mining is likely to be in excess of 10 metres. It could only be caused by mining going a lot deeper than scheduled. An investigation as to why mining had exceeded its scheduled depth (by a considerable margin) would be undertaken.
- If there are areas where the depth of carbonaceous material remaining is a little as 2.5m there would be a concern that if there were measurement errors in the survey measurements – they could be enough to mean that there might be a violation of the 2m limit. The

area would be resurveyed to ensure that where the thickness was estimated to be below 2.5m it was not actually less than 2m.

- There are no adverse environmental implications resulting from the depth of the carbonaceous material below the in-pit tailing facility being between 2m and 2.5m and therefore no need to undertake any mitigating measures.
- However, for the trigger level to be reached would imply that mining had been undertaken to a far greater depth than expected and so measures would be put in place to ensure that there was no a similar problem likely to eventuate where mining was occurring that would be generating the next in-pit tailings facility.

Threshold Criterion 2: *Threshold Contingency Actions*

- The in-pit tailings facilities will be located in areas where the carbonaceous material beneath the pit floor was already known to be deep enough to ensure compliance with condition 15-1(2); if a survey of the pit floor found that the estimated layer of carbonaceous material remaining after mining, was in places as little as 2.0 metres that would be a surprise as the minimum layer remaining after mining is likely to be in excess of 10 metres. It could only be caused by mining going a lot deeper than scheduled. An investigation as to why mining had exceeded its scheduled depth (by a considerable margin) would be undertaken.
- The area would be resurveyed to check that there weren't measurement errors generating apparent non-compliance with condition 15-1(2) and also to determine where the carbonaceous material was estimated to be sufficiently thick that it would be able to generate 'borrow' to increase the thickness in areas that were deficient.
- The floor of the pit would be re-levelled by taking carbonaceous material from where the thickness was above 2m and depositing it in areas where the thickness was below 2m until overall compliance with Condition 15-1(2) was achieved. (In the unlikely event that there was insufficient available within the pit – then carbonaceous material would have to be trucked in from the next mining area being developed).
- After the re-leveling had taken place the pit floor would be resurveyed to ensure compliance.
- Since any lack of compliance with Ministerial Condition 15-1(2) would be picked up during a survey undertaken before the in-pit tailings facility was used as a tailings facility there would not be the potential for any adverse environmental impacts to develop.
- However, for the threshold level to be reached would imply that mining had been undertaken to a far greater depth than expected and so measures would be put in place to ensure that there was no a similar problem likely to eventuate where mining was occurring that would be generating the next in-pit tailings facility.

Trigger Criterion 3: *Trigger Level Actions*

- If an above ground TSF is constructed, it will be constructed with at least 1m of clay liner beneath it. In practice the clay liner would be constructed with an additional thickness of clay as a margin sufficient to ensure that the requirement for at least 1m of clay in Condition 15-1(2) was met. That margin would be an additional 20 cm. The area of the above ground TSF would be surveyed before and after the clay liner was spread and the measurements compared. If the comparison suggested that any areas had a clay layer less than 1.2m thick those areas would be re-surveyed to ensure that there was no measurement errors and that there was no risk that the thickness could actually be below 1m.

- If, after re-surveying, it is established that the clay liner is everywhere thicker than 1m (despite areas being in places thinner than the Trigger Criterion) then the liner complies with Condition 15-1(2). There would therefore be no potential adverse impact on the environment, no non-compliance with Condition 15-1(2) and therefore no requirement to undertake any mitigation measures.

Threshold Criterion 3: *Threshold Contingency Actions*

- If an above ground TSF is constructed, it will be constructed with at least 1m of clay liner beneath it. In practice the clay liner would be constructed with an additional thickness of clay as a margin sufficient to ensure that the requirement for at least 1m of clay in Condition 15-1(2) was met. That margin would be an additional 20 cm. The area of the above ground TSF would be surveyed before and after the clay liner was spread and the measurements compared. If the comparison suggested that any areas had a clay layer less than 1m it would indicate significant errors in construction which if confirmed after a re-survey would require an additional layer of clay to be added.
- An additional layer of at least 20cm of clay (or however much was indicated to be necessary to ensure than the thickness was everywhere above 1m plus the margin of 20cm) would be spread over any areas that the survey indicated had a layer of clay less than 1m thick.
- After the additional clay had been spread the entire area would be resurveyed to ensure compliance with Condition 15-1(2).
- Since any above ground TSF would not be utilised before the surveying had taken place and if the thickness was too thin would not be utilised before the shortfall was remedied – there would be no adverse environmental impacts and no need to undertake any mitigation measures other than the mitigation measured already described of increasing the thickness of the clay to meet Condition 15-1(2).

Trigger Criterion 4: *Trigger Level Actions*

- All tailings facilities will be constructed with at least 1m of appropriate material to act as a capillary break as a covering at the time of closure. In practice the material acting as a capillary break would be constructed with an additional thickness of material as a margin sufficient to ensure that the requirement for at least 1m of capillary break material in Condition 15-1(2)&(3) was met. That margin would be an additional 20 cm. The area of the tailings' facility to which the capillary break material was about to be added would be surveyed before and after the capillary break material was put in place, and the measurements compared. If the comparison suggested that any areas had a capillary break layer less than 1.2m thick those areas would be re-surveyed to ensure that there was no measurement errors and that there was no risk that the thickness could actually be below 1m.
- If, after re-surveying, it is established that the capillary break layer is everywhere thicker than 1m (despite areas being in places thinner than the Trigger Criterion of 1.2m) then the capillary break will comply with Condition 15-1(2)&(3). There would therefore be no potential adverse impact on the environment, no non-compliance with Condition 15-1(2)&(3) and therefore no requirement to undertake any mitigation measures.

Threshold Criterion 4: *Threshold Contingency Actions*

- All tailings facilities will be constructed with at least 1m of appropriate material to act as a capillary break as a covering at the time of closure. In practice the material acting as a capillary break would be constructed with an additional thickness of material as a margin sufficient to ensure that the requirement for at least 1m of capillary break material in

Condition 15-1(2) or (3) was met. If the comparison suggested that any areas had a capillary break layer of less than 1m it would indicate significant errors in construction which if confirmed after a re-survey would require an additional layer of capillary break material to be added.

- An additional layer of at least 20cm of capillary break material (or however much was indicated to be necessary to ensure than the thickness was everywhere above 1m plus the margin of 20cm) would be added to the existing capillary break material that the survey indicated was less than the required 1m thick.
- After the additional capillary break material had been added, the entire area would be resurveyed to ensure compliance with Condition 15-1(2) or (3).
- Once it is established that the correct thickness of capillary break material has been put in place the TSF facility that was being readied for closure would have an additional 1m of growth material put over the top. There would have been no opportunity for adverse impacts upon the environment as a result of the capillary break being temporarily below the requirements of Condition 15-1(2) or (3) – there would be no adverse environmental impacts and no need to undertake any mitigation measures other than the mitigation measured already described of increasing the thickness of the capillary break material to meet Condition 15-1(2) or (3).

2.4 Monitoring

For each performance indicator (environmental criteria) listed in Section 2.2, a specific monitoring program or task will be undertaken to measure performance against the environmental outcome and whether the Trigger Level Actions or Threshold Contingency Actions listed in Section 2.3 need to be implemented. If monitoring identifies that the performance indicators have not been met, then there is a risk that the environmental outcome will also not be achieved.

The specific monitoring tasks to be undertaken for each performance indicator are outlined below.

Performance Indicator	Monitoring
Trigger Criteria 1a and 1b / Threshold Criterion 1	<p>Monitoring will initially be undertaken at both the Trigger Monitoring Bores and the Threshold Monitoring Bores on a six-monthly basis for the first two years whilst baseline data is being compiled.</p> <p>Once baseline data has been established monitoring will be undertaken on a continuous basis at both the Trigger Monitoring Bores and the Threshold Monitoring Bores for pH and salinity. The average value over a three month period (the monitoring period) will be calculated each quarter and logged. In the event that the Trigger Criterion 1a is exceeded the water will be sampled for metal ions and checked against Trigger Criterion 1b and will continue for a period of five years after active operations cease in the Princess and Ambassador Mine Pits (Mulga Rock East) or until Completion Criteria outlined in the Mine Closure Plan are met, whichever is longer.</p>

Performance Indicator	Monitoring
Trigger Criterion 2 / Threshold Criterion 2	<p>Annual audit of groundwater monitoring data from the Trigger Monitoring Bores and the Threshold Monitoring Bores</p> <p>Monitoring will also take place as part of Groundwater MMP at bores located in proximity to mining areas.</p> <p>Prior to commissioning of each in-pit TSFs the area that will become the floor of the facility will be surveyed to ensure that there will be at least 2 metres of carbonaceous material beneath what will be the TSF floor. This will be achieved by comparing the geological block model for the area showing the base of the carbonaceous layer with the in-pit survey of the pit floor which shows how thick the carbonaceous material is above that base.</p> <p>All areas where the mine pit floor (or the floor of the in-pit TSFs) is $\leq 2.5\text{m}$ above the base of the carbonaceous layer (i.e. not meeting the Trigger Criterion) will be identified, along with all areas not meeting the Threshold Criterion (i.e. $\leq 2\text{m}$). In each case the area will be resurveyed to confirm the measurements and then surveyed again after remedial measures have been implemented.</p> <p>The monitoring is necessarily a one-off process that starts when it is proposed to commission an in-pit tailings facility and finishes once it is confirmed that the required thickness of carbonaceous material is present and the in-pit tailings facility proceeds to be utilised.</p>
Trigger Criterion 3 / Threshold Criterion 3	<p>Prior to commissioning of the above ground TSF, the surveyed base (<i>in situ</i> floor) of the TSF and the upper surface of the constructed clay liner will be compared to identify all areas where the clay liner is $\leq 1.2\text{m}$ above (i.e. not meeting the Trigger Criterion) and all areas not meeting the Threshold Criterion (i.e. $\leq 2\text{m}$).</p> <p>The upper surface of the mitigated clay liner will be resurveyed to confirm the Threshold Criterion is met, and all three surfaces (mitigated upper clay liner surface, the original clay liner surface and the base of the clay liner) will be submitted as justification.</p> <p>The monitoring is necessarily a one-off process that starts when it is proposed to commission an above ground TSF and finishes once it is confirmed that the required thickness of clay layer is present beneath the proposed area.</p>
Trigger Criterion 4 / Threshold Criterion 4	<p>Prior to construction of the capillary break, the final dried / consolidated tailings upper surface will be surveyed. The upper surface of the constructed capillary break will also be surveyed and compared with the surveyed tailings surface to identify all areas where the capillary break thickness is $\leq 1.2\text{m}$ (i.e. not meeting the Trigger Criterion) and all areas not meeting the Threshold Criterion (i.e. $\leq 1\text{m}$).</p>

Performance Indicator	Monitoring
	<p>The upper surface of the mitigated capillary break will be resurveyed to confirm the Threshold Criterion is met, and all three surfaces (mitigated upper capillary break surface, the original capillary break surface and the upper tailings surface) will be submitted as justification.</p> <p>The monitoring is necessarily a one-off process that starts when it is proposed to close an in-pit TSF, which also requires that the surface has dried and consolidated sufficiently to enable closure to begin and finishes once it has been established that the required capillary break thickness is present where required.</p>

As specified in Condition 6-4, if the above monitoring indicates exceedance of Trigger Criteria and / or Threshold Criteria, then:

- (1) Report the exceedance to the CEO of DWER in writing within seven (7) days of the exceedance being identified;
- (2) Immediately implement the Trigger Level Actions and / or Threshold Contingency Actions specified in the Condition Environmental Management Plan(s) and continue implementation of those actions until the Trigger Criteria and / or Threshold Criteria are being met and implementation of the Trigger Level Actions and / or Threshold Contingency Actions are no longer required;
- (3) Investigate to determine the cause of the Trigger Criteria and / or Threshold Criteria being exceeded;
- (4) Identify additional measures required to prevent the Trigger Criteria and / or Threshold Criteria being exceeded in the future;
- (5) Investigate to determine potential environment harm or alteration of the environmental that occurred due to Threshold Criteria being exceeded; and
- (6) Provide a report to the CEO of DWER within ninety (90) days of the exceedance being reported.

The report will include:

- (a) details of Trigger Level Actions or Threshold Contingency Actions implemented;
- (b) the effectiveness of the Trigger Level Actions, or Threshold Contingency Actions implemented, monitored and measured against Trigger Criteria and Threshold Criteria;
- (c) the findings of the investigations required by Condition 6-4(3) and 6-4(5);
- (d) additional measures to prevent the Trigger or Threshold Criteria being exceeded in the future; and
- (e) measures to prevent, control, or abate the environmental harm which may have occurred.

2.5 Reporting

Reporting of the above monitoring results, and achievement of the performance indicators that satisfy the environmental outcome, will occur in the Compliance Assessment Report (CAR) to be submitted annually (in March, starting in 2018) to the CEO of DWER.

In accordance with Condition 4-6, the CAR shall:

- (1) Be endorsed by Vimy's CEO or other person delegated to sign on the CEO's behalf;
- (2) Include a statement as to whether Vimy has complied with the conditions;
- (3) Identify all potential non-compliances and describe corrective and preventative actions taken;
- (4) Be made publicly available in accordance with the approved Compliance Assessment Plan (CAP); and
- (5) Indicate any proposed changes to the CAP required by Condition 4-1.

The CAR will also include:

- Monitoring results and trends against performance indicators;
- Any exceedance of Trigger Criteria and / or Threshold Criteria;
- A review of the response actions and their appropriateness in achieving the performance indicators and the overall environmental outcome; and
- Proposed revision of the performance indicators, and corresponding response actions, if required, to obtain formal approval from DWER to amend the CEMP.

In addition to the CAR, all results from specific monitoring programs (e.g. dust monitoring, radiation monitoring) and details of any environmental discharges (e.g. saline water spills) will be presented in the Annual Environmental Report (AER). Furthermore, results of rehabilitation performance will be reported in the annual Mine Rehabilitation Fund (MRF) document.

3. Adaptive Management and Review of the Condition EMP

3.1 Review and revision of performance indicators and response actions

In the event that a performance indicator (trigger or threshold) is exceeded, or the identified response actions do not result in the performance indicator(s) being met, then Vimy will review and revise the risk assessment, review and revise performance indicator(s) and response actions, and identify additional response actions where necessary.

Risks and key impacts associated with response actions and priorities will be reviewed and revised and, if necessary, implement the following adaptive management procedure:

- Investigate the potential cause for the performance indicator exceedance and identify any impacts to groundwater quality, and the surrounding environment, resulting from this exceedance.
- If the causes of the exceedance or the efficacy of the response actions are found to be deficient, then the risk assessment will be reviewed and revised risk-based response actions will be implemented, following formal approval from DWER, so that the MRUP environmental outcome is met.

Vimy will also implement adaptive management to learn from the implementation of mitigation measures, monitoring and evaluation against performance indicators, to meet the environmental outcome more effectively. The following approach will be followed:

- Monitoring data will be systematically evaluated and compared to baseline and reference site data in a process of adaptive management to verify whether responses to the impact are the same or similar to predictions.
- Re-evaluate the risk assessment and revision of risk-based priorities on the basis of monitored information.
- Increased understanding of the local and regional ecological regime.
- Revision when response actions are not as effective as predicted.
- External changes during the life of the proposal (e.g. changes to the sensitivity of the key environmental factor, implementation of other activities in the area, etc.).
- Review of CEMP – changes to CEMP provisions required by a condition, timeframe, etc.

Trigger Criteria 1a and 1b have been set at ‘1.65 standard deviations’ away from adjusted (to compensate for skew and kurtosis) mean values established during the collection of baseline data. At the end of the two year period when the data has been collected, the issue of the exact level at which to set trigger values will be revisited with a view to considering whether the trigger values should be replaced with bore specific fixed trigger values for pH, salinity and contained metals.

Since the Monitoring Bores (Trigger and Threshold) will continuously monitor for pH and salinity both the Trigger Criteria and the Threshold Criterion will be subject to annual review as part of the annual audit as to whether it would be appropriate to amend the defined Trigger and Threshold Values in light of accumulated data.

3.2 Early response indicators, criteria, and actions

As specified in Section 2.2, Trigger Criteria 1a and 1b apply to the Trigger Monitoring Bores (located approximately 2 kilometres north of the Threshold Monitoring Bores) and Threshold Criterion 1 applies to the Threshold Monitoring Bores located at (geographic co-ordinates in Schedule 2 of MS1046 that relate to) the ML39/1080 lease boundary. It is considered that the same Trigger and Threshold Criteria will apply to monitoring bores located closer to the TSFs to provide an early response indicator of the impact that the tailings plume is having on baseline groundwater quality. These bores will be strategically located so as to provide both spatial distribution of the tailings plume and also the rate of migration away from the TSF; hence these bores will be located at various distances downstream of the TSF, so that the flow rate of the tailings plume can be determined.

The proposed locations of the early response groundwater monitoring bores is shown in Figure 1; although the actual locations of these bores will be finalised, and approved by DWER, prior to active tailings discharge into the TSFs. It is the objective of the early response monitoring bores to detect a change in groundwater quality in response to the TSF’s and thus the bores will be strategically located to achieve this objective.

4. Stakeholder consultation

Extensive consultation regarding groundwater quality risks of the TSFs occurred during the Public Environmental Review (PER). Specific consultation with regards to this CEMP with the DMIRS (previously DMP; Resources Safety Division) is outlined below.

Date	Decision Making Authority	Comment	Response
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Tailing Storage Facility Monitoring and Management Plan

Mulga Rock Uranium Project

29/12/2016	DMP	Met with Ian Mitchell and Emily Safe to discuss MRUP and the requirements under Condition 15 and 16 regarding potential risks to the stability of the above-ground TSF.	No response needed
22/02/2017	DMP	Met with DMP Environmental Officers to discuss the Draft CEMP and its fulfilment of Ministerial Statement 1046	Vimy to ensure that this CEMP is prepared in accordance with MS 1046
24/05/2017	DMP	Met with Ian Mitchell, Damien Montague and Emily Safe to discuss specific management of AMD and other aspects that may impact soil quality.	No response needed

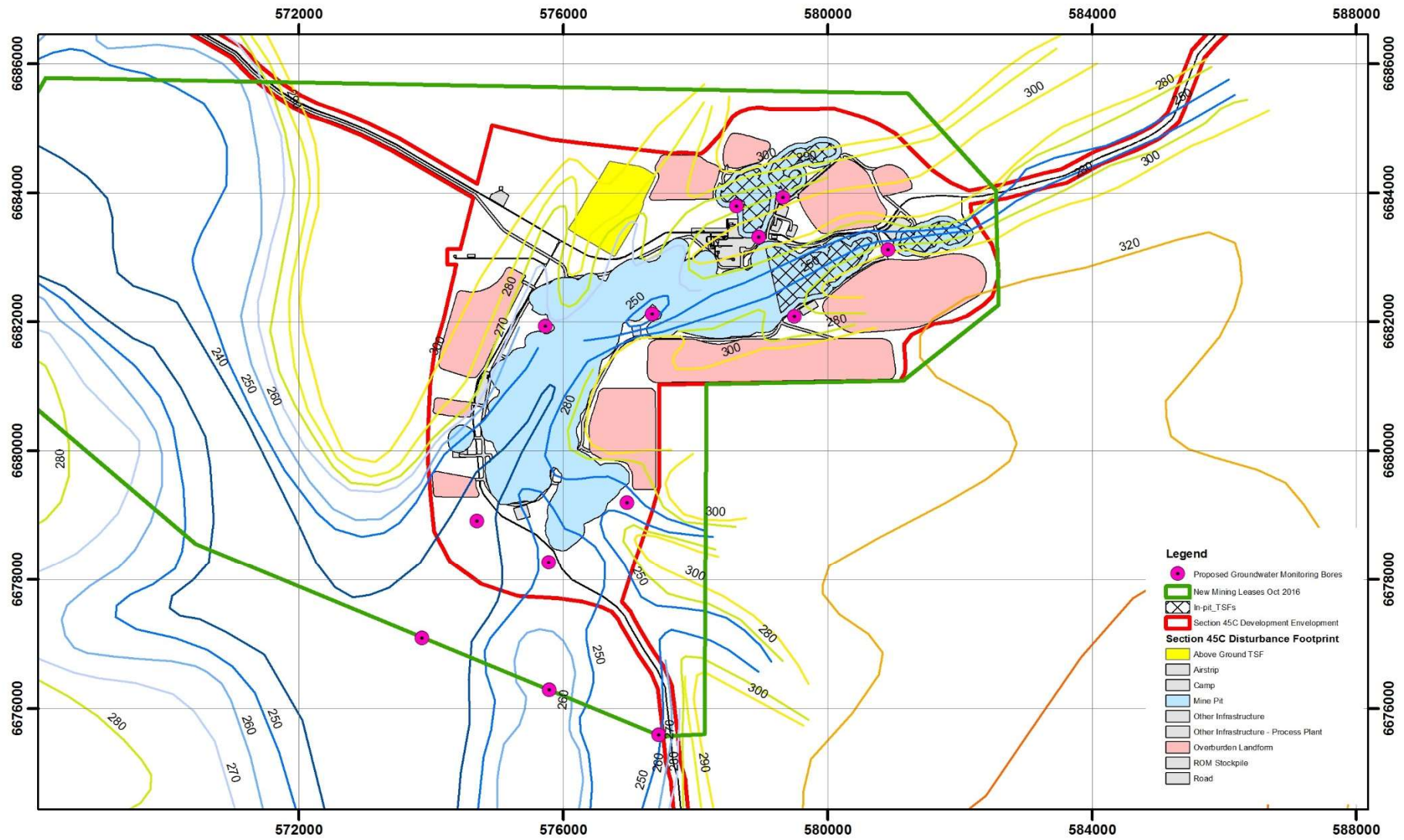


Figure 1: Proposed early response groundwater monitoring bores

Table 1: CEMP Provisions (outcome-based) table

Purpose of EMP	To meet the legal requirements of Condition 15 of Ministerial Statement 1046			
EPA Factor	Inland Water Environmental Quality			
EPA Objective	To maintain the quality of groundwater and surface water, sediment, and biota so that the environmental values, both ecological and social, are protected			
MS 1046 Condition 16-1 Environmental Outcome:	(1) Ensure that the tailings plume is within background groundwater concentrations at the M39/1080 lease boundary as shown in Figure 4 of Schedule 1 and defined by the geographic coordinates in Schedule 2;			
	(2) Ensure that the in-pit TSFs are designed to have at least 2 metres of carbonaceous material beneath them and they are covered with a minimum of 1 metre of appropriate material to act as a capillary break at closure; and			
	(3) Ensure that the above-ground Tailings Storage Facility is designed to have at least a 1 metre clay liner beneath it and is covered with a minimum of 1 metre of appropriate material to act as a capillary break at closure.			
Management-based provisions				
Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
Groundwater quality	Trigger Criterion 1a: Groundwater quality (as measured by pH and TDS) \geq 1.65 standard deviations different from background groundwater when measured at the Trigger Monitoring Bores (located between the lease boundary and the southernmost area of the mining pit – approximately 2km north of the lease boundary). Data will be adjusted for skew and kurtosis or whatever transformation is required to create a standard normal distribution.	Trigger Level Actions <ul style="list-style-type: none"> Investigate potential sources and contributing factors for the Trigger Criteria exceedance – initially this would involve extended pumping from the Trigger Monitoring Bores to check whether the levels being recorded are stable under extended pumping and sampling of monitoring bores both upstream and downstream from the Trigger Monitoring Bores (i.e. at the lease boundary and monitoring bores in close proximity to the active mining area) to establish whether this systematic increase in concentration levels at the Trigger Monitoring Bores is coming from the mining area. Undertake a risk assessment to determine whether the trigger level exceedance combined with upstream sampling suggested that there 	Monitoring will initially be undertaken at both the Trigger Monitoring Bores and the Threshold Monitoring Bores on a six-monthly basis for the first two years whilst baseline data is being compiled. Once baseline data has been established monitoring will be undertaken on a continuous basis at both the Trigger Monitoring Bores and the Threshold Monitoring Bores for pH and salinity. The average value over a three month period (the monitoring period) will be calculated each quarter and logged. In the event	CAR AER

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
	<p>Trigger Criterion 1b: Water sampling for metal ions (Zn, Ni, Cu, Co, U – in mg/L) ≥ 1.65 standard deviations above baseline data for the same bore when tested as a result of Trigger Criterion 1a being exceeded. Data will be adjusted for skew and kurtosis or whatever transformation is required to create a standard normal distribution.</p>	<p>was a possibility that Condition 15-1(1) could be exceeded in future.</p> <ul style="list-style-type: none"> Implement mitigation measures to ensure that the assessed tailings plume would not subsequently be able to result in background groundwater concentrations at lease boundary M39/1140 exceeding normal levels of variation. <ul style="list-style-type: none"> Regardless of the parameter (TDS, pH, or particular metal ion) that was expected in future to exceed background groundwater concentrations at the lease boundary the most likely mitigation measure would be to use the monitoring bores as intercept bores and pump some of the groundwater containing plume material back to the mining area for disposal back into tailings facilities. However there are other options such as injecting mine dewatering water or even the relatively fresh water from Karaook North into the plume to dilute it back to groundwater levels or simply use it to slow the flow of the plume (by injecting water in advance of the plume) to allow more time for dilution, dispersion and sequestration to have an impact . Exact mitigation measures would be determined after establishing why the tailings were releasing more liquid than expected, why the plume was travelling much faster than expected and why carbonaceous material was not sequestering the metals in the plume. 	<p>that the Trigger Criterion 1a is exceeded the water will be sampled for metal ions and checked against Trigger Criterion 1b and will continue for a period of five years after active operations cease in the Princess and Ambassador Mine Pits (Mulga Rock East) or until Completion Criteria outlined in the Mine Closure Plan are met, whichever is longer.</p> <p>Annual audit of groundwater monitoring data from the Trigger Monitoring Bores and the Threshold Monitoring Bores</p>	

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
		<ul style="list-style-type: none"> Mitigation measures would be implemented until water quality in the plume was brought back within background levels and therefore would not have the potential to exceed background levels when it reached the lease boundary. Continue monitoring to confirm efficacy of mitigation strategies. Cease mitigation works when the Trigger Criteria are met and / or Trigger Level Actions are no longer required. Identify additional measures to prevent the Trigger Criterion being exceeded in the future. 		
	<p>Threshold Criteria 1: Groundwater quality ≥ 2 standard deviations above background groundwater concentrations at the 'geographic co-ordinates in Schedule 2 of MS1046 that relate to the ML39/1080 lease boundary' for three or more consecutive monitoring periods (a monitoring period is three months). Data will be adjusted for skew and kurtosis or whatever transformation is required to create a standard normal distribution.</p>	<p>Threshold Contingency Actions</p> <ul style="list-style-type: none"> Investigate potential sources and contributing factors for the threshold exceedance – initially this would involve sampling of monitoring bores upstream from the lease boundary to establish whether this systematic increase in concentration levels at the lease boundary was the result of a plume from the tailings facility – in which case there would also be consistently high readings upstream. Undertake a risk assessment to determine whether the threshold exceedance combined with upstream sampling suggested that Condition 15-1(1) was not being complied with, and to what extent that might require mitigation measures in excess of those necessary to bring groundwater quality in the plume back to normal groundwater levels at the lease boundary. 		

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
		<ul style="list-style-type: none"> • Implement mitigation measures to ensure that the tailings plume is intercepted or diluted or retarded in a manner that would bring the plume at the lease boundary back into compliance with Condition 15-1(1) and that if there were any further impacts to groundwater (such as the plume having already passed the lease boundary) this material was also similarly intercepted or diluted or retarded. • Continue monitoring to confirm efficacy of mitigation measures. • Cease mitigation works when the established extent of the plume has been sufficiently intercepted and pumped back to disposal in tailings or diluted or retarded such that at the lease boundary it will all be 'at' or 'below' background groundwater concentrations. • Identify additional measures to prevent the Threshold Criterion being exceeded in the future. • Note – there are no sensitive environmental receptors along the path that any plume from the tailings' facilities will travel (being confined to the paleochannel) and therefore no possibility of there being an adverse impact upon the environment. 		
Carbonaceous layer	Trigger Criterion 2: Carbonaceous layer beneath the in-pit TSFs ≤ 2.5m	<p>Trigger Level Actions</p> <ul style="list-style-type: none"> • The in-pit tailings facilities will be located in areas where the carbonaceous material beneath the pit floor was already known to be deep enough to ensure compliance with condition 15-1(2); if a survey of the pit floor found that the estimated layer of carbonaceous 	Prior to commissioning of each in-pit TSFs the area that will become the floor of the facility will be surveyed to ensure that there will be at least 2 metres of carbonaceous material beneath what will be the TSF floor. This will	CAR

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
		<p>material remaining after mining, was in places as little as 2.5 metres that would be a surprise as the minimum layer remaining after mining is likely to be in excess of 10 metres. It could only be caused by mining going a lot deeper than scheduled. An investigation as to why mining had exceeded its scheduled depth (by a considerable margin) would be undertaken.</p> <ul style="list-style-type: none"> • If there are areas where the depth of carbonaceous material remaining is a little as 2.5m there would be a concern that if there were measurement errors in the survey measurements – they could be enough to mean that there might be a violation of the 2m limit. The area would be resurveyed to ensure that where the thickness was estimated to be below 2.5m it was not actually less than 2m. • There are no adverse environmental implications resulting from the depth of the carbonaceous material below the in-pit tailing facility being between 2m and 2.5m and therefore no need to undertake any mitigating measures. • However, for the trigger level to be reached would imply that mining had been undertaken to a far greater depth than expected and so measures would be put in place to ensure that there was no a similar problem likely to eventuate where mining was occurring that would be generating the next in-pit tailings facility. 	<p>be achieved by comparing the geological block model for the area showing the base of the carbonaceous layer with the in-pit survey of the pit floor which shows how thick the carbonaceous material is above that base.</p> <p>All areas where the mine pit floor (or the floor of the in-pit TSFs) is \leq 2.5m above the base of the carbonaceous layer (i.e. not meeting the Trigger Criterion) will be identified, along with all areas not meeting the Threshold Criterion (i.e. \leq 2m). In each case the area will be resurveyed to confirm the measurements and then surveyed again after remedial measures have been implemented.</p> <p>The monitoring is necessarily a one-off process that starts when it is proposed to commission an in-pit tailings facility and finishes once it is confirmed that the required thickness of carbonaceous material is present and the in-pit tailings facility proceeds to be utilised.</p>	

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
	<p>Threshold Criterion 2: Carbonaceous layer beneath the in-pit TSFs \leq 2m</p>	<p>Threshold Contingency Actions</p> <ul style="list-style-type: none"> • The in-pit tailings facilities will be located in areas where the carbonaceous material beneath the pit floor was already known to be deep enough to ensure compliance with condition 15-1(2); if a survey of the pit floor found that the estimated layer of carbonaceous material remaining after mining, was in places as little as 2.0 metres that would be a surprise as the minimum layer remaining after mining is likely to be in excess of 10 metres. It could only be caused by mining going a lot deeper than scheduled. An investigation as to why mining had exceeded its scheduled depth (by a considerable margin) would be undertaken. • The area would be resurveyed to check that there weren't measurement errors generating apparent non-compliance with condition 15-1(2) and also to determine where the carbonaceous material was estimated to be sufficiently thick that it would be able to generate 'borrow' to increase the thickness in areas that were deficient. • The floor of the pit would be re-levelled by taking carbonaceous material from where the thickness was above 2m and depositing it in areas where the thickness was below 2m until overall compliance with Condition 15-1(2) was achieved. (In the unlikely event that there was insufficient available within the pit – then carbonaceous material would have to be trucked in from the next mining area being developed). 		

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
		<ul style="list-style-type: none"> • After the re-leveling had taken place the pit floor would be resurveyed to ensure compliance. • Since any lack of compliance with Ministerial Condition 15-1(2) would be picked up during a survey undertaken before the in-pit tailings facility was used as a tailings facility there would not be the potential for any adverse environmental impacts to develop. • However, for the threshold level to be reached would imply that mining had been undertaken to a far greater depth than expected and so measures would be put in place to ensure that there was no a similar problem likely to eventuate where mining was occurring that would be generating the next in-pit tailings facility. 		
Clay Liner	Trigger Criterion 3: Clay liner beneath above ground TSF \leq 1.2m	<p>Trigger Level Actions</p> <ul style="list-style-type: none"> • If an above ground TSF is constructed, it will be constructed with at least 1m of clay liner beneath it. In practice the clay liner would be constructed with an additional thickness of clay as a margin sufficient to ensure that the requirement for at least 1m of clay in Condition 15-1(2) was met. That margin would be an additional 20 cm. The area of the above ground TSF would be surveyed before and after the clay liner was spread and the measurements compared. If the comparison suggested that any areas had a clay layer less than 1.2m thick those areas would be re-surveyed to ensure that there was no 	<p>Prior to commissioning of the above ground TSF, the surveyed base (<i>in situ</i> floor) of the TSF and the upper surface of the constructed clay liner will be compared to identify all areas where the clay liner is \leq 1.2m above (i.e. not meeting the Trigger Criterion) and all areas not meeting the Threshold Criterion (i.e. \leq 2m).</p> <p>The upper surface of the mitigated clay liner will be resurveyed to confirm the Threshold Criterion is</p>	CAR

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
	<p>Threshold Criterion 3: Clay liner beneath above ground TSF $\leq 1\text{m}$</p>	<p>measurement errors and that there was no risk that the thickness could actually be below 1m.</p> <ul style="list-style-type: none"> If, after re-surveying, it is established that the clay liner is everywhere thicker than 1m (despite areas being in places thinner than the Trigger Criterion) then the liner complies with Condition 15-1(2). There would therefore be no potential adverse impact on the environment, no non-compliance with Condition 15-1(2) and therefore no requirement to undertake any mitigation measures. <p>Threshold Contingency Actions</p> <ul style="list-style-type: none"> If an above ground TSF is constructed, it will be constructed with at least 1m of clay liner beneath it. In practice the clay liner would be constructed with an additional thickness of clay as a margin sufficient to ensure that the requirement for at least 1m of clay in Condition 15-1(2) was met. That margin would be an additional 20 cm. The area of the above ground TSF would be surveyed before and after the clay liner was spread and the measurements compared. If the comparison suggested that any areas had a clay layer less than 1m it would indicate significant errors in construction which if confirmed after a re-survey would require an additional layer of clay to be added. An additional layer of at least 20cm of clay (or however much was indicated to be necessary to ensure than the thickness was everywhere above 1m plus the margin of 20cm) would be 	<p>met, and all three surfaces (mitigated upper clay liner surface, the original clay liner surface and the base of the clay liner) will be submitted as justification.</p> <p>The monitoring is necessarily a one-off process that starts when it is proposed to commission an above ground TSF and finishes once it is confirmed that the required thickness of clay layer is present beneath the proposed area.</p>	

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
		<p>spread over any areas that the survey indicated had a layer of clay less than 1m thick.</p> <ul style="list-style-type: none"> • After the additional clay had been spread the entire area would be resurveyed to ensure compliance with Condition 15-1(2). • Since any above ground TSF would not be utilised before the surveying had taken place and if the thickness was too thin would not be utilised before the shortfall was remedied – there would be no adverse environmental impacts and no need to undertake any mitigation measures other than the mitigation measured already described of increasing the thickness of the clay to meet Condition 15-1(2). 		
Capillary break	<p>Trigger Criterion 4: Capillary break above the dried / consolidated tailings surface is $\leq 1.2\text{m}$</p>	<p>Trigger Level Actions</p> <ul style="list-style-type: none"> • All tailings facilities will be constructed with at least 1m of appropriate material to act as a capillary break as a covering at the time of closure. In practice the material acting as a capillary break would be constructed with an additional thickness of material as a margin sufficient to ensure that the requirement for at least 1m of capillary break material in Conditions 15-1(2) & (3) were met. That margin would be an additional 20 cm. The area of the tailings' facility to which the capillary break material was about to be added would be surveyed before and after the capillary break material was put in place, and the measurements compared. If the comparison suggested that any areas had a capillary break layer less than 1.2m thick those areas would be re-surveyed to ensure that there was no 	<p>Prior to construction of the capillary break, the final dried / consolidated tailings upper surface will be surveyed. The upper surface of the constructed capillary break will also be surveyed and compared with the surveyed tailings surface to identify all areas where the capillary break thickness is $\leq 1.2\text{m}$ (i.e. not meeting the Trigger Criterion) and all areas not meeting the Threshold Criterion (i.e. $\leq 1\text{m}$).</p> <p>The upper surface of the mitigated capillary break will be resurveyed to confirm the Threshold Criterion is met, and all three surfaces (mitigated upper capillary break</p>	CAR

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
	<p>Threshold Criterion 4: Capillary break above the dried / consolidated tailings surface is $\leq 1\text{m}$</p>	<p>measurement errors and that there was no risk that the thickness could actually be below 1m.</p> <ul style="list-style-type: none"> If, after re-surveying, it is established that the capillary break layer is everywhere thicker than 1m (despite areas being in places thinner than the Trigger Criterion of 1.2m) then the capillary break will comply with Conditions 15-1(2) & (3). There would therefore be no potential adverse impact on the environment, no non-compliance with Conditions 15-1(2) & (3) and therefore no requirement to undertake any mitigation measures. <p>Threshold Contingency Actions</p> <ul style="list-style-type: none"> All tailings facilities will be constructed with at least 1m of appropriate material to act as a capillary break as a covering at the time of closure. In practice the material acting as a capillary break would be constructed with an additional thickness of material as a margin sufficient to ensure that the requirement for at least 1m of capillary break material in Conditions 15-1(2) or (3) was met. If the comparison suggested that any areas had a capillary break layer of less than 1m it would indicate significant errors in construction which if confirmed after a re-survey would require an additional layer of capillary break material to be added. An additional layer of at least 20cm of capillary break material (or however much was indicated to be necessary to ensure than the thickness was everywhere above 1m plus the margin of 20cm) would be added to the existing capillary 	<p>surface, the original capillary break surface and the upper tailings surface) will be submitted as justification.</p> <p>The monitoring is necessarily a one-off process that starts when it is proposed to close an in-pit TSF, which also requires that the surface has dried and consolidated sufficiently to enable closure to begin and finishes once it has been established that the required capillary break thickness is present where required.</p>	

Risk / Impact	Environmental Criteria	Response Actions	Monitoring	Reporting
		<p>break material that the survey indicated was less than the required 1m thick.</p> <ul style="list-style-type: none"> • After the additional capillary break material had been added, the entire area would be resurveyed to ensure compliance with Condition 15-1(2) or (3). • Once it is established that the correct thickness of capillary break material has been put in place the TSF facility that was being readied for closure would have an additional 1m of growth material put over the top. There would have been no opportunity for adverse impacts upon the environment as a result of the capillary break being temporarily below the requirements of Condition 15-1(2) or (3) – there would be no adverse environmental impacts and no need to undertake any mitigation measures other than the mitigation measured already described of increasing the thickness of the capillary break material to meet Condition 15-1(2) or (3). 		



5. References

EPA (2015) *Title of Condition Environmental Management Plan, Environmental Outcome-based condition model template*. Environmental Protection Authority, Perth, Western Australia.

Vimy (2015). *Mulga Rock Uranium Project Public Environmental Review*. Vimy Resources Limited (Vimy).