

Challenger Gold Operations

Appendix I

2015 – 2016 TSF2 Water Balance

Year - 2016	JANUARY 31	FEBRUARY 28.25	MARCH 31	APRIL 30	MAY 31	JUNE 30	JULY 31	AUGUST 31	SEPTEMBER 29	OCTOBER 31	NOVEMBER 30	DECEMBER 31	TOTAL 364.25
INFLOWS													
RAINFALL													
Recorded Total Rainfall (mm)	0.0	1.5	71.5	0.0	0.5	32.5	23.5	15.0	32.0	4.5	3.0	43.5	227.50
Daily Average (mm/day)	-	0.05	2.31	-	0.02	1.08	0.76	0.48	1.10	0.15	0.10	1.40	0.62
TSF Storage Area (m ²)	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	
Runoff Coefficient (tailings) =	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
Catchment Area Above TSF Storage Area (m ²) =	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	
Runoff Coefficient (catchment) =	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Pond Area (m ²)	1,256.64	1,256.64	1,256.64	5,026.55	5,026.55	5,026.55	5,026.55	5,026.55	5,026.55	1,256.64	1,256.64	1,256.64	
Winter Pond Radius (m) = 40 m													
Summer Pond Radius (m) = 20 m													
Rainfall INFLOW Total Volume (m ³ /day)	0.00	9.55	414.88	0.00	2.92	196.09	137.22	87.58	199.73	26.11	17.99	252.41	
SLURRY WATER													
Total tonnes (dry) per month	47,831	47,153	7,390	0	16,860	46,525	50,558	51,630	49,409	50,085	53,497	54,126	475,064
Tailings Slurry % Solids	60.5%	76.5%	66.9%	100.0%	31.5%	66.8%	66.3%	63.8%	72.6%	66.2%	63.4%	58.7%	66.1%
Tailings Output Solids (tpd)	1,543	1,669	238	0	544	1,551	1,631	1,665	1,704	1,616	1,783	1,746	1,308
Slurry Water INFLOW Total Volume (m ³ /day)	1,007.37	512.74	117.95	0.00	1,182.70	770.77	828.98	944.99	643.02	824.91	1,029.44	1,228.45	757.61
OTHER INFLOWS													
Waste Water INFLOW (m ³ /day)	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	1.2
TOTAL INFLOWS (m³/day)	1007	522	533	0	1186	967	966	1033	843	851	1048	1481	759
OUTFLOWS/LOSSES													
EVAPORATION (from pond and running beaches)													
Evaporation Rate (Pan Total - mm)	641.0	562.5	191.5	0.0	5.0	113.5	134.5	225.5	239.5	492.5	680.0	722.5	4,008
Pan Factor	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Evaporation Rate (mm/month)	481	422	144	0	4	85	101	169	180	369	510	542	251
Evaporation Rate (mm/day)	15.5	14.9	4.6	0.0	0.1	2.8	3.3	5.5	6.2	11.9	17.0	17.5	8
Running Beaches (m ²) =	2,600	2,600	2,600	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,600	2,600	2,483
(running beaches based on 1 operating spigots, 1 prior spigot locations, an average width of 5m and applied over a length of 280m less the pond radius)													
Pond Area and Running Beaches (m ²)	3,857	3,857	3,857	7,427	7,427	7,427	7,427	7,427	7,427	3,657	3,857	3,857	5,625
Evaporation LOSS Total Volume (m ³ /day)	59.81	57.59	17.87	-	0.90	21.07	24.17	40.52	46.00	43.57	65.56	67.41	37
EVAPOTRANSPIRATION (from drying tailings)													
Evapotranspiration Rate (Pan Total/3 - mm)	214	188	64	-	2	38	45	75	80	164	227	241	111
Evapotranspiration Rate (mm/day)	6.9	6.6	2.1	-	0.1	1.3	1.4	2.4	2.8	5.3	7.6	7.8	4
Area Transpiring (m ²)	12,057	12,057	12,057	11,879	11,879	11,879	11,879	11,879	11,879	12,067	12,057	12,057	11,969
Evapotranspiration LOSS Total Volume (m ³ /day)	83.10	80.03	24.83	-	0.64	14.98	17.18	28.80	32.70	63.90	91.10	93.67	
SEEPAGE													
LOSS Beneath Perimeter Embankment Total Volume (m ³ /day)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Seepage Through Base of TSF													
Coefficient of Permeability (m/second/m ²)	5.00E-09 m/sec/m ²												
LOSS Through Base of TSF Total Volume (m ³ /day)	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	-
Seepage LOSS Total Volume (m ³ /day)	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	-
RETENTION													
Moisture Content of Tailings (assumed average - %)	35%												
Water Retained in Tailings (m ³ /day)	540.03	584.20	83.44	-	190.35	542.79	570.82	582.92	596.32	565.48	624.13	611.10	458
TOTAL OUTFLOWS/LOSSES (m³/day)	788.78	827.66	231.97	105.84	297.73	684.68	718.00	758.08	780.86	778.79	886.63	878.02	645
WATER BALANCE (inflow - outflow) Excluding Water Recovery													
m ³ /day	218.69	305.26	300.95	105.74	887.99	282.28	248.29	274.60	62.00	72.32	160.89	602.93	225
m ³ /month	6,779.32	8,623.54	9,329.44	3,172.20	27,527.63	8,468.42	7,697.04	8,512.45	1,797.91	2,242.06	4,826.76	18,690.76	84,076
WATER RECOVERY (to plant via process water pond)													
Decant Water Recovery Total Volume (m ³ /month)	450	533	80	720	76	481	493	475	523	493	457	436	435
Decant Water Recovery Total Volume (m ³ /day)	15	19	3	24	2	16	16	15	18	16	15	14	14
WATER RECOVERY (%)	1%	4%	0%	100%	0%	2%	2%	1%	2%	2%	1%	1%	9.7%
WATER BALANCE (inflow - outflow) Including Water Recovery													
m ³ /day	204.17	324.13	298.37	129.74	885.54	266.25	232.39	259.27	43.96	56.42	145.66	588.86	211
m ³ /month	6,329.32	9,156.54	9,249.44	3,892.20	27,451.63	7,987.42	7,204.04	8,037.45	1,274.91	1,749.06	4,369.76	18,254.76	78,859

Year - 2015	JANUARY 31	FEBRUARY 28.25	MARCH 31	APRIL 30	MAY 31	JUNE 30	JULY 31	AUGUST 31	SEPTEMBER 29	OCTOBER 31	NOVEMBER 30	DECEMBER 31	TOTAL 364.25
INFLOWS													
RAINFALL													
Recorded Total Rainfall (mm)	31.5	0.5	0.5	1.6	36.0	14.0	2.1	5.5	0.5	6.0	16.5	4.5	119.20
Daily Average (mm/day)	1.02	0.02	0.02	0.05	1.16	0.47	0.07	0.18	0.02	0.19	0.55	0.15	0.33
TSF Storage Area (m ²)	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	245,000	
Runoff Coefficient (tailings) =	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
Catchment Area Above TSF Storage Area (m ²) =	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	
Runoff Coefficient (catchment) =	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Pond Area (m ²)	1,256.64	1,256.64	1,256.64	5,026.55	5,026.55	5,026.55	5,026.55	5,026.55	5,026.55	1,256.64	1,256.64	1,256.64	
Winter Pond Radius (m) = 40 m													
Summer Pond Radius (m) = 20 m													
Rainfall INFLOW Total Volume (m ³ /day)	182.78	3.18	2.90	9.65	210.20	84.47	12.26	32.11	3.12	34.81	98.93	26.11	
SLURRY WATER													
Total tonnes (dry) per month	43,915	43,803	46,454	44,524	41,233	46,058	48,379	50,483	49,386	48,328	51,869	39,372	553,804
Tailings Slurry % Solids	63.1%	63.2%	62.8%	62.4%	62.4%	62.1%	61.6%	61.8%	59.9%	61.8%	61.4%	54.3%	61.4%
Tailings Output Solids (tpd)	1,417	1,551	1,499	1,484	1,330	1,535	1,561	1,628	1,703	1,559	1,729	1,270	1,522
Slurry Water INFLOW Total Volume (m ³ /day)	828.42	902.85	887.66	894.29	801.47	936.98	972.85	1,006.60	1,140.05	963.63	1,086.94	1,068.91	957.55
OTHER INFLOWS													
Waste Water INFLOW (m ³ /day)	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	1.2
TOTAL INFLOWS (m³/day)	1011	906	891	904	1012	1022	985	1039	1143	999	1186	1095	959
OUTFLOWS/LOSSES													
EVAPORATION (from pond and running beaches)													
Evaporation Rate (Pan Total - mm)	631.0	633.5	477.0	267.0	158.0	109.5	150.0	224.0	281.5	538.0	586.5	733.0	4,789
Pan Factor	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Evaporation Rate (mm/month)	473	475	358	200	119	82	113	168	211	404	440	550	299
Evaporation Rate (mm/day)	15.3	16.8	11.5	6.7	3.8	2.7	3.6	5.4	7.3	13.0	14.7	17.7	10
Running Beaches (m ²) =	2,600	2,600	2,600	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,600	2,600	2,483
(running beaches based on 1 operating spigots, 1 prior spigot locations, an average width of 5m and applied over a length of 280m less the pond radius)													
Pond Area and Running Beaches (m ²)	3,857	3,857	3,857	7,427	7,427	7,427	7,427	7,427	7,427	3,657	3,857	3,857	5,625
Evaporation LOSS Total Volume (m ³ /day)	58.88	64.86	44.51	49.57	28.39	20.33	26.95	40.25	54.07	47.60	56.55	68.39	47
EVAPOTRANSPIRATION (from drying tailings)													
Evapotranspiration Rate (Pan Total/3 - mm)	210	211	159	89	53	37	50	75	94	179	196	244	133
Evapotranspiration Rate (mm/day)	6.8	7.5	5.1	3.0	1.7	1.2	1.6	2.4	3.2	5.8	6.5	7.9	4
Area Transpiring (m ²)	12,057	12,057	12,057	11,879	11,879	11,879	11,879	11,879	11,879	12,067	12,057	12,057	11,969
Evapotranspiration LOSS Total Volume (m ³ /day)	81.81	90.13	61.84	35.24	20.18	14.45	19.16	28.61	38.44	69.81	78.57	95.03	
SEEPAGE													
LOSS Beneath Perimeter Embankment Total Volume (m ³ /day)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Seepage Through Base of TSF													
Coefficient of Permeability (m/second/m ²)	5.00E-09	5.00E-09	5.00E-09	5.00E-09	5.00E-09	5.00E-09	5.00E-09	5.00E-09	5.00E-09	5.00E-09	5.00E-09	5.00E-09	
LOSS Through Base of TSF Total Volume (m ³ /day)	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	-
Seepage LOSS Total Volume (m ³ /day)	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	105.84	-
RETENTION													
Moisture Content of Tailings (assumed average - %)	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	
Water Retained in Tailings (m ³ /day)	495.81	542.69	524.48	519.45	465.53	537.34	546.21	569.97	596.04	545.64	605.14	444.52	533
TOTAL OUTFLOWS/LOSSES (m³/day)	742.34	803.52	736.67	710.10	619.94	677.97	698.16	744.67	794.38	768.88	846.10	713.79	738
WATER BALANCE (inflow - outflow) Excluding Water Recovery													
m ³ /day	268.95	102.62	153.98	193.94	391.82	343.59	287.04	294.15	348.89	229.66	339.87	381.33	278
m ³ /month	8,337.54	2,899.00	4,773.53	5,818.21	12,146.57	10,307.61	8,898.34	9,118.56	10,117.91	7,119.57	10,196.20	11,821.34	101,554
WATER RECOVERY (to plant via process water pond)													
Decant Water Recovery Total Volume (m ³ /month)	50	6	0	0	0	13	626	395	903	1429	442	404	356
Decant Water Recovery Total Volume (m ³ /day)	2	0	-	-	-	0	20	13	31	46	15	13	12
WATER RECOVERY (%)	0%	0%	0%	0%	0%	0%	2%	1%	3%	5%	1%	1%	1.1%
WATER BALANCE (inflow - outflow) Including Water Recovery													
m ³ /day	267.34	102.41	153.98	193.94	391.82	343.15	266.85	281.41	317.76	183.57	325.14	368.30	266
m ³ /month	8,287.54	2,893.00	4,773.53	5,818.21	12,146.57	10,294.61	8,272.34	8,723.56	9,214.91	5,690.57	9,754.20	11,417.34	97,286

Appendix J

Forward Work Plan

Table 1 Current and future works program

Impact Event ID	Activity	Start date	Completion date	Planned date for submission to DSD	Justification of timing for works	Responsibility
C1, V1	Finalise Conceptual Closure Surface Water Management Plan to appropriately manage surface water flows	Q4 2018	Q2 2019	2019	Provides adequate time for site closure Considers operating mine site requirements and progressive rehabilitation program	CGO General Manager and Environment Advisor with specialist technical subconsultants, as required
C1, V1	Implement closure surface water management plan	Q4 2021 (or at LOM if sooner)	2022	2022	Considers realistic time of implementation of the Plan within the context of the progressive rehabilitation program	CGO General Manager
C2	Determine erosion factors and assessment criteria for rehabilitated surfaces	Q2 2018	2019	2019	Provides adequate time for final rehabilitation specification for localised areas to achieve best results for revegetation Consideration to budget priorities	CGO General Manager and Environment Advisor with specialist technical subconsultants, as required
C2	Assessment and trials of alternative methods of slope stability and surfacing (subsoil and topsoil application)	2017-2018	2019	2019	Provides adequate time for final rehabilitation specification for localised areas to achieve best results for revegetation Consideration to budget priorities	CGO General Manager and Environment Advisor with specialist technical subconsultants, as required
C5	Tailings Operation Manual revision	Q3 2017	2017	2017	TSF2 active and annual audits period based revision.	CGO General Manager, TSF Engineer and Environment Advisor

Impact Event ID	Activity	Start date	Completion date	Planned date for submission to DSD	Justification of timing for works	Responsibility
						with specialist subconsultants, as required
C11	Assessment of suitability of COW1 SWL criteria	Q2 2018	2018	Compliance reporting	Availability of additional operational monitoring data to that already collected	CGO General Manager and Environment Advisor with specialist subconsultants, as required
C6, G3, G6, V4	Review modelling predictions with groundwater monitoring results and revise accordingly Validate groundwater model	Q2 2020	2020	Compliance reporting	Validation of model continuously undertaken with operational groundwater monitoring, and review of model undertaken as part of 2017 PEPR review. This validation of the model is for mine site completion	CGO General Manager and Environment Advisor with specialist technical subconsultants, as required
G3, G6	Determine appropriate groundwater monitoring closure criteria to confirm trends align with model predictions such that groundwater monitoring can be ceased	Q2 2020	2020	2021	Requires outcome of modelling review	CGO General Manager and Environment Advisor with specialist subconsultants, as required
C15a	Erosion testing of waste rock	current	2017	2018	Data gap considered a priority	CGO General Manager and Environment Advisor with specialist subconsultants, as required
V1	Develop a final IWL decommissioning plan with detailed design, specific landform treatment and stabilisation methods (drainage and cover design) based on closure considerations S 7.9.2	Q1 2018	2018	2019	Provides adequate time to provide detail for design of completion landform treatment of the IWL Consideration to budget priorities and requirement of results from C2 future works	Manager and Environment Advisor with specialist subconsultants, as required

Impact Event ID	Activity	Start date	Completion date	Planned date for submission to DSD	Justification of timing for works	Responsibility
V1	Calibrate erosion parameters for the compacted oxide material and waste rock materials, both fresh as well as oxidised waste rock, in order to improve the reliability of the erosion simulations and predictions using aerial and GPS survey data with two detailed surveys. (Metago, 2011) - i.e. assessment of weathering and erosive potential	Q4 2017 & Q4 2021 (or at LOM if sooner)	2017 & 2021	2021	Provides adequate time to provide detail for design of completion landform treatment of the IWL Consideration to budget priorities and requirement of results from C2 future works	CGO General Manager and Environment Advisor with specialist subconsultants, as required
V1	Conduct modelling to predict extent of erosion dispersion using closure design parameters (with and without toe bund) and reduce uncertainty regarding vegetation impacts.	Q2 2018	2019	2019	Provides adequate time to provide detail for design of completion landform treatment of the IWL Consideration to budget priorities and requirement of results from C2 future works	CGO General Manager and Environment Advisor with specialist subconsultants, as required
V1	If erosion is determined to be dispersed amongst vegetation, determine significance and develop protection plan/alter closure design as required.	Q3 2018	2019	2019	Provides adequate time to provide detail for design of completion landform treatment of the IWL Consideration to budget priorities and requirement of results from C2 future works	CGO General Manager and Environment Advisor with specialist subconsultants, as required
V1	Continue ecosystem function analysis (EFA), or similar to determine success of rehabilitated sites and adjust rehabilitation activities as appropriate based on the results	ongoing	2022	Compliance reporting	Annual assessment, post-closure assessment to provide assessment statements for completion	CGO General Manager and Environment Advisor with specialist subconsultants, as required
V1	Conduct cover trials on TSF1 and apply learnings to TSF2 cover design	from Q2 2018	2019	2019	Provides adequate time for final rehabilitation specification for localised areas to achieve best results for revegetation Consideration to budget priorities	CGO General Manager and Environment Advisor with specialist technical subconsultants, as required
V7	Inclusion of closure works into weed operating	Q2 2018	2018	2019	Weed management	CGO General

Impact Event ID	Activity	Start date	Completion date	Planned date for submission to DSD	Justification of timing for works	Responsibility
	procedure				considerations need to be understood prior to advanced progressive rehabilitation	Manager and Environment Advisor with specialist subconsultants, as required
V6, F6, G4	Contaminated site assessment of operational areas	post closure	2021	2021	For completion (required to be undertaken after decommissioning and remedial works)	CGO General Manager and Environment Advisor with specialist subconsultants, as required
PS2, PS3, PS4, TP2, TP4	Legal asset transfer agreement to be compiled and agreed by all relevant parties, and as per Closure Outcome 1	prior to LOM	2021	2021	Completion requirement	WPG management, CGO General Manager and Environment Advisor with specialist subconsultants, as required
PS5	Finalisation of closure design and implementation of barriers	post LOM	2021	2021	For completion	CGO General Manager and Environment Advisor with specialist subconsultants, as required
PS3, PS4	Closure activities - signage and abandonment bund are in place	post closure	2021	2021	For completion	CGO General Manager and Environment Advisor with specialist subconsultants, as required

Appendix K

Native Vegetation Management Plan



**Kingsgate
Limited**

A.C.N. 000 715 882

Consolidated Registered Office and Principal Business Address:
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Native Vegetation Management Plan

1.0 Project Background

Challenger mine site is located within the north-west portion of the Gawler Craton in the eastern regions of the Great Victoria Desert (**Figure 1**). The climate is arid, receiving an average 180 mm rainfall per annum.



Figure 1: Challenger Locality

The mine site covers approximately 3 km² of pastoral country (**Figure 22**) consisting of four land units; calcrete platforms (14.5%), sand sheets and banks (45.5%), stony slopes and platforms (33%) and drainage lines (7%). Baseline flora surveys have been supplemented by independent annual flora surveys since operations commenced, and include:

- Ecological Horizons (2001) Challenger Gold Mine Preliminary Baseline Survey;
- Outback Ecology Services (2001) Baseline Environmental Studies;
- Badman Environmental (2003, 2004, 2005, 2006, 2007, 2008, 2009 and 2010) Annual Spring Flora Surveys;
- Outback Ecology Services (2011); and
- Badman Environmental (2004) Weed Survey.

Independent baseline environmental surveys found that the Challenger area generally comprises predominantly ubiquitous arid species contained within the four land units, each with a recognisable common vegetation association. The region has historically been subject to heavy grazing pressure from pastoral activities. The associated vegetation structure (**Figure 3**) of these land units are described as follows;

- Calcrete Platforms – the predominant vegetation was sparsely distributed low shrubs with virtually no taller shrubs or trees.
- Sand Sheets and Banks – the predominant vegetation was scattered tall perennial shrubs to 2 metres (m), with mid and low shrubs sparse in density and scattered between the taller shrubs. Grazing pressure had resulted in a general scarcity of grasses.
- Stony Slopes and Platforms – had the lowest species diversity of the four land units described. The vegetation comprised scattered taller shrubs and trees up to approximately 5 m with the smaller mid-sized shrubs. Annuals and grasses were scarce due to grazing.
- Drainage Lines and Foci – the vegetation comprised low woodland with scattered mid and tall shrubs under the canopy. Weed species and annuals were also present.

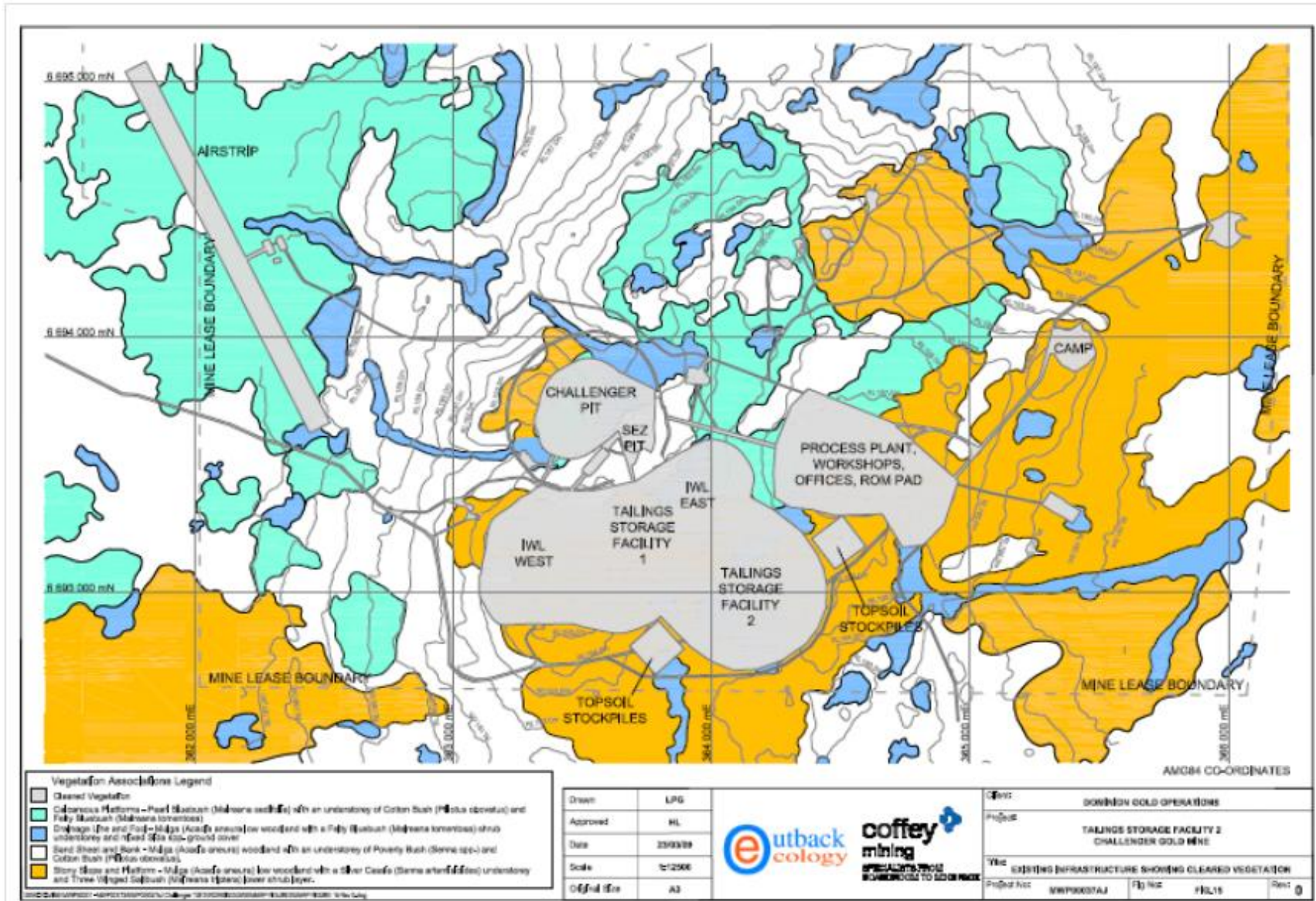


Figure 3: Challenger Gold Mine land units

In alignment with the land unit classifications, flora is further classified into four main vegetation areas (OES 2001):

- *Maireana sedifolia* dwarf scrub over *Ptilotus obovatus* and *M. tomentosa* dwarf scrub.
- *Acacia aneura* open low woodland over *Senna* sp. low scrub over *Ptilotus obovatus* open dwarf scrub.
- *Acacia aneura* open low woodland over *Senna artemisioides* open low scrub over *Maireana triptera* dwarf scrub.
- *Acacia aneura* low woodland over *Maireana tomentosa* dwarf scrub over open herbs of *Sida* sp.

Annual flora assessments have been undertaken and consist of 100-metre line transects, one-hectare quadrats, and photographic monitoring points at near-mine, intermediate mine and pastoral locations within the various land unit types.

No threatened species, as listed by either the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*, or the South Australian *National Parks and Wildlife Act 1972*, is known to occur in the Project area. Four threatened taxa reported during an earlier survey (Ecological Horizons 2002) included one species that has since been de-listed and three taxa that were based on misidentifications of voucher collections (Badman 2003, 2007).

Annual flora monitoring of analogue sites around the mine have concluded that there is no indication that significant changes in vegetation could be attributed to mining operations or ancillary activities (Outback, 2011). These sites will continue to be monitored annually for the life of the mine for closure and rehabilitation purposes. The mining lease has been fenced to exclude livestock from surrounding pastoral activities, and this is expected to improve the quality of existing native vegetation and facilitate rehabilitation activities.

The occurrence of weeds is very low at Challenger. A dedicated weed survey was carried out in 2004 by Badman Environmental and several new weed species were recorded, both on the mining lease and the nearby pastoral lease. None of the species recorded were proclaimed weed species in South Australia. The 2004 weed survey indicated that the incidence of weed species at the Challenger Mine was lower than in most other parts of South Australia (Badman 2004). This was confirmed from the 2009 monitoring with only four weed species recorded (Badman 2009).

Despite the preceding wet summer, the 2011 spring flora survey found only two exotic weed species, *Solanum nigrum* and *Sonchus oleraceus*, both of which had previously been recorded from the site (Outback, 2011).

The areas of clearing proposed for the Challenger Project are contained within four landform types which are typically found in the region. They are classified as Stony Plains, Sandy Sheets, Calcrete Platforms and Drainage Foci as identified in baseline surveys in 2002. In some areas, the sand sheet overlays portions of the calcrete platforms. The land use was previously pastoral country and therefore grazing was prevalent.

The four landforms affected by clearing at Challenger are summarised as follows:

- Stony Plains: very gentle slopes with mantles of siliceous or ironstone cobbles and gravels. These support scattered taller shrubs and trees up to five metres in height. Smaller shrubs also occur between the larger plants (**Plate 1**).
- Calcrete Platforms: gently undulating low rises with calcrete and ironstone gravels and occasional calcrete rubble. These support sparse chenopod low shrubland, with a few emergent trees or taller shrubs (**Plate 2**).
- Sand Sheets: undulating deep red or shallow sands overlaying calcrete and often fringing calcrete platforms. Tall shrubs to two metres in height, with sparse low shrubs scattered between them, dominate the vegetation (**Plate 3**).
- Drainage Foci: shallow drainage lines 150-400 metres wide, with no defined channels and with red and brown clay soils. These support low woodland vegetation with low and tall shrubs under the canopy (**Plate 4**).

All landforms support a variety of forbs and grasses in good seasons. Some shortlived perennial grasses occur depending on season and grazing pressure.



Plate 1 Stony Plain landform in the area proposed for clearing



Plate 2 Calcrete Platform Landform in the area proposed for clearing



Plate 3 Sandy Sheet landform in the area proposed for clearing



Plate 4: Drainage Foci landform in the area proposed for clearing

2.0 Vegetation Clearing at Challenger

The vegetation surrounding Challenger is well represented within the Gawler Craton. Most seed sources are available to regenerate the original vegetation structure. There are obvious signs of grazing with patchy areas of soil crust, bare ground and tracks with minor clearing.

As the vegetation is well represented within the surrounding area of the mining lease, progressive rehabilitation is the most practicable option to return the area to its previous status prior to clearing. A Significant Environmental Benefit would be the most appropriate method to offset native vegetation cleared within the Challenger Project.

Unnecessary destruction of native vegetation and habitat for future infrastructure and construction projects will be avoided with controlled and minimal clearing. All possible attempts will be made to avoid clearing of significant trees and other faunal niches during the planning stage. A native vegetation permit for clearing will be obtained from DMITRE prior to removal of vegetation. Cleared areas no longer used for mining will be progressively rehabilitated and seeded with native species.

The SEB ratio used to calculate the amount payable into the Native Vegetation fund in accordance with the Guidelines for a Native Vegetation Significant Environmental Benefit Policy for the Clearance of Native Vegetation associated with the Minerals and Petroleum Industry (Department of Water, Land and Biodiversity Conservation 2005).

The assessment of vegetation condition based on the SEB ratio concluded that the area to be cleared is native vegetation with some disturbance:

SEB ratio 6:1 - Native vegetation with some disturbance

Indicated by:

Vegetation structure altered (e.g. one or more vegetation strata depleted)

Most seed sources available to regenerate original structure

Obvious signs of disturbance (e.g. Tracks, bare ground)

A native vegetation clearing permit for Challenger Gold Mine is attached in **Appendix A**.

3.0 References

Badman (2003) Challenger Gold Mine. Annual Spring Flora Survey. Prepared by Badman Environmental for Dominion Gold Operation Pty Ltd.

Badman (2004) Challenger Gold Mine. Weed Survey. Prepared by Badman Environmental for Dominion Gold Operation Pty Ltd.

Badman (2007) Challenger Gold Mine. Annual Spring Flora Survey. Prepared by Badman Environmental for Dominion Gold Operation Pty Ltd.

Badman (2009) Challenger Gold Mine. Annual Spring Flora Survey. Prepared by Badman Environmental for Dominion Gold Operation Pty Ltd.

Outback Ecology Services (2001) Baseline Environmental Studies. Challenger Project. Gawler Craton South Australia.

Outback Ecology Services (2011) Challenger 2011 Annual Spring Flora Survey Executive Summary 2010-11 Challenger Vegetation Photographic Monitoring Points.

Appendix L

Flora and Fauna Monitoring Review



**Challenger Mine
Flora and Fauna Monitoring Review**

Challenger Mine Flora and Fauna Monitoring Review

5 June 2017

Version 4

Prepared by EBS Ecology for Environmental Projects

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GLOSSARY AND ABBREVIATION OF TERMS

DSD	Department for State Development
EBS	EBS Ecology
ML	Mineral Lease
PL	Pastoral Lease
PEPR	Program for Environment Protection and Rehabilitation
SAALNRM	South Australian Arid Lands Natural Resource Management Board
Site	Monitoring site where flora and fauna survey is undertaken

Plant life cycles

Annual	Completes the full cycle of germination to fruiting within a single year and then dies usually at the same time of year annually
Ephemeral	Emerges as a response to episodic rainfall events completing its entire lifecycle in the period thereafter.
Short-lived perennial	Lives for a period of two to at most three seasons, commonly represented by species of the genus <i>Sclerolaena</i> .
Long Lived Perennial	Life span extending over more than two growing seasons.

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1 INTRODUCTION

EBS Ecology was commissioned by Challenger Gold Operations (CGO) to perform a review of the annual flora fauna and rehabilitation monitoring program for the Challenger Gold Mine. The mine is located approximately 170 km west of the Stuart Highway and 150 km south-west of Coober Pedy, on Mobella Pastoral Lease (PL2169) (Figure 1). At a regional level, the project site falls within the north-west pastoral zone. The landscape is described as a sandy plain and vegetation cover is dominated by mulga open woodland over chenopod shrubs.

This review primarily focusses around flora and fauna measurement criteria for inclusion in the new Program for Environment Protection and Rehabilitation (PEPR) in order to satisfy requirements of Ministerial Determination 005 in accordance with regulation 65(7) of the Mining Regulations 2011. The recommendations are made based on existing knowledge of the site in the wake of flora, fauna and rehabilitation monitoring at the site.

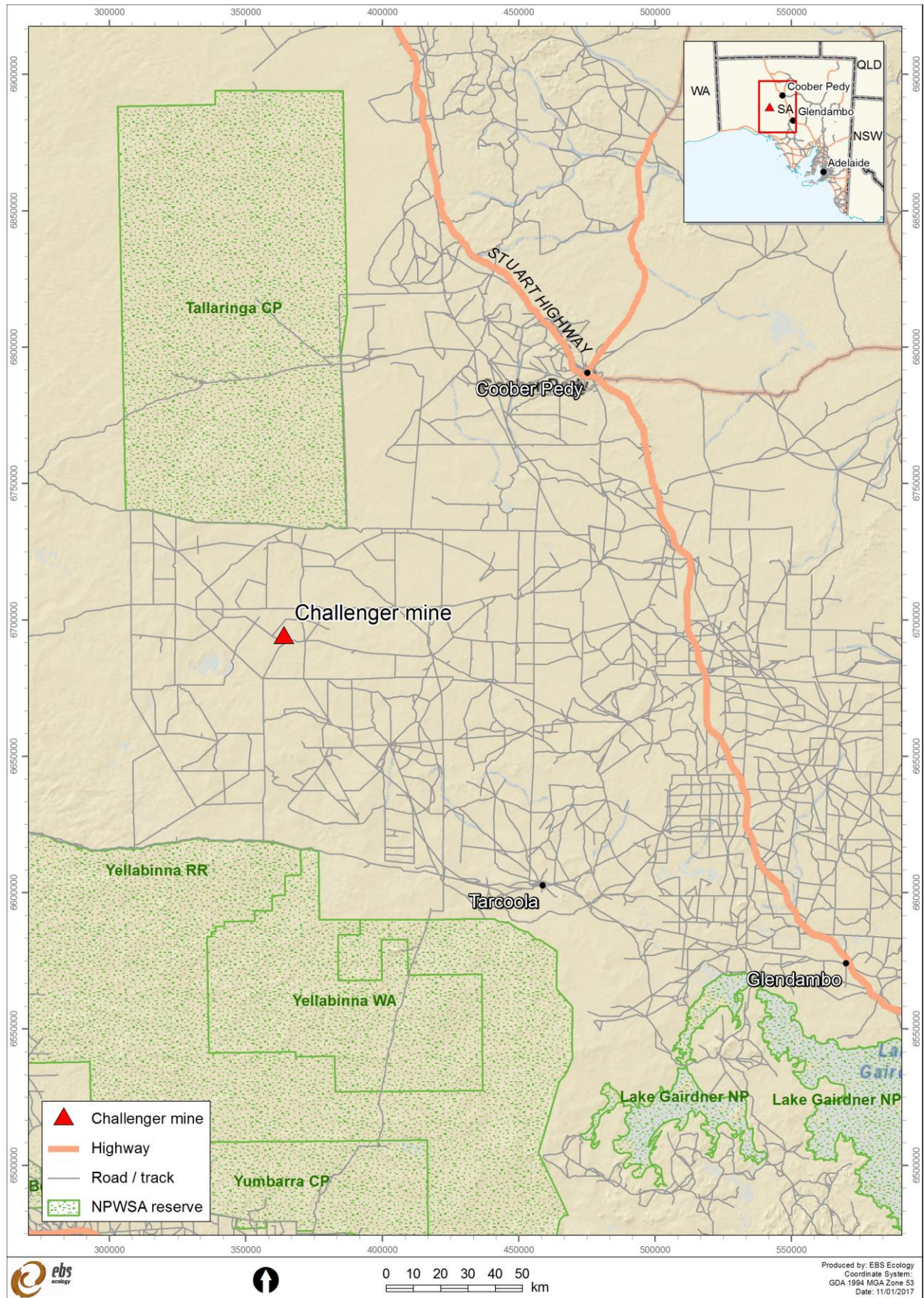


Figure 1. Location of Challenger Gold Mine

2 BACKGROUND INFORMATION

Baseline ecological surveys were undertaken by Outback Ecology in January 2001. Flora, fauna and rehabilitation monitoring has occurred at the Challenger site on an annual basis since the baseline survey with the first monitoring period in spring 2002. The baseline methodology has been used continually until this point which has generated a significant base of data on which to draw information from. The report findings were made based on known ecological attributes located in and around Challenger and recorded annually since 2001.

The following sections summarise the existing flora, fauna and rehabilitation knowledge from Challenger.

2.1 Landforms

Landform units observed within the Challenger area were fully described as;

Calcrete Platforms – gently undulating low rises with 1-2m relief, sheeted with calcrete and ironstone gravels and occasional calcrete rubble, occupying approximately 14.5% of the Challenger project area.

Sand Sheets and Banks – undulating deep red or shallow sands overlaying calcrete and often fringing calcrete platforms, occupying approximately 45.5% of the Challenger project area.

Stony Slopes and Platforms – very-gentle slopes with mantles of siliceous or ironstone cobbles and gravels, occupying 33% of the Challenger area.

Drainage Lines – sluggish drainage tracts 150 - 400 m wide, lacking defined channels. Red and brown clay soils with gravel scree, overlay calcrete at depth. Small drainage foci and clay pan areas situated within the drainage systems occupying 7% of the Challenger project area.

2.2 Fauna

2.2.1 Site locations

The fauna monitoring program has run annually since 2001. A total of eight systematic monitoring sites were established by Outback Ecology in 2001, four of which are classed as 'mine sites'; located on the ML, and four classed as 'pastoral sites'; located on the adjacent PL (refer to Figure 2 and Table 1). To allow for comparison, the same four discrete landforms are surveyed on the ML and PL. These landforms classes are:

- drainage foci;
- sand sheet;
- stony plain; and
- calcrete platform.

Table 1. Systematic survey sites and descriptions (From MWH 2015)

Site ID	Site Location	Coordinates (UTM 53J)		Habitat type	Vegetation	Distance from disturbance
		Easting	Northing			
CHA03	Mine Site	364309	6694178	Drainage Lines and Foci (DL)	<i>Acacia aneura</i> over <i>Maireana tomentosa</i> and <i>Sida</i> spp.	170 m
CHA05	Mine Site	363006	6694116	Sand Sheets and Banks (SS)	<i>Acacia aneura</i> with an understorey of <i>Senna</i> spp. And <i>Ptilotus obovatus</i>	370 m
CHA06	Mine Site	363719	6692836	Stony Slopes and Platforms (ST)	<i>Acacia aneura</i> with an understorey of <i>Senna artemisioides</i> and <i>Maireana triptera</i>	170 m
CHA10	Mine Site	361611	6693111	Calcareous Platforms (CP)	<i>Maireana sedifolia</i> with an understorey of <i>Ptilotus obovatus</i>	900 m (700 m from airstrip)
CHA01	Pastoral Site	366561	6694124	Stony Slopes and Platforms (ST)	<i>Acacia aneura</i> with an understorey of <i>Senna artemisioides</i> and <i>Maireana triptera</i>	620 m
CHA02	Pastoral Site	361611	6693111	Calcareous Platforms (CP)	<i>Maireana sedifolia</i> with an understorey of <i>Ptilotus obovatus</i>	1,670 m
CHA07	Pastoral Site	361050	6695136	Drainage Lines and Foci (DL)	<i>Acacia aneura</i> over <i>Maireana tomentosa</i> and <i>Sida</i> spp.	2,560 m (800 m from airstrip)
CHA08	Pastoral Site	363212	6692643	Sand Sheets and Banks (SS)	<i>Acacia aneura</i> with an understorey of <i>Senna</i> spp. and <i>Ptilotus obovatus</i>	480 m

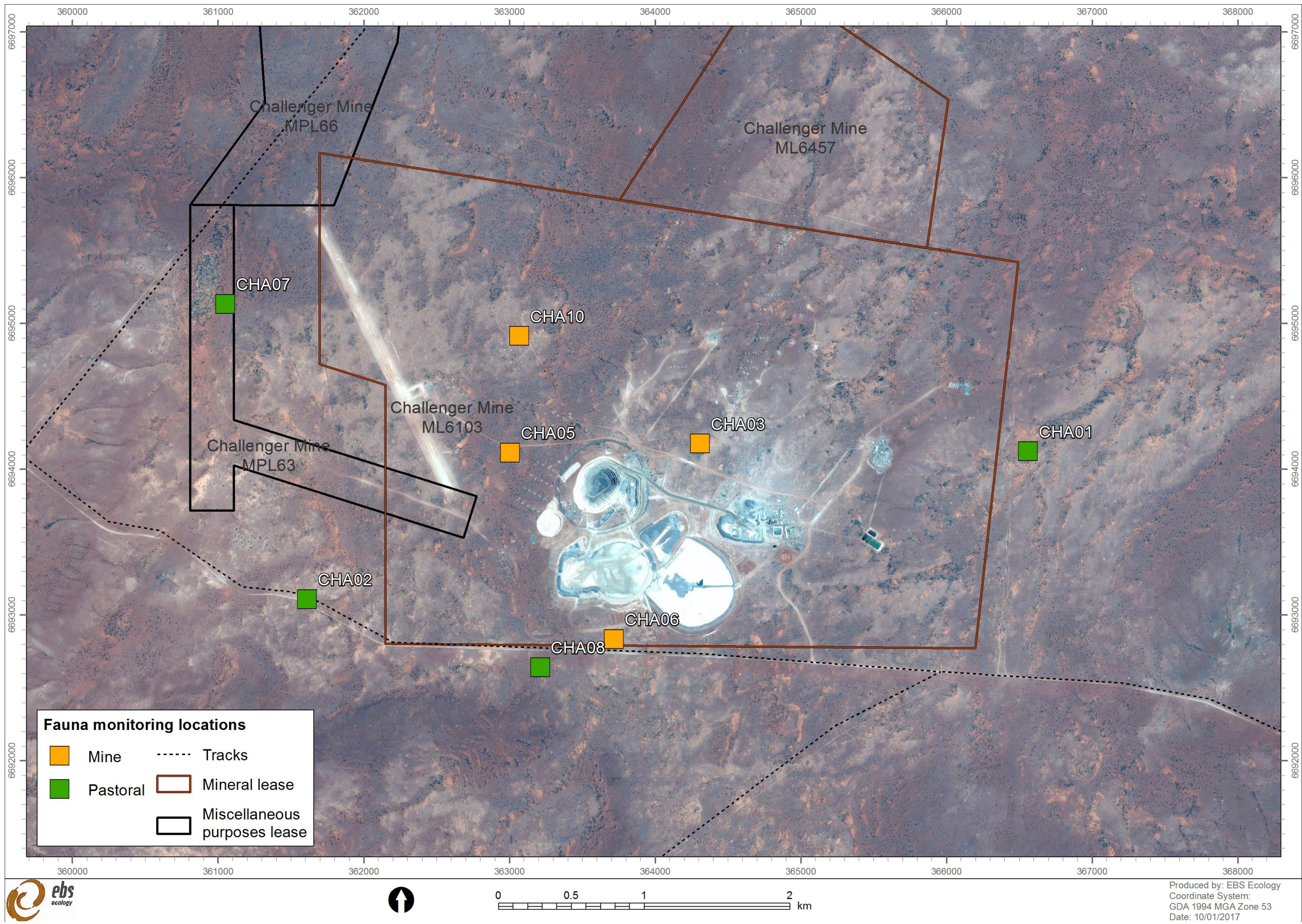


Figure 2. Location of fauna monitoring sites inside and outside of the Challenger Gold Mine ML

2.2.2 Existing fauna sampling methodology

Fauna surveys have been conducted annually since 2002 with two surveys conducted in 2007 (early and late) in lieu of a 2006 survey for a total of 15 surveys. During this period 175 species have been recorded through a variety of methods as outlined below in Table 2.

Table 2. Summary of existing methodology

Method	Intensity	Targeted species	Frequency
Pitfall Trapping	8 sites, six pitfall buckets (400 mm x 150 mm) spaced 10 m apart at each site	Reptiles / Mammals	Annually
Elliott traps	8 sites, 20 Elliott traps per site	Reptiles / Mammals	Annually
Funnel Traps	8 sites, 10 per site	Reptiles / Mammals	Annually
Point count	8 sites, 20 minutes per site	Birds	Annually
Echolocation	2 sites	Bats	Annually
Motion sensing cameras	8 sites 2 nights per site	Predator pests	Annually
Targeted surveys	2 hours per habitat area	Threatened species	Annually
Spotlighting	4 hours per survey	Any	Annually
Opportunistic	Observation	Any	Annually

2.2.3 Results summary

Data shows that the avifauna census for birds and trapping for mammals and reptiles allow the greatest number of observations (Table 3). The trapping and census methodologies are defined, repeatable and reduce variation in comparison to other methodologies such as with limitations or constraints including

- Opportunistic (variable dependent on observer effort and skill, time period extent and spatial).
- Active searching (effort put in by observer, time period extent and spatial).
- Targeted search (time period extent), spotlighting (highly weather dependent, temp, wind).

Table 3. Number of observations from historical sampling for all years 2001 – 2016.

Assessment Type	Number of observations
Avifauna Census	1856
Trapping	1244
Opportunistic	699
Active Search	175
Targeted Search	175
Motion sensor camera	116
Anabat	98
Spotlighting	59

2.2.4 Correlations

Data analysis for trapping sites (mammals and reptiles) and avifauna census sites shows that there has been a trend for increased abundance of reptiles and mammals with increasing annual rainfall (Figure 3). This trend is strongly reversed for birds which suggests that during drier periods, local water sources attract

more birds to these areas such as pastoral water supplies and mine water sources such as the sewerage farm.

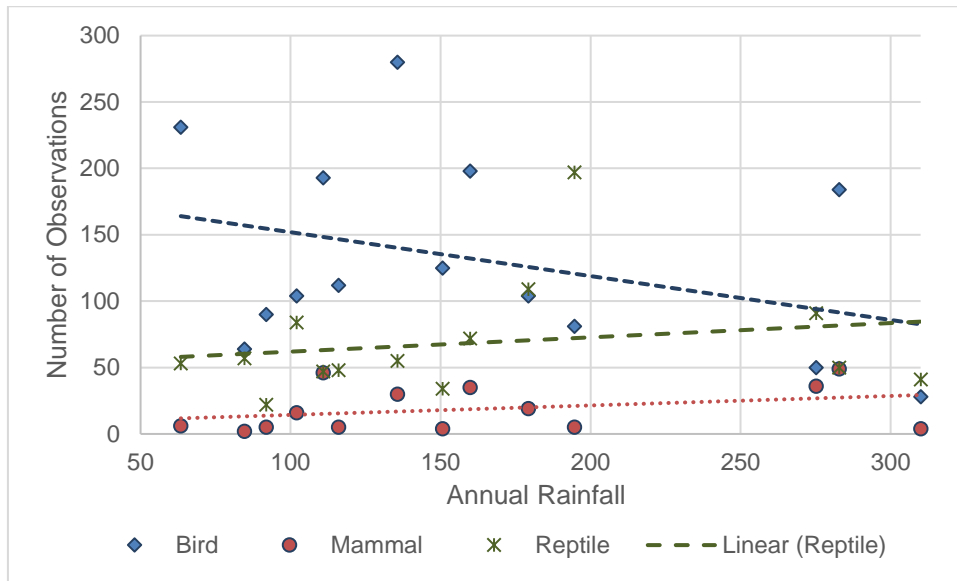


Figure 3. Observations versus annual rainfall over fauna monitoring duration

When looking at distance from infrastructure to fauna observation abundance, the trends are reversed with mammals and reptiles having higher abundance near infrastructure and lower abundance away from the mine (Figure 4). Birds have shown better abundance with distance from the mine at avifauna census sites.

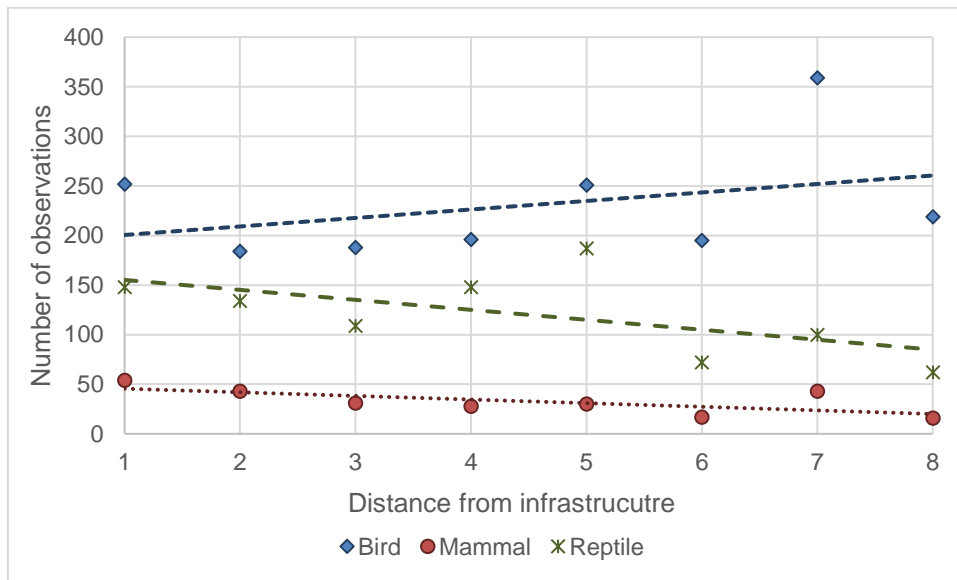


Figure 4. Correlations between observations and distance from mine infrastructure

Conclusions from fauna analysis suggest that it may be beneficial to follow an approach that focusses on species which are less transient and not likely to be influenced in a positive way by mining operations. Transient bird species are less likely to be present consistently, being either dispersive when times are good or concentrated in areas such as the mine during drier periods. The focus of this analysis is therefore on species prominent in the local area.

2.2.5 Residency

Thirty-five fauna species have been recorded on ten or more occasions out of 16 monitoring seasons with 70 bird species observed at least once over the entire period. Just 11 species have been recorded in all 16 surveys. This demonstrates the low level of permanent residency for species within the Challenger area.

Analysis of data was undertaken to establish mammals birds and reptiles by the relevant methods as to which species are observed at a frequency that makes them suitable as indicators rather than as itinerant visitors which are recorded infrequently. From a monitoring perspective species which are rarely recorded are unsuitable for data as presence or absence is naturally variable and unable to be used for disturbance related outcomes.

Reptiles and birds which have occurred during >65% of annual surveys (9 times), were analysed to assess which sites provide indicative presence of these species. Mammals were less frequent, having life history strategies which enable periods of torpor and remain during periods of low rainfall or resource abundance as demonstrated above in Figure 3. Analysis of reptiles and birds and mammals as a percentage of the frequency at monitoring sites per year was made. Most bird species were recorded at all sites (Figure 5). Reptiles were present most often at sites 1,3,6 and 8. Mammals showed similar trends however lower capture rates of these species give poor quality data for making accurate conclusions.

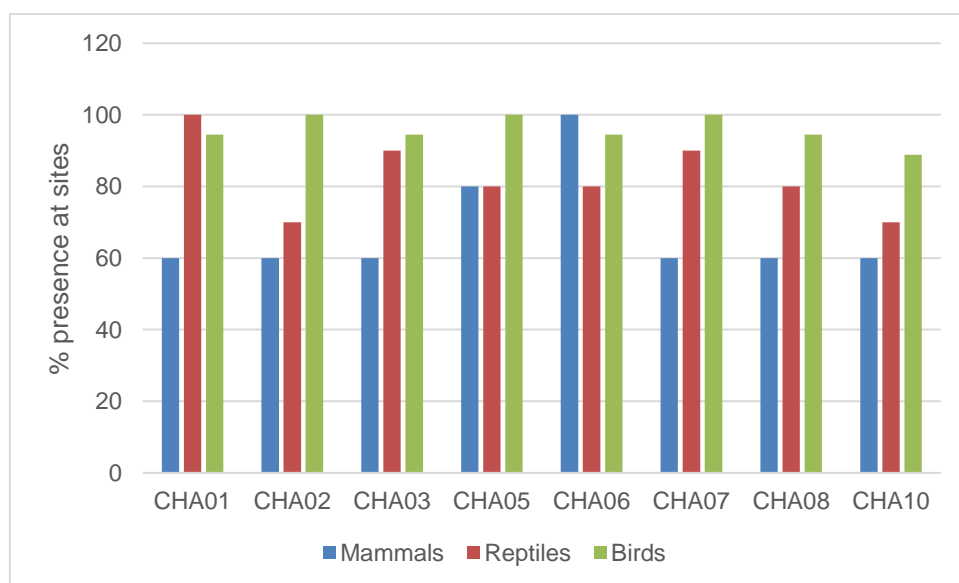


Figure 5. Percentage of presence of resident species at monitoring sites per year

As an average abundance recorded at each site (Figure 6), mammals and reptiles show preference for 1,3,5 and 6, of which three are near infrastructure sites. Birds have high abundance at site 7, then 3,1,8,6 and 2 in order from most to least respectively.

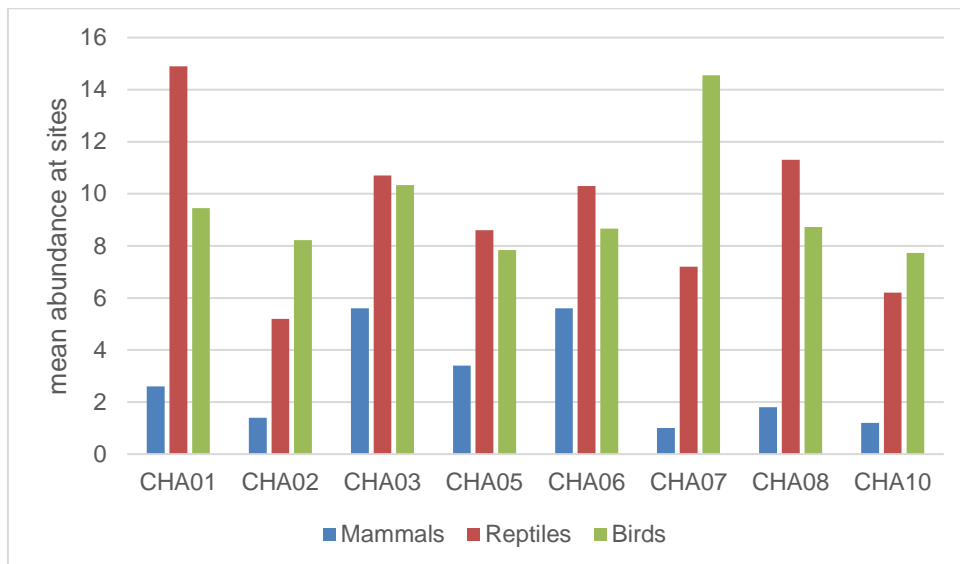


Figure 6. Mean abundance of resident species at monitoring sites annually

Based on the findings, the best trapping sites for mammals and reptiles are 1, 3, 6 and 8. Birds are most prevalent at 1, 3, 7 and 6. These sites will provide reliable quality data on an ongoing basis, for comparison with the 14 years data currently collated as a benchmark.

2.2.6 Bats

Bats have been surveyed at the sewage ponds since 2007 (Table 4). Over the past eight survey events, a total of eight bat species have been recorded. The Gould's Wattled Bat (*Chalinolobus gouldii*) has been recorded on all surveys, while the Free-tailed Bat (*Mormopterus sp 3 or 4*) and Inland Broad-nosed Bat (*Scotorepens balstoni*) were recorded on six and five surveys, respectively. One new species was recorded in 2016; the Lesser or Central Long-eared Bat (*Nyctophilus geoffroyi/major tor*). There are no observable trends in the presence of bat species (confirmation of some species and overall abundance cannot be determined). Therefore, the quality of data collected as part of bat surveys has significant doubt around its ability to determine the relevance of bat call presence with impacts associated with operations.

Table 4. Species of bat present at the sewage ponds from 2007 to 2016

Common Name	Scientific Name	2007 b	2009	2011	2012	2013	2014	2015	2016
Free-tailed Bat	<i>Mormopterus sp 3 or 4</i>	x		x	x	x		x	x
Gould's Wattled Bat	<i>Chalinolobus gouldii</i>	x	x	x	x	x	x	x	x
Inland Broad-nosed Bat	<i>Scotorepens balstoni</i>		x	x		x	x	x	
Inland Cave Bat	<i>Vespadelus finlaysoni</i>			x					
Inland Forest Bat	<i>Vespadelus baverstocki</i>							x	
White-striped Freetail Bat	<i>Tadarida australis</i>			x					
Yellow-bellied Sheath tail Bat	<i>Scotorepens balstoni</i>	x							
Lesser Long-eared Bat/Central Long-eared Bat	<i>Nyctophilus geoffroyi/major tor</i>								x

2.2.7 Amphibians

Only one species of amphibian; the Trilling Frog (*Neobatrachus centralis*) has been recorded at Challenger since surveys commenced. The Trilling Frog has been captured in 2002, 2003 and 2007a, on both the ML and PL. This species would be continued to be trapped however provides little by way of observable trends.

2.2.8 Introduced Species

The numbers of each introduced species observed at Challenger over the entire annual survey period vary considerably between years. This data is difficult to quantify as the methodology does not discriminate between one individual being recorded several times. House mouse is the most commonly occurring exotic fauna species and this is typical in arid regions where numbers fluctuate largely between years dependent on the availability of resources.

2.3 Flora

2.3.1 Site locations

Twelve monitoring sites were assessed with each site assigned an impact class and landform category. This results in four sites each at Near Mine, Intermediate and Pastoral impact classes for a total of twelve sites. Each of these sites within individual impact classes are made up of one of four landforms. These are summarised below (Table 5 and Figure 7).

Table 5. Challenger Gold Mine flora monitoring site summary

Site #	Impact class	Landform	Brg (°)	Location	
				Easting	Northing
CHA01	Pastoral	Stony Plain	55°	366561	6694124
CHA02	Pastoral	Calcareous Platform	17°	361611	6693111
CHA03	Near-mine	Drainage Foci	194°	364309	6693146
CHA04B	Near-mine	Calcareous Platform	209°	362886	6693147
CHA05	Near-mine	Sand Sheet	206°	363006	6694116
CHA06B	Near-mine	Stony Plain	160°	363752	6692993
CHA07	Pastoral	Drainage Foci	137°	361050	6695136
CHA08	Pastoral	Sand Sheet	238°	363212	6692643
CHA09	Intermediate	Sand Sheet	160°	364218	6695223
CHA10	Intermediate	Calcareous Platform	155°	363069	6694916
CHA11	Intermediate	Drainage Foci	145°	363379	6695237
CHA12	Intermediate	Stony Plain	180°	366378	6694941

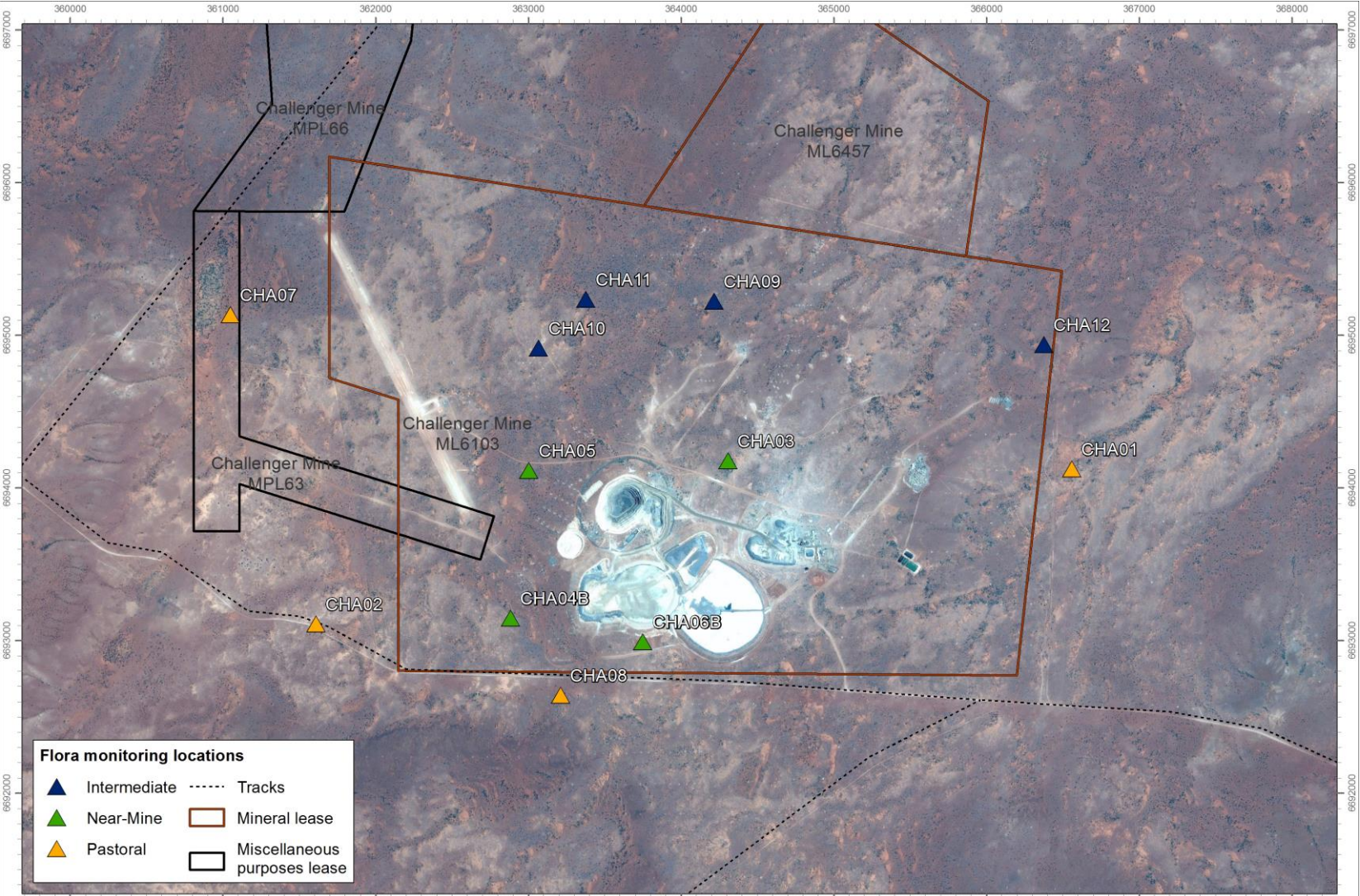


Figure 7. Flora monitoring locations and impact class

2.3.2 Existing flora sampling effort

The annual vegetation monitoring program consists of key measurements collected by three methodologies. These are intended to capture variation in vegetation condition, both spatially and temporally:

- **Transects (Line Intercept Method):** percentage foliage cover and species richness were recorded along a permanent 100 m line transect: A 100 m tape was laid out between each marker peg in line with a sighter peg. Individual plant cover was then recorded according to the distance in centimetres (cm) measured along the tape.
- **Plant Species Richness:** was assessed using established 100 m x 100 m quadrat. The quadrats established are consistent with the one hectare (ha) vegetation monitoring quadrats.
- **Photo Point Monitoring:** A single photograph is taken along each line transect from a permanent site marker peg.
- **Photo Point monitoring at vent shaft outlets** to determine any qualitative loss of vegetation within the immediate vicinity.
- **Rehabilitation monitoring** is undertaken using the same approach for assessing landscape functioning, vegetative growth and habitat development using EFA is described by Tongway et al (1997). Using this approach, field data (soil condition, vegetation data, habitat complexity and erosion) was collected to provide information on key ecosystem processes, reflecting the functionality of the ecosystem overall. Perennial vegetation cover and density was recorded for lower storey vegetation at all transects, and was recorded for upper storey vegetation (>3 m) at transects where present

2.3.3 Results summary

Species richness for all 1ha plots has been consistent when analysis between land use types is considered (Table 6). The species richness is expected to fluctuate between survey periods dependent on seasonal condition experienced both prior to and during survey periods.

Table 6. Species richness for 1ha flora monitoring plots for all years 2001 -2015.

Year assessed	Mean		
	Near-mine	Intermediate	Pastoral
2001	34.3	-	34.0
2002	-	-	-
2003	48.8	47.0	51.5
2004	55.3	53.3	56.3
2005	24.3	27.5	24.3
2006	31.8	30.3	31.0
2007	47.0	38.3	43.0
2008	28.0	23.8	27.0
2009	32.0	33.3	38.8
2010	32.5	31.8	33.0
2011	33.3	30.5	32.3
2012	40.0	31.8	35.8

Year assessed	Mean		
	Near-mine	Intermediate	Pastoral
2013	29.8	25.3	28.5
2014	47.8	46.5	49.8
2015	41.8	37.0	36.5
Average	37.3	34.9	37.3

Species cover values analysed by land use category show similar trends to the species richness with large fluctuations from survey to survey with changes between land use categories relatively similar (Table 7).

Table 7. Species cover for 1ha flora monitoring plots for all years 2001 -2015.

Year assessed	Mean		
	Near-mine	Intermediate	Pastoral
2001	11.7	8.9	9.5
2002	8.9	6.8	4.8
2003	31.6	25.5	24.6
2004	33.8	34.7	30.0
2005	7.2	6.8	6.5
2006	5.2	3.3	4.9
2007	16.0	15.5	15.4
2008	10.0	4.9	8.9
2009	18.3	18.5	19.8
2010	19.3	20.8	23.8
2011	23.5	25.0	24.8
2012	15.8	15.3	16.4
2013	39.2	54.4	36.8
2014	17.4	19.8	22.5
2015	7.7	13.8	11.1
Average	17.7	18.3	17.3

2.3.4 Correlations

Species richness trends from 2001 – 2015 show that the trends for cover over the period in order of distance from operational areas remain similar with a slight increase at distant sites (trend line comparison from 2001 – 2015). The average trend however is in keeping with the 2001 values which indicates that there has been no decline in overall cover values at near mine sites in comparison to sites further away (Figure 8).

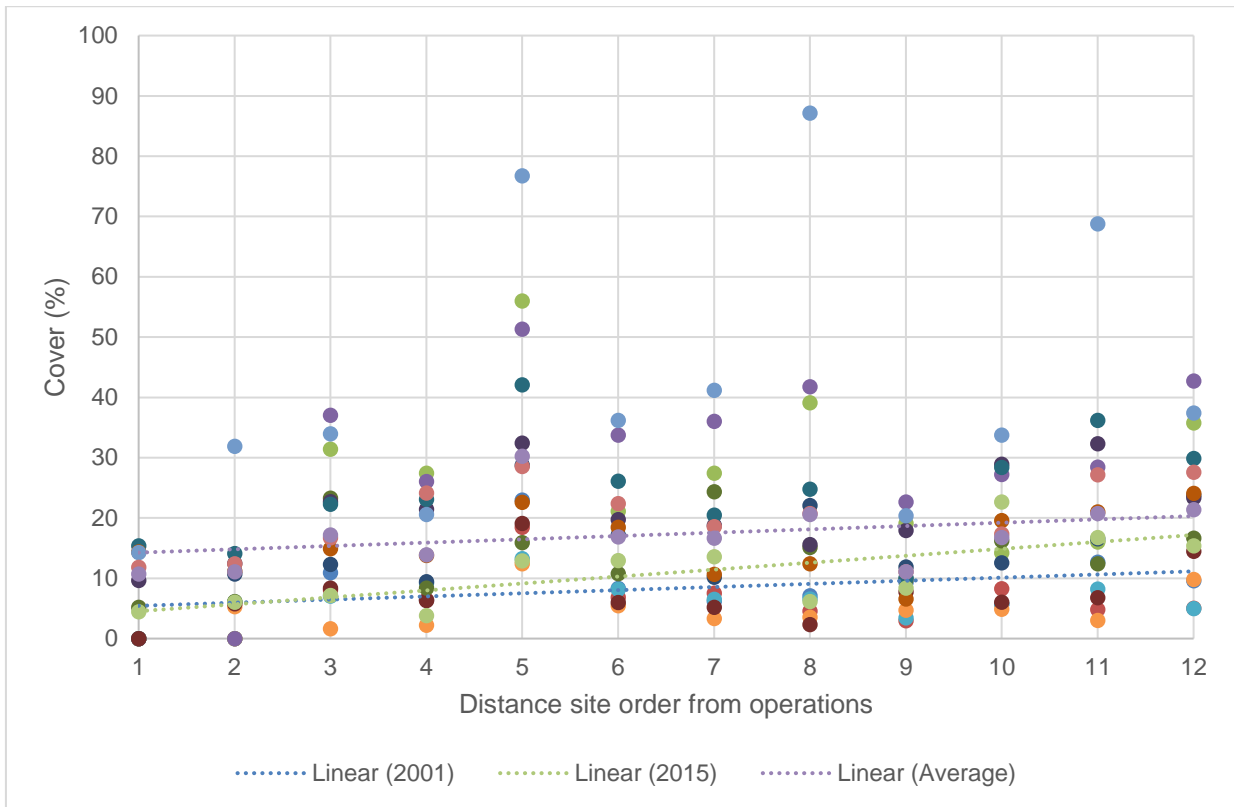


Figure 8. Cover trends at sites sorted by distance from operational areas 2001 – 2015.

Species richness trends from 2001 – 2015 are similar to cover values in observing lower species richness at near mine sites in comparison to more distant sites. This trend was opposite in 2001 however the average trend for all years is consistent with 2015 values (Figure 9).

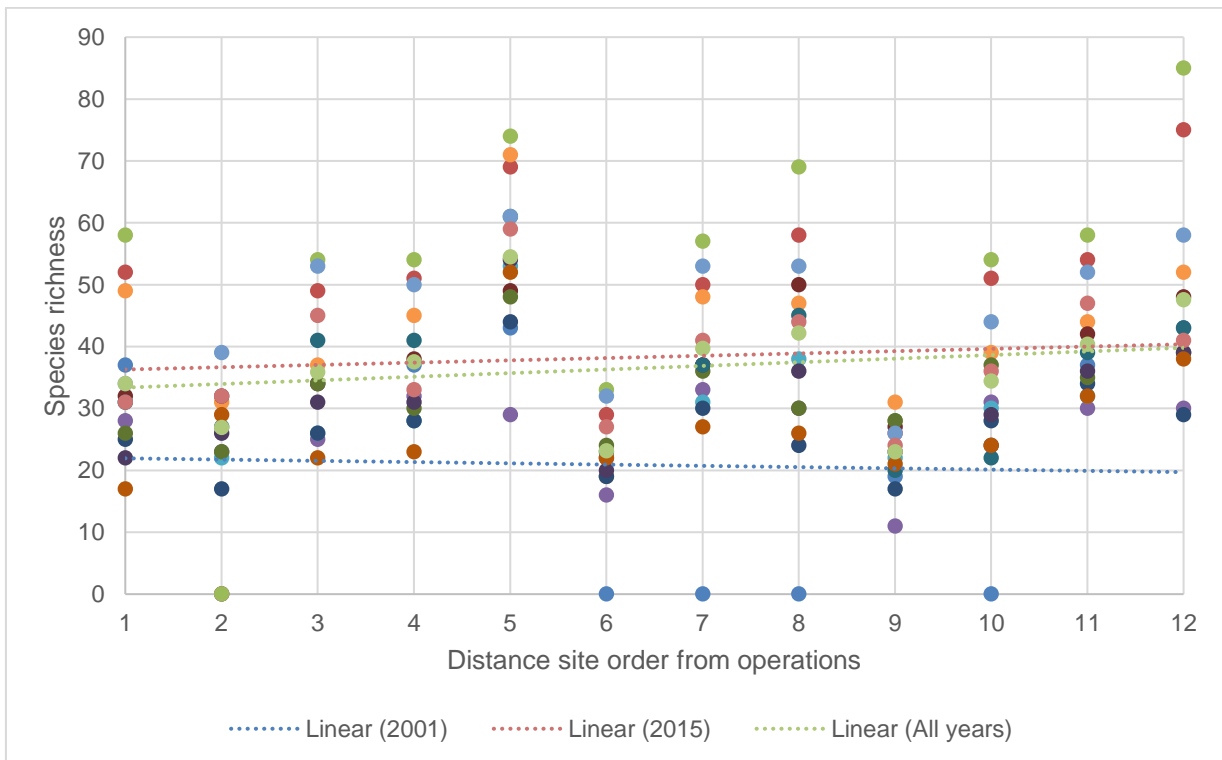


Figure 9. Species richness trends at sites sorted by distance from operational areas 2001 – 2015.

2.3.5 Exotic species

Fourteen introduced flora species have been recorded at the Challenger mine site and on nearby pastoral land since 2001. This represents only 7% of the 193 vascular flora taxa recorded during annual monitoring since 2001. Badman (2010) described the presence of species such as *Solanum Lycopersicon* (Tomato) and *Pisum sativum* (Field Pea), both recorded in 2004, as being directly attributable to the presence of the mine, but suggested that it would not be capable of persisting beyond exceptional seasonal conditions experienced around this time. Despite favorable seasonal conditions in 2013 these species were not detected, furthermore they have not been detected since (MWH 2015).

Of the fourteen weed species recorded since 2001, only three are considered to be of concern in terms of their invasiveness. While not “proclaimed” species, *Carrichtera annua* (Ward's Weed), *Salvia verbenaca* (Wild Sage) and *Solanum nigrum* (Black Nightshade) can spread readily and outcompete native species in certain habitats (MWH 2015)

2.3.6 Ecosystem function analysis

Four analogue sites are currently assessed as part of the rehabilitation survey. Eight separate rehabilitation sites have been established since initial rehab works in 2011 and 2014, and have been monitored annually since 2012. These sites are summarised below (Table 8). The performance of these in achieving benchmark values is shown in Table 9.

Table 8. EFA site details

Areas Monitored	Transect	Location GDA 94 53J	
		Easting	Northing
Flat Analogue (Acacia)	CHL01	366385	6694979
Flat Analogue (Chenopod)	CHL02	363100	6694918
Sloping Analogue (Acacia)	CHL11	368552	6692014
Sloping Analogue (Chenopod)	CHL12	360223	6695066
IWL Eastern Wing (2004)	CHL03	364225	6693720
IWL Western Wing (2004)	CHL05	363561	6693068
IWL Western Wing (2004)	CHL06	363382	6693510
IWL Western Wing (2004)	CHL09	363273	6693338
TSF 2 – Lift 1 (2011)	CHL07	364040	6692993
TSF 2 – Lift 1 (2011)	CHL08	364173	6692906
TSF 2 – Lift 2 (2014)	CHL10A	364106	6692943
TSF 2 – Lift 2 (2014)	CHL10B	364262	6692890

Table 9. Summary of the relative performance of rehabilitated areas at Challenger Gold Mine in terms of Completion Criteria thresholds (80% of analogue mean) over the past five years of assessment (2012 to 2016)

Criteria	Landform/Year of monitoring																	
	IWL Eastern Wing (CHA03)					IWL Western Wing (CHA05, 06, 09)					TSF 2 - Lift 1 (CHA07, 08)					TSF 2 - Lift 2 (CHA10A, 10B)		
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2014	2015	2016
Stability	Green	Green	Green	Yellow	Green	Green	Green	Green	Yellow	Green	Yellow	Yellow	Green	Green	Green	Green	Yellow	Green
Infiltration	Green	Green	Green	Yellow	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Yellow	Green
Nutrient cycling	Green	Green	Green	Yellow	Green	Green	Yellow	Green	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Yellow
Criteria met	Green																	
Criteria not met	Yellow																	

2.4 Data knowledge summary

Given the knowledge we now have from the Challenger site over 14 years of annual data collection the following summary has been provided in order to address the uncertainty and assumptions made in the measurement criteria (Table 10).

Table 10. Flora and fauna data knowledge summary

Element	Summary
Fauna	<ul style="list-style-type: none"> • Pitfall trapping and avifauna census sites provide the most reliable and objective data quality. • Data from other methods lacks veracity through inconsistent methodologies or lack of benchmark data (particularly bats). • No significant change in abundance from near mine sites to surrounding pastoral control sites. • Resident mammals and reptiles are more frequent during higher rainfall years and more abundant in proximity to the mine • Birds have higher frequency away from the mine and have higher species richness and abundance during dry periods. • Many species are transient and therefore only utilise the site for resources on occasional periods. • Most commonly observed pest species is house mice with few other records. Fauna predator species abundance hard to quantify due to methodology.
Flora	<ul style="list-style-type: none"> • Very consistent fluctuations in species richness and cover values observed between near mine and off lease sites showing no evidence for impacts due to mine operations. • Fluctuations in richness due to seasonal conditions in the three to six months in the lead up to the survey periods. Rainfall will provide germination for annual and ephemeral species. • Rehabilitation has shown consistent trends of improvement in values towards benchmark analogue sites. • No significant weed incursions have occurred over the life of the mine to 2015.

2.5 Existing environmental outcomes and measurement criteria review

In assessing 14 years of recorded data against the existing measurement criteria removes some uncertainty and assumptions and allows for optimisation of the monitoring program to better assess achievement of outcomes. Table 9 below, summarises the existing environmental outcomes, monitoring and measurement criteria used to demonstrate compliance with the PEPR. This includes commentary on historical uncertainty and assumptions along with sensitivity to any change based on the flora and fauna knowledge garnered from this review.

Table 11. Existing flora monitoring and measurement criteria associated with operations of the Challenger Mine

Outcome	Monitoring	Measurement criteria	Comments	Recommendation
To maintain the abundance, diversity, and productivity of flora at ecosystems levels	Annual flora survey by an independent authority. Specific monitoring will include plant mortality, plant health as measured by vigour of new growth/ flowers, vegetation condition and extent of smothering from potential dust impacts by visual observation.	Native vegetation clearance permitting and surveys demonstrate that all clearance of native vegetation compliant with the Native Vegetation management plan (Appendix D). A SEB permit application can be found in the Native Vegetation Management Plan (updated as per 2012 comments by DMITRE).	Most arid zone flora species are naturally resilient to background airborne dust contamination. The infrequent rainfall which tends to remove dust outfall from the leaves of plants will be the limiting factor in relieving dust coverage. The frequency of this rainfall is the factor which determines the level of dust settlement and deposition. Flora presence and abundance of annual, ephemeral and short lived species is reliant on seasonal conditions and does not reflect the resilience or function of the surrounding environment.	Results from the past fourteen years of annual flora monitoring have shown no change in vegetation community structure when compared to baseline data and sites in pastoral areas external to the mine lease. No evidence of dust contamination providing long term impacts to surrounding vegetation has been reported historically. The monitoring program has included periods of extended low rainfall which have not as yet determined any impact through dust. The outcome is that this methodology has determined that the outcome is achieved under current practices. Reduction in monitoring requirement and change of focus to functional attributes and abundance of long lived perennial species to track actual landscape health. Primary concerns relate to overall species composition being constantly changing as a response to seasonal conditions and not indicative of resilience of landscape.
	Photo monitoring and condition assessment of vegetation surrounding vent rise.	No visual signs of vegetation stress or death attributed to saline water emissions. If vegetation is being affected by saline aquifer emissions from the vent rise, actions will be undertaken to mitigate impact.	No reportable incidents and qualitative results do not show any decrease in vegetation abundance in proximity to the vent shaft. It would be deemed that there is a low uncertainty with ingoing saline aerosol output not expected to increase.	It would appear that monitoring associated with this impact event is unnecessary based on no previous non-compliance or reporting noted over 14 years monitoring. There is no unexpected sensitivity associated with this outcome given dewatering process and unexpected increase in water intrusion to vent shaft.
	Survey and map actual clearance boundaries for proposed new infrastructure (where clearing is required), then record and report as part of the MARCR submitted to PIRSA.	Permitting and surveys demonstrate that all clearance of native vegetation is as per Native Vegetation management plan (Appendix D).	Assumption that current project stage would require very little if any additional clearance requirements.	Generic criteria for compliance of PEPR. Should remain however no monitoring is required as part of measurement criteria until actual clearance occurs.

Outcome	Monitoring	Measurement criteria	Comments	Recommendation
	Periodic weed surveys to assess any changes to weed density and composition compared to baseline levels (baseline survey was included in original PEPR).	No substantial variations in weed density and distribution compared to baseline survey.	Isolation of site allows for lower risk than areas closer to Stuart Highway or similar transit routes such as railway corridor. Assumption of random weed infiltration. Monthly checks unnecessary unless significant rainfall events occur. Lack of targeted approach and direction into which weeds pose the greatest threat. Control measure re: transport vehicles, any measures in place to ensure compliance. See weed management plan.	Potential establishment of exotic species on fringes of lease or in pockets not monitored. Change of monitoring program to target specific species based on Kingoonya NRM region target weed list. Monitoring to follow on from significant rainfall events and in areas with high risk such as wash down areas, transport hubs/warehousing and drainage zones. While the current methodology has not located significant weed outbreaks the risk remains high, especially for species such as Buffell Grass. Suggest targeted monitoring approach.
	Daily inspections and logging of observation in relation to the operation of TSFs. This will include monthly inspections for any perennial plant deaths in the immediate vicinity.	No visual signs of vegetation stress or death of flora surrounding the TSFs attributed to groundwater mounding or dust. If any of the above criteria are not met, control measures will be reviewed and additional mitigation measures will be implemented as required.	14 years monitoring has shown rehabilitation will be achieved with all monitoring sites looking on track to achieve near benchmark analogue values used from adjoining vegetation communities. Assume that ongoing rehabilitation using same methodology that already undertaken will continue to show success. Uncertainty round seasonal conditions enabling establishment during drought periods.	In the case of extended drought, other measures to ensure the stability of waste rock landforms may be required in control and management strategies. Ongoing monitoring required to ensure ongoing rehabilitation in the absence of climatic conditions conducive to plant growth to determine alternate control and management measures. Significant analogue data now exists and biennial survey of these or rolling 2x2 survey (ie: 1 of each landform / year alternated) is required.

Table 12. Fauna species measurement criteria breakdown with regard to operations of the Challenger Mine

Outcome	Monitoring	Measurement criteria	Comments	Recommendation
To maintain the abundance, diversity, and productivity of fauna at ecosystems levels through the avoidance	Annual fauna surveys are conducted to assess fauna composition and abundance within and in close vicinity to the ML6103. Comparison with the baseline survey	Loss of fauna abundance and diversity attributed to mining activities. Records indicate Weed management plan (ref) is implemented within 48 hours of weed occurrences recorded during monthly mine inspections for	Uncertainties are centred on species movement at the time of surveys due to climatic factors which can limit the presence/absence data under certain circumstances. Analysis of data highlights which species are transient or simply passing through the areas at the time of surveys. Presence absence data.	The data recorded over 14 years has shown that mammal and reptile fauna species abundance and richness in trapping sites is increased with proximity to the mine site. Bird species richness is higher at pastoral lease sites however this data increases during dry periods which suggests that birds move from more arid, non-pastoral

Outcome	Monitoring	Measurement criteria	Comments	Recommendation
<p>or management of adverse impacts.</p>	<p>(included in original PEPR) and pastoral land unaffected by mining activities surrounding the site.</p>	<p>weeds or during flora surveys.</p>	<p>largely determines that the animals are present within an area at a certain given time. Bat survey data results largely unconfirmed due to lack of baseline bat call data. Species identification to genus level only mean that data is poor indicator and not indicative of impacts due to mine operations. There should be no theoretical increase in predator and exotic fauna species abundance due to mine operations. Motion sensing camera traps measure the presence of predator species however abundance cannot be measured by this with one animal potentially recorded on repeat occasions. We can assume that any predators removed from an area as part of management strategies will be replaced by recruits dispersed from other areas.</p>	<p>areas further north to where availability of alternative water in the local area is more frequent. Most bird species are recorded infrequently making most species unsuitable for ongoing monitoring. As no data suggests that fauna is impacted as part of mine operations, it is recommend targeted surveys of fewer sites that are known to provide habitat for resident mammal, reptile and bird species is undertaken. Bat surveys have provided no data that can be used as a tool in measuring significant outcomes due to species identification difficulties and unknown abundance. Annual monitoring very inefficient methodology. Recommend due diligence monthly baiting and trapping program with captures humanely euthanised to remove feral predators conducted by onsite environmental staff.</p>
	<p>Daily inspections and logging of observation in relation to the operation of TSFs. This will include visual inspections for any deaths of fauna/flora surrounding the TSFs.</p>	<p>No more than one death per year of fauna due to ponded water within TSF1 / TSF2. If any of the above criteria is not met, control measures will be reviewed and additional mitigation measures will be implemented as required.</p>	<p>No previous reportable incidents over the prescribed measurement criteria historically. Current measurement criteria allows for demonstration of compliance with this outcome.</p>	<p>Maintain existing monitoring as a compliance measure and to provide ethical stewardship of the ML in terms of fauna management.</p>

3 PROPOSED ENVIRONMENTAL OUTCOMES

3.1 Flora outcomes

Based on the review of the existing outcomes, the key driver of vegetation community change in the rangeland areas is climatic variation. Measurement of the cover and species richness on an annual basis has not reliably informed the condition of vegetation health but is reflective of seasonal condition.

A monitoring methodology which focuses on the functional attributes of communities will more accurately portray the capability of the community to be resilient following times of drought and disturbance. In many cases, Challenger areas are fenced to exclude pastoral activity and in doing so, often result in vegetation community health that is above that of the neighbouring pastoral areas. This will not be accurately demonstrated as species richness and cover values.

Primary stabilising factors in rangeland communities are provided by root growth, litter cover and canopy cover. The species that provide functions within these communities over extended periods are long lived perennial shrubs and trees which also provide key habitat and resources such as seed, fruit, vegetative material and shelter. They often provide soil and resource accumulation sites and successive germination zones for species such as perennial grasses. Subsequently, the ideal outcome of a monitoring program is to ensure that the factors which drive resilience are present even following extended periods of drought when traditional cover and species richness indicators will give very poor or no data. Functional measures also benefit in describing any increase in vegetation community condition in the absence of ungulate grazing with factors such as soil crust disturbance and grazing utilisation. A change in the flora environmental outcome to focus on this would be beneficial in providing a targeted approach to the key rangeland drivers on site given the existing vegetation monitoring program has shown very little discrepancy between on lease and off lease sites. The methodology has the advantage of being quick to assess with low divergence of data due to variation in assessors from survey to survey.

The existing weed monitoring program requires a targeted approach to weed species which are part of the Kingoonya NRM weed strategy as these have been identified as key threats to regional biodiversity and this is in line with existing outcomes and should continue. Any focus should be in line with this in order to gain benefit in a region wide program and ability to contribute to weed dispersal knowledge and control programs. The isolation of the Challenger site provides some weed infiltration security compared to sites with higher frequency transport hubs such as rail sidings. Targeting areas annually in locations that are most likely to see establishment of weed species such as wash down bays, on site transport hubs and water shedding zones around the mine site allows for a high likelihood of interception of outbreaks prior to establishment if coupled with monitoring following significant rainfall events of greater than 25mm and timed for 3-4 weeks later.

Rehabilitation monitoring has shown a trend of improved condition at rehabilitation sites and this should be continued until sites reach benchmark levels. The analogue sites have a good baseline dataset and can be reduced to a biennial monitoring to continue the background data but at a lower intensity.

The following outcomes and measurement criteria are provided for the ongoing monitoring of the Challenger site flora values based on the background information, data collation and existing outcome criteria (Table 13).

Table 13. Flora environmental outcomes and measurement criteria

Proposed Outcome	Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Baseline data
<p>No loss of key functional attributes which provide stability and resilience of rangeland vegetation communities on or off lease through;</p> <ul style="list-style-type: none"> • Clearance • Dust contamination / deposition • Fire • Other damage <p>Unless prior approval under the relevant legislation is obtained.</p>	<p>Annual monitoring program that will measure abundance and key functional attributes.</p>	<p>Landscape functional attributes. Include;</p> <ul style="list-style-type: none"> • Abundance of long lived perennial shrubs, • Cover of long lived perennial shrubs • Fecundity of perennial shrubs • Presence / cover of seed resource • Litter deposition • Grazing utilisation • Juvenile abundance • Presence of perennial grass species 	<p>Existing monitoring sites (refer to Figure 7) reduced to a 5x2 metre plot in line with biological survey plot size.</p>	<p>On lease sites to match or exceed off lease site values.</p>	<p>Annual</p>	<p>Baseline observations and 14 years' data collation 2002 -2016.</p>
	<p>Annual weed monitoring program with targeted checks following rainfall totals of >25mm.</p>	<p>Presence and abundance of Kingoonya NRM board target weed species.</p>	<p>Selected locations based on risk assessment.</p>	<p>No new weed incursions established after 12 months.</p>	<p>Annual and following significant rainfall totals.</p>	<p>Kingoonya NRM target weed list and historical annual flora monitoring data.</p>
	<p>LFA monitoring program.</p>	<p>Functional indices and plant cover data on rehabilitation transects.</p>	<p>Conducted on waste rock dump, TSF wall and any other areas of rehabilitation of an area greater than 1ha. Two analogue sites, one in each vegetation community type for rehabilitation.</p>	<p>Trend of continual improvement and move towards analogue values.</p>	<p>Annual for rehabilitation and biennial for analogue sites.</p>	<p>Historical LFA data.</p>

3.2 Fauna outcomes

The data review demonstrated consistent trends in fauna species richness and abundance with a trend for increased values in proximity to the mining area. Flora results showed very consistent trends within land use groups. As a result, it is arguable that ongoing monitoring of fauna species communities is largely unnecessary given it has been demonstrated that if flora communities remain intact, fauna species abundance and richness remains consistent or above that in areas external to operations associated with mining.

With flora functional indicators measured around the site with new outcome and measurement criteria, the following assumptions can be specified in regards to fauna monitoring outcomes;

- Provided the mine operations continue consistent with historical management, resident fauna species are undeterred from utilising habitat within close proximity to the mine.
- If flora communities remain intact, habitat resources related to food and any other ecological functions for fauna communities will continue.
- Resident fauna species have small home ranges and therefore are not impacted significantly by clearance as this tends to not fragment individual communities.

There is however an expectation that due diligence is applied in regards to fauna and therefore fauna monitoring is recommended to continue, albeit at a reduced intensity. Fauna trapping monitoring at two on lease and two off lease sites which provide the highest abundance and richness in historical data will ensure that fauna communities are benchmarked against previous deductions. Avian surveys at the same monitoring intensity as fauna trapping will be measured against previous mean abundance and richness values recorded for the respective sites.

It is recommended that predator species monitoring is limited to sighting logs contributed to by mine staff who are moving around the operative area. Any increase in predators can be actioned in the form of periodic pest species trapping employed on an as needs or as a regular trapping program eg: quarterly.

Daily TSF checks are in line with due diligence in ethical operation of the TSF and are recommended to be continued as per previous PEPR requirements.

Based on these findings, the fauna outcomes remain the same as previously listed in the 2012 PEPR. For a summary of the proposed fauna monitoring see Table 14 below

Table 14. Fauna environmental outcomes and measurement criteria

Proposed Outcome	Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Baseline data
To maintain the abundance, diversity, and productivity of fauna at ecosystems levels through the avoidance or management of adverse impacts.	Annual mammal and reptile focussed survey to measure abundance and richness of resident species (refer to Appendix 1 and 2).	Species abundance and richness of key resident species.	Two near mine and tow off lease sites.	Within 80% of mean equivalent site values collated over 14 years.	Annual	Baseline observations and 14 years data collation 2002 -2016.
	Bird surveys of resident species (refer Appendix 3).	Bird species abundance and richness of known resident species.	Two near mine and two off lease monitoring sites previously established as part of baseline and compliance monitoring.	Within 80% of mean long term values for equivalent monitoring sites.	Annual	Baseline observations and 14 years data collation 2002 -2016.
	Pest predator species monitoring at levels not significantly exceeding previous data from 2002 -2016.	Frequency utilising baited motion sensing cameras.	Selected based on availability of stock water troughs and alternate water resources.	Below upper value previously recorded.	Annual	Baseline observations and 14 years data collation 2002 -2016.
	Inspections and logging of observations in relation to the operation of TSFs.	Presence / abundance of species, identification to species level, reported in annual compliance report.	TSF1 and TSF2.	Annual number <1 individual.	Daily	Historical data.

4 PROPOSED MONITORING STRATEGY SUMMARY

4.1 Flora monitoring

The table below summarises the proposed flora monitoring program going forward (Table 15). This will provide for the demonstration of outcomes as described in Table 13 & Table 13. It should be noted however that DEWNR are shortly rolling out a new rangeland assessment technique which is expected to be very similar to the methodology tabled below. This methodology may be altered to correspond with DEWNR methodology if it occurs prior to the next monitoring period and deemed appropriate.

Table 15. Flora monitoring program summary to demonstrate outcomes

Type	Sites	Category	Measurement criteria	Score and measurement type	Frequency
Flora monitoring	1, 3, 5, and 8, 5x2 m monitoring plot	Abundance adult	Number of individual indicator species with woody stems >100mm tall. eg: <i>Maireana aphylla</i> , <i>M. astrotricha</i> , <i>Atriplex vesicaria</i> .	Number (Abundance)	Annual
		Abundance juvenile	Number of individual long lived perennial indicator species with semi woody stems < 100mm tall. <i>Maireana aphylla</i> , <i>M. astrotricha</i> , <i>Atriplex vesicaria</i> .	Number (Abundance)	Annual
		Number of indicator shrubs	Number of indicator shrub species present.	Number (1-4) (Life form)	Annual
		Utilisation by grazing	Grazing impact assessment low med high score 0-5%, 5-30%, >30%.	3,2 or 1 (Function)	Annual
		Litter / ephemeral cover	Cover provided by annual species and litter, 0-5%, 5-30%, >30%.	1,2 or 3 (Function)	Annual
		Perennial Grass species present	Number of Perennial grass species in plot. <i>Dichanthium sericeum</i> , <i>Enteropogon ramosus</i> , <i>Digitaria brownii</i> , <i>Aristida contorta</i> , <i>Astrebla pectinata</i>	Number (Life form)	Annual
		Perennial shrub species	Number of additional perennial palatable shrub species in assessment plot, eg; <i>Maireana</i> , <i>Ptilotus</i> , <i>Rhagodia</i> , <i>Enchylaena</i> , <i>Minuria</i> .	Number, (Life form)	Annual
		Mature fruit presence	Presence of mature fruit on shrubs, 0-5%, 5-30%, >30%.	1,2 or 3 (Function)	Annual
		Destabilisation	Disturbance to soil crust 0-5%, 5-30% >30%	3,2 or 1 (Function)	Annual
Weed	To be selected, area to be defined	Weeds	Abundance/Cover, Braun Blanquet scale	Cover	Annually and 4 weeks following >25mm rainfall.
Rehabilitation	CHL 03,05,06,09, 07,08,10a,10b	Rehab sites	EFA analysis consistent with previous rehabilitation monitoring.	As per manual	Annual
	CHL 01, 02 11,12	Analogue sites	EFA analysis	As per manual	Biennial

4.2 Fauna monitoring

The proposed Fauna monitoring methodology has been aligned to demonstrate the required environmental outcomes as described in Table 13. This methodology reduces the previous intensity by half however will continue to show the same outcomes as the previous 14 years.

Table 16. Fauna monitoring program summary to demonstrate outcomes

Targeted species	Method	Intensity	Frequency
Reptiles / Mammals	Pitfall Trapping	Four sites, 1, 3, 6 and 8 (2 impact 2 control). Six pitfall buckets (400 mm x 150 mm) spaced 10 m apart at each site.	Annually
Reptiles / Mammals	Funnel Traps	4 per site.	Annually
Birds	Point count	4 sites 1, 3, 6 and 7 (2 impact, 2 control), 20 minutes per site.	Annually
Birds	Observation	Check of TSF.	Daily

4.3 Flora and fauna change in monitoring strategy summary

Table 17. Changes to monitoring program summary.

Type	Element	New	Previous	Validation
Flora quadrat monitoring	Sites	12	12	6 control 6 impact, continued on from previous survey methodology to maintain vegetation community spread.
	Plot	20m ²	1ha	Smaller plot allowing for accurate data collection and targeted towards functional indices.
	Measure	Cover, abundance, fecundity, grazing, soil crust disturbance, seed resource, Litter cover, Lifeforms	Cover/ richness	Lower bias towards seasonal conditions and measure of community resilience and ability to recover following disturbance and drought. Distinct measure of variation between pastoral and on lease non pastoral sites.
Vent shaft monitoring	Qualitative	Removed	Monthly	No reportable incidents in 14 years of monitoring. No change expected from current impact level.
Weed monitoring	Sites	Annual targeted approach with selected sites based on likelihood of invasion	Monthly inspection	Region wide approach to weed monitoring and control of outbreaks.
	Measure	Cover / Abundance	Unsure	Simple approach and annual measure for non-complex situation.
Rehabilitation analogue sites	Sites	2 per year (1 each veg community) alternating	4	Significant baseline data exists and unlikely to change significantly in future, decrease in frequency.
	Function indices	Biennial	Annual	Continue until reaching benchmark levels.
Rehabilitation impact sites	Sites	8	8	Appropriate number based on existing rehabilitation status.
	Function indices	Annual	Annual	Annual measure ensures compliance.
Fauna pitfall trapping	Sites	8	4	14 years data shows improved abundance and richness at on lease sites and correlation of change from on lease to off lease.
	Elliott Traps	removed	20 per site	Extremely low capture rate, suitable for baseline studies only or species not resident at Challenger.
	Funnel traps	4 per site	10 per site	Contribute little other than to capture inconspicuous species and snakes.

Type	Element	New	Previous	Validation
Avian census	Sites	8 (20mins/site)	4 (20mins/site)	Consistent trends over 14 years of data collation, select most prolific on lease and off lease sites as representative for entire site.
Bat census	Echolocation	Removed	2 sites	Inconsequential data, shows presence only, unsuitable for monitoring.
Spotlighting	Observation	Removed	4 hrs per survey	Lack quantitative analysis.
Opportunistic	Random	Removed	Throughout	Unreliable and not set methodology, suitable for baseline data only.

5 REFERENCES

Hodges, P. (2014) *Kingoonya NRM Weed Strategy*. South Australian Arid Lands Natural Resource Management Board, Port Augusta, South Australia.

MWH (2015) *Ecosystem Function Analysis of the Rehabilitated Integrated Waste Landform and Tailings Storage Facility* Prepared for Kingsgate Consolidated Ltd November 2015

Tongway, D. and Hindley, N. (1995) *Manual for soil condition assessment of tropical grasslands*. CSIRO, Canberra.

Appendix 1. Most commonly recorded mammal species at trapping sites 2002 – 2015.

Scientific Name	Common Name	2002	2003	2004	2005	2007 a	2007 b	2008	2009	2010	2011	2012	2013	2014	2015	#	Total
<i>Mus musculus</i>	House Mouse		1	19	6	2	5	1	1	9	37	3	2	36	19	13	141
<i>Pseudomys bolami</i>	Bolam's Mouse	1	2	15	6	8				10	2		1		3	9	48
<i>Sminthopsis ooldea</i>	Ooldea Dunnart		2	2	2	5		1						1	2	7	15
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse					1				13	1		3	12	3	6	33
<i>Sminthopsis crassicaudata</i>	Fat-tailed Dunnart				2	3		2		1	2					5	10

Appendix 2. Most commonly recorded reptile species at trapping sites 2002 – 2015.

Scientific Name	Common Name	2002	2003	2004	2005	2007 a	2007 b	2008	2009	2010	2011	2012	2013	2014	2015	#	Total
<i>Diplodactylus conspicillatus</i>	Fat-tailed Gecko	5	1	3	8	7	18	1	7	2	3	5	6	4	4	14	74
<i>Lucasium stenodactylum</i>	Sandplain Gecko	6	5	13	17	21	53	11	13	18	1	5	1	3	1	14	168
<i>Tympanocryptis lineata</i>	Five-lined Earless Dragon	2	3	1	2	5	7	1	2	5	5	1	3	1	5	14	43
<i>Ctenophorus nuchalis</i>	Central Netted Dragon	2	2	6	10	12	15	2	1	3	5	4		3	4	13	69
<i>Ctenotus schomburgkii</i>	Sandplain Ctenotus	4	9	30	34	47	43		12	17	9	4	12	4	6	13	231
<i>Rhynchoedura ornata</i>	Beaked Gecko	3	1	4	2	8	18	2	5	4	2	1	1		1	13	52
<i>Ctenotus leonhardii</i>	Common Desert Ctenotus	3	1	23	2	3	7	1	6				5	7	6	11	64
<i>Lerista desertorum</i>	Great Desert Slider	1		1			7	1	1	2	3	2			1	9	19
<i>Lerista labialis</i>	Eastern Two-toed Slider	2		6	2		22	7	5	3	5		2			9	54
<i>Varanus gouldii</i>	Sand Goanna	1			4	1		1	1	1		2		1	4	9	16

Appendix 3. Most commonly recorded avian species at census sites 2002 - 2015

Scientific Name	Common Name	2013	2014	2015	2002	2003	2004	2005	2007 a	2007 b	2008	2009	2010	2011	2012	#	total
<i>Corvus bennetti</i>	White-browed Babbler	10	3	7	7	6	5	13	10	8	2	1	7	10	6	14	95
<i>Taeniopygia guttata</i>	Crested Pigeon	1	10	9	3	6	2	10	8	8	1	2	4	5	4	14	73
<i>Aphelocephala leucopsis</i>	Australasian Pipit	3	1	12	1	4	2	1	1	7	1	1	3	1	7	14	45
<i>Pomatostomus superciliosus</i>	Zebra Finch	16	27	5	2	20	6	3	4	14		2	33	32	10	13	174
<i>Lichenostomus virescens</i>	White-winged Fairy-wren	2	5	18	3		4	1	3	1	3	2	12	21	3	13	78
<i>Malurus leucopterus</i>	Chestnut-rumped Thornbill	3	13	19	3	6	1	3	5	2	5	4		1	11	13	76
<i>Acanthiza uropygialis</i>	Little Crow	29	31	46	4			18	13	9	6	22	21	37	17	12	253
<i>Ocyphaps lophotes</i>	Blue Bonnet	8		10	4	4	3	3	2	9		1	6	3	9	12	62
<i>Melopsittacus undulatus</i>	Yellow-throated Miner	1	6	2	4	8	4	7	2			3	4	5	1	12	47
<i>Artamus cinereus</i>	Southern Whiteface	8		36	5			12	7	6	4	5	24	10	16	11	133
<i>Northiella haematogaster</i>	Singing Honeyeater	12	2	19	6			7	16	3	2	3		8	2	11	80
<i>Manorina flavigula</i>	Galah	4	5	2	5	2	1	1		1		1	8		3	11	33
<i>Anthus novaeseelandiae</i>	Nankeen Kestrel	2	3	7			1	5	2	4		3		8	1	10	36
<i>Epthianura tricolor</i>	Mulga Parrot	6	1	2	5	8	1		1				1	6	2	10	33
<i>Falco cenchroides</i>	Black-faced Woodswallow	8	18	5			7	3	5				7	9	3	9	65
<i>Eolophus roseicapilla</i>	Red-backed Kingfisher	6		1	2	2				1		5	7	1	2	9	27
<i>Psephotus varius</i>	Willie Wagtail	1	6	6		2				1	1		2	6	1	9	26
<i>Psophodes occidentalis</i>	Australian Magpie		2	1	6	2		1	6	1				1	3	9	23



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Appendix M

Groundwater study for 2017 PEPR

WPG Resources Ltd
**Challenger Gold Project -
groundwater study for 2017 PEPR**



WPG Resources Ltd
**Challenger Gold Project -
groundwater study for 2017 PEPR**

24 November 2017

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Executive summary

Introduction

The Challenger Gold Mine is located in the arid Far North of South Australia. Site infrastructure includes the water supply wellfields, a decommissioned mine pit, operational decline(s), two tailings storage facilities (one decommissioned and one active) constructed within an integrated waste landform, a process plant, camp and airstrip.

The water supply for the mine project is drawn from deeply buried palaeochannel sediments (the mine and process supply) and local fractured rock aquifers (RO feed water). The salinity of groundwater drawn from the palaeochannel aquifer ranges from saline to hypersaline, whilst groundwater drawn from fractured rock aquifers ranges from brackish to saline.

A third aquifer that is used for stockwater supply is formed in calcareous and sandy sediments that overlie the palaeochannel. Groundwater sourced from this shallow aquifer is slightly brackish. Observed groundwater chemistry and pressure head data strongly suggest the shallow aquifer is effectively isolated from the other aquifers of the Challenger area.

The South Australian Department of Sustainable Development has identified that sensitive groundwater receptors may be exposed to possibly adverse effects associated with the detection of cyanide in some groundwater samples collected from the Challenger compliance monitoring network. Consequently, the Department is seeking demonstration that sensitive water receptors are not exposed to adverse effects associated with mine-related activities and that the existing understanding of hydrogeological processes around the mine and its environs is sound, and predictions of the numerical groundwater, and fate transport model developed for the project in 2009 remain valid.

Review outcomes

Groundwater system response to pumping

The review presented in this report shows the different aquifers that are active within the area of the mine project are responding to pumping in a manner consistent with the conceptualisation developed in the early stages of mining, particularly:

- Large pressure drawdowns (typically between 40 and 140 m) have been experienced in the semi-confined palaeochannel aquifer
- Depressurisation of the palaeochannel aquifer induces leakage from the overlying clayey aquitard and adjoining basement (fractured) rocks to sustain pumping rates
- Depressurisation of the palaeochannel aquifer has not resulted in drawdown in groundwater pressures in either of the shallow stockwater aquifer or fractured rock aquifers that is directly attributable to pumping from the palaeochannel
- Moderate drawdowns have been experienced in the fractured rock aquifer in response to pumping for RO feed water supply (tens of metres whilst pumping occurs)
- There are no potentially sensitive groundwater receptors that are likely to be exposed to lowered groundwater pressures because of groundwater pumping to support the mine operation

Groundwater system response to mine dewatering

The review shows that dewatering of the Challenger mine pit and declines has resulted in significant drawdown around the pit, which is consistent with the conceptualisation developed in the early stages of mining. This drawdown acts to capture seepage emanating from the tailings storages located within the integrated waste landform.

Groundwater system response to tailings disposal

The review also shows that groundwater mounding has occurred beneath the tailings storage facilities because of seepage from the facilities. This observation is also consistent with the conceptualisation developed in the early stages of mining, particularly:

- Water quality impacts have arisen as a result of seepage of tailings leachate to groundwater, particularly in regard to salinity concentrations
- The mounding and associated water quality impacts (including presence of cyanide) appear to be localised around the tailings storage facilities
- The drawdown associated with mine pit dewatering has been buffered on the south side of the pit by the groundwater mound that has developed beneath the storages

There are irregular reports of low level concentrations of cyanide in water samples collected from monitoring wells located some distance from the tailings storage facility, in areas where there are little to no indications of groundwater head change due to operation of the facility. An analysis of groundwater flow velocities indicates potentially tailings leachate impacted groundwater is very unlikely to have reached off-site monitoring wells in the time since first tailings placement, meaning any reports of cyanide in groundwater sampled from off-site wells is unlikely attributable to the mine's tailings facilities. Rather than an indication of the mine operation impacting adversely on groundwater quality, the reports of cyanide in groundwater at these locations appear likely to be a result of assigning the laboratory level of reporting as a concentration in the water quality dataset, sampling methods, the existence of other (non-anthropogenic) sources of cyanide in the environment, or a combination of two or more of these factors.

Numerical flow, and fate and transport model

The results of the review presented in this report indicate the 2009 groundwater model represents the conceptual hydrogeological model for the Challenger Mine area:

- The numerical flow model predicts development of a groundwater mound beneath the tailings storage facility, a groundwater sink around the mine pit and declines, and reduced groundwater pressures in aquifers supporting groundwater production, all of which are consistent with observed responses
- The fate and transport model is shown to provide reasonable predictions of cyanide concentrations in groundwater compared to observed

The 2009 model predicts that the mine will intercept the majority, if not all, of the groundwater that might be impacted by tailings seepage, and the available groundwater level data are consistent with this prediction. Given this, and the low threat profile associated with mine-related effects on the

groundwater system, it is considered the mine does not present any unacceptable risk to sensitive groundwater receptors in the area.

Groundwater effects assessment

A groundwater effects assessment has been prepared for the Challenger Mine based on observed 'direct' effects since commencement of mining. These direct effects are linked to the mine pit and decline(s), groundwater pumping and tailings disposal, and have considered the potential for sensitive groundwater receptors to be exposed to adverse effects as a result of altered groundwater conditions, i.e.:

- Water quantity
- Water quality
- Groundwater and surface water interactions
- Aquifer disruption

The effects assessment has shown:

- The only potential threat posed to sensitive groundwater receptors is in relation to possible water logging of vadophytic vegetation around the tailings storage facility due to water table mounding
- Sensitive groundwater receptors that are likely to rely on the stockwater aquifer that overlies the palaeochannel aquifer (e.g. stock water wells, potential phreatophytic vegetation) are very unlikely to be exposed to adverse effects associated with mining activities.

Section 1 Introduction

1.1 Background

1.1.1 General information

Environmental Projects Pty Ltd (EP), on behalf of WPG Resources Ltd (WPG), has requested CDM Smith Australia Pty Ltd (CDM Smith) to provide groundwater-related advice to assist in preparation of a Program of Environmental Protection and Rehabilitation (PEPR) for the Challenger Gold Mine (Challenger). Challenger is located in the northwest portion of the Gawler Craton, in South Australia's Great Victoria Desert (Figure 1).



Figure 1
Challenger Gold Mine locality plan

Open cut mining of the Challenger ore body commenced in May 2002, and was followed by underground development in 2004. The main infrastructure on the site includes the mine pit and decline, two tailings storage facilities (TSFs; TSF-1 (decommissioned) and TSF-2 (active)), a process plant, camp, airstrip and water supply wellfields (Figure 2).

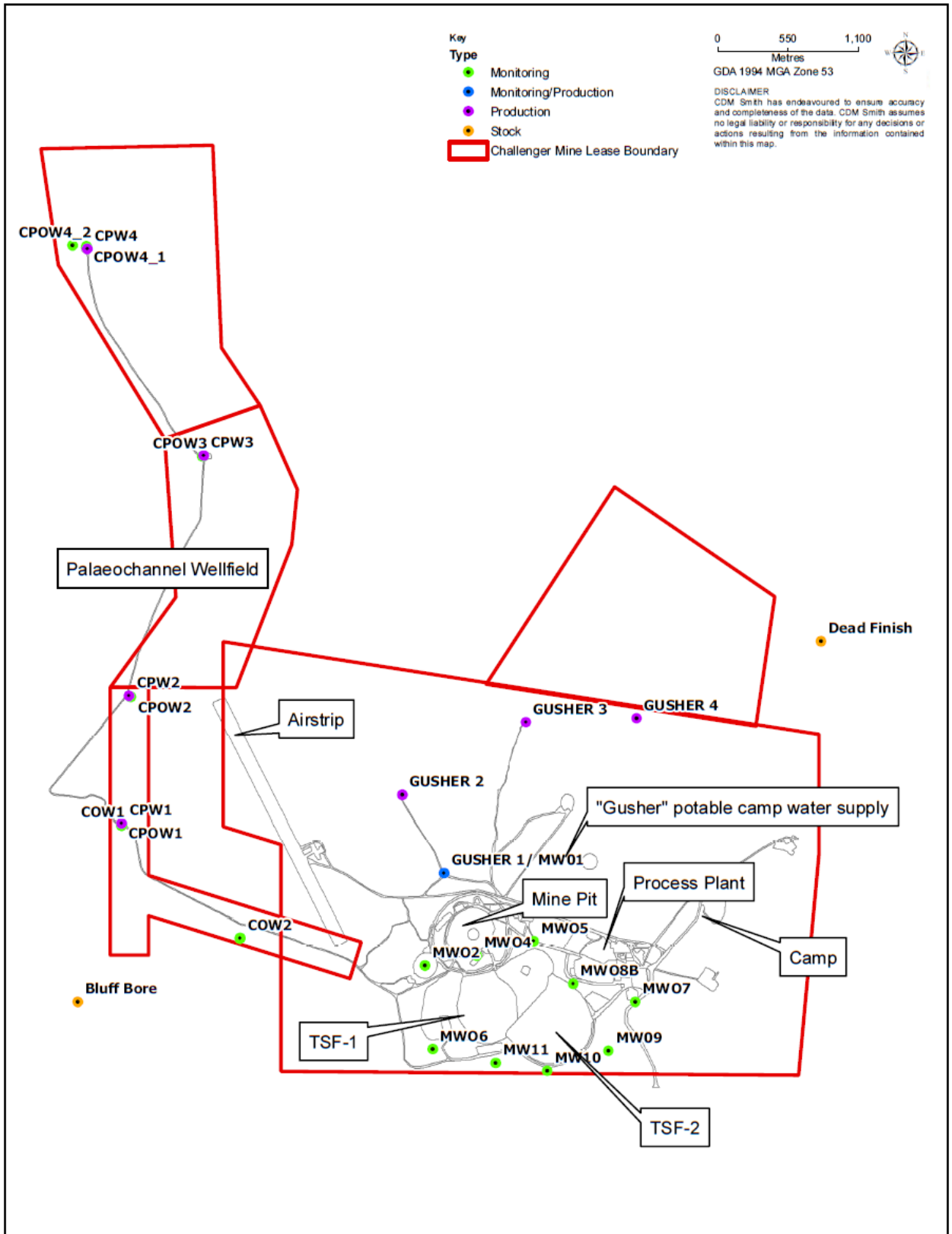


Figure 2 Challenger Gold Mine infrastructure locality plan

1.1.2 Water supply

The mine water supply wellfield (the Challenger Wellfield), comprises production wells CPW1, CPW2, CPW3 and CPW4¹, which draw water from deep palaeochannel sediments found to the northwest of the main mine infrastructure (Figure 2). Over the life of mine (LOM), wellfield abstractions have typically ranged between 18 and 45 ML/month.

Feed water for the reverse osmosis (RO) plant is sourced from three production wells which abstract groundwater from a fractured rock aquifer to meet potable water demand. The wells are located approximately 0.4 km (Gusher 1), 1 km (Gusher 2) and 1.4 km (Gusher 3) north of the mine pit (Figure 2). Gusher 4 has been constructed but remains as a back-up if later required. Over the LOM, RO feed water wellfield abstractions have typically ranged around 5.5 ML/month.

A network of groundwater monitoring wells (Figure 2) has been installed near to the production wells, including a single (sentinel) well has been installed between the mine / TSF and palaeochannel wellfield. These wells are routinely gauged and sampled for a range of water quality analytes (e.g. major ions, metals, cyanide (CN) and total dissolved solids (TDS)) and physical parameters (e.g. temperature, pH, electrical conductivity (EC)).

1.1.3 Tailings storage

Tailings storage occurs within an integrated waste landform (IWL), that incorporates the storages within waste rock storages. Up until 2009, tailings were stored in TSF-1 after which it was decommissioned and TSF-2 was commissioned (Figure 2). A network of groundwater monitoring wells (Figure 2) has been installed around TSF-1 and TSF-2, and these wells are routinely gauged and sampled for a range of water quality analytes (e.g. major ions, metals, CN and TDS) and physical parameters (e.g. temperature, pH, EC).

Since commencement of mining, water has been recovered from the decant ponds of TSFs for re-use in the mine process. With the introduction of a tailings thickener in the process circuit in around 2010, the amount of water sent to and recovered from the TSF is significantly less than that prior to 2010.

1.2 Objectives and work scope

1.2.1 Objectives

The South Australian Department of Premier and Cabinet, Mining Regulation (DPC) has identified that sensitive groundwater receptors may be exposed to possibly adverse effects associated with the detection of cyanide in some groundwater samples collected from the Challenger compliance monitoring network. DPC is seeking WPG to demonstrate sensitive water receptors are not posed to adverse effects associated with mine-related activities through the development of an improved understanding of hydrogeological processes in the area of the mine and its environs.

1.2.2 Scope of work

CDM Smith has been requested to address the following scope of work for this report:

¹ During late-2010 the production casing of well CPW4 was damaged. The well was decommissioned and a replacement well subsequently installed in late November – early December 2011.

- Review and provide comment on local hydrology/hydrogeology, specifically with respect to the lack of hydrogeological connection between the mine site and the perched aquifer overlying the palaeochannel, and the absence of a perched aquifer at the TSF
- Comparison of measured groundwater data to groundwater model predictions and commentary as to the accuracy/currency of the model and whether or not it represents a conservative view
- Comment as to conditions of groundwater effects, as they relate to closure (e.g. pit related groundwater sink providing containment or otherwise)

1.3 References

In addition to specific references noted in the test of this report, a number of more general references have been used to prepare this report. The following provides a list:

- CDM Smith. 2014. Challenger Gold Mine – 2014 annual environmental review (groundwater). Prepared for Kingsgate Consolidated Limited by CDM Smith Australia Pty Ltd.
- REM. 2002a. Challenger Gold Project – Drilling and aquifer testing completion report. Prepared for Dominion Mining Limited by Resource & Environmental Management Pty Ltd.
- REM. 2002b. Challenger Gold Project – Conceptual hydrogeological model and assessment of project water supply viability. Prepared for Dominion Mining Limited by Resource & Environmental Management Pty Ltd.
- SKM. 2009a. Challenger Gold Mine Expansion – Assessment of TSF expansion groundwater effects. Prepared for Kingsgate Consolidated Limited by Sinclair Knight Merz Pty Ltd.
- SKM. 2009b. Challenger Gold Mine – 2008-09 water supply extension drilling and aquifer testing completion report. Prepared for Kingsgate Consolidated Limited by Sinclair Knight Merz Pty Ltd.
- SKM. 2009c. Challenger Gold Mine – 2008-09 annual environmental review (groundwater). Prepared for Kingsgate Consolidated Limited by Sinclair Knight Merz Pty Ltd.
- SKM. 2010. Challenger Gold Mine – 2009-10 annual environmental review (groundwater). Prepared for Kingsgate Consolidated Limited by Sinclair Knight Merz Pty Ltd.

Section 2 Physical setting

2.1 Climate and topography

The average annual rainfall for the Challenger mine site is around 160 mm. The average annual evaporation rate is above 4,000 mm. Evaporation rates typically exceed rainfall rates in all months of the year. Figure 3 presents a chart showing site derived cumulative deviation from the mean rainfall data. The chart shows climate variability results in multi-year periods of below or above average rainfall trends.

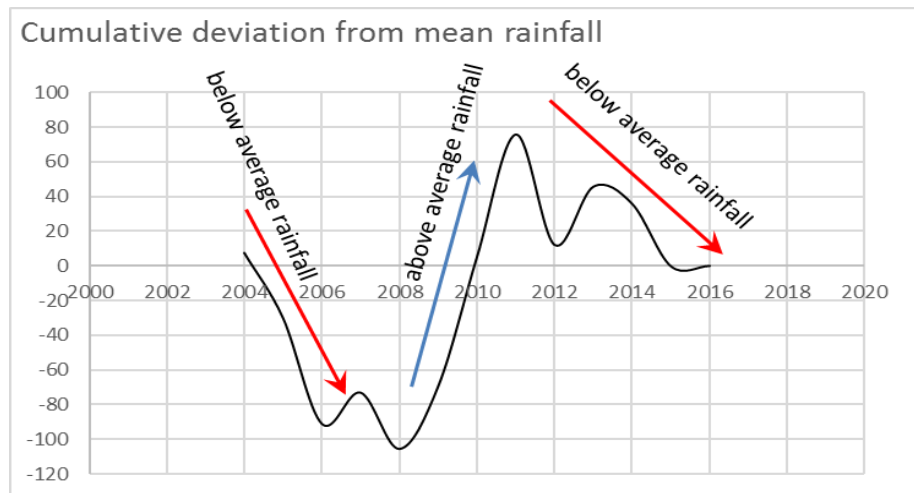


Figure 3 Site rainfall trends

Ground surface elevations in the Challenger area generally range from 170 to 210 mAHD (Australian Height Datum). The mine area itself has very little topographic relief, ranging from around 190 to 200 mAHD. A poorly defined valley characterised by Gilgai soils, coincident with the Challenger Palaeochannel, lies within 3 km of the mine to the west. The surface soils within this shallow depression are calcareous and show evidence of enhanced recharge capacity in some areas, e.g. around the location of the Bluff Bore stockwater well.

2.2 Hydrogeology

A detailed understanding of the groundwater system has been developed for the Challenger area. Three main hydrostratigraphic units (HSUs) have been identified, from youngest to oldest:

- An areally restricted perched water table aquifer, formed in Tertiary and Quaternary aged gravels, sands, silts and clays. This aquifer overlies carbonaceous clayey sediments that form the confining unit to the Challenger Palaeochannel (see below). This aquifer is accessed to support some stockwater supplies near the mine
- A deep and confined Tertiary palaeochannel aquifer that drains the regional groundwater system of the project area. The Challenger Wellfield draws water from this aquifer to meet mine and process demand (Challenger Palaeochannel)
- A regional water table groundwater system formed predominantly in weathered and competent fractured crystalline Archaean to Early Proterozoic rocks belonging to the

Mulgathing Complex. This aquifer supports stockwater supplies near the mine, as well as the mine potable supply.

Pumping from the Challenger Palaeochannel Wellfield draws on confined storage from the palaeochannel aquifer and induces leakage from the surrounding water table (fractured basement) aquifer and overlying confining clay sequence. Groundwater level, pumping and chemistry data indicate very poor hydraulic connection exists between the perched water table system and either of the fractured basement or confined palaeochannel aquifers.

Section 3 Data review

3.1 Groundwater pressures

3.1.1 Production wellfields

Two wellfields operate at Challenger, the mine and process wellfield (sourced from the Challenger Palaeochannel) and the RO-feed wellfield (sourced from fractured rock aquifers north of the mine pit). The following presents a summary of wellfield production data:

- Palaeochannel wellfield - average production rates for individual wells ranges between around 1 and 4 L/sec, for a total average of around 11 L/sec (around 1 ML/day)
- RO-feed wellfield - average production rates for individual wells ranges between around 0.1 to 1.3 L/sec, for a total average of around 2 L/sec (around 0.18 ML/day)

Palaeochannel groundwater pressures near the production wells have declined from pre-mine levels by between 40 and 140 m with the largest declines occurring at CPW1 and CPW2, which have supported the mine operation since commissioning in the early 2000s. Figure 4 presents hydrographs for palaeochannel observation wells, which are located close to each of the production wells.

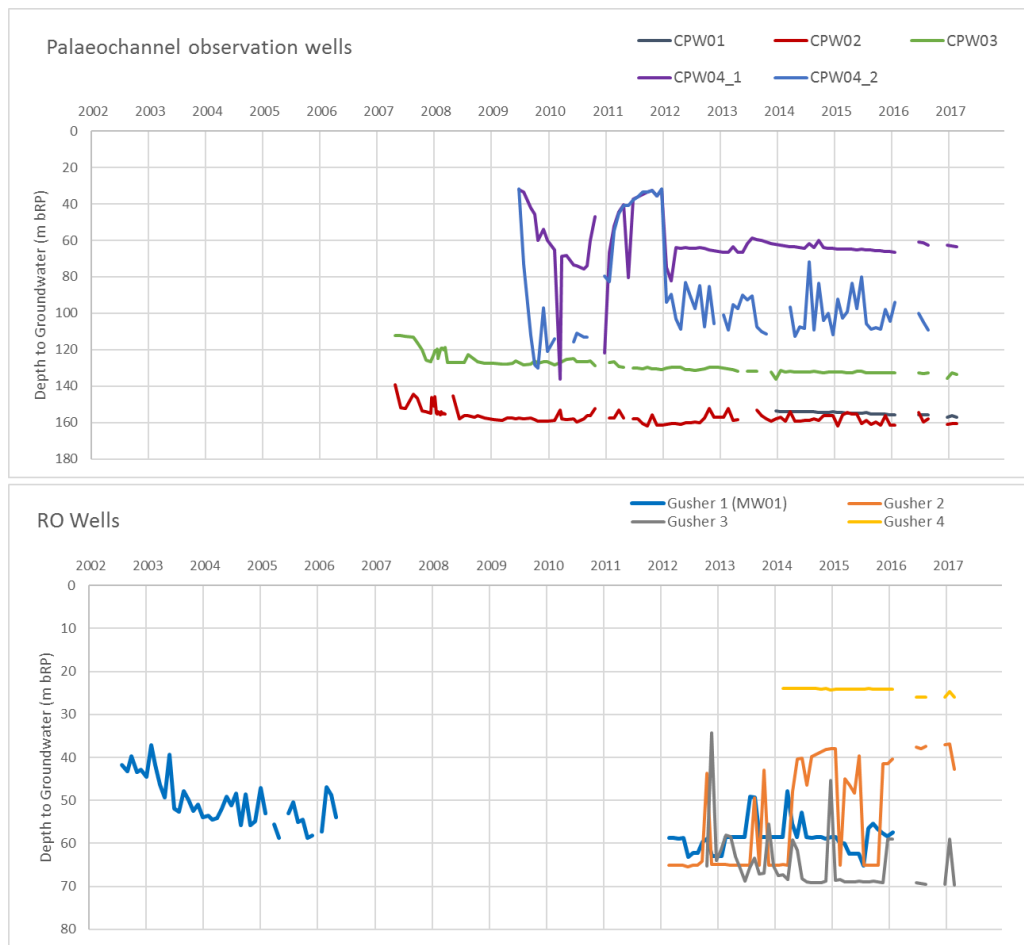


Figure 4 Groundwater pressure response to pumping

Groundwater pressures at the locations of the RO-feed production wells have declined from pre-mine levels by between 20 and 45 m in response to intermittent pumping from the wells. Figure 4 presents pumping water level hydrographs for each of the production wells.

3.1.2 Environmental monitoring network

The wells comprising the groundwater monitoring network around the mine pit, declines and TSFs provide visibility of the way the fractured rock and shallow alluvial / colluvial cover groundwater system responds to mine operations. The following presents an overview of the responses, which are shown on the hydrographs presented in Figure 5:

- MW02 – an initial head decline of around 10 m occurred following commencement of the open pit mining operation, followed by a steep decline of another 35 m or so following commencement of the Challenger West decline in 2013
- MW04 - an initial head decline of more than 20 m occurred following commencement of the open pit mining operation, which was followed by slight recovery of a few metres between one and two years after commencement of tailings deposition
- MW05 and MW07 – gradual rise in head of between 5 and 10 m from the commencement of tailings deposition, with the rate of rise appearing to stabilise from around 2015
- MW08B - gradual rise in head of around 15 m from the commencement of tailings deposition (the effect of commissioning TSF2 is evident from around 2012), followed by a relatively rapid rise of around 10 m and then stabilisation
- MW06 and MW09 – gradual rise in head of around 5 m from commencement of monitoring prior to commissioning of TSF2, with the rate of rise now appearing to stabilise
- MW10 – relatively steep rise in head of around 10 m from commencement of monitoring prior to commissioning of TSF2, with stabilisation of rise now apparent
- MW10 – relatively steep rise in head of around 10 m from commencement of monitoring prior to commissioning of TSF2, with stabilisation of rise now apparent
- MW11 – relatively stable head since commencement of monitoring prior to commissioning of TSF2

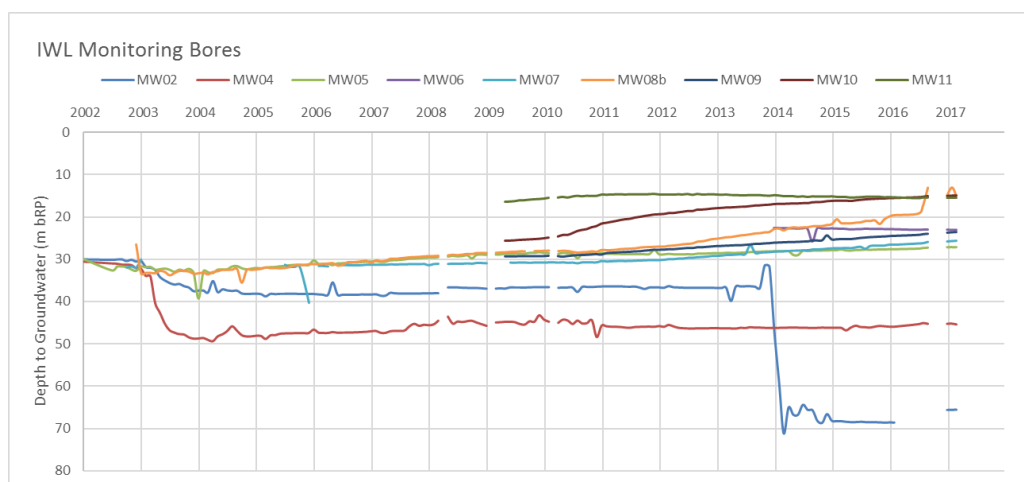


Figure 5 Groundwater pressure response to mine operations

3.1.3 Other wells

Two important monitoring wells that are located between the mine and the palaeochannel are COW1 and COW2:

- COW1 screens the water table aquifer that overlies the clayey palaeochannel confining unit (inferred to support the stockwater supply drawn from Bluff Bore) - and the well has been installed as a sentinel well (for assessing pumping and mine related impacts on the stockwater aquifer)
- COW2 screens the shallow sediments that flank the palaeodrainage - the well has been installed between the mine and stockwater aquifer to act as a sentinel well

Figure 6 shows that groundwater pressures at both the sentinel monitoring wells have experienced slight drawdown (around 0.5 m) over the LOM but appear to have been stabilising for some time². In the case of both wells, the trend may be a result of depressurisation of the clayey sediments underlying the stockwater aquifer due to pumping from the palaeochannel aquifer, however comparison with cumulative deviation from the mean rainfall data (Figure 6) suggest the response is more likely due to climate (and recharge rate) variability.

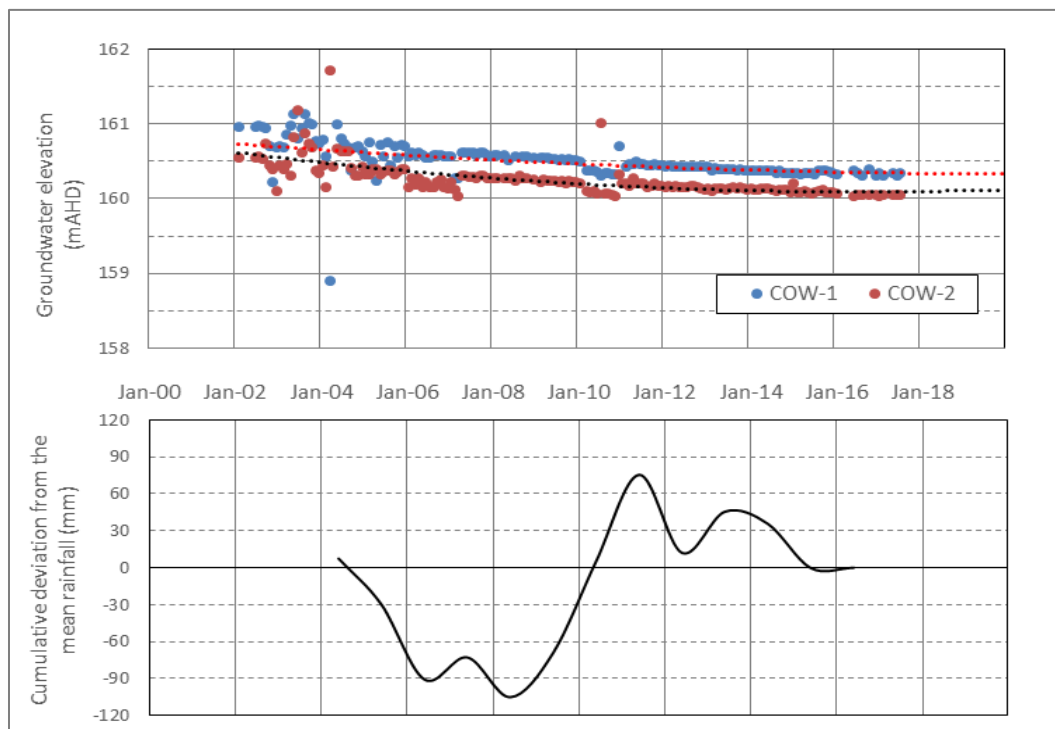


Figure 6 Groundwater head trends for the sentinel wells COW-1 and COW-2, and cumulative deviation from the mean rainfall data

The water table elevation at COW1 is noted to be consistently higher than the water table elevation at COW-2, indicating groundwater flow potential in the water table aquifer away from well COW-1 (Figure 6).

² Note the relatively large decline in COW-1 head in 2003, which was due to damaged (but repaired) casing for the nearby production well CPW1

3.1.4 Groundwater elevation contours

Figure 7 to Figure 10 present water table elevation contours that have been inferred from gauged groundwater level data sourced from available monitoring wells for the period pre-mine to 2016. The following observations are made:

- Pre-mine – Groundwater flows from the stock water aquifer (COW1 in the west) toward the east, and groundwater flows from the basement aquifer (in the east) toward the west, converging on a north-south trending zone around COW2. It is inferred from this that this zone may be a palaeochannel recharge zone aligned with the margins of the palaeodrainage.
- 2004 – The influence of the mine pit and pumping from the RP plant feed water wells is apparent with drawdown of more than 20 m centred around the pit, and more than 100 m beneath the pit. The influence of potential seepage from the TSF is not yet apparent. The hydraulic gradient from the stock water aquifer (COW1) toward the east remains relatively consistent.
- 2008 – The influence of the mine pit and pumping from the RP plant feed water wells continues to impose on the water table elevation, and seepage from the TSF is evident with water table mounding beneath the facility. The hydraulic gradient from the stock water aquifer (COW1) toward the east remains relatively consistent.
- 2012 – The influence of the mine pit and pumping from the RP plant feed water wells has stabilised, but continued seepage from the TSF (including the recently commissioned TSF2) results in water table mounding beneath the facility expanding. The hydraulic gradient from the stock water aquifer (COW1) toward the east remains relatively consistent.
- 2016 - The influence of the mine pit and pumping from the RP plant feed water wells remains relatively stable, although the additional influence of the Challenger West decline is evident. Continued seepage from the TSF results in water table mounding beneath the facility further expanding. The hydraulic gradient from the stock water aquifer (COW1) toward the east remains relatively consistent.

Figure 11 presents a west-east hydrostratigraphic profile of the Challenger site along with inferred equipotential contours and flow lines. The figure demonstrates the impact of evaporative losses from the mine pit on local flow lines and the long-term potential for seepage from the TSF to be captured by the pit. The figure also demonstrates the conceptualised interaction between the fractured rock aquifer, the stockwater aquifer and the palaeochannel aquifer, i.e. the palaeochannel forms a regional-scale drain for groundwater systems.

3.1.5 Potential for water table mounding beneath TSF

As expected and acknowledged in earlier environmental reports (e.g. SKM, 2009³), Figure 9 and Figure 10 show water table mounding is occurring beneath the TSF (from around 2008 onwards). The available monitoring data (see Figure 5) suggests the mound has not reached the surface, with the water table around its perimeter being 10 m or more below ground level.

³ SKM. 2009. Challenger Gold Mine Expansion- Assessment of TSF expansion groundwater effects. Prepared for Dominion Mining Limited by Sinclair Knight Merz.

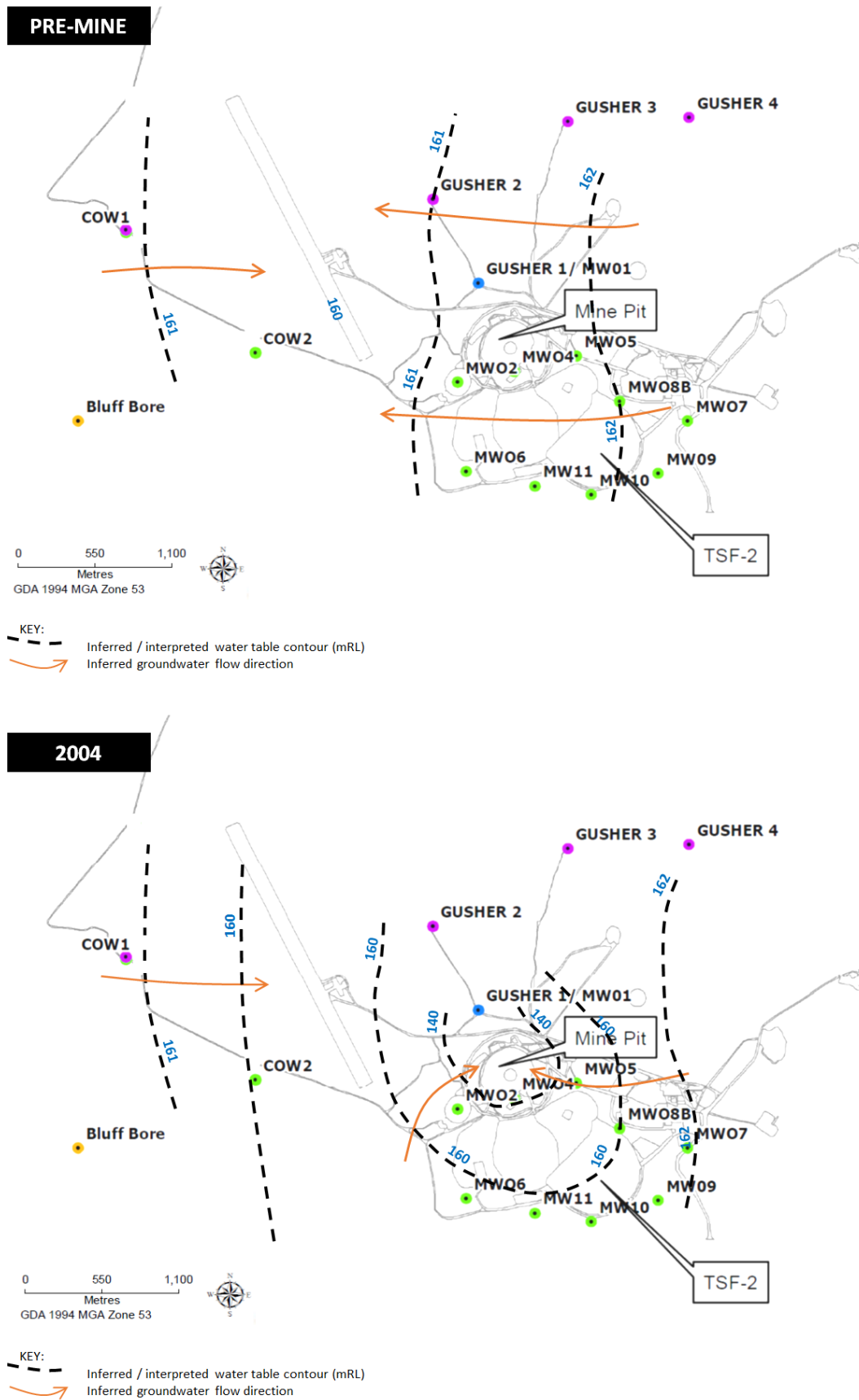


Figure 7 Inferred water table elevation contours – pre-mine (2002) and 2004

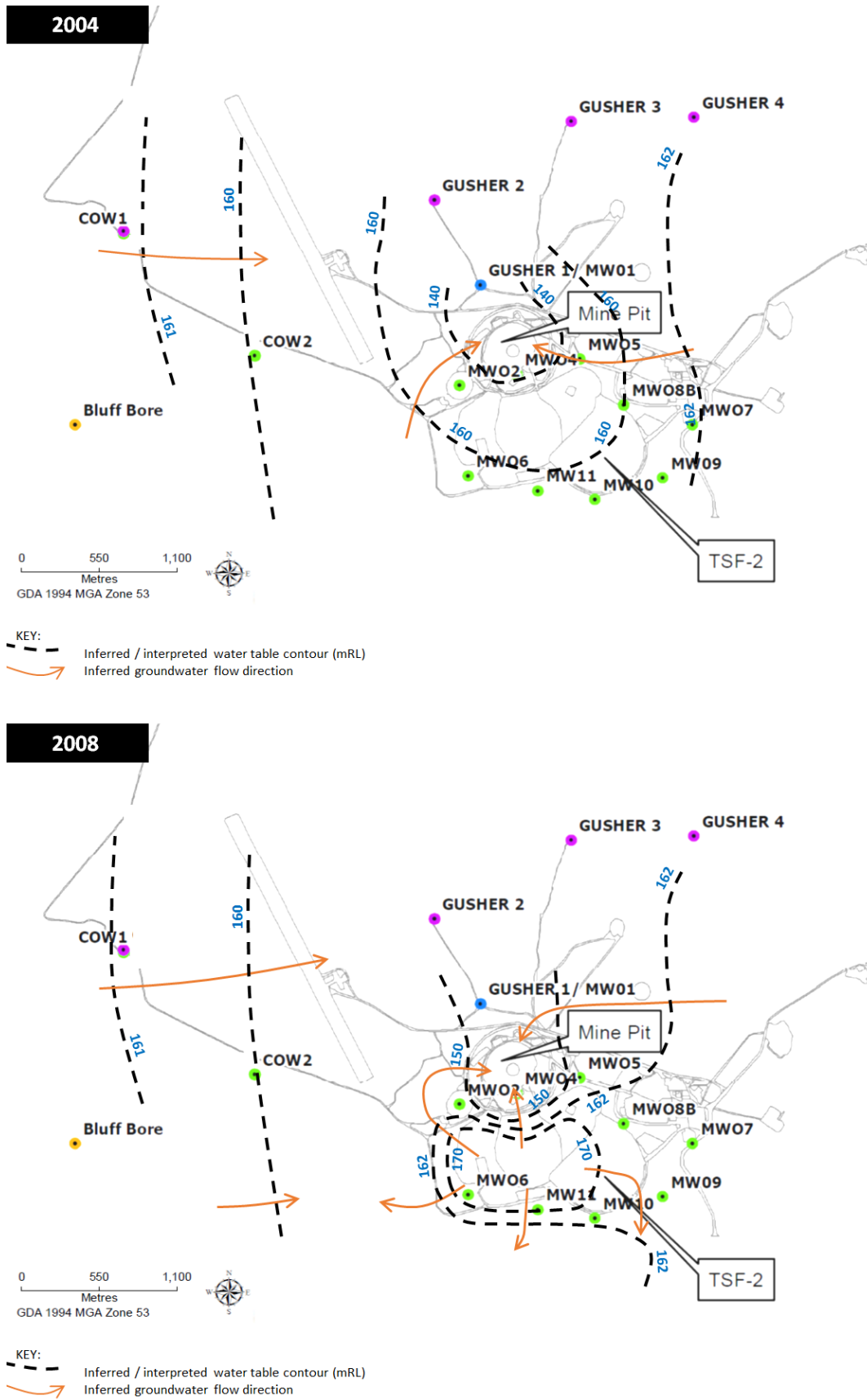


Figure 8 Inferred water table elevation contours – 2004 and 2008

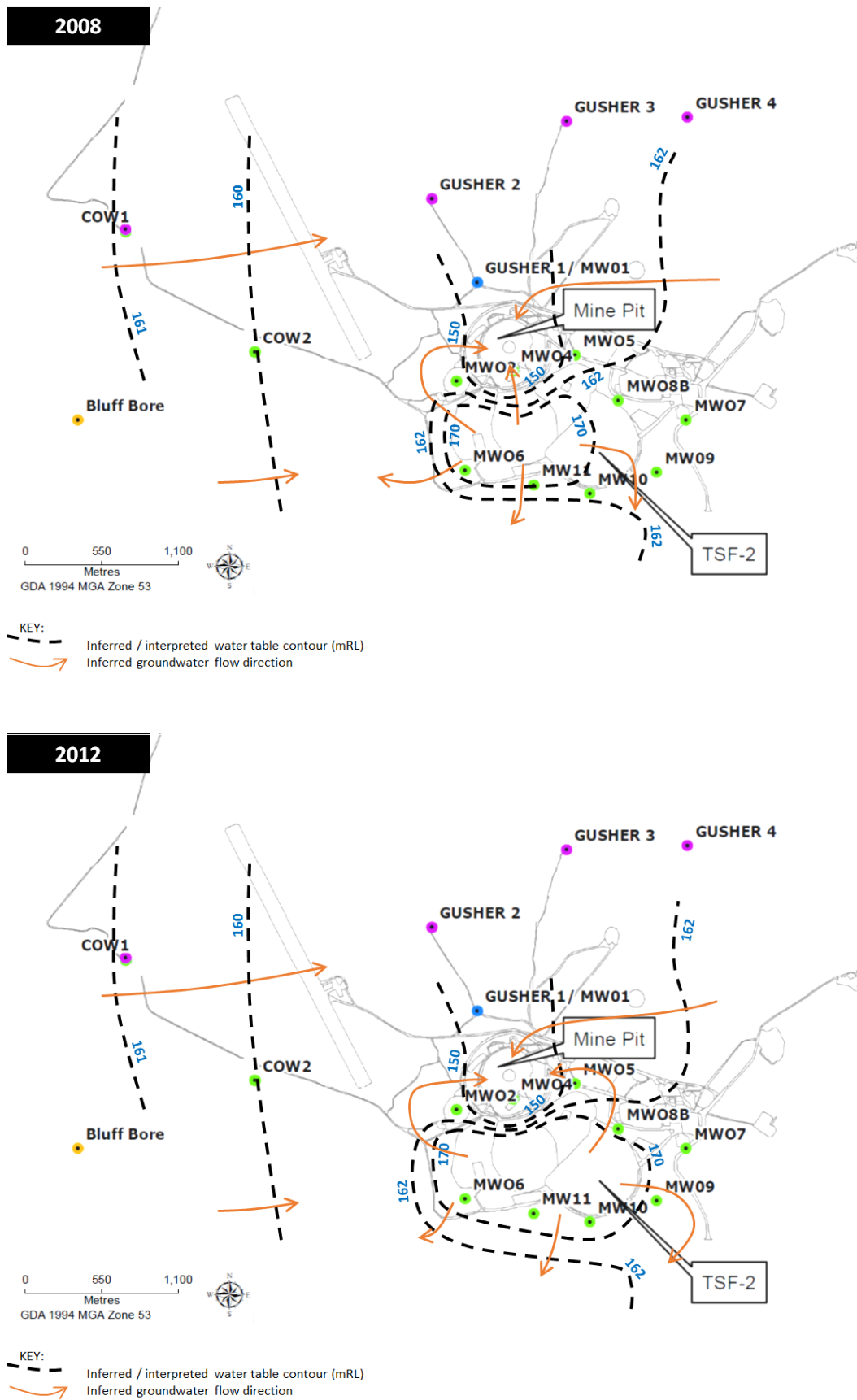


Figure 9 Inferred water table elevation contours – 2008 and 2012

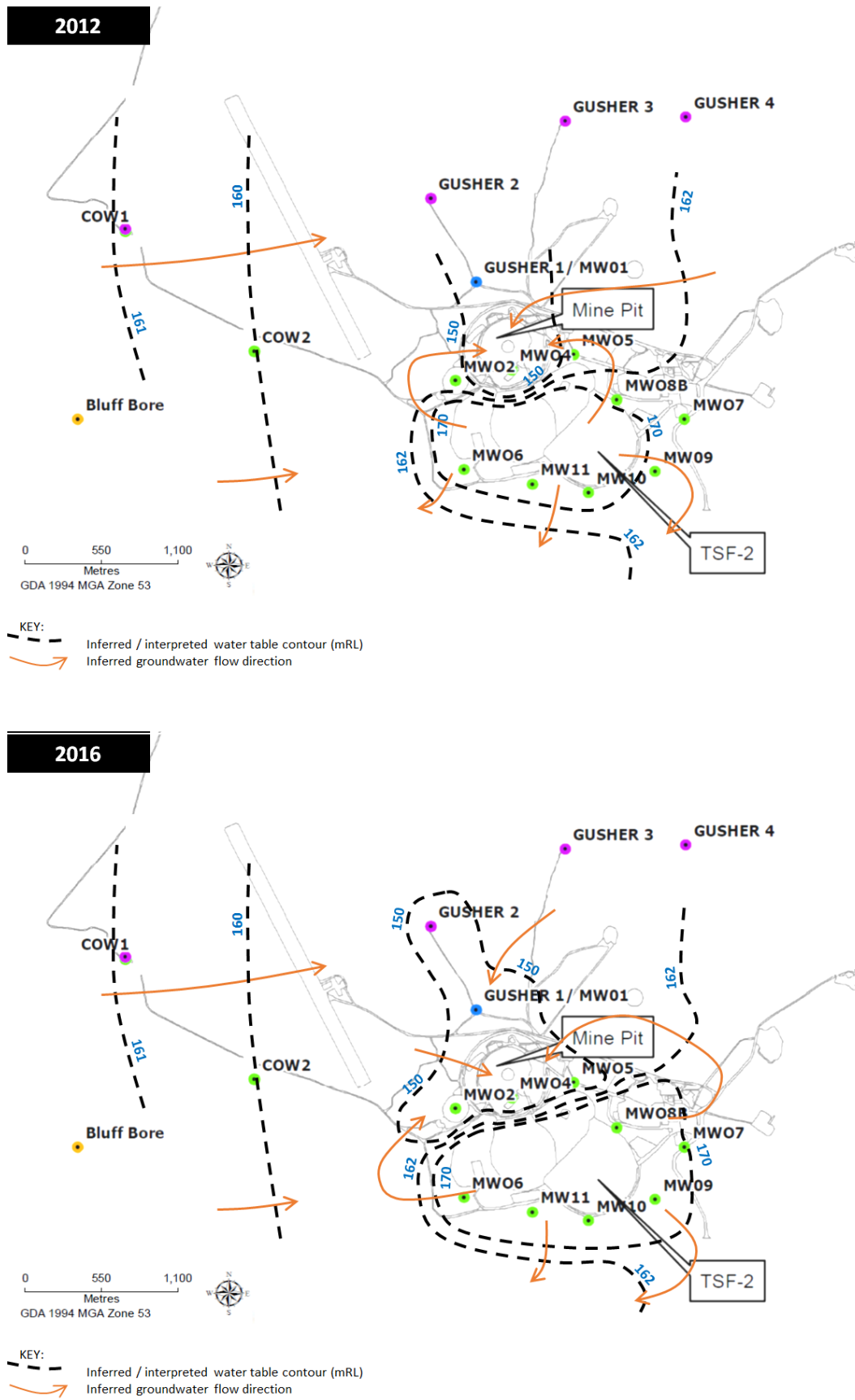


Figure 10 Inferred water table elevation contours – 2012 and 2016

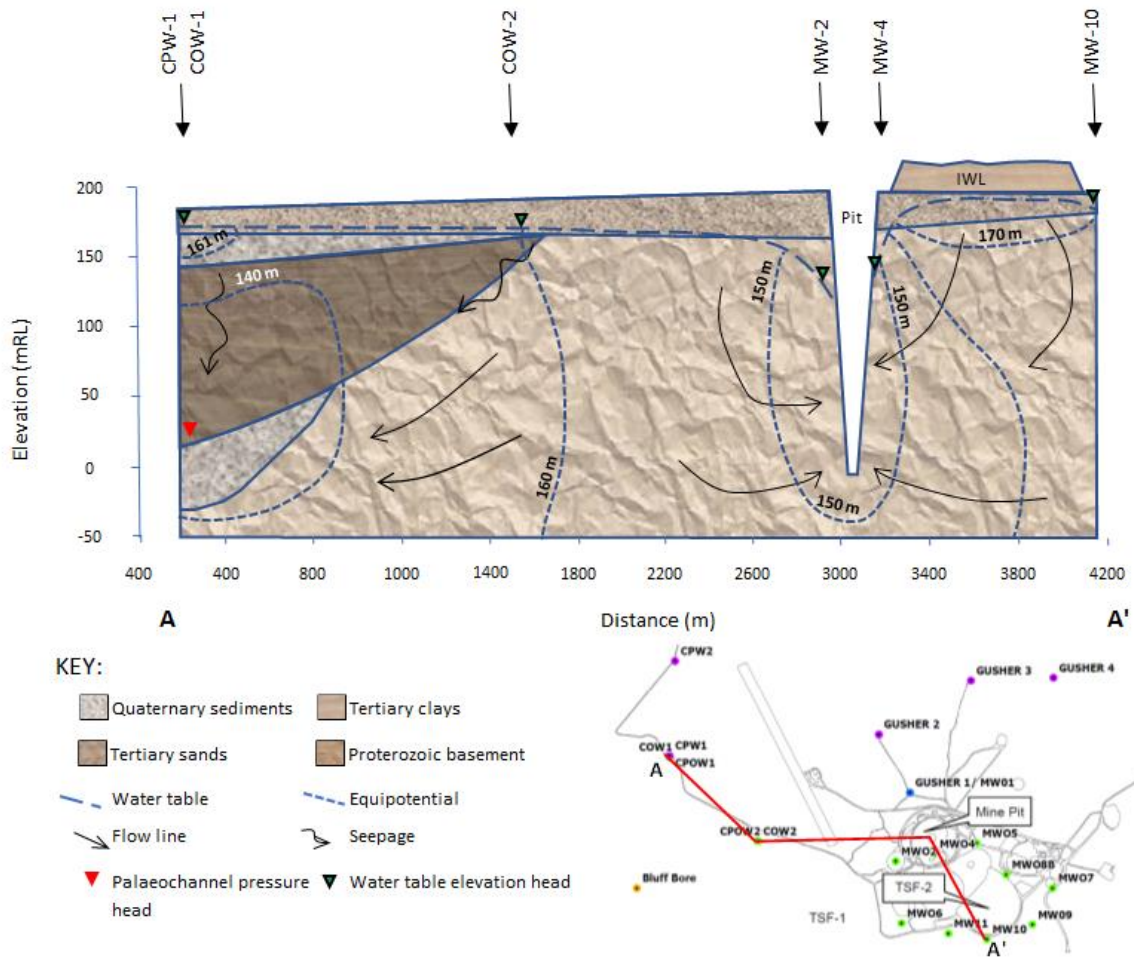


Figure 11 Challenger site hydrostratigraphic profile, inferred equipotential contours and flow lines

In 2017, wet ground was observed within a table drain at the southern end of the TSF (around the location of MW10 and MW11; see Figure 2) and considered as possibly being the result of seepage of tailings leachate from the facility or the result of a shallow water table (mound) forming beneath the TSF. LBW Environmental Projects Pty Ltd (EP) undertook soil and surface water sampling and testing and determined the source of the wet ground was unlikely to be seepage of tailings leachate through the TSF wall.

It is also considered unlikely the source of the wet ground is water table mounding beneath the TSF because:

- The closest monitoring wells show the water table to be more than 10 m below ground level
- Vadophytic vegetation near the toe of the TSF in the area where wet ground has been observed does not appear to be stressed, as would be expected if water logging of the ground is occurring (see Plate 1)

Rainfall of 44 and 26 mm was experienced at the Challenger site during December 2016 and January 2017. It is probable the source of the water observed in the wet area is the result of runoff pooling in a local depression. Plate 1 shows the same area after a rainfall event in early October 2017, and supports this conclusion.



Plate 1 Wet ground near south embankment wall of TSF

3.2 Groundwater quality

3.2.1 Salinity and major ions

There is a stark range in groundwater salinity concentrations between the different components of the Challenger groundwater system – palaeochannel sediments, fractured rock and stockwater aquifer sediments. Table 1 presents statistics for reported salinity data, showing:

- Stockwater aquifer groundwater is brackish
- Palaeochannel aquifer groundwater ranges between saline to hypersaline
- Fractured rock aquifer groundwater ranges between brackish and saline

Comparing the relationship between cations and anions for different groundwater samples provides a basis for assessing the possible degree of interconnectivity between different groundwater sources. Figure 12 presents a Piper plot of groundwater chemistry for the paleochannel (CPW1 and CPW2), stockwater (COW1) and fractured rock (COW2, MW02 and MW06) aquifers, and the chemistry data are presented as Appendix B. The Piper plot shows stockwater aquifer groundwater chemistry is quite distinct from the other water sources (particularly in the ratio of bicarbonate compared to other ions) indicating limited if any interconnectivity between this and other aquifers.

Table 1 Groundwater salinity concentration statistics

Groundwater system component	Groundwater salinity concentration (mg/L)		
	Min.	Max.	Mean
Stockwater aquifer	460	4,500	3,166
Palaeochannel aquifer	23,000	112,700	58,660
Fractured rock aquifer ^[1]	6,890	22,700	12,511

Notes: 1. Including data for RO wellfield but excluding bias from mine monitoring network (potentially tailings impacted)

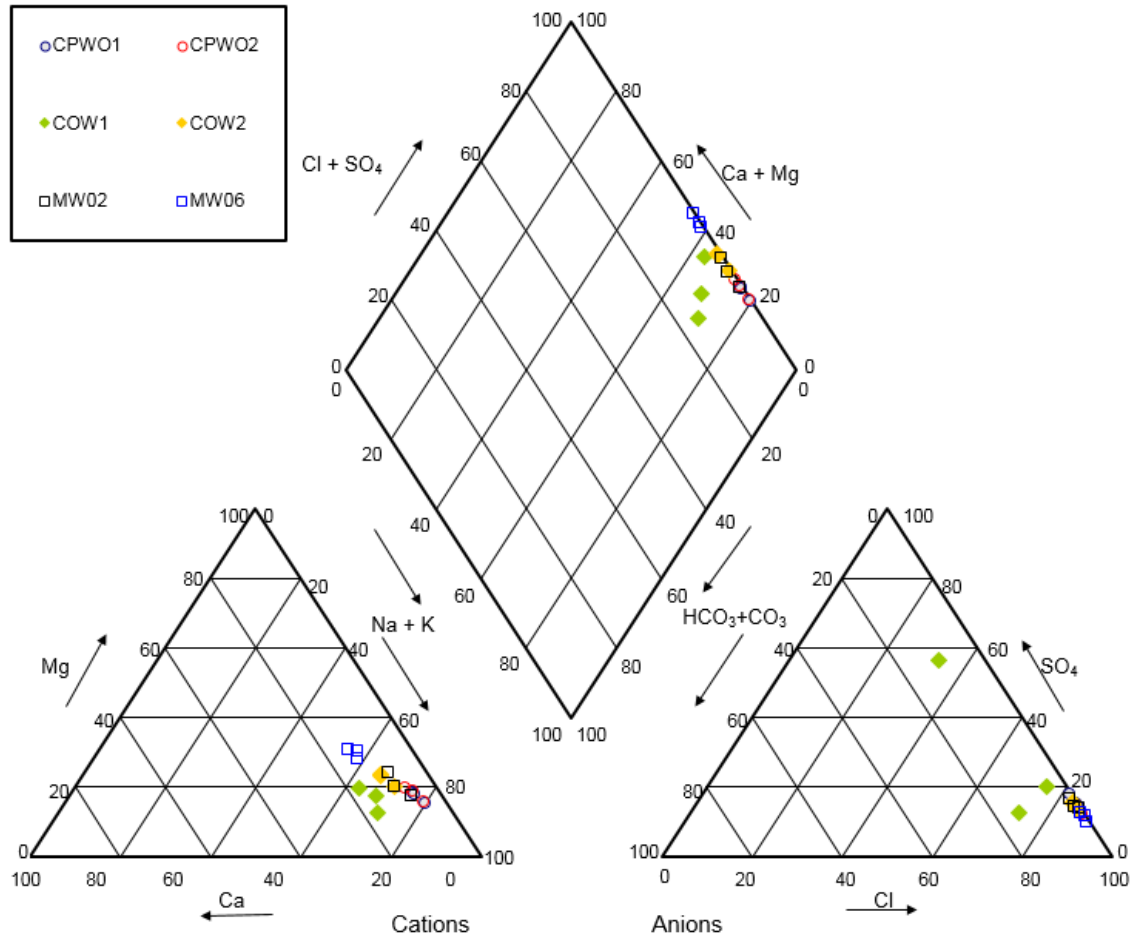


Figure 12 Graphical representation of major ions from selected monitoring wells and groundwater sources as a Piper plot

3.2.2 Cyanide

Cyanide (CN) is used in the mine process, and consequently reports to the TSFs with tailings discharge. Three processes can occur at the TSF – the first is that some CN breaks down due to exposure to light, the second is that some CN returns to the process circuit with recovered decant water and the third is that some CN infiltrates the tailings beaches. Historically, CN concentrations in the tailings and decant streams range between around 30 and 10 mg/L, respectively.

CN has been detected in groundwater sampled from most monitoring locations at Challenger, including the stock water aquifer and the fractured rock aquifer(s) since the earliest days of mining. Figure 13 presents time-series laboratory reported concentrations in groundwater for a selected number of wells (note; the time series data presented in the graphs are for times when CN has been reported above the laboratory level of reporting, and non-detects have not been plotted). There is likely an issue in regards to how CN concentrations, as well as other analytes, have been stored on the Challenger water quality database – it is likely that in many or all cases that laboratory levels of reporting (LOR; which are essentially non-detects) have been entered into the database as values rather than non-detects.

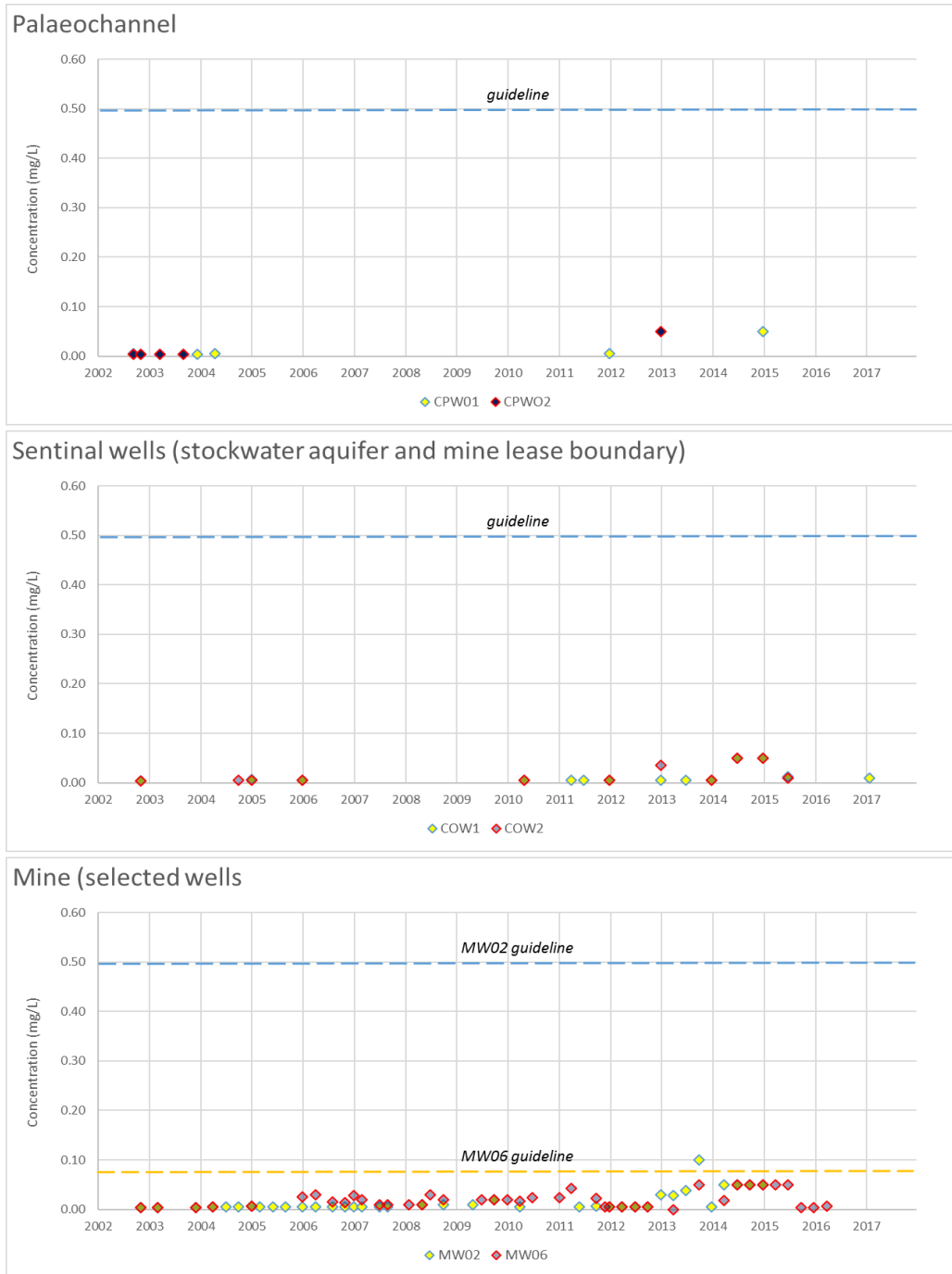


Figure 13 Reported CN_{WAD} concentration data

Typically, CN concentrations have been reported at near the laboratory level of reporting (LOR; which has varied over the years from 0.004 to 0.01 mg/L), and below the relevant compliance guideline applying to different well groupings (e.g. MW06, MW07, MW09, MW10 and MW11 have a guideline of 0.08 mg/L, whilst all other wells have a guideline of 0.5 mg/L).

The reported CN concentrations in groundwater sampled from the stockwater aquifer monitoring well (COW1) as far back as 2002 are difficult to explain given the hydrogeological setting. This is particularly so for COW1 which has a head higher than the head recorded at COW2 (density corrected level; Appendix A), which is located at the margins of the Challenger palaeodrainage

between COW1 and the IWL. Appendix C presents an assessment of groundwater flow velocities for the Challenger site and shows that, even without a hydraulic barrier (i.e. COW1 is located up-hydraulic gradient of COW2), it would take many 100s of years for groundwater to flow from the IWL to the stockwater aquifer. That is, it is highly unlikely that CN-contaminated groundwater sourced from the mine could have travelled between the IWL and COW1 in the time available since placement of first tails (less than 20 years).

It is likely that sampling procedures have impacted on data quality over the period that monitoring has occurred at Challenger, or there are alternative sources of CN in the environment, e.g. acacias are known to produce the compound to ward off pests.

3.3 TSF2 model predictions

3.3.1 Overview

Groundwater modeling undertaken in support of gaining regulatory approvals for an expansion of the TSF, which is constructed within the IWL, in 2010 simulated seepage from the TSF (TSFs 1⁴ and 2⁵) and the mine pit evaporative sink to predict groundwater system response to the expanded mine operation, including the groundwater flow field and solute mass transport. Sections 3.3.2 and 3.3.3 present a comparison of model predictions that represent 2017 against observed data for the same time.

3.3.2 Groundwater pressures

Figure 7 to Figure 10 present time series inferred water table elevation contours maps of the Challenger site, whilst Figure 11 presents inferred groundwater potentiometric contours for the fractured rock, stockwater and palaeochannel aquifers.

The potentiometric contours presented in Figure 11 are consistent with the model predicted contours presented in SKM (2009a; Figure 5-20), and represented as Figure 14. Note that Figure 13 does not show water table elevations, but shows potentiometric contours for the fractured rock and palaeochannel aquifers.

3.3.3 CN concentration in groundwater

Table 2 presents a summary of model predicted CN concentrations against observed and shows, whilst there are some data points that do not closely agree, there are no significant discrepancies between the predicted and observed datasets. Reported concentrations of CN in water samples collected from monitoring wells MW09, MW10 and MW11As (constructed after closure of TSF-1) are consistent with the reported concentrations in samples collected from MW06. As such, and given the observations presented in Section 3.2.2, the 2009 fate and transport model can be considered reasonably representative of the interactions between the TSFs and Challenger groundwater system.

⁴ Which was to be decommissioned

⁵ Which was to be commissioned

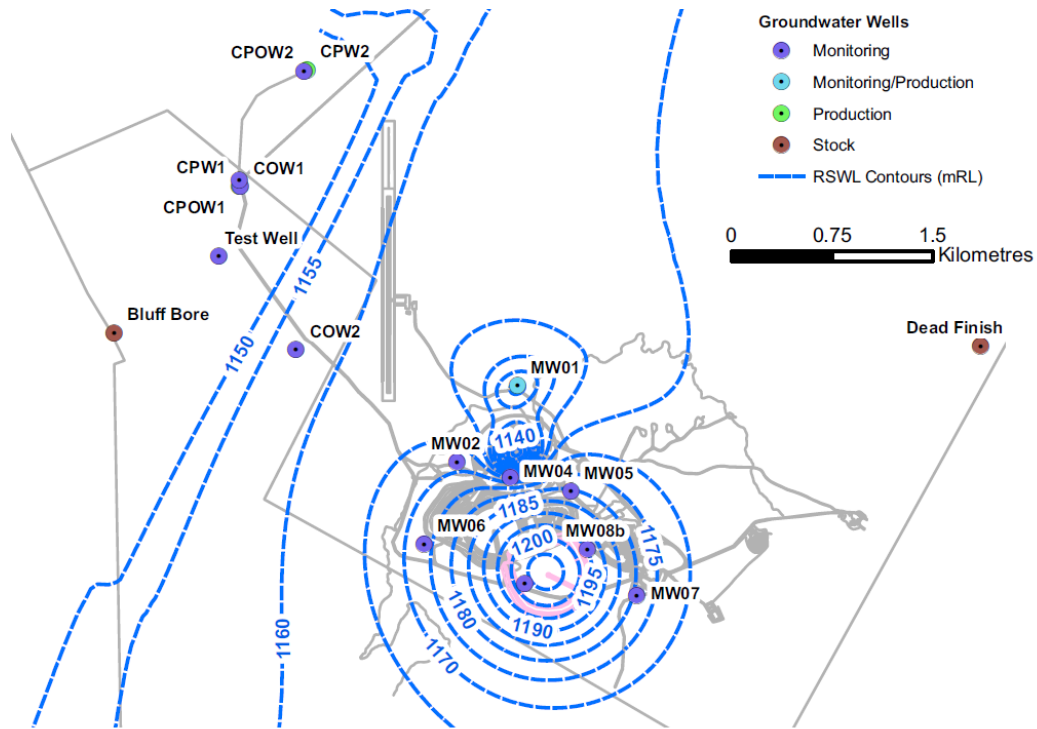


Figure 14 Model predicted potentiometric contours for around 2017 (after SKM, 2009a; arrows show interpreted groundwater flow directions)

Table 2 Predicted and reported CN concentrations (mg/L) ^[1]

Well	2009		2017	
	Predicted	Observed ^[2]	Predicted	Observed
MW01	0.000	0.000	0.000	0.000
MW02	0.000	0.01	0.000	0.000
MW04	0.002	0.050	0.560	0.010
MW05	0.000	0.030	0.000	0.009
MW06	0.000	0.020	0.000	<0.004
MW07	0.000	<0.010	0.000	0.020
MW08B	0.000	<0.010	1.050	0.026

Notes: 1. Model predicted at 'end of mining', year 17, which aligns relatively closely with early 2017
 2. Average for samples collected in 2009

Section 4 Conceptual hydrogeological model

Prior to commencement of pumping from the palaeochannel aquifer, the density corrected pressure head of the palaeochannel aquifer was above the stockwater aquifer head (see Appendix A), this would suggest the potential for upward leakage from the palaeochannel to the stockwater aquifer. However, the significant difference in salinity concentration and major ion speciation (see Section 3.2.1) does not support this observation. Post et al (2007⁶) presents an approach to density correction that allows consideration of the constraint a confining unit imposes on connectivity between a confined aquifer and a shallower aquifer. Appendix A presents the calculations, which show that a downward hydraulic gradient between the stockwater aquifer and the top 20 to 30 m of the confining unit likely exists, although the corrected heads suggest that an upward hydraulic gradient exists. The calculations presented as Appendix A are supported by observed data presented in this report (see Section 3).

The assessed interaction between the stockwater and palaeochannel aquifer combined with the observation that the stockwater aquifer has a higher head than the adjacent fractured rock aquifer (at COW2) strongly suggests that the stockwater aquifer is essentially independent of the other groundwater systems active in the area of Challenger.

The only evidence that suggests the stockwater aquifer may be exposed to impacts associated with the mine operation is the reported concentrations of CN in groundwater samples collected for some sampling events. As described earlier, the presence of mine-sourced CN in groundwater sampled from the stockwater aquifer is considered very unlikely – the pressure head in the stockwater aquifer (at COW1) is higher than the pressure head in the fractured rock aquifer (COW2), and the first reported CN in COW1 groundwater occurring only one month after commencement of processing in 2002 (groundwater velocities will be insufficient to allow that to happen). It seems there is a data quality issue with some water quality analytes, and CN is considered one of the more difficult analytes for maintaining strict quality control. Reliance on detections of CN in groundwater is not necessarily an indication that the conceptual hydrogeological model for Challenger is incorrect, given alternative evidence that the conceptualisation is correct.

Figure 15 presents a schematic of the existing conceptualisation of the interactions between the main components of the Challenger groundwater system. The following key points are made:

- The palaeochannel aquifer is a regional groundwater discharge feature, that drains the basement rocks of the Gawler Craton in the Challenger area
- A thick sequence of plastic clays overlie the palaeochannel aquifer, confining it and separating it from the shallow stockwater aquifer
- The stockwater aquifer is recharged directly by rainfall runoff, with recharge occurring relatively rapidly through the calcareous soils occurring in the topographic low associated with this aquifer
- The stockwater aquifer discharges to the underlying clay aquitard and via evapotranspiration, and may spill to provide local recharge to the regional fractured rock aquifer and the sediments that overlie the fractured rocks

⁶ Post V., H.Kooi and C.Simmons. 2007. Using hydraulic head measurements in variable-density groundwater flow analysis. In: Groundwater vo. 45, Issue 6, pp 664-671.

- The stockwater aquifer is effectively isolated from 'receiving' any interactions with the other components of the Challenger groundwater system

Figure 16 presents a schematic of the existing conceptualisation of the interactions between the fractured rock groundwater system, and the IWL and mine pit. The following key points are made:

- The IWL and mine pit interrupt the pre-mine groundwater flow field
- TSF-2, and formerly TSF-1, acts as an additional source of groundwater recharge to the local sedimentary aquifers and underlying fractured basement rocks (these local sedimentary aquifers are distinct from the stockwater aquifer that overlies the Challenger Palaeochannel)
- The mine pit acts as a regional groundwater sink that captures groundwater moving within the fractured basement rocks
- Numerical modeling (2009) predicts the mine pit, over the very long term, captures the majority if not all TSF leachate

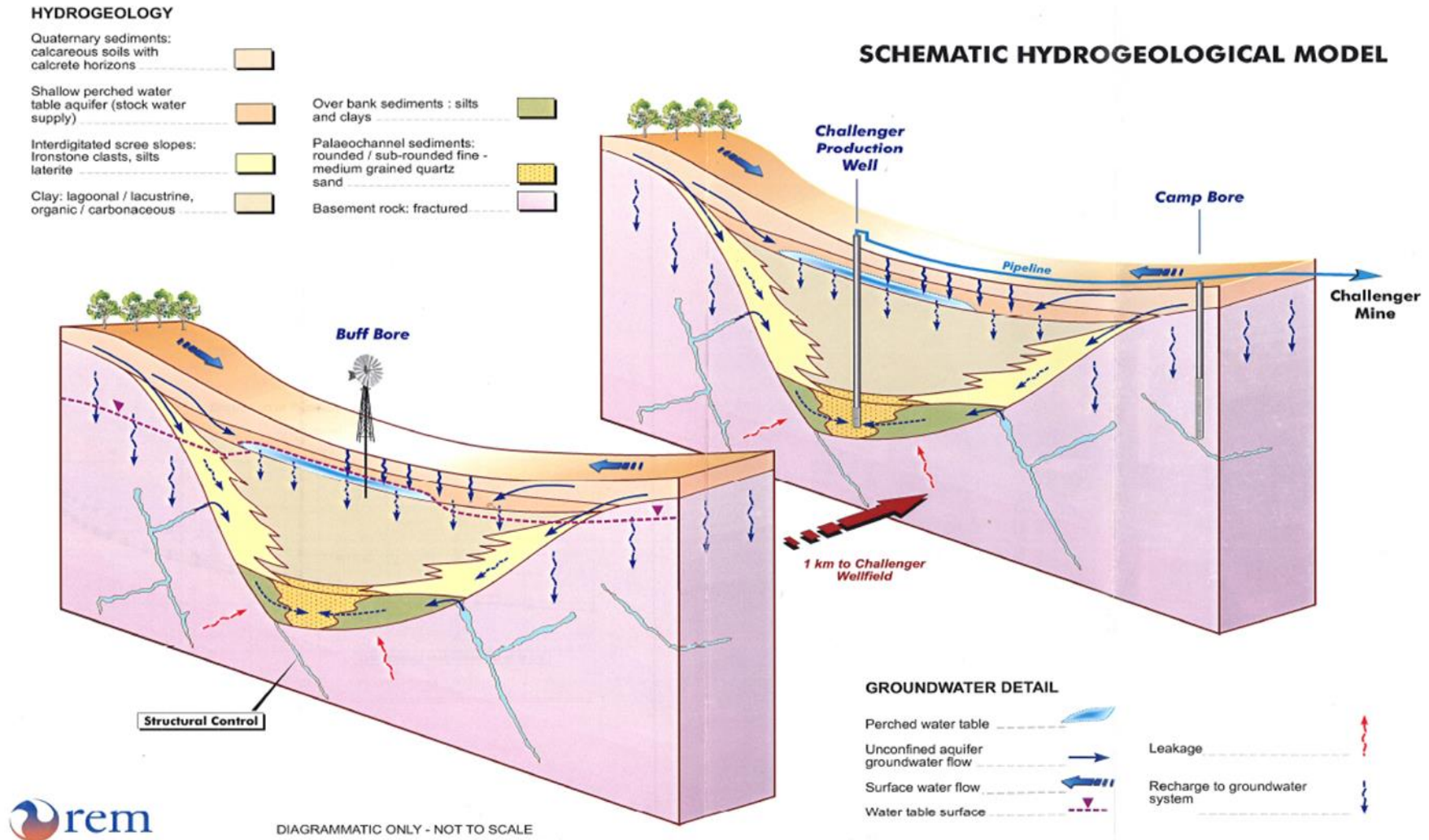


Figure 15 Conceptual hydrogeological model of Challenger Palaeochannel and stockwater aquifers

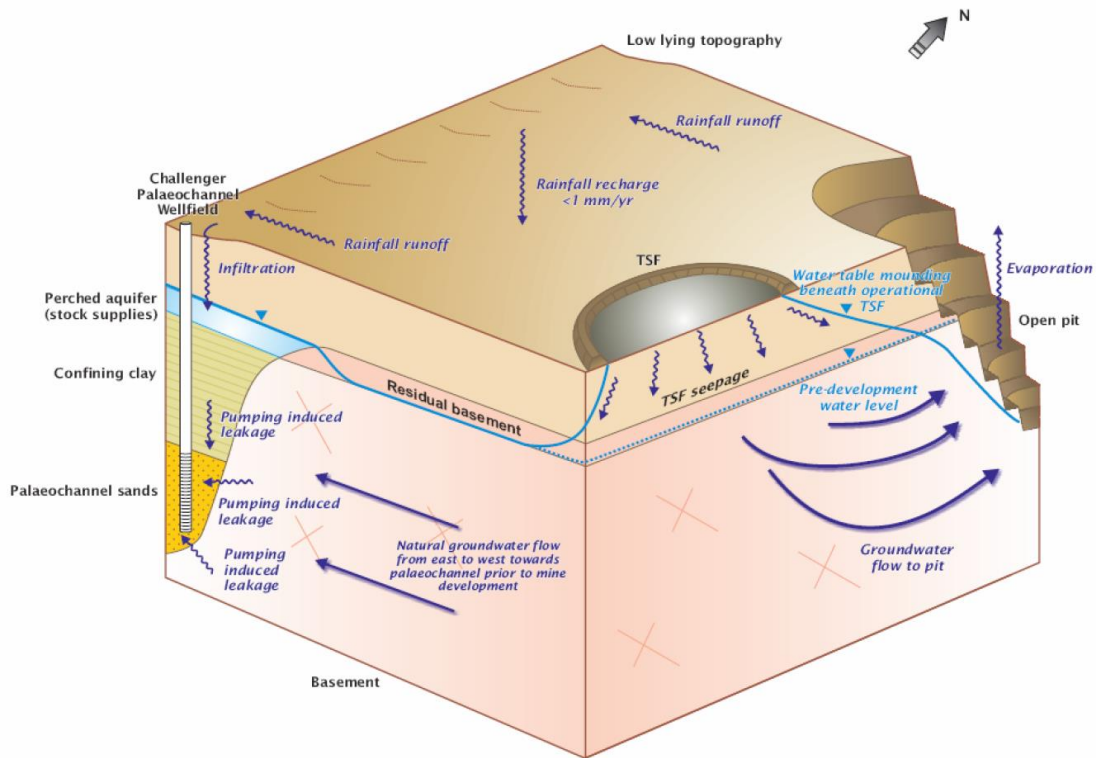


Figure 16 Conceptual hydrogeological model of Challenger Palaeochannel and mine operations

Section 5 Effects assessment

This section presents a groundwater effects assessment for Challenger that outlines a measured assessment of potential groundwater management issues to assist in communicating outcomes to Project stakeholders (e.g. DPC), based on observed effects since commencement of mining.

The effects assessment adopts the general methodology outlined in the mining risk framework developed by the National Water Commission as part of the National Water Initiative (Howe, 2011⁷). This framework is risk-based and developed to promote a rigorous, transparent and nationally consistent approach to assessing and managing potential impacts of mining activities on (ground)water resources and the receptors that rely wholly or partly on those resources. The framework consists of several steps (see Figure 17) to guide groundwater impact assessments in a logical, structured and defensible manner, with the first, third and fourth steps being of relevance to this report:

- **Step 1 Context Setting** places the project site into a regional context, focusing on hydrogeology but also providing a brief overview of topography, climate and hydrology. The development of a robust hydrogeological conceptual model is a key component of this stage of the assessment.
- **Step 3 Groundwater Effects Assessment** considers mining-related activities that have the potential to alter the groundwater regime. The effects are described in the context of alterations to quantity and quality of groundwater, surface water - groundwater interaction and physical disruption of aquifers.
- **Step 4 Receptor Exposure Assessment** considers the potential exposure pathways between potentially sensitive groundwater receptors and direct effects associated with mining and processing.

Table 3 presents a summary of those direct effects that are active at the Challenger site and require consideration as part of the Receptor Exposure Assessment.

Table 3 Groundwater effects assessment - summary

Water affecting activity	Quantity	Quality	Aquifer disruption	Groundwater - surface water interaction
Mine pit and underground mines	✓	✓	✓	
TSF	✓	✓		
Palaeochannel water supply	✓			
Fractured rock water supply	✓			

Notes: ✓ direct effect active

⁷ Howe, P. 2011. Framework for assessing potential local and cumulative effects of mining on groundwater – project summary report, Waterlines report, National Water Commission, Canberra.

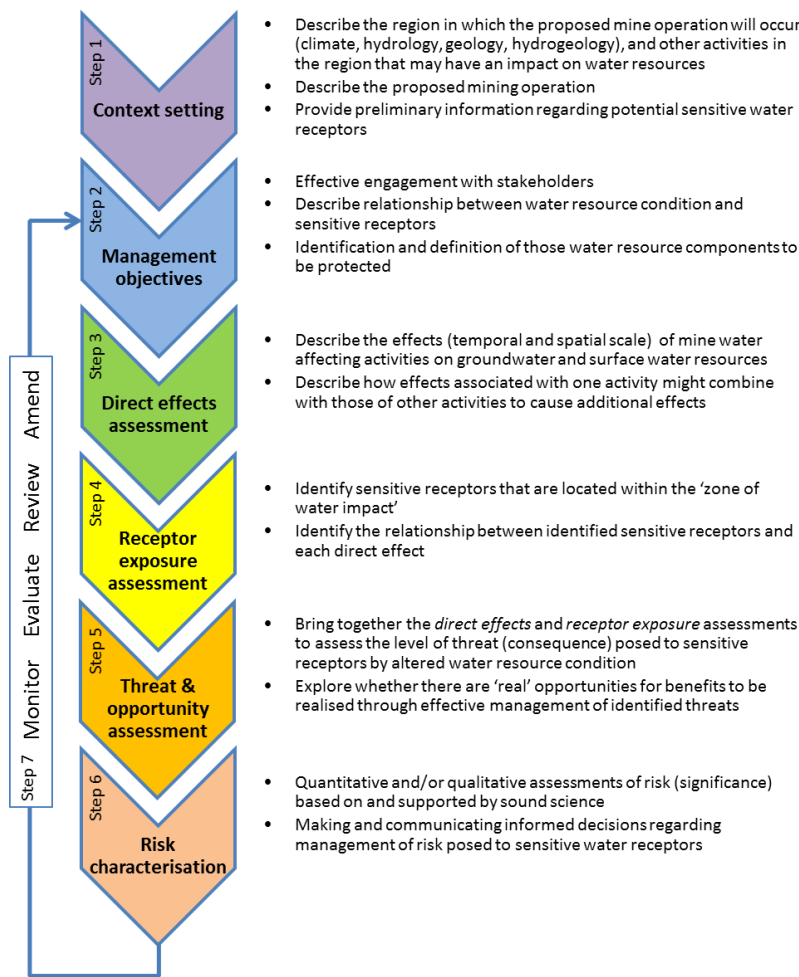


Figure 17 NWC risk assessment framework for cumulative effects assessment of mining on groundwater and connected systems (after Fuentes et al. 2014⁸)

Table 4 presents a summary of the mine- and process-related water affecting activities at Challenger and the likely associated direct effects (changes to groundwater quantity and quality, changes to groundwater and surface water interaction, and aquifer disruption). The table also provides an assessment of whether there is sufficient information available to assess potential risks (i.e. are there knowledge gaps) and a ranking relating to potential water management implications.

⁸ Fuentes R., Howe P.J and Glue S. 2014. Assessing and communicating the effects of mining on sensitive water receptors within a social licence to operate context. Water in Mining 2014 Conference. Gecamin, Santiago de Chile.

Table 4 Receptor effects and threat assessment

Direct effect	Present	Description	Receptors	Info. gap	Threat
Groundwater affecting activity: MINE PIT					
Groundwater quantity	Yes	<p>During mining, operation of the wellfields will reduce groundwater pressures in the immediate area of the mine and the palaeochannel, and operation of the declines and pit will capture local groundwater flow</p> <p>Post-mining, the mine pit will act as a permanent groundwater sink for the local area</p> <p>Groundwater pumping and mine pit groundwater capture is very unlikely to impact on stockwater aquifer groundwater levels</p>	<p>Stygofauna are unlikely to exist in the Challenger area (SKM, 2009c)</p> <p>Phreatophytic vegetation reliant in fractured rock and palaeochannel aquifer not identified</p> <p>Potential phreatophytes reliant on stockwater aquifer are unlikely to be exposed to water stress due to pumping or the mine pit</p>	None	Low
Groundwater quality	Yes	Mine pit will act as a permanent evaporative sink, resulting in salinization of any water body that forms in the base of the pit	None	None	n/a
Groundwater & surface water interaction	No	<p>Ephemeral water courses occur but none are impacted by mine pit and IWL</p> <p>Ephemeral runoff directly recharges stockwater aquifer, but this process is not impacted by mine during or following operations</p>	Riparian vegetation associated with ephemeral watercourse overlying stockwater aquifer	None	Low
Aquifer disruption	Yes	The mine pit extends into the fractured rock aquifer, which is not an aquifer of any significance	None	None	n/a

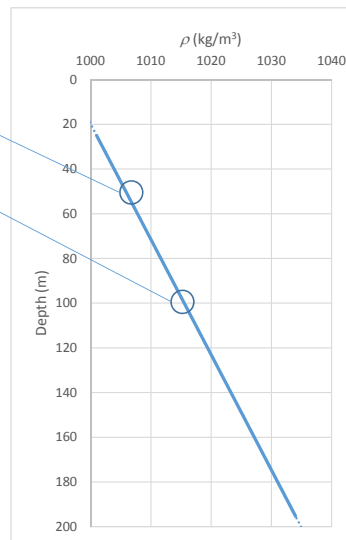
Table 3 Groundwater effects assessment (cont.)

Direct effect	Present	Description	Receptors	Info. gap	Threat
Groundwater affecting activity: TSFs					
Groundwater quantity	Yes	<p>During mine operation, the TSFs will act as local recharge sources resulting in local water table mounding</p> <p>After closure, the tailings will desaturate and recharge rates will likely reduce</p>	<p>Terrestrial vadophytic vegetation near to IWL could become water logged, but this has not been observed to date</p> <p>Troglofauna are unlikely to exist in the Challenger area (fractured rock is typically saturated)</p>	None	Moderate
Groundwater quality	Yes	<p>TSF seepage locally impacting groundwater quality in fractured rock aquifer</p> <p>Potential exists for the palaeochannel to be impacted in the very long-term by tailings seepage, but this is unlikely due to the effect of mine pit acting as a long-term groundwater sink</p> <p>Stockwater aquifer is effectively hydraulically isolated from mine site fractured rock aquifer</p>	<p>Third party water users (pastoralists) utilise shallow groundwater in areas where salinity concentrations are suitable for stockwater supply, but these supplies are located up-gradient of the mine (Dead Finish Bore) or hydraulically isolated (Bluff Bore)</p> <p>Palaeochannel aquifer is not suitable for stockwater supply</p>	None	Low
Groundwater & surface water interaction	No	IWL does not interrupt any permanent watercourses	None	None	n/a
Aquifer disruption	Yes	Seepage from TSFs has caused a local water table mound beneath the IWL, which interrupts to a minor extent, groundwater moving toward palaeochannel	None	None	n/a

Appendix - A
Density correction to
groundwater heads

Well	GL (mAHD)	SWL (depth, m)	SWL (mAHD, h_i)	Density (ρ_w , kg/L)	Screen mid-point (z_i)	Flux to stock water aquifer from:				
						Freshwater density (ρ_f)	Freshwater head ($h_{f,i}$)	q_z (m/d)	q_z (mm/d)	q_z (mm/y)
CPW1	179.7	21.62	158.08	1.034	-16.3	1.000	164.0	1.8011E-07	0.00018011	0.065785
Aquitard point 1	179.4		160	1.007	129.4	1.000	160.2	-3.1378E-07	-0.000313776	-0.11461
Aquitard point 2	179.4		160	1.015	79.4	1.000	161.2	3.40773E-08	3.40773E-05	0.012447
COW1	179.1	18.15	160.95	1.001	153.1	1.000	161.0			
COW2	183	23.45	159.55	1.013	157.0	1.000	159.6			
MW1/Gusl	189.8	57.35	132.45	1.009	114.8	1.000	132.6			
MW2	193	65.55	127.45	1.01425	123.0	1.000	127.5			
MW3	193.4		193.4		133.4	1.000	133.4			
MW4	193.9	45.45	148.45	1.033	167.9	1.000	147.8			
MW5	195.2	27.1	168.1	1.024	127.7	1.000	169.1			
MW6	194.5	23.1	171.4	1.0225	134.5	1.000	172.2			
MW7	195.5	25.54	169.96	1.01725	169.5	1.000	170.0			
MW8B	196.8	15	181.8	1.045	170.8	1.000	182.3			
MW9	194.8	23.65	171.15	1.007125	131.8	1.000	171.4			
MW10	193.9	14.9	179	1.00645	121.9	1.000	179.4			
MW11	192.7	15.4	177.3	1.01725	143.7	1.000	177.9			
Gusher 2	176	42.8	133.2	1.009	108.5	1.000	133.4			
Gusher 3	188	69.6	118.4	1.01125	108.5	1.000	118.5			
Gusher 4	187	26.04	160.96	1		1.000	161.0			
CPW01	190	157.05	32.95	1.03675	5.0	1.000	34.0			
CPW02	190	160.75	29.25	1.036	40.0	1.000	28.9			
CPW03	190	133.6	56.4	1.04875		65000	1.000	59.1		

Confining unit
K 0.00001



Density correction for freshwater head

$$h_{f,j} = \frac{\rho_i}{\rho_f} h_i - \frac{\rho_i - \rho_f}{\rho_f} z_i$$
 Eq. 6 (Post V., H.Kooi and C.Simmons. 2007. Using hydraulic head measurements in variable density groundwater flow analyses. In: Groundwater, vol. 46, issue 6, pp 664-671)

Vertical flow component through clayey aquitard

$$q_z = -K_f \frac{\Delta h_{e,i}}{\Delta z}$$
 Eq. 16 (Post V., H.Kooi and C.Simmons. 2007. Using hydraulic head measurements in variable density groundwater flow analyses. In: Groundwater, vol. 46, issue 6, pp 664-671)

cf. Figure 2 of Post V., H.Kooi and C.Simmons. 2007. Using hydraulic head measurements in variable density groundwater flow analyses. In: Groundwater, vol. 46, issue 6, pp 664-671)

Appendix - B
Water chemistry

Sample ID	Date Sampled	CATIONS					ANIONS				WATER QUALITY DATA		
		Na mg/L	K mg/L	Ca mg/L	Mg mg/L	Fe mg/L	CO ₃ mg/L	HCO ₃ mg/L	SO ₄ mg/L	Cl mg/L	pH pH units	EC mS/cm	TDS mg/L
CPOW1	10/02/02	13200.0	147.0	861.0	1710.0	5.1		250.0	5380.0	23000.0	7.0	51000.0	47000.0
CPOW1	17/01/10	12300.0	144.0	823.0	1530.0	4.4		254.0	5000.0	17000.0	7.7	41900.0	45000.0
CPOW1	16/02/17	19000.0	210.0	1000.0	1900.0	6.0		240.0	5700.0	23000.0	7.6	55000.0	49000.0
CPOW2	10/02/02	9440.0	152.0	779.0	1350.0	1.8		262.0	4060.0	17400.0	6.9	45000.0	42000.0
CPOW2	17/01/10	10800.0	143.0	723.0	1420.0	7.0		262.0	5000.0	26000.0	7.6	35900.0	45000.0
CPOW2	16/02/17	18000.0	220.0	950.0	1900.0	6.6		240.0	5300.0	22000.0	7.4	54000.0	48000.0
COW1	01/07/02	1050.0	38.1	201.0	144.0	0.4		160.0	692.0	300.0	7.4	5230.0	2800.0
COW1	01/05/10	880.0	35.0	210.0	150.0	0.1		160.0	580.0	1600.0	8.1	6600.0	4300.0
COW1	02/02/17	350.0	28.0	76.0	34.0	0.1		160.0	110.0	470.0	7.7	2000.0	1200.0
COW2	01/05/02	3870.0	140.0	540.0	739.0	1.4		176.0	1930.0	7760.0	7.0	23700.0	14000.0
COW2	01/05/10	3900.0	210.0	560.0	760.0	0.1		176.0	1900.0	8900.0	8.0	20000.0	17000.0
COW2	02/02/17	5700.0	180.0	650.0	870.0	1.0		150.0	1900.0	7400.0	7.6	20000.0	18000.0
MW02	01/07/02	5740.0	208.0	656.0	1110.0	2.1		146.0	2650.0	12100.0	6.9	33600.0	23300.0
MW02	01/04/10	4130.0	135.0	465.0	637.0	0.0		142.0	1500.0	6400.0	8.1	22400.0	17000.0
MW02	01/02/17	5900.0	180.0	460.0	740.0	0.0		150.0	2200.0	8000.0	6.9	21000.0	19000.0
MW06	01/11/02	4600.0	210.0	930.0	1200.0	1.3		151.0	1800.0	12000.0	7.2	22000.0	20000.0
MW06	01/04/10	4690.0	200.0	1070.0	1430.0	0.0		163.0	4800.0	27000.0	8.0	29300.0	24000.0
MW06	01/02/17	7000.0	240.0	1300.0	2000.0	0.0		140.0	3000.0	15000.0	7.2	35000.0	30000.0

		Water Quality Results										Table 1	
Date: 5/06/2017		Project: Challenger				Description: 2017 PEPR							
PATH: \\sydsvr1\pro\Project\AWS170074.01 - Challenger-Groundwater-PEPR\7Work1\Analysis\Water Chemistry Analysis2.xlsm]Report Table 1		Project No: AWS170074				Client: WPG						CDM Smith	

Appendix - C
Groundwater flow velocity
calculations

Well	COW-1	COW-2	MW02	MW06
Ground elevation (m RL)	178.8	183	192	194
Distance (km)	0	1.33	2.83	3
Year	Groundwater head (mRL)			
Jan-02	160.96	160.55	162.82	162.88
Jan-04	160.74	160.35	155.44	163.4
Jan-06	160.7	160.4	154.63	167.2
Jan-10	160.51	160.23	156.25	170.7
Jan-14	160.37	160.12	145.79	171.57
Aug-17	160.35	160.05	127.25	171.12
Years for flow from IWL to reach				
HIGH EFFECTIVE POROSITY VALUE			$V_x = Ki/n_e$	
Parameter	COW-1	COW-2	} Silty sand	
Eff. Porosity (-) *	0.35	0.35		
Hyd. Cond. (m/d)	0.2	0.2		
Hyd. Gdt (-)	0.0006	0.0014		
Velocity (m/d)	0.00037	0.00080		
Velocity (m/y)	0.133	0.291		
Time (years)	22474.3	5738.8		
LOW EFFECTIVE POROSITY VALUE			$V_x = Ki/n_e$	
Parameter	COW-1	COW-2	} Silty sand	
Eff. Porosity (-) *	0.2	0.2		
Hyd. Cond. (m/d)	0.2	0.2		
Hyd. Gdt (-)	0.0006	0.0014		
Velocity (m/d)	0.00064	0.00140		
Velocity (m/y)	0.234	0.509		
Time (years)	12842.5	3279.3		
* Fetter C.W. 1988. Applied Hydrogeology. 2nd Ed. Merrill Publishing Co.				

Disclaimer and Limitations

This report has been prepared by CDM Smith Australia Pty Ltd (CDM Smith) for the sole benefit of Challenger Gold Mine JV for the sole purpose of demonstrating the existing conceptual hydrogeological model of the Challenger Mine area is representative and that sensitive water receptors are not posed to adverse effects associated with mine-related activities.

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- (a) has relied upon and presumed the accuracy of this information;
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- (c) has not made any independent investigations or enquiries in respect of those matters of which it has no actual knowledge at the time of giving this report to Challenger Gold Mine JV; and
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If further information becomes available, or additional assumptions need to be made, CDM Smith reserves its right to amend this report.

Appendix N

Challenger Gold Operation - TSF1, TSF2 and IWL Stability

Challenger Tailings Storage Facility 1 &2 and Waste Rock Landform - Stability

Date:	5 June 2016
Client	Environmental Projects – WPG Resources
Project Number	CC170012
Author:	Nicole Edkins
Revision:	0
Our Reference:	CC170012_1

1 Introduction

The following document outlines the findings of a desktop review of documentation pertaining to the stability of the Challenger Tailings Storage Facility 1 (TSF1), Tailings Storage Facility 2 (TSF2) and the Waste Rock landform. TSF1 and the waste rock material form the Integrated Waste Landform (IWL), with TSF2 located to the south-east, adjoining that portion of the IWL.

This review is limited to the documents provided in the reference list. As CCA cannot comment on the veracity of the various reports, they have been assumed complete and correct.

2 Review Notes

2.1 Integrated Waste Landform - Tailings Storage Facility 1

2.1.1 Embankment Design

The design of TSF1 was undertaken in 2001 by Soil and Rock Engineering, including a stability analysis that addressed a conservative phreatic surface (i.e. worst case) and assessed earthquake loading. Subsequent changes to lift height resulted in two addendums to the design undertaken in 2005 by Coffey Geosciences Pty Ltd and in 2007 by Coffey Mining Pty Ltd, with the latter incorporating the Integrated Waste Landform (IWL) concept. Both design updates were subject to stability assessment against ANCOLD 1999, with factors of safety above the required level. The addition of the waste rock dump to form the Integrated Waste Landform has further reinforced the embankment stability.

2.1.2 Construction Verification

TSF1 was constructed in a series of stages up to the current, Stage 4, crest level of RL 1216.5 m. The current design for TSF1, as per the 2005 and 2007 addendums, permitted raising of the perimeter embankment crest level to a final RL 1229.5 m, which would provide storage for nominally 4,150,000 m³ of tailings. Deposition into TSF1 stopped at Stage 4 (RL 1216.5 m).

Throughout all four stages of construction, monitoring was undertaken, with as-built construction reports developed following each construction phase. Stage 1 construction was undertaken in 2002, with subsequent raising undertaken through until 2007 when the Stage 4 raise was undertaken.

Challenger TSF1, TSF2 and IWL

2.1.3 Operational Management

Annual audits and management reviews of TSF1 have been undertaken each year since commissioning in October 2002 and continues to be reviewed in the annual audits now occurring predominantly for TSF2.

Throughout the operation of TSF1 in-situ density of the tailings was measured and consistently was above the design average dry density. As such the TSF capacity is improved and the permeability reduced (a key measure in reducing seepage).

Each Audit reviewed the water balance for the facility and the groundwater response. Consistently, each audit found that results were within expectations for such a facility. TSF1 was also consistently reported as in compliance with the Mining Lease requirements.

2.1.4 Closure

TSF1 was decommissioned in 2009 and the surface was predominantly covered with mine waste to reduce the potential for dust generation due to wind remobilising the drying deposited tailings. Capping and closure landform earthworks have continued, with the progressive covering of the remaining batters with mine waste and capping material.

2.2 Integrated Waste Landform – Waste Rock

Waste rock from the mine that cannot be used underground is brought to surface and placed in the waste rock portions of the IWL. Early characterisation of the waste material was conducted by Graeme Campbell and Associates in 2001, prior to mining. The waste was classified as NAF and low-grade ore classified as PAF. Since this initial assessment reviews of the waste rock management have been undertaken, most recently by MWH in 2015. Some areas of waste, from close to the orebody have been classified as potential acid forming – low capacity. This material once identified has been encased by NAF within the IWL. Only NAF material has been used for rock armouring and any final surfaces of the IWL. Final slope profiling, rock armouring and use of topsoil is ongoing, with revegetation trials informing future approaches. Final slopes of the waste rock are between 18 and 20 degrees which is well below the angle of repose for the material; thus the slopes are assumed as stable.

2.3 Tailings Storage Facility 2

2.3.1 Embankment Design

The design of TSF2 was undertaken by Coffey in 2009. The design report documents the stability analysis (as per ANCOLD guideline, including post seismic), the Qualitative Risk Assessment and outlines the seepage analysis undertaken. Again, due to alterations in lift configuration (height) two design updates were issued, Stage 3 by Worley Parsons in 2014 and Stage 4 by Advisian in 2015. Both design updates included revised stability assessments in line against ANCOLD 2012 guidelines, with factors of safety above the required level. .

2.3.2 Construction Verification

TSF2 was commissioned in September 2009, with Stage 2 construction undertaken in October 2011 and Stage 3 construction completed in April 2014. The original design included Stage 3 raising to RL 1207.7 m (a 4.5 m raise), however due to the reduced requirements for tailings storage capacity based on limited mine life, the Stage 3 raise was only taken to RL 1205.7 m (a 2.5 m raise). Design work for a further 2.5 m raise (Stage 4) was undertaken by Worley Parsons in 2015 with construction of the raise completed in May 2016 during the 2016 audit period. The Stage 4 raise increased the crest to its current level of RL 1208.2 m and provided additional tailings storage capacity for another 14 months of mining production.

Throughout all four stages of construction, monitoring was undertaken, with as-built construction reports developed following each construction phase. Stage 1 construction was undertaken in 2009, with subsequent raises in 2012, 2014 and 2016. Design and construction of a Stage 5 raise is planned for 2017.

2.3.3 Operational Management

Annual audits and management reviews of TSF2 have been undertaken in conjunction with the TSF1 audit and management reviews each year since commissioning in September 2009.

Throughout the operation of TSF2 in-situ density of the tailings has been measured and consistently was above the design average dry density. As such the TSF capacity is improved and the permeability reduced (a key measure in reducing seepage).

Each Audit reviewed the water balance for the facility and the groundwater response. Consistently, each audit found that results were within expectations for such a facility. The 2016 audit of TSF2 reports it as in compliance with the Mining Lease requirements.

2.3.4 Closure Considerations

The first two batters of TSF2 have been flattened, with topsoil placed and revegetation progressing well. There is an opportunity for further closure planning for TSF2 to take into consideration key learnings from the decommissioning of TSF1. In particular, the closure capping approach can be refined with knowledge from the trial stage for TSF1.

3 Closing Notes

There is over 15 years of design, analysis, auditing and verification reporting pertaining to TSF1, TSF2 and the broader IWL. Early works, prior to commencement of activities, informed the design process with design reassessment completed periodically and as required. The facility has been audited annually, with operations documented as consistently within expectations. The rigorous design, construction verification and auditing process has ensured issues are addressed and the documents clearly outline a well operated and physically stable facility.



4 Reference Documents

4.1 Annual Audit Reports 2003-2016

Tailings Storage Audit, Inspection and Management Review - Tailings Storage No.1 - Challenger Gold Project, Soil & Rock Engineering 2003

Tailings Storage Audit and Management Review - Tailings Storage No.1 - Challenger Gold Project, Coffey Geosciences 2004

Tailings Storage Audit and Management Review - Tailings Storage No.1 - Challenger Gold Project, Coffey Geosciences 2005

Tailings Storage Audit, Inspection and Management Review - Tailings Storage No.1 - Challenger Gold Mine, Coffey Mining 2006

Tailings Storage Audit and Management Review - Challenger Gold Mine Coffey Mining 2007

Tailings Storage Audit and Management Review - Challenger Gold Project, Coffey Mining 2008

Tailings Storage Audit and Management Review - Challenger Gold Project, Coffey Mining 2009

Tailings Storage Audit and Management Review - Challenger Gold Project, Coffey Mining 2010

Tailings Storage Audit and Management Review - Challenger Gold Project, Coffey Mining 2011

Tailings Storage Audit and Management Review - Challenger Gold Mine, Worley Parsons 2012

Tailings Storage Facility Audit and Management Review Main Report - Challenger Gold Mine, Worley Parsons Consulting 2013

Tailings Storage Facility Audit and Management Review Main Report- Challenger Gold Mine, Worley Parsons Consulting 2014

Tailings Storage Facility Audit and Management Review - Challenger Gold Mine, Advisian 2015

Challenger Gold Mine Annual TSF Operational Audit, SMEC 2016

4.2 Design Reports and Addendums

Tailings Storage Facility - TSF1 Construction Starter Embankment and Design – Challenger Gold Project, Soil and Rock Engineering 2001

Tailings Storage Facility 1 - TSF1 Addendum to Design - Challenger Gold mine, Coffey Mining 2005

Integrated Waste Landform - Amendment to Design - Challenger Gold Project, Coffey Mining 2007

Tailings Storage Facility 2 - Design Report (including Geotech) - Coffey Mining Challenger Gold Mine 2009

Tailings Storage Facility - TSF2 Stage 3 Raising Design Report - Challenger Gold Mine, Worley Parsons 2014

Tailings Storage Facility - TSF2, Stage 4 Raising Design Report - Challenger Gold Mine Worley Parsons 2015



Challenger TSF1, TSF2 and IWL

4.3 Construction Reports

TSF1 Stage 1 Construction Report Challenger Gold Project, Soil and Rock Engineering 2002

TSF1 Stage 2 Construction Report Challenger Gold Project, Soil and Rock Engineering 2004

TSF1 Stage 3 Construction Report Challenger Gold Project, Coffey Mining 2006

TSF1 Stage 4 Construction Report Challenger Gold Project, Coffey Mining 2007

TSF2 Stage 1 Construction Report Challenger Gold Project, Coffey Mining 2009

TSF2 Stage 2 Construction Report Challenger Gold Project, Coffey Mining 2012

TSF2 Stage 3 Construction Report Challenger Gold Project, Worley Parsons 2014

TSF2 Stage 4 Construction Report Challenger Gold Project, SMEC 2016

4.4 Geochemical Characterisation

Geochemical Characterisation of Waste and Low-Grade ore samples – Implications for Mine Waste Management - Challenger Gold Project, Graeme Campbell and Associates, 2001

Geochemical Characterisation of Process Tailings samples – Implications for Tailings Management - Challenger Gold Project, Graeme Campbell and Associates, 2001

Soil and Waste Rock Characterisation Report – Challenger Gold Mine, MWH 2015

Appendix O

Challenger Gold Operations Groundwater Monitoring Plan

CGO WI: Groundwater Monitoring Program

1 Task Overview

1.1 Context

This Work Instruction (WI) forms part of the CGO Groundwater Monitoring Program and outlines the process for undertaking the quarterly and biannual Groundwater Monitoring Events (GMEs) at Challenger Gold Mine.

This program has been developed to ensure groundwater monitoring is undertaken in accordance with the approved PEPR and legislative requirements as follows:

- J National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM) 1999 (as amended 2013);
- J AS/NZS 5667.1:1998 Water quality—sampling—guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples;
- J AS/NZS 5667.11:1998 Water quality—sampling—guidance on sampling of groundwaters;
- J Safe Drinking Water Act 2011;
- J Safe Drinking Water Regulations 2012;
- J EPA Guidelines, Regulator monitoring and testing, *Groundwater Sampling*, dated June 2007;
- J EPA Guidelines— Regulatory monitoring and testing: Waters and wastewater sampling (2007);
- J Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000); and
- J Australian Drinking Water Guidelines 2011 (ADWG) - Updated November 2016.

This WI applies to and must be understood by all personnel involved in the GME’s at Challenger Gold Mine.

1.2 Roles & Responsibilities

General Manager	Compliance with regulatory requirements
WHSE Manager	Managing resources to achieve compliance
Environment Officer	Collection and assessment of data to demonstrate compliance

2 Background

Groundwater monitoring has been undertaken at Challenger Gold Mine (Challenger) since 2002, with groundwater wells of various purposes located across the mineral and miscellaneous purpose leases. Two Pastoral bores are also located on pastoral land.

Groundwater Monitoring Events (GME’s) involve collecting information regarding standing water levels (SWLs), field parameters, and collecting water samples for analysis at a National Association of Testing Authorities (NATA) accredited laboratory.

Process	Sub Process
Authorised by	Last Updated

GME's at Challenger are to be conducted biannually in January and July.

Section 5 provides detail regarding what wells require sampling during each event.

Historic groundwater monitoring methodologies across the monitoring and observation well network at Challenger have been variable and in some instances, did not align with industry standard best practices as outlined in the current EPA guidelines and Australian Standards listed above. These methodologies may have contributed to occasional, but discontinuous trace detections of WAD cyanide at COW 1, and potentially may have prohibited the collection of reliably accurate representative groundwater samples at other wells.

Groundwater monitoring at Challenger has been conducted using low flow methodology at all monitoring wells and COW 1 since July 2016, and all monitoring and observations wells since October 2016. Low flow methodology involves purging groundwater from a well at low flow rates, minimising drawdown of the static water within the well and instead drawing water directly through the well screen from the aquifer. Low flow purging minimises the need to remove large volumes of stagnant water from a well while allowing for the reliable collection of groundwater samples that are representative of formation groundwater. Low flow purging methodology is endorsed by SA EPA and is widely accepted as industry best practice.

This WI outlines the monitoring and sampling methodologies for ongoing GME's at Challenger to allow for the collection of the most accurate, representative groundwater samples.

3 Task Resources and Preparation

3.1 Supervision & Personnel Required

GME's are conducted by 2 field consultants from Environmental Projects. Field consultants are required to:

-) Organise all field tools and equipment (outlined in Section 3.3);
-) Organising site access, including (but not limited to) completing accommodation booking forms, remote travel permits and freight forms with Challenger administration (applicable forms are found in the administration drive on the Challenger server);
-) Drive to and from Challenger Gold Mine as per the CGO Remote Travel Procedure and CGO Remote Travel Permit;
-) Conduct the groundwater monitoring event as per this work instruction and instructions from project management;
-) Organising laboratory testing requests as per this work instruction;
-) Processing data

Field consultants who travel to Challenger are required to comply with all CGO site rules and procedures. Field consultants are also required to physically 'check in' with the Work, Health, Safety and Environment (WHSE) department every morning before commencing work and at night prior to heading back to camp.

Project management support is provided by the appropriate Environmental Projects personnel to assist the field consultants in:

-) Organising site access and accommodation;
-) Laboratory testing requests;
-) Processing data; and

-) Appropriate communication with site following the monitoring event.

3.2 Specific Training/Qualifications Required

Field consultants who travel to Challenger must:

-) Have completed all CGO inductions and met all site access requirements;
-) Be competent in groundwater low flow methodology;
-) Be competent in appropriate groundwater sampling methodology;
-) Be fit and capable of heavy lifting;
-) Be competent at driving a 4WD vehicle on sealed and unsealed roads;

3.3 Tools/Equipment & Resources Required

Tools/equipment required are outlined in Table 1 below. Details for the preferred suppliers listed in the 'Sourced From' column are as follows:

-) Envirolab Group (Envirolab):
 -) Contact: Alex Stenta
 -) Phone: 08 7087 6800 or 0406 350 706
 -) Email: adelaide@envirolab.com.au
 -) Address: 7a The Parade, Norwood SA 5067
-) Thermofisher Scientific (Thermofisher):
 -) Contact: Andrew Herreen or Volker Stroeher
 -) Phone:
 -) Adelaide: 08 8334 0011
 -) Scoresby: 03 9757 4377
 -) Email:
 -) andrew.herreen@thermofisher.com
 -) volker.stroeher@thermofisher.com
 -) sarah.stroeher@thermofisher.com
 -) debbie.ngo@thermofisher.com
 -) Address: 33 King Street, Norwood SA 5067
-) Cedrent:
 -) Phone: 08 8268 1025;
 -) Email: info@cedrent.com.au
 -) Address:
 -) Adelaide: 224/226 South Road, Mile End SA 5031;
-) Complete Ute and Van Hire:
 -) Phone: 08 8234 1300;
 -) Email: sales@completeuteandvanhire.com.au;
 -) Address: 125 Holbrooks Road, Underdale SA 5032
-) Electric Bug:
 -) Contact: Nick;

-) Phone: 08 8346 9234;
-) Email: nick@electricbug.com.au;
-) Address: 199-203 Torrens Road, Ridleyton SA 5008

Groundwater monitoring events are conducted by 2 field consultants from Environmental Projects.

Table 1: Tools and Equipment Required for Groundwater Monitoring Events

Tool/Equipment:	Purpose:	Sourced From:
Hire Car (preferably Toyota Hilux or Landcruiser dual cab drop side tray ute)	Travel to Challenger Gold Mine from Adelaide and carry all sampling equipment around site	Cedrent or Complete Ute and Van Hire
Satellite Phone	Required in the CGO Remote Travel Procedure, allow contact with office in Adelaide while working around site	Cedrent or Electric Bug
Groundwater Bottles	Collect groundwater samples	Envirolab Group <ul style="list-style-type: none">) Further details regarding the required bottles can be found in Section 5.4
Fieldwork Booklet	EHS plan, monitoring data records	Various items located on Environmental Projects server or WI Attachments. See Section 6.1.1 for more details.
200 m dipper/Interface Probe (IP)	Measure and monitor groundwater standing water level (SWL)	Hired from Thermofisher
Pump (T1200/Metal T1200)	Displace water from the well	
Pump controller (MP10H)	Controls the pressure at which compressed air can travel to the pump, to displace water out of the well	
Nitrogen Gas Cylinders (x6)	Provides the compressed gas for the pump controller	
Twin Tubing	Allows air from the controller to travel to the pump in the well through the small tube, allowing water to travel from the pump to the surface through the larger tube.	Labelled dedicated tubing for each requiring a submersible pump is stored in the Environment container at Challenger. If new tubing is required, purchase from Thermofisher. Tubing is purchased in 100 m rolls.
Water Quality Meter (WQM) (with flow cell)	Monitor groundwater parameters during purging	Hired from Thermofisher. Alternatively, there is a WQM

CGO WI: CGO WI: GROUNDWATER MONITORING PROGRAM

		located in the CGO Environment Office.
Steri cups (2 x boxes for quarterly events, 3 x boxes for biannual events)	Field filter groundwater for heavy metals and cyanide testing at applicable wells	Purchased from Thermofisher
Hand pump	Connect to the steri cup at each well to provide a vacuum, which allows the groundwater sample to filter through the cup	Brought from Environmental Projects office or hired from Thermofisher
Shifters (1 x large, 1 x small)	Connect air pipelines to nitrogen cylinders and replace fittings on pump (if required)	Environmental Projects
Leatherman Tools	Various tools	Environmental Projects
Tarpaulin (Tarp)	When placed on the ground at each well allows for a clean work area, so tubing and equipment does not become contaminated.	1 Tarp is located in the Environment container at Challenger.
2 x 20 L buckets with lids	<ul style="list-style-type: none">) 1 x bucket used for decontaminating the pump;) 1 x bucket used for rinsing the pump 	Brought to site with Environmental Projects. Spare buckets are located in the Environment container at Challenger.
2 x 10 L buckets with volume graduations	Purging water from the well	
Gloves	Used while handling sampling equipment and while sampling to ensure groundwater does not come in contact with hands	Purchased from Thermofisher. Some spare gloves are often located in the Environment office at Challenger.
Decon90 Solution	Mix with water to decontaminate sampling equipment	Decon90 is left on site, however can be purchased from Thermofisher
Deionised (DI) Water	Rinse sampling equipment and collect equipment rinse samples	Can be requested from the laboratory in addition to sampling bottles
Bailers	Manually purge groundwater wells	Located in the environment container at Challenger or can be purchased from Thermofisher.
Bailer cord	Connect to the top of the bailer to pull it back to the surface	Cord with reel hired from Thermofisher. Spare cord with reel stored in Environment office.



Large plastic container/tub	Store rubbish in ute tray	Brought to site with Environmental Projects
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3.4 PPE Required

3.4.1 Standard site PPE required:

 Day-Night high-vis clothing	 Hard hat	 Safety glasses
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3.4.2 Additional PPE required for this task

 HAND PROTECTION MUST BE WORN	 HEARING PROTECTION MUST BE WORN					
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3.5 Hazards and Control Measures

Hazards and control measures are outlined in the appropriate Environment, Health and Safety Plan (EHS plan) prepared prior to each event. The EHS plan should cover the following hazards, and outline the specific control measured:

-) Motor vehicle accidents leading to injury or death;
-) Work in a remote arid environment;
-) Injury due to manual labour;
-) Injury due to slips, trips and falls;
-) Injury due to exposure to extreme climatic conditions;
-) Lighting strike/electrocution;
-) Injury from exposure to chemicals;
-) Exposure to potentially contaminated groundwater;
-) Injury due to wildlife (bites/stings, attacks); and
-) Working with pressurised nitrogen gas.

4 Monitoring Locations

4.1 Location Descriptions

CGO GME's involve monitoring and sampling at the following types of wells. A sample location plan is provided in Attachment 1.

4.1.1 Challenger Mine Monitoring Wells (MW):

Monitoring wells require a submersible low flow pump for the collection of field parameters and laboratory samples. Where purging with the low flow pump is not possible, a bailer can be used to collect a sample.

All monitoring wells should be field filtered for metals, and field filtered and pre-treated in lead acetate solution for cyanide.

See Section 6.4 for purging and sampling methodology.

Applicable well construction details are included in Attachment 2.

) MW2:

-) Sampled biannually;
-) Located within the Challenger West pit, access is from the haul road or from the ring road heading to the production wellfield;
-) Sampled biannually
-) Hard hats are required in this area

) MW4:

-) Sampled biannually;
-) Located next to the compressors at the southern edge of the pit;
-) Access from the ring road heading out to the production wellfield, or from the haul road;
-) Hard hats are required in this area.

) MW5:

-) Sampled biannually;
-) Located on the northern side of the haul road;
-) Access from the haul road;
-) Hard hats are required in this area.

) MW6:

-) Sampled biannually;
-) Located near the landfill on the south-western side of the waste landform;
-) Access by the ring road.

) MW7:

-) Sampled biannually;
-) Located near the mine entrance. As you enter the mine, you can see the standpipe on the left side of the road;
-) Access by the mine access road.

) MW8b:

-) Sampled biannually;
-) Located between TSF 2 and the ROM Pad;
-) Access from the ring road, heading south around TSF2 (in the direction of the landfill). Instead of turning left onto the ring road, turn right to head between the landforms.

) MW9:

-) Sampled biannually;

-) Located on the eastern side of TSF2, approximately 100 m east of the ring road;
-) Access by the ring road.
-) MW10:
 -) Sampled biannually;
 -) Located directly to the south of TSF2, and is visible from the ring road on the left-hand side if you're travelling from the office;
 -) Access by the ring road.
-) MW11:
 -) Sampled biannually;
 -) Located to the south west of TSF2;
 -) Access by the ring road.

4.1.2 Challenger Observation Wells (COW):

Observation wells require a submersible low flow pump for the collection of field parameters and laboratory samples. Where purging with the low flow pump is not possible, a bailer can be used to collect a sample

See Section 6.4 for purging and sampling methodology.

-) COW1:
 -) Located inside the fence line at CPW1;
-) COW2:
 -) Located along the production well access road, approximately 50 m west of the mineral lease fence line on the southern side of the road;
-) Test Well:
 -) Located approximately 200 m south of CPW1 and approximately 200 m west of the production well access road, behind some earth mounds.
 -) Test well does not require collection of a sample for lab analysis, only the collection of standing water level (SWL) and field parameters using a bailer.

4.1.3 Challenger Production Wells (CPW):

Permanent generator pumps are installed at these wells. SWL measurements must be taken from the Challenger Production Observation Wells (Section 4.1.4). Flow readings must also be collected from the flow meter located at each wellhead.

Production wells are located along the production well access road, accessed from the ring road.

See Section 6.5 for sampling methodology.

The following wells are located at Challenger:

-) CPW1, CPW2, CPW3, CPW4:

4.1.4 Challenger Production Observation Wells: (CPOW)

Production Observation Wells are located in close proximity to each of the corresponding Production Wells and are used for measuring the SWL. The following wells are located at Challenger:

-) CPOW1, CPOW2, CPOW3, CPOW4_1, CPOW4_2:

4.1.5 Potable Water Wells:

Permanent generator pumps are installed at all potable water wells (except Gusher 4). Potable water wells are located on the northern side of the airport road and are accessed from the airport road. If you're travelling from the office along the airport road, take the third turn off on the northern side of the road.

Potable samples must be at the laboratory within 24 hours of sampling due to the short holding time of the bacteria samples. Potable samples are therefore best taken Tuesday or Wednesday mid-morning, before being freighted to Adelaide on the afternoon flight. See Section 6.9.1 for further details.

See Section 6.5 for sampling methodology.

Laboratory samples collected from these locations should not be field filtered.

- J Gusher 1:
 - J Once on the potable water well road, veer left
- J Gusher 2;
 - J Continue along past Gusher 1.
- J Gusher 3;
 - J Travel back towards the airport road from Gusher 1 and 2 and veer left. Continue along this road.
- J Gusher 4;
 - J Continue on a small access track visible at Gusher 3. Travel along this track for approximately 1 km, Gusher 4 should be located approximately 200 m south east of the track that you're travelling along;
 - J Gusher 4 only requires SWL measurements, no field parameters or laboratory samples are required.
- J RBDW3;
 - J RBDW3 is located at the underground mine ventilation fan (Vent Fan);
 - J When travelling back from Gusher 3, take the first track that appears on the left;
 - J SWL measurements are taken from RBDW2, which is the well located on the south western corner of the vent fan;
 - J The sampling point for RBDW3 is a tap located to the east of the vent fan near the scrub vegetation.

4.1.6 Potable Tap Samples

Potable tap samples are taken at the locations described in Table 2 for each corresponding sampling event:

Table 2: Potable Tap Sampling Locations

Location	January (quarterly)	April (biannual)	July (quarterly)	October (biannual)
Camp Main Kitchen	✓	✓	✓	✓
CGO Main Kitchen	✓			✓
CGO Processing & Maintenance Crib Room		✓		
CGO Processing & Maintenance Cooler	✓		✓	

ByrneCut Crib Room		✓		✓
ByrneCut Maintenance Workshop Cooler	✓		✓	
ByrneCut Iceroom Sink		✓		✓
Village Room			✓	

Potable samples must be at the laboratory within 24 hours of sampling due to the short holding time of the bacteria samples. Potable samples are therefore best taken Tuesday or Wednesday mid-morning, before being freighted to Adelaide on the afternoon flight. See Section 6.9.1 for further details.

See Section 6.6 for sampling methodology. Laboratory samples collected from these locations should not be field filtered.

4.1.7 Pastoral Bores:

Pastoral Bores are located to the north east and west of the mineral lease. Permanent windmills/generator pumps are installed at these wells.

Samples and field parameters should be collected directly from the pipe inlet leading into the concrete water tank at each location.

-) Dead Finish Bore:
 -) Travel from the offices to the site access road, and head east (back towards the highway). Turn north before travelling over the first cattle grid and follow the boundary road and fence line until you reach the next corner. Travel through the gate in the fence, then continue north along the track to the windmill and sheep yards.
-) Bluff Bore:
 -) Travel from the offices to the site access road and turn west (away from the highway). Follow the road over the first cattle grid. Continue along this road until the windmill and sheep yards appear on the southern side of the road.

5 Monitoring Requirements

5.1 Screening Criteria

5.1.1 PEPR Measurement Criteria

The approved PEPR specifies the following measurement criteria in relation to groundwater monitoring:

-) COW 1:
 -) SWL > 19.2 mBTOC (159.9 mAHD);
 -) TDS must not exceed 7,000 mg/L over two consecutive six monthly samples;
-) MW6, MW7, MW9, MW10, MW11:
 -) Any two of the following must not exceed these guidelines within the same sample:
 -) TDS <50,000 mg/L
 -) WAD Cyanide <0.08 mg/L
 -) pH > 6 and < 9; and
 -) Arsenic <0.5 mg/L
-) CPW:
 -) TDS <130,000 mg/L

-) Pastoral Bores:
 -) TDS <10,000 mg/L

5.1.2 Groundwater

Groundwater data should be compared to the following criteria:

-) Approved PEPR; and
-) ANZECC 2000 Stock Drinking Water

5.1.3 Potable Water

Potable water data should be tabulated and compared to the following criteria:

-) ADWG 2016 for health protection; and
-) ADWG 2016 for aesthetic protection

5.2 Quarterly GME (January and October):

All wells on site require monitoring and sampling during a quarterly monitoring event. Details regarding the methodology to collect SWL, field parameters, lab samples and flow readings can be found in Section 6.

Quarterly monitoring should be conducted as per Table 3 below.

Table 3: Quarterly GME

Location Type	Location/Sample IDs	Monitoring Requirements				Total No. of Primary Laboratory Samples Required
		SWL	Field Parameters	Lab Sample	Flow Readings	
MW	MW2, MW4, MW5, MW6, MW7, MW8b, MW9, MW10, MW11	✓	✓	✓		9
COW	COW1	✓	✓	✓		3
	COW2	✓	✓	✓		1
	Test Well	✓	✓			0
CPW	CPW1, CPW2, CPW3, CPW4		✓	✓	✓	4
CPOW	CPOW1, CPOW2, CPOW3, CPOW4_1, CPOW4_2	✓				0
Regional Bores	Dead Finish Bore, Bluff Bore		✓	✓		2

Potable Water Wells	Gusher 1, Gusher 2, Gusher 3, RBDW3	✓	✓	✓	✓	4
	Gusher 4	✓				0
Potable Tap Samples	See Section 4.1.6		✓	✓		4

5.3 Biannual GME (April and July):

Details regarding the methodology to collect SWL, field parameters, lab samples and flow readings can be found in Section 6.

Monitoring for a biannual GME should be conducted as per Table 4 below.

Table 4: Biannual GME

Location Type	Location/Sample IDs	Monitoring Requirements				Total No. of Primary Laboratory Samples Required
		SWL	Field Parameters	Lab Sample	Flow Readings	
MW	MW4, MW5, MW6, MW9, MW10, MW11	✓	✓	✓		6
COW	COW1	✓	✓	✓		3
Potable Water Wells	Gusher 1, Gusher 2, Gusher 3, RBDW3	✓	✓	✓	✓	4
	Gusher 4	✓				0
Potable Tap Samples	See Section 4.1.6		✓	✓		4

5.4 Analytical Testing

The analytical suites required for each location type is outlined in Table X below. The applicable testing required within each suite is outlined in Table X.

Table 5: Analytical Suites

Testing Suite	Location Type/Sample ID					
	MW	COW (COW 2)	COW (COW 1, COW 1.F, COW 1.L)	CPW	Potable	Pastoral
Metals 1	✓					
Metals 2					✓	
Metals 3				✓		
Metals 4		✓	✓			
Cobalt						✓
Nutrients + Bromide	✓	✓	✓	✓		
Nutrients					✓	
Inorganics	✓	✓	✓	✓	✓	✓
Ionic Balance + Fluoride	✓	✓	✓	✓	✓	
Cyanide (WAD)	✓	✓		✓	✓	
Cyanide (COW1)			✓			
Bacteria					✓	
Iodide					✓	

Table 6: Analytical Testing

Testing Suite	Testing Required
Metals 1	Sb, As, Bi, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Th, Sn, Ti, V, Zn
Metals 2	As, Ba, B, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Sr, U, Zn
Metals 3	As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Zn
Metals 4	As, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Mo, Zn
Cobalt	Co

Nutrients + Bromide	NO3, NO2, PO4, Bromide
Nutrients	NO2, NO3, TKN, PO4, Tot P
Inorganics	pH, EC, TDS
Ionic Balance + Fluoride	Ca, K, Mg, Na, Cl, SO4, Alkalinity, Fluoride
Cyanide (WAD)	WAD Cyanide
Cyanide (COW1)	WAD Cyanide, total cyanide, free cyanide, thiocyanate
Bacteria	E.coli + Total Plate Count
Iodide	Iodide

When requesting sample bottles from Envirolab:

-) Outline the wells which require sampling for that event;
-) Outline the testing required for each of the wells;
-) Request that Envirolab provide the correct number bottles with the appropriate preservative for the applicable testing;
-) Request that Envirolab place the sampling bottles into plastic bags labelled with each sample ID in eskies for easy identification while on site;
-) Request enough lead acetate pre-treatment bottles for all samples on site (see Section 5.4.1);
-) Request at least 3 additional metals bottles for equipment blank purposes;
-) Request two additional sets of bottles for COW 1 for duplicate purposes;
-) Request at least 4 extra sets of groundwater bottles and 4 extra sets of potable samples for duplicate and spare bottle purposes.

5.4.1 Duplicate Samples

Duplicate samples are required to be collected for quality purposes. A minimum of one Intralaboratory (tested at the same laboratory) duplicate and one Interlaboratory (tested at a different laboratory) duplicate per 10 primary samples are required to be collected for groundwater monitoring. Duplicates are collected by filling an additional set of sampling bottles at a specific location.

At Challenger, two duplicate samples are collected at COW 1 (DUP 1 and DUP 2, see Section 6.4.3.2 for more information). The following duplicates should also be collected:

-) Intralaboratory duplicate:
 -) 1 x groundwater well; and
 -) 1 x potable well/tap
-) Interlaboratory duplicate:
 -) 1 x groundwater well; and
 -) 1 x potable well/tap

Duplicate samples should be:

- J Blind coded (i.e labelled DUP 3, DUP 4 etc) so the laboratory can't determine what primary sample the duplicate belongs to;
- J Clearly marked on the purge sheet of the primary well so the project manager can determine what duplicate related to what primary sample; and
- J Recorded on all COC documentation.

5.4.2 Lead-Acetate Pre-Treatment

All samples need to be treated in a lead-acetate solution prior to decanting into the preserved cyanide bottles to assist in removing sulphur from the groundwater, which can cause false positive detections of cyanide when testing at the laboratory.

The most time efficient way to complete this pre-treatment at each well is to ensure you begin the field filtering and lead-acetate pre-treatment prior to filling any other sampling bottles.

The lead acetate pre-treatment methodology is as follows:

- J Field filter the sample using a sterilised steri-cup and hand pump;
- J Pour the field filtered sample into a lead-acetate bottle;
- J Place the lid on the bottle and allow the sample to sit for a minimum of 10 minutes and a maximum of 15 minutes;
 - J A precipitate may form in the bottle during this time, which is not a concern;
- J Decant the sample (without the precipitate) into the appropriately labelled cyanide sample bottle.

Lead-acetate bottles should be requested from the laboratory along with the appropriate bottles for the sampling event. Ensure to request enough lead-acetate bottles for every sample taken on site (including duplicate samples).

The lead-acetate pre-treatment process is the same for all wells with the exception of COW 1, see Section 6.4.3.2 for the COW 1 sampling methodology.

6 Monitoring and Sampling Methodology

6.1 Event Preparation and Logistics

Detailed and careful planning is required to deliver a successful monitoring event in an efficient manner with appropriate quality outcomes. The planning and logistical tasks should commence at least 2 weeks prior to the planned sampling event and ideally completed at least one week prior.

The following tasks should be completed by the field consultant or delegate:

- J Communicate with EP project management CGO WHSE management regarding an appropriate time for the monitoring event:
 - J Monitoring events should be organised for travel to site on a Monday, work on site Tuesday/Wednesday and return from site Thursday/Friday. Quarterly events typically take a little longer than biannual events;
 - J Once an appropriate week has been identified, contact CGO administration to determine if there will be accommodation space on site during that time.
- J Organise site access, including (but not limited to) completing accommodation booking forms, remote travel permits (for travel to and from site) and freight forms with Challenger administration;

-) applicable forms are found in the administration drive on the Challenger server;
-) Organise all field tools, equipment and sampling bottles:
 -) field tools and equipment required are detailed in in Section 3.3;
 -) Information regarding sampling bottles are provided in Section 5.4;
 -) Ensure to request the additional lead-acetate pre-treatment bottles as outlined in Section 5.4.1;
 -) keep in mind what equipment is stored at Challenger and what needs to be brought to site;
-) Organise for equipment to be freighted to site (if applicable);
-) Prepare fieldwork booklet (see Section 6.1.1);
-) Collect hire car and all field equipment. Secure all equipment in the ute for travel to site;
-) Check on site weather conditions (easiest way is to check the weather forecast for Tarcoola, SA). If it appears it may be raining leading up to the sampling event, liaise with Challenger WHSE and Administration to determine if the site is accessible via the access road.

6.1.1 Fieldwork Booklet

The fieldwork booklet should be a bound document containing the following:

-) Approved Environment, Health and Safety (EHS) plan;
-) A copy of this WI, including all attachments;
-) CGO purge sheets;
 -) A blank MW and COW purge sheet is provided in Attachment 3 of this document;
 -) At least 12 of these sheets are required for a quarterly event and at least 7 for a biannual event;
 -) A blank Production Well, Regional Well, Potable Well and Potable Tap purge sheet is provided in Attachment 4 of this document;
 -) At least 15 of these sheets are required for a quarterly event and at least 9 for a biannual event;
-) A copy of the CGO Remote Travel Procedure (found on the CGO public drive);
-) A copy of the completed CGO Remote Travel Permit's (found on the CGO public drive) (once approved by CGO admin);
-) A sample location plan (also included as Attachment 1 of this document);
-) The previous event's purge sheets (found on EP and CGO server);
-) A copy of the current Challenger flight schedule (found on the CGO public drive);
-) Chain of Custody (COC) documentation
 -) A blank COC document is provided in Attachment 5 of this document; and
-) Any other notes regarding specific instructions for the sampling event.

6.2 Mobilisation to Site

Challenger Gold Mine is located approximately 850 km north west of Adelaide, and is accessible by the Commonwealth Hill access road, located approximately 150 km north of Glendambo. Charter planes also fly to Challenger on Tuesdays to Fridays, however as a vehicle is required to conduct the GME it is recommended the field consultants drive to site.

-) Drive to site as per the approved EHS plan and Remote Travel Procedure requirements;

-)] If there is a possibility the access road may be closed, ring Challenger Administration prior to leaving Adelaide, and if necessary check in with them for an update on road conditions while in Port Augusta;
-)] Allow approximately 10 hours for travel to site;
-)] Once arrived on site, place the ice bricks in the eskies in the freezer for use in the coming days.

6.3 Preparing for Sampling

-)] Collect all equipment from the environment container (located at the geology camp, which is past the CGO main camp);
 -)] Equipment stored in the container includes dedicated tubing, buckets, spare tubing and bailers;
-)] Collect water in a bucket with lids for decontaminating the pump and other applicable sampling equipment. In the absence of large volumes of deionised water, collect potable water in another bucket with a lid to rinse the equipment;
-)] Collect at least 5 L of potable drinking water per person for the day in the drinking water containers in the environment office;
-)] Ensure to speak to the WHSE manager or site nurse to inform them of your planned actions across site for the day;
 -)] If you're sampling plans suddenly change significantly throughout the day, head back to camp to inform the managers or call them over the radio;
-)] Plan when to collect the potable well and potable tap samples;
 -)] Potable samples must be at the laboratory within 24 hours of sampling due to the short holding time of the bacteria samples;
 -)] Potable samples are best taken Tuesday or Wednesday mid-morning, before being freighted to Adelaide on the afternoon flight. See Section 6.9.1 for further details;
-)] Locate your first well using the sampling plans and maps.

6.3.1 Decontaminating Equipment

-)] Put on disposable nitrile gloves;
-)] Ensure the pump, dipper and the pump hanging cable have been decontaminated by submersing and cleaning in a mix of 90% potable water and 10% Decon-90 solution;
 -)] Take care to ensure no water gets into the air tube inlet at the top of the pump;
 -)] Ensure the inside of the pump has been cleaned by trapping decon water inside from the bottom of the pump (by blocking the pump water inlet with your hand), tipping the pump upside down and moving the water through the pump and out the water inlet at the top;
-)] Rinse equipment in the same manner in potable water.

6.3.2 Collecting an Equipment Rinse Sample

Equipment rinse samples (or rinsate samples) are collected to demonstrate that decontamination procedures have been effective in decreasing the risk of cross contamination between wells.

At least one rinsate sample must be collected each day the pump is used on site.

To collect a rinsate sample:

-)] Decontaminate the pump as per Section 6.3.1;
-)] Label a spare metals bottle with the project ID, date, and record the sample ID as FB;

- J Turn the pump upside down;
- J Use DI water to rinse through the water inlet at the bottom of the pump. Once water is poured through, it should exit the pump at the water tube outlet at the top;
- J Once the inside of the pump has been rinsed with DI water, continue holding the pump upside down. Place the labelled bottle beneath the pump water tube outlet, and pour DI water through the pump as previous, collecting the water in the sample bottle;
- J Place the sample bottle back in the esky;
- J Ensure to record all sample details on the appropriate COC documentation.

6.4 Groundwater Monitoring and Sampling (MW, COW)

Groundwater monitoring and sampling at MW and COW wells (except Test Well) is undertaken using low flow methodology with a submersible pump.

Groundwater monitoring and sampling must be undertaken by experienced personnel who are adequately trained in pump assembly, trouble shooting, and appropriate monitoring methodology. A basic methodology for low flow purging, monitoring and sampling is outlined below.

Before monitoring and sampling a specific well, review the previous purge sheets to familiarise yourself with the previous:

- J SWL measurements;
- J Purge methodology;
- J Controller settings; and
- J Final field parameters

6.4.1 Measure SWL

- J Put on a pair of disposable nitrile gloves;
- J Decontaminate the dipper as per Section 6.3.1;
- J Turn on the dipper by pressing the black button on the side. The dipper should 'chirp' when it's on and the light besides the on/off button should flash;
- J Carefully place the probe inside the well casing and lower into the well using the handle on the reel;
 - J Try to avoid sliding the tape over the edge of the casing as it could damage the tape;
- J When the probe is approximately 1 m above the last recorded SWL, slow the probe and continue lowering the probe slowly;
- J The probe will continuously 'chirp' when it hits the water, and the light next to the on/off switch will flash on and off;
- J Wind the tape back above the SWL (the chirping will stop when the probe is out of the water), then very slowly lower the tape back towards the water until the chirping begins again;
- J If the chirping doesn't stop when lifting the probe:
 - J Ensure the probe is actually clear of the water column; and
 - J Adjust the sensitivity of the probe using the small dial next to the on/off button
- J Repeat until lowering the probe by 1 mm initiates the chirping.
- J Record the measurement on the tape to 3 decimal places at the reference point on the stand pipe;
- J Wind the tape back up the well, again trying to avoid dragging the tape over the edge of the casing;
- J The probe will turn itself off automatically.

6.4.2 Purging and Monitoring

6.4.2.1 Low Flow Pump

For more detail regarding low flow purging and sampling methods, refer to EPA Guidelines, Regulator monitoring and testing, *Groundwater Sampling*, dated June 2007.

-) Decontaminate the appropriate equipment as per Section 6.3.1;
-) Assemble the pump, hanging cable, appropriate tubing and pump controller in an appropriate manner next to the well on the clean tarp;
 -) Ensure the pump and tubing do not come into contact with soil;
-) Double check the pump and tubing has been assembled correctly;
 -) Ensure the water and air tubes have been inserted into the pump correctly;
-) If using dedicated tubing, connect the air tube to the controller;
 -) This ensures the tubing is connected to something at the surface before it's placed in the well;
-) Place the pump in the well and lower slightly, before placing the dipper/IP on top of the pump;
 -) Having the dipper/IP at the top of the pump allows you to keep track of how deep the pump is in the well;
-) Lower the pump to approximately 10 m below the top of the well screen (see well construction details in Attachment 2);
 -) Take care to minimise disturbance to the water column;
 -) Dedicated tubing should already be cut to an appropriate length;
-) Secure the hanging cable at the top of the well casing using the steel plate and clamp;
-) If using new tubing, leave at least an extra 3-4 m of tubing exposed at the top of the well before cutting from the tubing roll and connecting the air tube to the controller;
-) Place the gas cylinder a safe distance from the work area, then connect the gas cylinder to the controller with the appropriate hoses;
-) Set up the water quality meter and flow cell in a bucket near the well on the tarp, and place the water tube into the bottom of the flow cell;
-) Once all equipment has been set up, turn on the gas cylinder;
 -) If there are any leaks in the air connections at the surface, you should be able to hear a 'hissing' sound;
 -) Check the controller is holding pressure;
-) Change the pressure on the controller to the pressure value on the previous purge sheet;
 -) Alter the controller pressure using the dial;
-) Press 'CYCLE' on the controller to start the pump;
 -) Record the start time on the purge sheet;
 -) Change the cycles per minute and recharge/discharge times based on the previous purge sheet to minimise drawdown;
-) Measure the SWL continuously until an equilibrium between the flow rate and draw down level has been established;
 -) Flow rates are typically 0.1-0.5 L/min with a drawdown generally less than 0.1 m;
-) When groundwater has reached the top of the water tubing and filled the flow cell, record the current time, SWL, and the field parameters;

-) Once the flow rate is established and stabilised (which is determined with a stable SWL), monitor the field parameters to determine when purging is complete;
-) Indicator parameters are considered stable when three consecutive readings, along with three consecutive stable SWL measurements, fall within the ranges in Table 7;

Table 7: Parameter Stabilisation Ranges

Parameter	EC	pH	Temp (°C)	DO	Redox (mV)
Acceptable range	5%	±0.1	0.2	10%	±10

-) Dissolved oxygen (DO) and electrical conductivity (EC) are the most reliable parameters used to determine when stabilisation has occurred;
-) The three consecutive readings should be at least three minutes apart, or the time taken to evacuate the equivalent of one volume of the flow through cell (the pump bladder and tubing volume), whichever is greater.
-) Once parameters have stabilised, record the final controller settings on the purge sheet.

6.4.2.2 Bailing

Bailing involves manually removing water from a well using a disposable plastic bailer. Water is removed by lowering the bailer into the water column, then pulling the bailer back out of the well full of water.

Bailing is considered the ‘back up’ sampling method to low flow purging at Challenger and should only be used if there are issues with the pump or the well. If bailing is required, the field consultant should record the appropriate details on the purge sheet for the well.

To recover a sample with a bailer, the following method should be used;

-) Decontaminate the appropriate equipment as in Section 6.3.1;
 -) A plastic bailer does not require decontamination if it’s travelled in the individual plastic seal;
-) Calculate the approximate bore volume of the well using the calculations found on the purge sheet; Due to the reasonably shallow SWL and depth of the wells at Challenger it is impractical to completely purge the wells appropriately using the bailing method. The field consultant should plan to remove as much water from the well as they can while monitoring the field parameters, and record details on the purge sheet regarding why they chose to stop purging at the volume they reach.
-) Prepare a bucket at the base of the well in preparation for collection of the purged water;
-) Place the flow cell and water quality meter probes in the bucket;
-) Remove the bailer from the plastic seal from the top end;
 -) The top of the bailer has the plastic hook to attach the bailer cord;
 -) Make sure to retain the small green bailer tip which is included in the plastic seal, this is used during the sampling process to attach to the end of the bailer to remove water into the sampling bottles;
-) Attach the bailer cord;
-) Lower the bailer into the well until it hits the water;
-) Allow the bailer to sink slightly, then quickly pull it back out of the well to keep as much water in the bailer as possible;

-) Once the bailer is at the surface, pour the water into the flow cell placed in the bucket. Record the initial field parameters;
-) Continue this process, recording field parameters at regular intervals;
-) Once sufficient volume has been bailed, the well can be sampled as per Section 6.4.3.

6.4.3 Sampling

6.4.3.1 MW and COW 2

-) Remove the labelled plastic bag from the esky and label all the applicable bottles;
 -) All bottles should be labelled with the job number, date and Well ID as a minimum;
 -) Duplicate samples should be labelled with the job number, date, and the appropriate duplicate number (i.e DUP 3, DUP 4);
 -) Labelling of bottles should be completed prior to collecting the final field parameters, to ensure sampling can begin promptly when the well has stabilised;
-) Put on nitrile gloves;
-) Collect a sample into the appropriate bottles;
 -) Field filter the cyanide and metals samples using a sterile steri cup and hand pump;
 -) Follow the lead acetate pre-treatment methodology outlined in Section 5.4.1 for the cyanide sample;
-) Place the filled sample bottles back into the labelled plastic bag, then place the plastic bag back into the esky;
 -) Placing the bottles back in the plastic bag helps ensure all samples for that well stay together during storage and transit;
-) Ensure applicable sample details are recorded on the appropriate COC documentation;
-) Turn the gas cylinder off first and allow the pump to run through a couple of cycles to remove any air from the lines, before turning the pump off by pressing 'CYCLE' on the controller;

6.4.3.2 COW 1

Due to historic trace detections of WAD cyanide in samples at COW 1, the analytical testing and therefore the field sampling methodology is slightly different to other MW wells and COW 2.

Since July 2017, a primary sample and two duplicate samples (DUP1 and DUP 2) along with two additional cyanide samples per sample group have been collected at COW 1.

The sampling methodology for COW 1 is as follows:

-) Complete the SWL measurements and purging and monitoring requirements outlined in Sections 6.4.1 and 6.4.2;
-) Remove the labelled plastic bags from the esky and label each set of bottles as per the following in Table 8;

Table 8: COW 1 Bottles and Labels

Bottle (Envirolab)	Analysis	Primary Sample	Duplicate 1	Duplicate 2
Green 500 ml bottle	Inorganics	COW 1	DUP 1	DUP 2
Green 250 ml bottle	Nutrients	COW 1	DUP 1	DUP 2

Red 250 ml bottle	Metals	COW 1	DUP 1	DUP 2
Pink 250 ml bottle	Nutrients	COW 1	DUP 1	DUP 2
Blue 250 ml bottle	Cyanide	COW 1	DUP 1	DUP 2
Blue 250 ml bottle	Cyanide	COW 1.F	DUP 1.F	DUP 2.F
Blue 250 ml bottle	Cyanide	COW 1.L	DUP 1.L	DUP 2.L

-) All bottles listed with sample ID’s in black text should be filled directly from the tubing into the sample bottle with no field filtering or pre-treatment;
-) All bottles listed with sample ID’s in red text should be field filtered before the sample is poured into the sample bottle, with no further pre-treatment;
-) All bottles listed with sample ID’s in blue text should follow the lead-acetate pre-treatment method outlined in Section 5.4.1.
-) The cyanide bottles collected should therefore reflect the sampling methodologies in Table 9:

Table 9: COW 1 Cyanide Sampling Methodologies

Blue Cyanide Bottle Sample ID’s	Field Sampling Methodology
COW 1, DUP 1, DUP 2	No field filtering or pre-treatment prior to decanting into sampling bottle
COW 1.F, DUP 1.F, DUP 2.F	Field filtering but no lead-acetate pre-treatment prior to decanting into sampling bottle
COW 1.L, DUP 1.L, DUP 2.L	Field filtering and lead acetate pre-treatment prior to decanting into sampling bottle

-) Place the filled sample bottles back into the labelled plastic bag, then place the plastic bag back into the esky;
-) Ensure applicable sample details are recorded on the appropriate COC documentation;
-) Turn the gas cylinder off first and allow the pump to run through a couple of cycles to remove any air from the lines, before turning the pump off by pressing ‘CYCLE’ on the controller.

6.5 Production Well and Potable Well Monitoring and Sampling

All production and potable water wells at Challenger contain a permanent submersible pump attached to a generator at the surface, to ensure the CGO Production department can continuously remove water from the aquifers. The water is then pumped to the appropriate location on site (production wells to the processing plant and potable wells to the Reverse Osmosis (RO) plant).

Each of these wells has a tap at the well head for the collection of field parameters and water samples.

Production and potable wells can only be sampled if the pump is actually removing water from the well at the time of sampling. This is usually obvious if the generator is turned on or off. If the field consultant is unsure if the generator is operational, the flow meter at the well head will show if water is flowing through the pipelines. If there is no flow, the well cannot be sampled. If this is the case, record on the purge sheet and collect the SWL.

Before monitoring and sampling a specific well, review the previous purge sheets to familiarise yourself with the previous:

-) SWL measurements;

-) Field parameters;
-) Flow rate; and
-) Flow meter reading.

To complete monitoring and sampling at production and potable wells:

-) Ensure the well is being sampled at an appropriate time;
 -) Potable well samples **must** be at the laboratory within 24 hours of sampling due to holding time issues with the bacterial samples;
-) Measure SWL as per Section 6.4.1;
 -) SWL at production wells should be measured from CPOW wells located in close proximity to each well head;
 -) SWL at potable wells should be measured directly from the well through the PVC dip tube (except at RBDW3, where the SWL is recorded from RBDW2);
-) Prepare the sampling bottles;
 -) Remove the labelled plastic bag from the esky and label all the applicable bottles;
 -) All bottles should be labelled with the job number, date and Well ID;
 -) Duplicate samples should be labelled with the job number, date, and the appropriate duplicate number (i.e DUP 3, DUP 4);
-) Put on nitrile gloves;
-) Turn on the tap at the well and allow to run for 20 seconds, or until the water begins to run clear;
-) Collect the applicable samples from the tap;
 -) At production wells;
 -) Field filter the metals and cyanide samples using a sterile steri cup and hand pump;
 -) Follow the lead acetate pre-treatment methodology outlined in Section 5.4.1 for the cyanide sample;
 -) At potable wells;
 -) Metals and cyanide samples must **not be field filtered**;
 -) Follow the lead acetate pre-treatment methodology outlined in Section 5.4.1 for the cyanide sample;
-) Fill the bucket and flow cell with water from the tap and record field parameters;
-) Turn the tap off;
-) Record the flow rate;
 -) The flow rate of the pump is demonstrated with the three small dials which all spin at different speeds;
 -) The easiest dial to follow is the one labelled x 0.01. Every time the hand moves past a number on the dial, this represents 10 L purged from the well;
 -) To measure the flow rate:
 -) Wait until the x 0.01 dial reaches '0' at the top, when it does begin timing 60 seconds;
 -) Count how many numbers the hand moves past during the 60 seconds;
 -) Use the calculation $XL/60$ seconds (shown on the purge sheet) to calculate the flow rate per minute.
-) Record the total flow reading

-) Place the filled sample bottles back into the labelled plastic bag, then place the plastic bag back into the esky;
-) Ensure applicable sample details are recorded on the appropriate COC documentation.

6.6 Potable Tap Monitoring and Sampling

Potable tap samples are collected directly from a tap located at the sampling points in Table XX, Section 4.1.6.

To complete monitoring and sampling at potable taps:

-) Ensure the tap is being sampled at an appropriate time;
 -) Potable tap samples **must** be at the laboratory within 24 hours of sampling due to holding time issues with the bacterial samples;
-) Prepare the sampling bottles;
 -) Remove the labelled plastic bag from the esky and label all the applicable bottles;
 -) All bottles should be labelled with the job number, date and Tap ID;
 -) Duplicate samples should be labelled with the job number, date, and the appropriate duplicate number (i.e DUP 3, DUP 4);
-) Put on nitrile gloves;
-) Turn on the tap at the well and allow to run for 5 seconds;
-) Collect the applicable samples from the tap;
 -) Metals and cyanide samples must **not be field filtered**;
 -) Follow the lead acetate pre-treatment methodology outlined in Section 5.4.1 for the cyanide sample;
-) Fill the bucket and flow cell with water from the tap and record field parameters;
-) Turn the tap off;
-) Place the filled sample bottles back into the labelled plastic bag, then place the plastic bag back into the esky;
-) Ensure applicable sample details are recorded on the appropriate COC documentation.

6.7 Regional Bores

Permanent windmills/generator pumps are installed at these wells. The bores can only be sampled if the windmills or generators are operational at the time of the site visit.

Samples and field parameters should be collected directly from the pipe inlet leading into the concrete water tank at each location. If there is no water coming from the pipe outlet, the bore cannot be sampled.

To complete monitoring and sampling at these locations:

-) Prepare the sampling bottles;
 -) Remove the labelled plastic bag from the esky and label all the applicable bottles;
 -) All bottles should be labelled with the job number, date and Location ID;
-) Put on nitrile gloves;
-) Collect the applicable samples from the tap;
 -) Field filter the metals sample using a sterile steri cup and hand pump;

- J Fill the bucket and flow cell with water from the tap and record field parameters;
- J Place the filled sample bottles back into the labelled plastic bag, then place the plastic bag back into the esky;
- J Ensure applicable sample details are recorded on the appropriate COC documentation.

6.8 Storing Samples

At the end of each day, all samples taken need to be removed from the eskies and placed in the sample fridge in the CGO kitchen.

Nutrient samples (small 250 ml green bottle) need to be placed in the freezer for preservation purposes.

All ice bricks used throughout the day should also be placed in the freezer for use the next day or for use in sample transportation.

6.9 Freight Samples from Site

6.9.1 Potable Samples

As described in Sections 4.1.5 and 4.1.6 all potable samples must be at the laboratory within 24 hours of sampling due to short laboratory holding times for bacteria samples, therefore potable samples **MUST** be freighted to Adelaide on the **same day** they're collected on site.

Prior to collecting the potable samples:

- J Check with admin if it will be possible to get the samples on the flight for that day;
- J Complete applicable freight forms and submit with administration on site; and
- J Inform Envirolab (see Section 3.3 or below for contact details) that **potable samples** will be arriving in Adelaide on the afternoon flight.

After collecting the potable samples:

- J Complete all COC documentation;
- J Package all samples into eskies with ice bricks;
- J Take a copy of the COC documentation, and place the original in the esky with the samples;
- J Package up the eskies for freight using the packing tape in the environment office;
- J Label each of the eskies with the following details:

Environmental Samples

Sent by: Environmental Projects

Pick up at Airport by: Envirolab – Alex Stenta

Contact: 08 7087 6800 or 0406 350 706

Esky number X of X

- J Take samples to airstrip prior to the flight check in time
 - J The flight check in time can sometimes vary on site, so check with admin what time to have the freight at the airstrip.

6.9.2 Remaining Samples

All other samples can be freighted to Adelaide on any day, however it is preferable that they're sent to Adelaide no later than the Thursday afternoon flight so the samples don't sit in Adelaide over the weekend when the laboratories are closed.

To freight samples to Adelaide:

- J Check with admin if it will be possible to get the samples on the flight for that day;
- J Complete applicable freight forms and submit with administration on site; and
- J Inform Envirolab (see Section 3.3 or below for contact details) that groundwater samples will be arriving in Adelaide on the afternoon flight.
- J Complete all COC documentation;
- J Package all samples into eskies with ice bricks;
- J Take a copy of the COC documentation, and place the original in the esky with the samples;
- J Package up the eskies for freight using the packing tape in the environment office;
- J Label each of the eskies with the following details:

Environmental Samples

Sent by: Environmental Projects

Pick up at Airport by: Envirolab – Alex Stenta

Contact: 08 7087 6800 or 0406 350 706

Esky number X of X

- J Take samples to airstrip prior to the flight check in time
 - J The flight check in time can sometimes vary on site, so check with admin what time to have the freight at the airstrip.

6.10 Demobilising from Site

Confirm with the project manager that all work has been completed as per this WI prior to beginning demobilisation from site.

To demobilise from site:

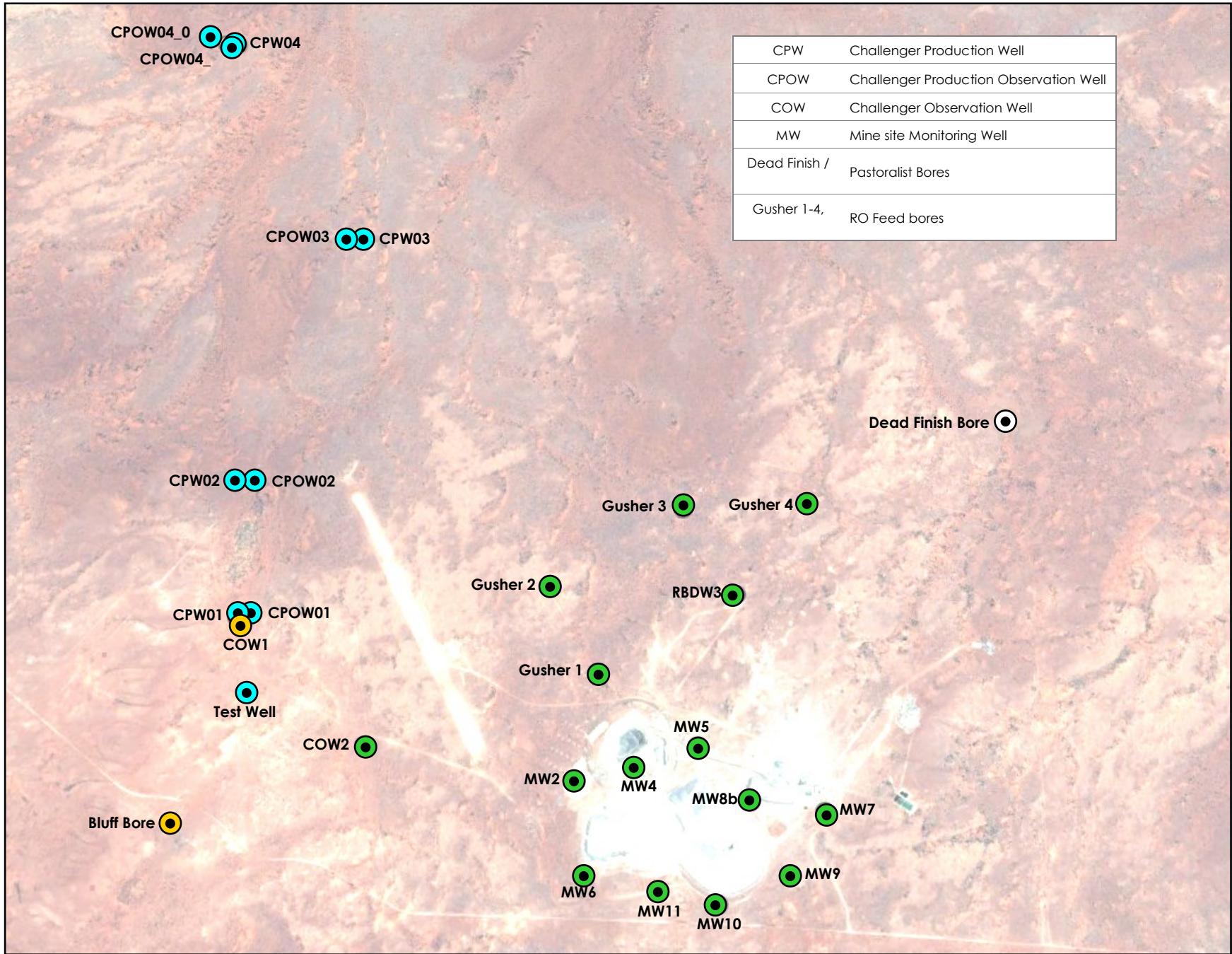
- J Ensure all remote travel permits are still valid, or submit a new remote travel permit;
- J Confirm with CGO administration that the access road is open;
- J Remove all rubbish from the hire vehicle;
- J Remove all rubbish from the environment office;
 - J Large rubbish items should be disposed at the landfill, all other minor rubbish can either be disposed at the bins around the mining offices or in the landfill;
- J Return all applicable equipment to the environment container or the environment office;
 - J Note if any equipment items are missing on site/running low on supply;
- J Return room keys to the camp office;
- J Begin journey management with admin and inform the project manager that you're leaving site;
- J Follow all EHS plan and remove travel procedure requirements.

7 Post Fieldwork

The following work needs to be completed post fieldwork by the project manager or delegate:

- J Electronically file all field notes and purge sheets appropriately on the Challenger Environment and EP servers;
- J Complete the laboratory analysis requests for all samples (see Section 5.4 for details);
- J Update all challenger groundwater monitoring spreadsheets with field data from the GME.
 - J Monitoring spreadsheets can be found at CGO/Environment/Monitoring/Groundwater;
- J Tabulate and review potable sampling results against applicable screening criteria within 24 hours of receiving the data from the laboratory;
 - J Potable water results should be summarised in the Potable Water Notification form found at CGO/Environment/Templates;
 - J Attach potable water results table in a PDF and send to WHSE, highlighting any exceedances of health screening criteria;
- J Tabulate and review groundwater sampling results against the PEPR and applicable screening criteria within 24 hours of receiving the data from the laboratory;
 - J Inform WHSE of groundwater results and any exceedances of PEPR and applicable screening criteria;
- J Add new GME data to existing monitoring data tables and file appropriately on CGO and EP servers;
- J File electronic chemical tables and laboratory reports in appropriate locations on CGO and EP servers;
 - J On CGO server, electronic files should be saved CGO/Environment/Monitoring/Groundwater;

Attachment 1

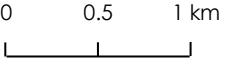


CPW	Challenger Production Well
CPOW	Challenger Production Observation Well
COW	Challenger Observation Well
MW	Mine site Monitoring Well
Dead Finish /	Pastoralist Bores
Gusher 1-4,	RO Feed bores

LEGEND

- Paleochannel aquifer wells (150–250 m below surface)
- Shallow fractured rock aquifer (38–105 m below surface)
- Shallow sandy aquifer (34 m below surface)
- Shallow perched water table

SCALE



Attachment 2

	Well	SWL August 16	Top of Screen	Bottom of Screen	Base Depth	Height of water	Well diameter	Well radius	Approximate well volume	Bore volume x 3
Observation Wells	COW1	18.775	17	34	34	15.225	0.05	0.025	29.8790625	89.6371875
	COW2	23.445	23	33	33	9.555	0.05	0.025	18.7516875	56.2550625
	Test Well	44.092	180	205	205	160.908				
Monitoring Wells	MW02	65.509	34	105	105	39.491	0.1	0.05	310.00435	930.01305
	MW04	45.074	55	150	150	104.926	0.1	0.05	823.6691	2471.0073
	MW05	27.382	44	95	95	67.618	0.05	0.025	132.700325	398.100975
	MW06	23.102	20	100	100	76.898	0.05	0.025	150.912325	452.736975
	MW07	26.114			101	74.886	0.05	0.025	146.963775	440.891325
	MW08B	17.921			101	83.079	0.05	0.025	163.042538	489.127613
	MW09	23.583	48	78	78	54.417	0.1	0.05	427.17345	1281.52035
	MW10	14.758	66	78	78	63.242	0.1	0.05	496.4497	1489.3491
MW11	15.46	43	55	55	39.54	0.1	0.05	310.389	931.167	

Attachment 3

Attachment 4



Generator/Tap Sampling Field Record

Site Details						
Site Name:			Well ID:			
Job Number:			Purge Date:			
Client:			Sample Date:			
Well Details			Flow Rate Calculation:			
Depth to groundwater (mBTOC):			Flow Rate = X L / 60 seconds Flow Dials: 0.1 = 100 L; 0.01 = 10 L; 0.001 = 1 L			
Sampling equipment						
Generator operational: Y / N						
Water quality meter:						
Calibration date:						
Sampling method:						
Water Quality						
Time (2400hr)	pH pH units	EC (mS/cm)	Redox (mV)	TDS (ppk)	DO (ppm)	Temp (°C)
Sample Details						
Sample ID			Sampled by:			
Duplicate Sample ID			Date sent to lab:			
Sampling Bottles						
Bottle description		No. filled	Bottle description		No. filled	
Notes						

Attachment 5