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6 September 2021		**Reference:**	**2021-00048 V3**

PROJECT NAME: TRANSALLOYS FE-CR TSF GEOCHEMICAL WASTE ASSESSMENT

1 INTRODUCTION

Artesium Consulting Services (Pty) Ltd (ACS) was appointed by Redco Services (Pty) Ltd to perform an updated geochemical analysis and waste assessment at the Transalloys FeCr tailings facility. The site is located approximately 14km west of eMalahleni (formerly known as Witbank) in the Mpumalanga province.

1.1 Objectives

The objectives of the study were:

1. Geochemical analysis of the tailings material.
2. Waste evaluation and risk assessment on groundwater with reference to GNR 635/GNR636.
3. Evaluation of the hydrochemical monitoring data of the site.

1.2 Scope of Work

The scope of work for the groundwater specialist study included the following:

1. Geochemical lab analysis and leach tests.
2. Waste assessment in terms of Government Notice Regulation (GNR) 635 and GNR 636.
3. Hydrochemical data analysis and incorporation thereof in the waste assessment on a risk based approach.
4. Memo report outlining the findings from the waste assessment.

2 GEOCHEMICAL WASTE ASESSMENT

A geochemical waste assessment was completed in accordance with GNR 635 and GNR 636 to investigate the mass potential from the Fe-Cr tailings facility. The facility will undergo the closure process at the Transalloys Site.

2.1 Regulatory Guidelines

The National Environmental Management: Waste Amendment Act (NEMWAA) was published on 2 June 2014. This Act included residue deposits and residue stockpiles as waste. New regulations for the planning and management of residue stockpiles and residue deposits were promulgated on 15 July 2015 (GNR 632) in terms of the NEMWAA. As residue deposits and stockpiles are considered waste in terms of the NEMWAA, the following regulations are applicable and were applied as part of this assessment:

- Regulation 635- National norms and standards for assessment of waste prior to the disposal to a landfill site (published under Government Notice Regulation (GNR) 635 in Government Gazette 36784, promulgated on 23 August 2013). These norms and standards recommend the requirements for the assessment of waste prior to the disposal to a landfill site in terms of Regulation 8(1)(a) of the Regulations.
- Regulation 636- National norms and standards for the disposal of waste to a landfill site (published under GNR 636 in Government Gazette 36784, promulgated on 23 August 2013), was used as a secondary reference.

2.2 Standards Assessment Methodology (GNR 635)

(1) "To assess waste for the purpose of disposal to landfill, the following is required-

- *Identification of chemical substances present in the waste;*
- *Sampling and analysis to determine the total concentration (TC) and leachable concentration (LC) of the elements and chemical substances that have been identified in the waste and that are specified in section 6 of these norms and Standards.*

(2) Within three (3) years of the date of commencement of the Regulations, all analyses of the TC and LC of elements and chemical substances in the waste must be conducted by laboratories accredited by the South African National Accreditation System (SANAS) to conduct the particular techniques and analysis methods required.

(3) The TC and LC limits of the chemical substances in the waste must be compared to the threshold limits specified in section 6 of these norms and standards for the total concentration threshold (TCT limits) and the leachable concentration threshold (LCT limits) of specific elements and chemical substances.

(4) Based on the TC and LC limits of the elements and chemical substances in the waste exceeding the corresponding TCT and LCT limits respectively, the specific type of waste for the disposal to a landfill must be determined in terms of section 7 of these Norms and Standards."

Table 2-1: Waste type classification criteria (GNR 636)

Waste type	Classification Information
Type 0	Wastes with any element or chemical substance concentration above the LCT3 or TCT2 limits (LC> LCT3 or TC> TCT2) are Type 0 Wastes;
Type 1	Wastes with any element or chemical substance concentration above the LCT2 but below or equal to the LCT3 limits, or above the TCT1 but below or equal to the TCT2 limits (LCT2 < LC ≤ LCT3 or TCT1 <TC ≤ TCT2), are Type 1 Wastes;
Type 2	Wastes with any element or chemical substance concentration above the LCT1 but below or equal to the LCT2 limits and all concentrations below or equal to the TCT1 limits (LCT1 < LC ≤ LCT2 and TC ≤ TCT1) are Type 2 Wastes;
Type 3	Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0 < LC ≤ LCT1 and TC ≤ TCT1) are Type 3 Wastes; or
Type 4	Wastes with all element and chemical substance concentration levels for metal ions and inorganic anions below or equal to the LCT0 and TCT0 limits (LC ≤ LCT0 and TC ≤ TCT0), and with all chemical substance concentration levels also below the following total concentration limits for organics and pesticides, are Type 4 Wastes-

2.3 Sampling and Analysis

A total of 19 samples of approximately 1.5kg per sample were collected by Redco on the 10th of June 2021 from the existing Fe-Cr tailings facility, the samples consisted of 9 samples from the top and 10 samples from the toe of the tailings facility in order to obtain a representative samples of the facility (See Figure 2-1 below). Artesium submitted the samples to Aquatico Laboratories which is a SANAS accredited laboratory. The 9 samples from the top of the facility were composited into a representative sample and the 10 samples from the toe of the facility were composited into a representative sample, both composite samples were analysed using the following methodologies:

- Closed vessel microwave digestion and ICP-MS analysis of the leachate to determine whole rock (solid Phase or TCT) metal and macro-chemical composition.
- A distilled water leach was done to simulate the leaching potential (aqueous phase or LCT).

Figure 2-1: Fe - Cr TSF sample locality map

2.4 Waste Assessment

The GNR 635 and GNR 636 requires that the results of both the leachate (LCT) assessment and the total (TCT) assessment need to be considered. A risk-based approach was followed to determine the waste impact potential on the aqueous environment. The risk-based approach referenced the GNR 635 analysis parameters for the leach test results as well as incorporating current and historical hydrochemical groundwater monitoring data was used to do a first level analysis of the waste material and risk to receptors via the groundwater pathway.

Total Concentration (TCT)

The total concentration values according to GNR 635 requires an analysis of the total (solid) concentration of specific chemical constituents in a sample. The total concentration refers to the mass elemental concentration of the material. For context, the results are compared to the Total Concentration Threshold (TCT) values stipulated in GNR 635. The regulations have three categories (TCT0, TCT1, and TCT2) as specified in GNR 635. The solid phase is irrelevant for the groundwater pathway as it is immobile and does not impact the groundwater directly, whereas the leachable or fluid phase is more applicable and represents the mobile component of the material with potential to influence the groundwater pathway.

Leachable concentration (LCT)

The leach assessment according to GNR 635 requires a distilled water leach for non-putrescible waste. After the leach test is completed, the leachate, i.e., the fluid phase, is analysed for its chemical composition and the results compared to the Leach Concentration Threshold (LCT) values stipulated in GNR 635. The regulation has four categories (LCT0, LCT1, LCT2, and LCT3) as specified in GNR 635.

Although both TCT and LCT results were obtained, from a groundwater perspective LCT results are more applicable as it indicates the leachable/mobile concentration from a given material.

2.4.1 Total Concentration (TCT) Results

The TCT results for both composite samples indicated that the majority of parameters were below the TCT0 thresholds with the following exceptions:

Composite sample 1 (Top of TSF):

- Barium (Ba), Chromium 6 (CrVI) and Manganese (Mn), significantly exceeded the respective TCT0 values.
- All results were below the TCT1 values

Composite sample 2 (Toe of TSF):

- Barium (Ba), Chromium 6 (CrVI) and Manganese (Mn), exceeded the respective TCT0 values.
- All results were below the TCT1 values

2.4.2 Leachable Concentration (LCT) Results

The LCT results for most parameters were below the LCT0 thresholds with the following exception identified

in both composite samples.

Composite sample 1 (Top of TSF):

- Chromium (Cr)
- Hexavalent Chromium 6 (Cr VI)
- No LCT1 threshold exceedances were recorded.
- The TDS is 203 mg/L and the pH of the leachate is 10.9.

Composite sample 2 (Toe of TSF):

- Chromium (Cr)
- Hexavalent Chromium 6 (Cr VI)
- No LCT1 threshold exceedances were recorded.
- The TDS is 234 mg/L and the pH of the leachate is 10.5.

Table 2-2: Waste Assessment Comparison to R635 Threshold Values and 2019 hydrochemical data

Redco Witbank Geochemical Waste Assessment												Water Quality Data															
	R635 Thresholds							Witbank Composite 1 (Top of TSF)		Witbank Composite 2 (Toe of TSF)		SANS 241 (2015)	Mar-19			Jun-19				Sep-19				Dec-19			
Parameter	R635 Total Concentration Threshold Values			R635 Leach Concentration Threshold Values				TCT	LCT	TCT	LCT		BH 2	BH 3	RGC 1	BH 2	BH 3	RGC 1	RBH 3	BH 2	BH 3	RGC 1	RBH 3	BH 2	BH 3	RGC 1	RBH 3
	TCT0	TCT1	TCT2	LCT0	LCT1	LCT2	LCT3																				
Unit	mg/kg	mg/kg	mg/kg	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Al									<1		<1	≤0.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	2.76	<0.01	<0.01	<0.01	3.12	0.01	<0.01	<0.01	3.48
As	5.8	500	2 000	0.01	0.5	1	4	<2.9	<0.01	<2.9	<0.01	≤0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	150	15 000	60 000	0.5	25	50	200	<75	<0.5	<75	<0.5	≤2.4	0.45	4.86	<0.01	0.44	4.44	<0.01	5.13	0.42	4.58	<0.01	6.07	0.46	4.84	<0.01	5.93
Ba	62.5	6 250	25 000	0.7	35	70	280	109	<0.7	218	<0.7	≤0.7	0.01	0.02	0.07	<0.01	<0.01	0.07	0.03	0.02	<0.01	0.08	0.04	0.05	<0.01	0.08	0.11
Ca								105850	76.8	103900	76.8		15.7	74.6	5.78	11.6	47.6	3.49	60.9	15	31.4	4.42	62.8	10.9	57.5	7.07	32.7
Cd	7.5	260	1 040	0.003	0.15	0.3	1.2	<3.75	<0.003	<3.75	<0.003	≤0.003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	50	5 000	20 000	0.5	25	50	200	<25	<0.4	<25	<0.4		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	0.14
Cr	46 000	800 000	n.a	0.1	5	10	40	1630	1.4	1420	2.03	≤0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cr(VI)	6.5	500	2 000	0.05	2.5	5	20	52.79	1.35	43.79	1.8		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cu	16	19 500	78 000	2	100	200	800	<8	<1	<8	<1	≤2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	0.08
Fe								3635	<0.4	3640	<0.4	≤2	0.36	0.06	0.23	0.1	0.13	0.09	0.02	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.08
Hg	0.93	160	640	0.006	0.3	0.6	2.4	<0.45	<0.006	<0.45	<0.006	≤0.006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K								494	4.68	1310	13		4.47	70.2	2.7	5.49	63.1	1.23	33.2	6.22	60.7	1.83	33.4	3.14	68.9	2.77	16.3
Mg								28700	<1	31150	<1		6.16	17.6	2.35	5.04	9	2.33	19.6	5.46	8.81	2.05	21.4	8.27	14	2.89	15.2
Mn	1 000	25 000	100 000	0.5	25	50	200	4940	<0.5	11700	<0.5	≤0.4	0.64	0.82	0.08	0.28	0.03	0.1	1.97	0.5	<0.01	0.16	2.08	0.41	2.31	0.13	2.8
Mo	40	1 000	4 000	0.07	3.5	7	28	13.1	<0.07	12.7	<0.07		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Na								<500	1.59	615	18.4	≤ 200	22.5	73.7	3.85	23.3	69.3	2.76	70	25.8	71.6	2.89	73.2	2.61	75.7	2.71	72.1
Ni	91	10 600	42 400	0.07	3.5	7	28	<25	<0.07	<25	<0.07	≤0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	20	1 900	7 600	0.01	0.5	1	4	<10	<0.01	<10	<0.01	≤0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sb	10	75	300	0.02	1	2	8	<5	<0.02	<5	<0.02		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Se	10	50	200	0.01	0.5	1	4	<5	<0.01	<5	<0.01	≤0.04	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02
Th													-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U								<0.750	<0.01	<0.750	<0.01		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	150	2 680	10 720	0.2	10	20	80	64	<0.2	66.5	<0.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	240	160 000	640 000	5	250	500	2 000	<50	<2	<50	<2	≤5	<0.01	<0.01	<0.01	0.53	<0.01	<0.01	0.18	<0.01	<0.01	<0.01	0.18	0.01	<0.01	<0.01	0.1
Inorganic Aions																											
pH									10.9		10.5	>6; <9	6.23	7.32	6.76	6.97	8.11	6.87	4.28	6.79	8.23	6.72	4.47	5.72	7.1	6.56	4.44
TDS									205		234	≤1200	157	683	38.1	131	527	27.8	614	149	486	29.7	656	91	610	39.9	479
Cl				300	15000	30000	120000		<50		<50	≤ 300	3.15	37	1.2	9.54	40	0.75	38.9	6.48	42.2	0.59	42	1.05	44.6	1.42	41.9
SO4				250	12500	25000	100000		<50		54	≤500	82.9	339	<0.5	40.4	245	<0.5	350	53.8	222	1.69	378	55	296	2.01	249
NO3-N				11	550	1100	4400		<10		<10	≤11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total F	100	10 000	40 000	2	75	150	600	3.45	<1	1.22	<1	≤1.5	<0.09	0.18	0.09	0.11	0.26	0.26	0.54	0.12	0.21	<0.09	0.47	<0.09	0.12	<0.09	0.43
CN (Total)	14	10 500	42 000	0.07	3.5	7	28	<5	<0.05	<5	<0.05	≤0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2-3: Waste Assessment Comparison to R635 Threshold Values and 2020 hydrochemical data

Redco Witbank Geochemical Waste Assessment												Water Quality Data															
	R635 Thresholds							Witbank Composite 1 (Top of TSF)		Witbank Composite 2 (Toe of TSF)		SANS 241 (2015)	Mar-20				Jun-20				Sep-20				Dec-20			
Parameter	R635 Total Concentration Threshold Values			R635 Leach Concentration Threshold Values				TCT	LCT	TCT	LCT		BH 2	BH 3	RGC 1	RBH 3	BH 2	BH 3	RGC 1	RBH 3	BH 2	BH 3	RGC 1	RBH 3	BH 2	BH 3	RGC 1	RBH 3
	TCT0	TCT1	TCT2	LCT0	LCT1	LCT2	LCT3																				
Unit	mg/kg	mg/kg	mg/kg	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Al									<1		<1	≤0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	5.8	500	2 000	0.01	0.5	1	4	<2.9	<0.01	<2.9	<0.01	≤0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	150	15 000	60 000	0.5	25	50	200	<75	<0.5	<75	<0.5	≤2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	62.5	6 250	25 000	0.7	35	70	280	109	<0.7	218	<0.7	≤0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca								105850	76.8	103900	76.8		13.8	10.44	2.18	34.61	12.6	61.3	2.46	34.5	28.8	48.5	4.53	44.4	26.3	91.9	12	60.2
Cd	7.5	260	1 040	0.003	0.15	0.3	1.2	<3.75	<0.003	<3.75	<0.003	≤0.003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	50	5 000	20 000	0.5	25	50	200	<25	<0.4	<25	<0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cr	46 000	800 000	n.a	0.1	5	10	40	1630	1.4	1420	2.03	≤0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cr(VI)	6.5	500	2 000	0.05	2.5	5	20	52.79	1.35	43.79	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	16	19 500	78 000	2	100	200	800	<8	<1	<8	<1	≤2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe								3635	<0.4	3640	<0.4	≤2	<0.01	<0.01	0.17	0.08	<0.01	<0.01	<0.01	<0.01	0.1	0.2	<0.01	0.02	0.01	0.01	0.07	0.01
Hg	0.93	160	640	0.006	0.3	0.6	2.4	<0.45	<0.006	<0.45	<0.006	≤0.006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K								494	4.68	1310	13		3.32	73.13	1.7	20.74	2.78	63.4	1.53	19.1	8.78	59.5	1.58	27.7	8.09	68	1.57	34.9
Mg								28700	<1	31150	<1		6.75	3.37	2.06	16.14	10.1	13	2.14	12.2	8.69	10	4.04	16.7	6.97	18.3	10.1	18.1
Mn	1 000	25 000	100 000	0.5	25	50	200	4940	<0.5	11700	<0.5	≤0.4	2.07	0.03	0.26	1.2	1.62	1.27	0.2	1.21	1	0.17	0.93	1.84	0.57	2.25	6.49	1.8
Mo	40	1 000	4 000	0.07	3.5	7	28	13.1	<0.07	12.7	<0.07		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Na								<500	1.59	615	18.4	≤ 200	14.6	77.3	3.01	56.51	12.7	70.5	68.7	51.7	52.1	2.98	3.71	60.7	51.6	84.5	5.47	70.6
Ni	91	10 600	42 400	0.07	3.5	7	28	<25	<0.07	<25	<0.07	≤0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	20	1 900	7 600	0.01	0.5	1	4	<10	<0.01	<10	<0.01	≤0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sb	10	75	300	0.02	1	2	8	<5	<0.02	<5	<0.02		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Se	10	50	200	0.01	0.5	1	4	<5	<0.01	<5	<0.01	≤0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Th													-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U								<0.750	<0.01	<0.750	<0.01		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	150	2 680	10 720	0.2	10	20	80	64	<0.2	66.5	<0.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	240	160 000	640 000	5	250	500	2 000	<50	<2	<50	<2	≤5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inorganic Aions																												
pH									10.9		10.5	>6; <9	6.03	8.58	7.75	4.43	6.18	6.64	6.72	4.48	6.21	7.91	6.9	4.89	5.89	6.75	6.87	4.31
TDS									205		234	≤1200	131	413	25	422	136	620	26	388	318	517	44	498	301	814	117	608
Cl				300	15000	30000	120000		<50		<50	≤ 300	4	28.1	2.02	36.1	2.99	28.3	1.98	30	4.75	32.8	3.01	36.3	3.88	36.5	0.99	35.2
SO4				250	12500	25000	100000		<50		54	≤500	68.19	126.73	<0.50	218.61	75.1	338	<0.50	203	202	246	14.7	274	191	445	69	345
NO3-N				11	550	1100	4400		<10		<10	≤11	<0.35	0.42	0.44	4.64	<0.35	<0.35	0.56	4.8	<0.35	<0.35	<0.35	3.39	<0.35	<0.35	<0.35	3.29
Total F	100	10 000	40 000	2	75	150	600	3.45	<1	1.22	<1	≤1.5	-	-	-	-	<0.09	<0.09	0.34	0.31	<0.09	0.17	<0.09	0.28	<0.09	0.46	<0.09	0.61
CN (Total)	14	10 500	42 000	0.07	3.5	7	28	<5	<0.05	<5	<0.05	≤0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2-4: Waste Assessment Comparison to R635 Threshold Values and to date 2021 hydrochemical data

Redco Witbank Geochemical Waste Assessment												Water Quality Data							
	R635 Thresholds							Witbank Composite 1 (Top of TSF)		Witbank Composite 2 (Toe of TSF)		SANS 241 (2015)	Mar-21				Jun-21			
Parameter	R635 Total Concentration Threshold Values			R635 Leach Concentration Threshold Values				TCT	LCT	TCT	LCT		BH 2	BH 3	RGC 1	RBH 3	BH 2	BH 3	RGC 1	RBH 3
	TCT0	TCT1	TCT2	LCT0	LCT1	LCT2	LCT3	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Unit	mg/kg	mg/kg	mg/kg	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ													
Al									<1		<1	≤0.3	<0.01	<0.01	0.06	3.81	0.02	0.02	0.02	3.14
As	5.8	500	2 000	0.01	0.5	1	4	<2.9	<0.01	<2.9	<0.01	≤0.01	-	-	-	-	-	-	-	-
B	150	15 000	60 000	0.5	25	50	200	<75	<0.5	<75	<0.5	≤2.4	0.52	6.81	0.04	5.4	0.3	3.89	0.17	3.12
Ba	62.5	6 250	25 000	0.7	35	70	280	109	<0.7	218	<0.7	≤0.7	0.03	0.02	0.08	0.06	0.01	0.02	0.07	0.04
Ca								105850	76.8	103900	76.8		27.231	103.736	3.83	62.187	20.44	91	3.67	61.6
Cd	7.5	260	1 040	0.003	0.15	0.3	1.2	<3.75	<0.003	<3.75	<0.003	≤0.003	-	-	-	-	-	-	-	-
Co	50	5 000	20 000	0.5	25	50	200	<25	<0.4	<25	<0.4		<0.01	0.02	<0.01	0.11	<0.01	0.03	<0.01	0.09
Cr	46 000	800 000	n.a	0.1	5	10	40	1630	1.4	1420	2.03	≤0.05	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.02
Cr(VI)	6.5	500	2 000	0.05	2.5	5	20	52.79	1.35	43.79	1.8		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cu	16	19 500	78 000	2	100	200	800	<8	<1	<8	<1	≤2	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	0.05
Fe								3635	<0.4	3640	<0.4	≤2	2.58	2.12	1.18	0.04	0.09	<0.01	0.02	<0.01
Hg	0.93	160	640	0.006	0.3	0.6	2.4	<0.45	<0.006	<0.45	<0.006	≤0.006	-	-	-	-	-	-	-	-
K								494	4.68	1310	13		7.31	67.3	1.17	33.59	6.75	58.8	1.19	34
Mg								28700	<1	31150	<1		6.43	20.2	2.98	20.704	5.64	19.8	2.62	20.3
Mn	1 000	25 000	100 000	0.5	25	50	200	4940	<0.5	11700	<0.5	≤0.4	0.7	3.41	0.09	2.01	0.3	2.46	0.07	1.7
Mo	40	1 000	4 000	0.07	3.5	7	28	13.1	<0.07	12.7	<0.07		-	-	-	-	-	-	-	-
Na								<500	1.59	615	18.4	≤ 200	49	81.1	3.29	71.766	37.6	74.1	3.43	69.6
Ni	91	10 600	42 400	0.07	3.5	7	28	<25	<0.07	<25	<0.07	≤0.07	-	-	-	-	-	-	-	-
Pb	20	1 900	7 600	0.01	0.5	1	4	<10	<0.01	<10	<0.01	≤0.01	-	-	-	-	-	-	-	-
Sb	10	75	300	0.02	1	2	8	<5	<0.02	<5	<0.02		-	-	-	-	-	-	-	-
Se	10	50	200	0.01	0.5	1	4	<5	<0.01	<5	<0.01	≤0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Th													-	-	-	-	-	-	-	-
U								<0.750	<0.01	<0.750	<0.01		-	-	-	-	-	-	-	-
V	150	2 680	10 720	0.2	10	20	80	64	<0.2	66.5	<0.2		-	-	-	-	-	-	-	-
Zn	240	160 000	640 000	5	250	500	2 000	<50	<2	<50	<2	≤5	-	-	-	-	-	-	-	-
Inorganic Aions																				
pH									10.9		10.5	>6; <9	5.91	6.31	7.14	4.23	6.44	6.33	7.68	4.85
TDS									205		234	≤1200	301.28672	864.24226	35.18214	646.8908	225.9621	769.21004	30.28252	635.41372
Cl				300	15000	30000	120000		<50		<50	≤ 300	4.86	39.4	2.24	36.9	4.67	39.97	1.44	36.72
SO4				250	12500	25000	100000		<50		54	≤500	186.63	485	1.03	375	129.44	439	1.85	378.48
NO3-N				11	550	1100	4400		<10		<10	≤11	0.38	0.46	0.45	4.18	<0.35	<0.35	<0.35	3.64
Total F	100	10 000	40 000	2	75	150	600	3.45	<1	1.22	<1	≤1.5	0.44	1.11	<0.09	0.68	<0.09	0.74	<0.09	1.11
CN (Total)	14	10 500	42 000	0.07	3.5	7	28	<5	<0.05	<5	<0.05	≤0.2	-	-	-	-	-	-	-	-

2.4.3 Waste Risk Assessment

From the geochemical analysis conducted, the exceedances recorded in the TCT and LCT are above the TCT0 and LCT0 thresholds and thus the waste will be classified as a type 3 waste (refer to Table 2-2). Although the LCT analysis indicates LCT0 threshold exceedances of chromium (Cr) in both composite samples, the current and historical groundwater and surface water monitoring results (March 2019 to June 2021) obtained from Redco, indicates insignificant Chromium (Cr) and Hexavalent Chromium (Cr VI), however aluminium (Al), Boron (B) and manganese (Mn) exceedances were recorded when compared to SANS 241:2015 drinking water limits.

The Fe – Cr TSF is located between the active Mn slag dump and Mn slimes dam (refer to Figure 2-1) and has not been in use since 2008. The TSF is a Geomembrane lined facility surrounded with an HDPE lined drain in which the underdrainage and penstock pipe discharges. (Redco, 2021). The upstream/background monitoring borehole indicates no exceedances of the SANS 241-1:2015 standards and thus the water chemistry is being influenced by the smelter activities on site. The main receptors is the Brug Spruit and its Western Tributary.

An initial but conservative[1] 1Dimensional Analytical solution (Ogata & Banks, 1961) was run for this site over a 100 year period and the Hexavalent Chromium transport was calculated. This analysis assumes free leakage from the system in the future when the synthetic liner has degraded with time.

The following assumptions were made when modelling the Hexavalent Chromium Transport:

- The porous media is homogenous and isotropic
- No mass transfer occurs between the solid and liquid phases
- The solute transport across any fixed plane, due to microscopic variations, may be quantitively expressed as the product of a dispersion coefficient and the concentration gradient
- The flow in the medium is assumed to be unidirectional and the average velocity is taken to be constant throughout the length of the flow field

Two analytical models were prepared, one modelling the advective transport and the other the reactive transport. The results are shown in Figure 2-2 and Figure 2-3 below.

[1] Calculated impact is greater than the actual expected.

Table 2-5: Model Parameters (Jones and Wagener, 2016)

Aquifer Unit	Aquifer parameter	Value/Comment	Source
Weathered aquifer	Thickness	9m	Monitoring borehole logs
	Groundwater level	6.08m	Monitoring borehole information
	Saturated thickness (project area)	2.92m	Calculated
	Transmissivity (T)	0.06 m^2/d	Geometric avg Rison (2006) and recent tests
	Hydraulic conductivity (K)	0.007 m/d	Geometric avg Rison (2006) and recent tests
	Vertical Hydraulic Conductivity (K_v)	0.0007 m/d	Assumed an order magnitude smaller than K
	Porosity	5%	Freeze and Cherry (1979)
	Specific yield (S_y)	1E-3	Assumption
	Rate of recharge	2% of MAP	Assumption
Confined Fractured Aquifer:	Thickness	50m	Assumption
	Groundwater level	8.02m	Monitoring borehole information
	Saturated thickness	41.98m	Calculated
	Transmissivity (T)	0.078 m^2/d	Geometric avg Rison (2006) and recent tests
	Hydraulic Conductivity (K)	0.002 m/d	Geometric avg Rison (2006) and recent tests
	Vertical Hydraulic Conductivity (K_v)	0.0002	Assumed an order magnitude smaller than K
	Porosity	<5%	Freeze and Cherry (1979)
	Storage coefficient (S)	1E-4	Assumed
	Rate of recharge	Not applicable	Seepage from weathered aquifer

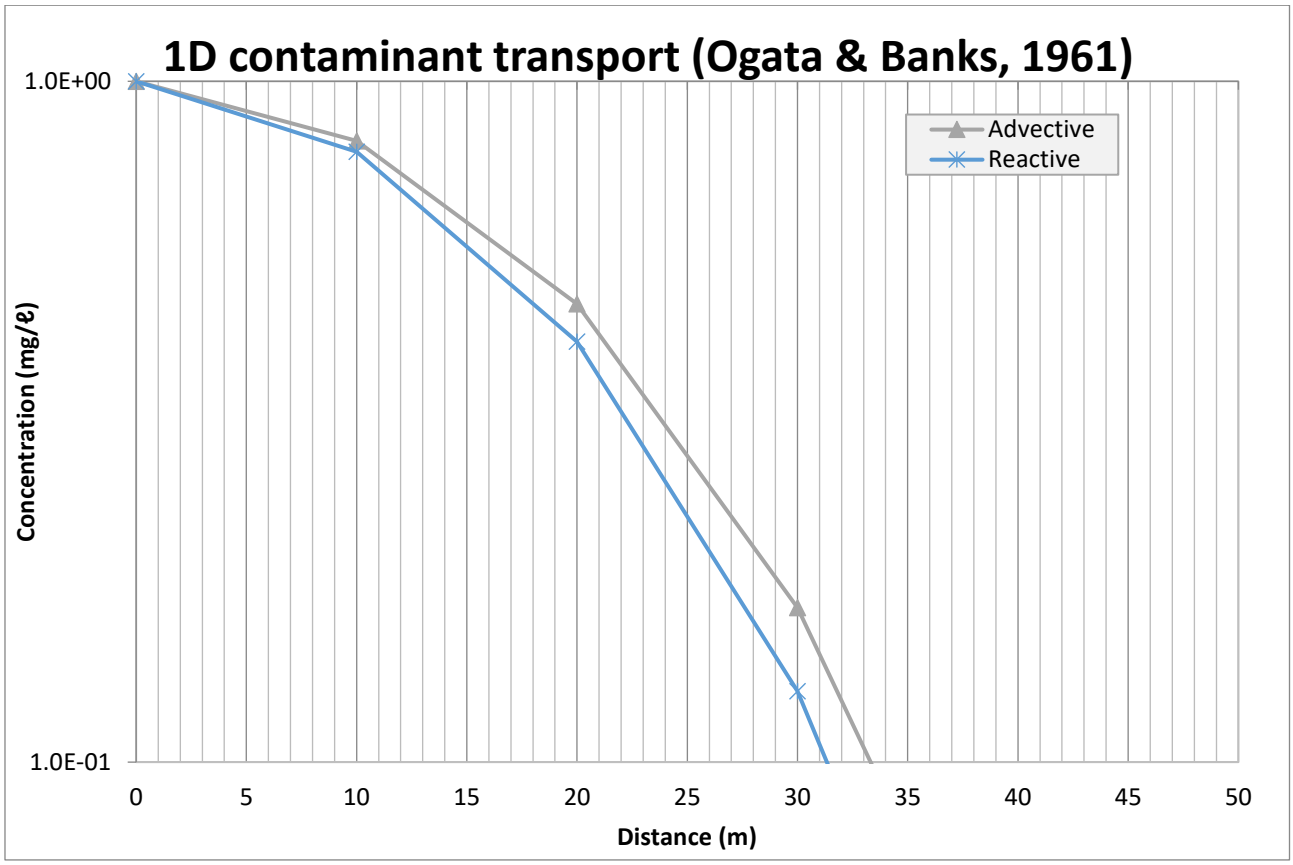

Figure 2-2: Weathered Aquifer 1D Contaminant Transport Model

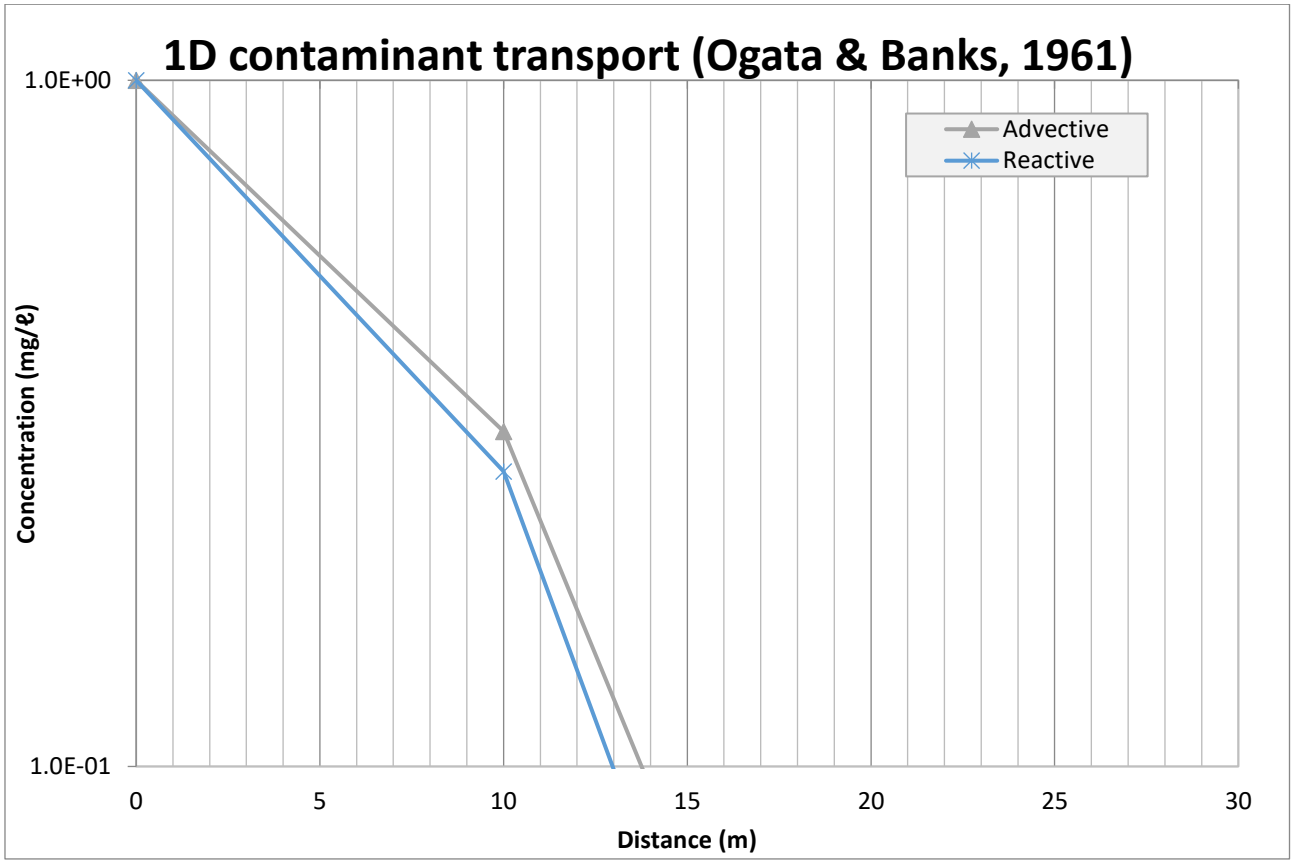

Figure 2-3: Fractured Aquifer 1D contaminant transport model

The results show that advective transport would transport of hexavalent chromium under an assumption of constant source leakage over a distance of approximately 34 m over a period of 100 years in the weathered aquifer and transport in the fractured aquifer reach approximately 15 m over a period of 100 years. If no artificial gradient is being caused the Hexavalent Chromium would likely never reach the Brug Spruit and its Western Tributary as it is referred to which is the main receptors. The above approach is considered conservative, however, numerical modelling would be required to better understand the mass transport of the site.

No groundwater users are located directly downstream of the site, but a groundwater buffer of 250m should be implemented from the Fe – Cr TSF to prohibit pumping of the groundwater and influencing the existing groundwater pollution plume. No surface water exceedances were recorded in the Brug spruit or its tributary, although Chromium and Hexavalent chromium were detected in the process water during the February 2019 and December 2019 sampling runs in surface water monitoring point S14. Refer to Figure 2-4 below for all the monitoring localities.

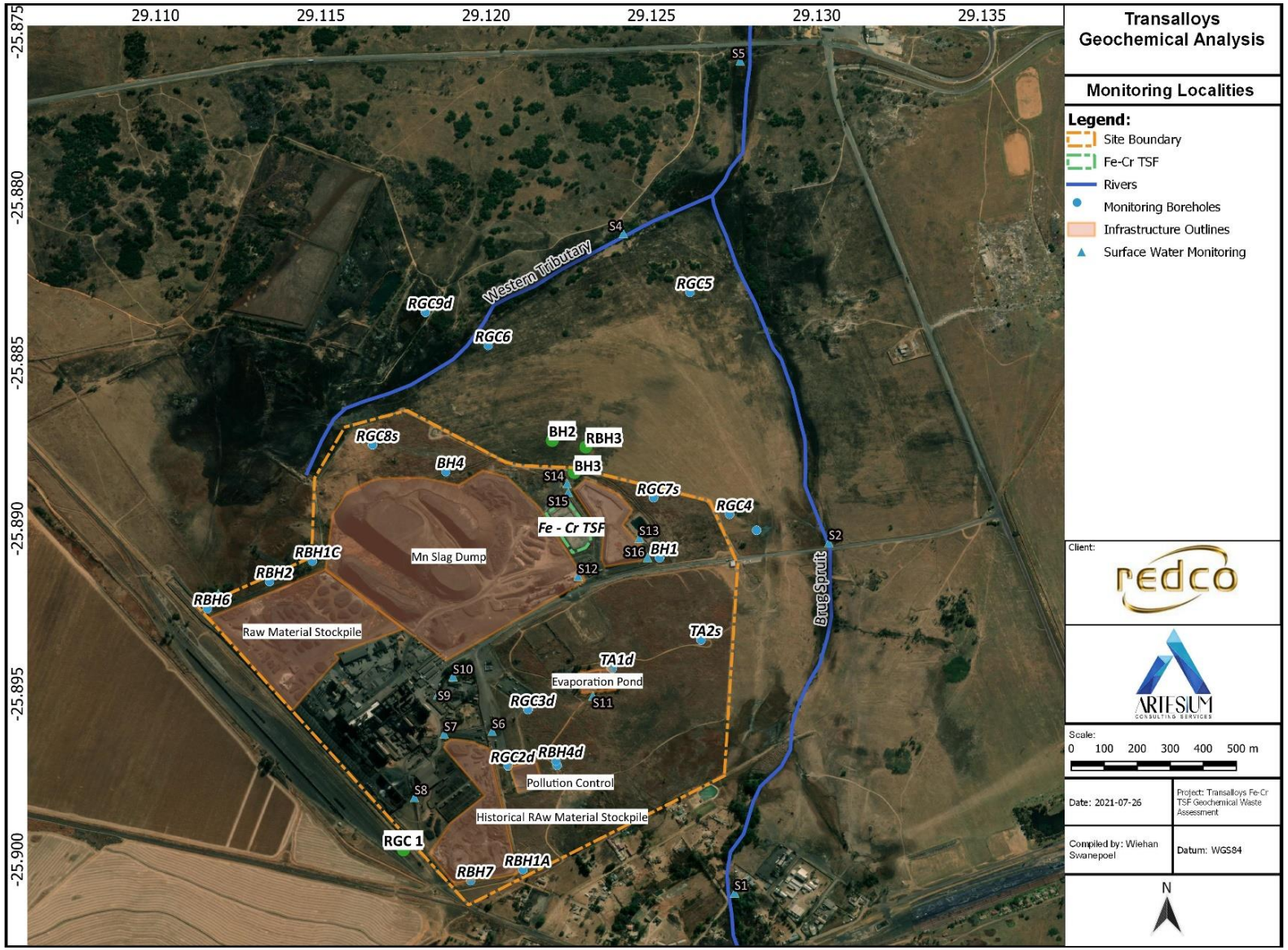

Figure 2-4: Site layout map depicting the monitoring boreholes on site and the relevant TSF

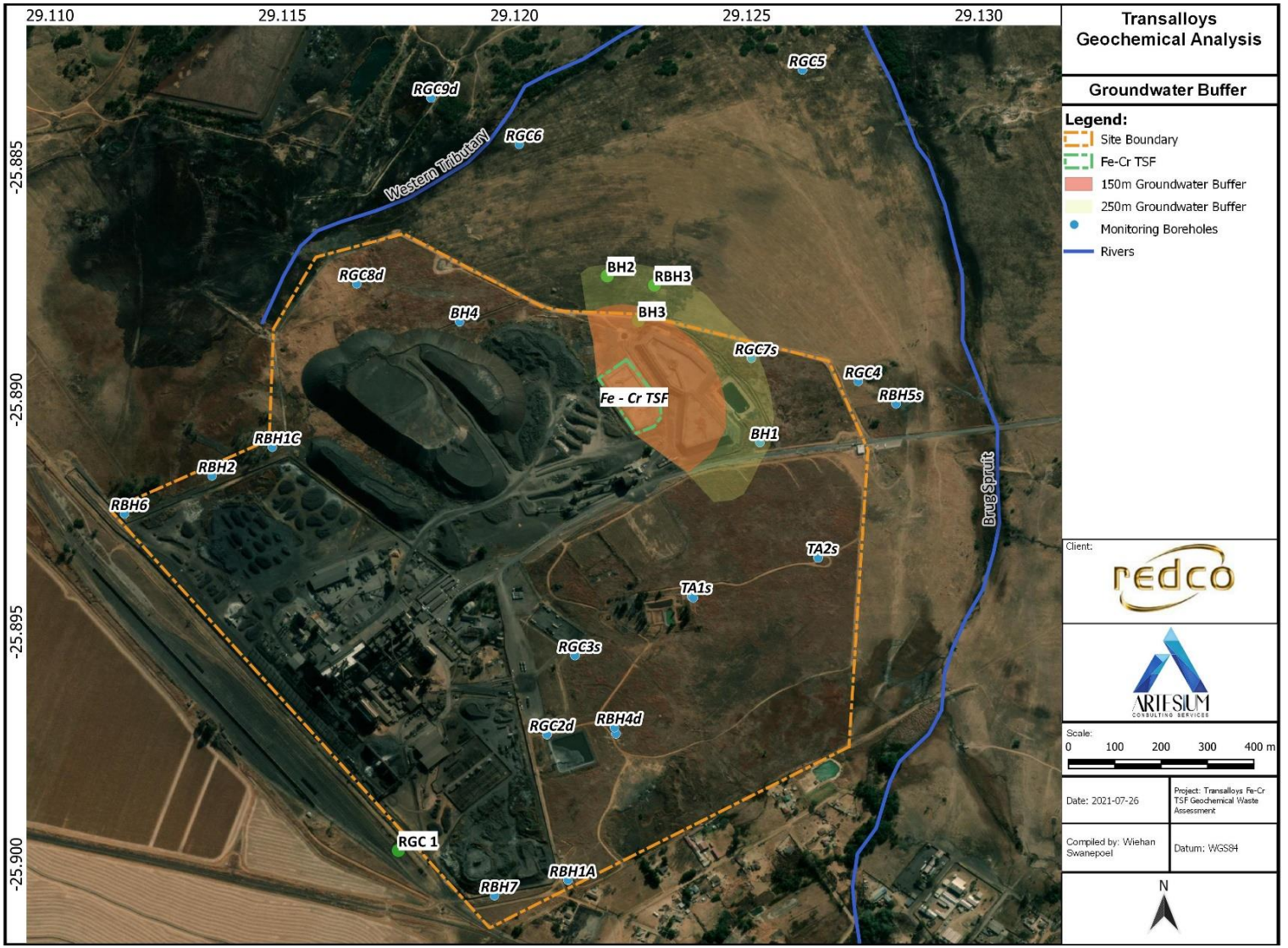

Figure 2-5: Groundwater use exclusion buffer zone

3 CONCLUSIONS

1. Based on GNR 635 the tailings sample from Composite 1 (top of tailings) and Composite 2 (toe of tailings) the tailings classifies as Type 3 waste due to TCT0 exceedances for Barium (Ba), Hexavalent Chrome (CrVI) and Manganese (Mn).
2. Chromium (Cr) and Hexavalent Chromium (CrVI) exceeded the LCT0 thresholds for both composite samples analysed and also classifies as Type 3 waste. The residue facility is lined with a synthetic liner.
3. Groundwater monitoring data indicated Aluminium, Boron and Manganese exceedances which is possibly from other sources on site.
4. When assessing the latest available hydrochemical data from March 2019 to December 2019, no Chromium or Hexavalent Chromium was detected in the groundwater or surface water monitoring localities in the Burg Spruit downstream of the Fe-Cr facility.
5. The waste from the Fe-Cr tailings facility is classified as Type 3, but it should be managed with care, due to the presence of hexavalent chromium.
6. The initial risk assessment indicated that there could be a future impact within a 250 m zone from the site should the liner degrade in the long-term future.

4 RECOMMENDATIONS

1. Groundwater monitoring must continue during and after closure and capping of the TSF as groundwater monitoring data can be considered as a long term leach test and is more informative than a short duration lab test. The post-closure monitoring time frame should be reviewed every 2 years based on the monitoring data findings.
2. An onsite monitoring borehole should be drilled immediately downstream from the TSF not further than 25 m from the facility for early detection of any potential leakages.
3. The capping material intended to be used should be modelled using numerical methods to determine the flow and mass transport potential over extended periods.
4. Based on this initial analysis, a 250m groundwater use exclusion buffer zone should be instated where no groundwater abstraction may take place. This buffer zone should be reviewed based on more accurate numerical modelling.
5. When monitoring ceases after closure borehole BH 3 used for monitoring should be properly sealed of to stop any potential groundwater abstraction in that area within the 250m buffer zone.
6. The optimal capping thickness (store and release cap) of the TSF should be numerically modelled for the infiltration and outflows to determine the long-term effects as the degradation of the liner installed must be taken into account.

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USEPA (2020) www.epa.gov/risk

APPENDIX A: LABORATORY CERTIFICATE

aquatico Laboratories (Pty). Ltd.

Test Report

Client: KC Vivier Pty Ltd
Address: 249 Draaihals Street, Leeuwfontein Estates, Kameeldrift East, Pretoria, 0005
Report no: 107397
Project: KC Vivier

Date of certificate: 19 July 2021
Date accepted: 28 June 2021
Date completed: 19 July 2021
Revision: 0

Locality name:					**Composite 1**		
Date sampled:					**28 June 2021**		
					Distilled Water	**Borax**	**TCLP**
Sample dry Mass(g):	**Leachable Concentrations**				**0.20**	**NR**	**NR**
Sample Volume (mL):	**LCT 0**	**LCT 1**	**LCT 2**	**LCT 3**	**400**	**NR**	**NR**
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Metal Ions							
Arsenic as As	0.010	0.500	1.00	4.00	<0.010	NR	NR
Boron as B	0.500	25.0	50.0	200	<0.500	NR	NR
Barium as Ba	0.700	35.0	70.0	280	<0.700	NR	NR
Cadmium as Cd	0.003	0.150	0.300	1.20	<0.030	NR	NR
Cobalt as Co	0.500	25.0	50.0	200	<0.400	NR	NR
Chromium as Cr	0.100	5.00	10.0	40.0	1.40	NR	NR
Hexavalent chromium (Cr^{6+})	0.050	2.50	5.00	20.0	1.35	NR	NR
Copper as Cu	2.00	100	200	800	<1.00	NR	NR
Mercury as Hg	0.006	0.300	0.600	2.40	<0.060	NR	NR
Manganese as Mn	0.500	25.0	50.0	200	<0.500	NR	NR
Molybdenum as Mo	0.070	3.50	7.00	28.0	<0.070	NR	NR
Nickel as Ni	0.070	3.50	7.00	28.0	<0.070	NR	NR
Lead as Pb	0.010	0.500	1.00	4.00	<0.010	NR	NR
Antimony as Sb	0.020	1.00	2.00	8.00	<0.020	NR	NR
Selenium as Se	0.010	0.500	1.00	4.00	<0.010	NR	NR
Vanadium as V	0.200	10.0	20.0	80.0	<0.200	NR	NR
Zinc as Zn	5.00	250	500	2000	<2.00	NR	NR
Inorganic Anions							
Total Dissolved solids @ 180°C	1000	12500	25000	100000	205	NR	NR
Chloride as Cl	300	15000	30000	120000	<50.0	NR	NR
Sulphate (SO_4)	250	12500	25000	100000	<50.0	NR	NR
Nitrate (NO_3) as N	11.0	550	1100	4400	<10.0	NR	NR
Fluoride as F	1.50	75.0	150	600	<1.00	NR	NR
Total Cyanide as CN	0.070	3.50	7.00	28.0	<0.05	NR	NR
Physical characteristics							
Paste pH (1:2)	-	-	-	-		NR	
Redox	-	-	-	-		NR	

O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report
N/A = Not Applicable

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Date of certificate: 19 July 2021
Date accepted: 28 June 2021
Date completed: 19 July 2021
Revision: 0

Locality name: Composite 1

Date sampled: 28 June 2021

	Leachable Concentrations				Distilled Water	Borax	TCLP
Sample dry Mass(g):					**0.20**	**NR**	**NR**
Sample Volume (mL):	**LCT 0**	**LCT 1**	**LCT 2**	**LCT 3**	**400**	**NR**	**NR**
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Variables							
pH @ 25°C	-	-	-	-	10.9	NR	NR
Total Alkalinity	-	-	-	-	79.7	NR	NR
Aluminium (Al)	-	-	-	-	<1.00	NR	NR
Iron (Fe)	-	-	-	-	<0.400	NR	NR
Calcium (Ca)	-	-	-	-	76.8	NR	NR
Magnesium (Mg)	-	-	-	-	<1.00	NR	NR
Sodium (Na)	-	-	-	-	1.59	NR	NR
Potassium (K)	-	-	-	-	4.68	NR	NR
Strontium (Sr)	-	-	-	-	<0.400	NR	NR
Carbonate alkalinity	-	-	-	-	36.6	NR	NR
Bicarbonate alkalinity	-	-	-	-	5.14	NR	NR
Dissolved Uranium (U)	-	-	-	-	<0.010	NR	NR
Silicon (Si)	-	-	-	-	10.3	NR	NR
Rubidium (Rb)	-	-	-	-	0.019	NR	NR
Tellurium (Te)	-	-	-	-	<0.020	NR	NR

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aquatico Laboratories (Pty). Ltd.

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Project: KC Vivier

Date of certificate: 19 July 2021
Date accepted: 28 June 2021
Date completed: 19 July 2021
Revision: 0

Locality name: Composite 2

Date sampled: 28 June 2021

					Distilled Water	Borax	TCLP
Sample dry Mass(g):	Leachable Concentrations				0.20	NR	NR
Sample Volume (mL):	LCT 0	LCT 1	LCT 2	LCT 3	400	NR	NR
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Metal Ions							
Arsenic as As	0.010	0.500	1.00	4.00	<0.010	NR	NR
Boron as B	0.500	25.0	50.0	200	1.44	NR	NR
Barium as Ba	0.700	35.0	70.0	280	<0.700	NR	NR
Cadmium as Cd	0.003	0.150	0.300	1.20	<0.030	NR	NR
Cobalt as Co	0.500	25.0	50.0	200	<0.400	NR	NR
Chromium as Cr	0.100	5.00	10.0	40.0	2.03	NR	NR
Hexavalent chromium (Cr^{6+})	0.050	2.50	5.00	20.0	1.80	NR	NR
Copper as Cu	2.00	100	200	800	<1.00	NR	NR
Mercury as Hg	0.006	0.300	0.600	2.40	<0.060	NR	NR
Manganese as Mn	0.500	25.0	50.0	200	<0.500	NR	NR
Molybdenum as Mo	0.070	3.50	7.00	28.0	<0.070	NR	NR
Nickel as Ni	0.070	3.50	7.00	28.0	<0.070	NR	NR
Lead as Pb	0.010	0.500	1.00	4.00	<0.010	NR	NR
Antimony as Sb	0.020	1.00	2.00	8.00	<0.020	NR	NR
Selenium as Se	0.010	0.500	1.00	4.00	<0.010	NR	NR
Vanadium as V	0.200	10.0	20.0	80.0	<0.200	NR	NR
Zinc as Zn	5.00	250	500	2000	<2.00	NR	NR
Inorganic Anions							
Total Dissolved solids @ 180°C	1000	12500	25000	100000	234	NR	NR
Chloride as Cl	300	15000	30000	120000	<50.0	NR	NR
Sulphate (SO_4)	250	12500	25000	100000	54.1	NR	NR
Nitrate (NO_3) as N	11.0	550	1100	4400	<10.0	NR	NR
Fluoride as F	1.50	75.0	150	600	<1.00	NR	NR
Total Cyanide as CN	0.070	3.50	7.00	28.0	<0.05	NR	NR
Physical characteristics							
Paste pH (1:2)	-	-	-	-		NR	
Redox	-	-	-	-		NR	

O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report
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Project: KC Vivier

Date of certificate: 19 July 2021
Date accepted: 28 June 2021
Date completed: 19 July 2021
Revision: 0

Locality name: Composite 2

Date sampled: 28 June 2021

	Leachable Concentrations				Distilled Water	Borax	TCLP
Sample dry Mass(g):					**0.20**	**NR**	**NR**
Sample Volume (mL):	**LCT 0**	**LCT 1**	**LCT 2**	**LCT 3**	**400**	**NR**	**NR**
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Variables							
pH @ 25°C	-	-	-	-	10.5	NR	NR
Total Alkalinity	-	-	-	-	53.6	NR	NR
Aluminium (Al)	-	-	-	-	<1.00	NR	NR
Iron (Fe)	-	-	-	-	<0.400	NR	NR
Calcium (Ca)	-	-	-	-	55.5	NR	NR
Magnesium (Mg)	-	-	-	-	<1.00	NR	NR
Sodium (Na)	-	-	-	-	18.4	NR	NR
Potassium (K)	-	-	-	-	13.0	NR	NR
Strontium (Sr)	-	-	-	-	<0.400	NR	NR
Carbonate alkalinity	-	-	-	-	28.6	NR	NR
Bicarbonate alkalinity	-	-	-	-	10.5	NR	NR
Dissolved Uranium (U)	-	-	-	-	<0.010	NR	NR
Silicon (Si)	-	-	-	-	6.90	NR	NR
Rubidium (Rb)	-	-	-	-	0.034	NR	NR
Tellurium (Te)	-	-	-	-	<0.020	NR	NR

O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report
N/A = Not Applicable

aquatico Laboratories (Pty). Ltd.

Test Report

Client: KC Vivier Pty Ltd
Address: 249 Draaihals Street, Leeuwfontein Estates, Kameeldrift East, Pretoria, 0005
Report no: 107398
Project: KC Vivier

Date of certificate: 19 July 2021
Date accepted: 28 June 2021
Date completed: 19 July 2021
Revision: 0

Locality name:		**Composite 1**			
Date sampled:		**25 June 2021**			
Sample dry Mass(g):					**1.00**
Sample Volume (mL):	**Total Concentrations**				**50.0**
Guideline Limits:	**TCT 0**	**TCT 1**	**TCT 2**		
Units:	**mg/Kg**	**mg/Kg**	**mg/Kg**	**mg/L**	**mg/Kg**
Metal Ions					
Arsenic as As	5.80	500	2000	<0.058	<2.90
Boron as B	150	15000	60000	<1.50	<75.0
Barium as Ba	62.5	6250	25000	2.18	109
Cadmium as Cd	7.50	260	1040	<0.075	<3.75
Cobalt as Co	50.0	5000	20000	<0.500	<25.0
Chromium as Cr	46000	800000	-	32.6	1630
Hexavalent chromium (Cr^{6+})	7	500	2000	NR	NR
Copper as Cu	16.0	19500	78000	<0.160	<8.00
Mercury as Hg	0.930	160	640	<0.009	<0.450
Manganese as Mn	1000	25000	100000	98.8	4940
Molybdenum as Mo	40.0	1000	4000	0.262	13.1
Nickel as Ni	91.0	10600	42400	<0.500	<25.0
Lead as Pb	20.0	1900	7600	<0.200	<10.0
Antimony as Sb	10.0	75.0	300	<0.100	<5.00
Selenium as Se	10.0	50.0	200	<0.100	<5.00
Vanadium as V	150	2680	10720	1.28	64.0
Zinc as Zn	240	160000	640000	<1.00	<50.0
Inorganic Anions					
Fluoride as F	100	10000	40000	NR	NR
Total Cyanide as CN	14.00	10500.00	42000.00	<0.100	<5.00
Percentage Solids					
Moisture %	-	-	-	16.6	
Solid %	-	-	-	NR	

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N/A = Not Applicable

Test Report

Client:	KC Vivier Pty Ltd	**Date of certificate:**	19 July 2021
Address:	249 Draaihals Street, Leeuwfontein Estates, Kameeldrift East, Pretoria, 0005	**Date accepted:**	28 June 2021
Report no:	107398	**Date completed:**	19 July 2021
Project:	KC Vivier	**Revision:**	0

Locality name:		**Composite 1**			
Date sampled:		**25 June 2021**			
Sample dry Mass(g):				**1.00**	
Sample Volume (mL):	**Total Concentrations**			**50.0**	
Guideline Limits:	**TCT 0**	**TCT 1**	**TCT 2**		
Units:	**mg/Kg**	**mg/Kg**	**mg/Kg**	**mg/L**	**mg/Kg**
Variables					
Iron as Fe	-	-	-	72.7	3635
Calcium as Ca	-	-	-	2117	105850
Sodium as Na	-	-	-	<10.0	<500
Magnesium as Mg	-	-	-	574	28700
Potassium	-	-	-	9.88	494
TC Strontium (Sr)	-	-	-	0.721	36.1
Rubidium (Rb)	-	-	-	0.218	10.9
Tellurium (Te)	-	-	-	<0.001	<0.050
Tin (Sn)	-	-	-	<0.001	<0.050
Silicon (Si)	-	-	-	37.6	1880
Dissolved Uranium (U)	-	-	-	<0.015	<0.750

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N/A = Not Applicable

aquatico Laboratories (Pty). Ltd.

Test Report

Client: KC Vivier Pty Ltd
Address: 249 Draaihals Street, Leeuwfontein Estates, Kameeldrift East, Pretoria, 0005
Report no: 107398
Project: KC Vivier

Date of certificate: 19 July 2021
Date accepted: 28 June 2021
Date completed: 19 July 2021
Revision: 0

Locality name:		**Composite 2**			
Date sampled:		**25 June 2021**			
Sample dry Mass(g):					**1.00**
Sample Volume (mL):	**Total Concentrations**				**50.0**
Guideline Limits:	**TCT 0**	**TCT 1**	**TCT 2**		
Units:	**mg/Kg**	**mg/Kg**	**mg/Kg**	**mg/L**	**mg/Kg**
Metal Ions					
Arsenic as As	5.80	500	2000	<0.058	<2.90
Boron as B	150	15000	60000	<1.50	<75.0
Barium as Ba	62.5	6250	25000	4.36	218
Cadmium as Cd	7.50	260	1040	<0.075	<3.75
Cobalt as Co	50.0	5000	20000	<0.500	<25.0
Chromium as Cr	46000	800000	-	28.4	1420
Hexavalent chromium (Cr^{6+})	7	500	2000	NR	NR
Copper as Cu	16.0	19500	78000	<0.160	<8.00
Mercury as Hg	0.930	160	640	<0.009	<0.450
Manganese as Mn	1000	25000	100000	234	11700
Molybdenum as Mo	40.0	1000	4000	0.253	12.7
Nickel as Ni	91.0	10600	42400	<0.500	<25.0
Lead as Pb	20.0	1900	7600	<0.200	<10.0
Antimony as Sb	10.0	75.0	300	<0.100	<5.00
Selenium as Se	10.0	50.0	200	<0.100	<5.00
Vanadium as V	150	2680	10720	1.33	66.5
Zinc as Zn	240	160000	640000	<1.00	<50.0
Inorganic Anions					
Fluoride as F	100	10000	40000	NR	NR
Total Cyanide as CN	14.00	10500.00	42000.00	<0.100	<5.00
Percentage Solids					
Moisture %	-	-	-	6.08	
Solid %	-	-	-	NR	

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N/A = Not Applicable

Test Report

Client:	KC Vivier Pty Ltd	**Date of certificate:**	19 July 2021
Address:	249 Draaihals Street, Leeuwfontein Estates, Kameeldrift East, Pretoria, 0005	**Date accepted:**	28 June 2021
Report no:	107398	**Date completed:**	19 July 2021
Project:	KC Vivier	**Revision:**	0

Locality name:		**Composite 2**			
Date sampled:		**25 June 2021**			
Sample dry Mass(g):					**1.00**
Sample Volume (mL):	**Total Concentrations**				**50.0**
Guideline Limits:	**TCT 0**	**TCT 1**	**TCT 2**		
Units:	**mg/Kg**	**mg/Kg**	**mg/Kg**	**mg/L**	**mg/Kg**
Variables					
Iron as Fe	-	-	-	72.8	3640
Calcium as Ca	-	-	-	2078	103900
Sodium as Na	-	-	-	12.3	615
Magnesium as Mg	-	-	-	623	31150
Potassium	-	-	-	26.2	1310
TC Strontium (Sr)	-	-	-	1.68	84.0
Rubidium (Rb)	-	-	-	0.331	16.6
Tellurium (Te)	-	-	-	<0.001	<0.050
Tin (Sn)	-	-	-	<0.001	<0.050
Silicon (Si)	-	-	-	30.2	1510
Dissolved Uranium (U)	-	-	-	<0.015	<0.750

O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report
N/A = Not Applicable

UIS SEDIBA LABORATORY

TEST REPORT
13050A

Client and Project Information

Client: Aquatico Laboratories Pty Ltd
Address: PO Box 905008, Garsfontein
Pretoria
0042

Attention: Hermie Holtzhausen
Tel: (012) 450 3800
Email: hermie@aquatico.co.za

Project number: MON- 4278
Project name: Batch No: 107399

Sample Information

Matrix: Soil
Units: mg/kg [ppm] (unless stated elsewhere)
Container: Plastic

Date Received: 2021/07/02
Date Issued: 2021/07/16

SAMPLE ID	F*	Cr(VI)*
23810- Composite 1	3.45	52.79
23811- Composite 2	1.22	43.79

Disclaimers

Miche Kannemeyer
Authorised Signatory

1) The results only relate to the test items provided, in the condition as received.

3) Parameters marked " * " are not included in the SANAS Schedule of Accreditation for this laboratory.

4) A = Concentration outside calibration range, ** = Outsourced analysis, UTD = Unable to Determine, NR = Not Requested.

5) Methods: UISSL-WL-001 (Conductivity), UISSL-WL-002 (Alkalinity), UISSL-WL-003 (pH), UISSL-WL-004 (TDS), UISSL-WL-007 (Metals), UISSL-WL-008 (Cr(VI)), UISSL-WL-009 (TOC), UISSL-WL-010 (Hg by DMA), UISSL-WL-011 (Anions by Discrete Analyser).

6) Uncertainty of measurement for all methods included in the SANAS Schedule of Accreditation is available on request.

www.uissl.co.za **13 Sovereign Drive Route21 Corporate Park Irene South Africa** **Tel: +27 12 345 1004 info@uisol.co.za**

APPENDIX B: PROJECT TEAM CV'S

Artesium Consulting Services (Pty) Ltd
Reg no 2021/447309/07

Email: koosvivier@gmail.com
Mobile: +27 64 512 4776

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Leeuwfontein Estates
Kameeldrift East
Pretoria
0005

Building 4e
CSIR
Meiring Naude Rd
Pretoria
0001

CURRICULUM VITAE

Jacobus Johannes Petrus Vivier

(P.hD, M.Sc.) Pr.Sci.Nat, MGSSA

PERSONAL DETAILS

Nationality:	South African
Date of birth:	14 February 1971
Residential address:	249 Draaihals Str, Leeuwfontein Estate, Leeuwfontein, Pretoria, 0001
Mobile:	+27 64 512 4776
Identity number:	710214 5052 087
Languages:	Afrikaans, English

QUALIFICATIONS

Matric (1989) Grey College Bloemfontein, with honours.

B.Sc Geology, Geochemistry and Geography. (1990-1992) University of the Free State

B.Sc. Honors Geohydrology (1993) University of the Free State

M.Sc. Geohydrology with distinction (1994-1995) University of the Free State. Thesis titled *The Influence of Geology on the Geohydrology of Karoo Aquifers*

P.hD Environmental Management (2011) North-West University. Thesis titled *Development of an Assured Systems Management Model for Environmental Decision-Making*

Registered Professional Scientist with the South African Council for Natural Scientific Professions since 2004, (Registration No 400177/05)

PROFESSIONAL AFFILIATIONS

Member: Groundwater Division of the Geological Society of South Africa.

EMPLOYMENT HISTORY

Present:	Hydrogeologist, Water Supply & Mine Water Solutions Specialist (Freelance)
Oct 1999 – May 2020	Managing Director and Senior Consulting Hydrogeologist Exigo Sustainability (PTY) Ltd
Iscor (now Kumba) Mining Company (1996-September 1997)	Manager Geohydrology Division
Atomic Energy Corporation of S.A Ltd. 1997	Specialist Scientist at the Nuclear Waste Safety Division

PROFESSIONAL SKILSS AND EXPERIENCE

Jacobus Vivier has 26 years' experience in hydrogeological data analysis, modelling, decision-making and mine water management. He has experience in the development and implementation of water management strategies with specific reference to integrated mine water management planning using systems thinking. Development of analytical and dynamic mine water and salt mass balance modelling and management solutions. Environmental and mine water financial modelling for value engineering through systems modelling and optimization to inform design criteria.

Specialized hydrogeological analysis using, numerical and statistical modelling of groundwater flow and mass transport processes and its application to mine dewatering, radioactive waste disposal facilities, mine waste contaminant transport and water supply. Experienced in modelling of complex systems, with development of analytical water flow, mass balance and transport modelling of porous and fractured media, model verification, validation and treatment of uncertainties through sensitivity analysis and stochastic (Monte Carlo) modelling.

Experienced in mine waste assessments through hydrogeochemical and statistical data analysis. Review and evaluation of hydrogeochemical specialist studies and models. Risk assessments on wastes through source-pathway-receptor analyses to inform design criteria.

Experienced in leading technical teams towards integration of specialized fields in mine dewatering strategies and design, mine waste assessments and hydrogeochemistry for optimization studies linked to financial models to enable value engineering.

Experienced in hydrogeological client relations, business development and project development with abilities to engage client and I&APs on complex projects.

Mine water and groundwater simulation and management codes: Feflow, EcoLego, Goldsim and @risk.

Guest lecturing at the Institute for Groundwater Studies in groundwater data analysis, modelling and decision-making

Act as a peer reviewer for WaterSA scientific water publications.

Act as external moderator for honours degree modelling course

Act as external examiner for MSc Thesis dissertations

References: Dr HJ Van Rensburg (082 991 2023), Dr Japie Van Blerk (082 806 6159), Prof Danie Vermeulen (072 321 6111), Dr David De Waal (083 227 8681)

INTERNATIONAL EXPERIENCE

- Participated in the Modelling and Data Group of the ISAM and BOSS Projects for the International Atomic Energy Association in Vienna, Austria. Attended working group sessions in Rio De Janeiro and Las Vegas (1997-1999).
- Mine dewatering of large open cast and underground mines in the DRC, Zambia and Botswana (2004-2009).
- Water and environmental liability assessments for mines and smelters in the nickel industry Macedonia, Eastern Europe (2007).
- (2010-2019) Mining projects in: DRC, Zambia, Saudi Arabia, Algeria, Tanzania, Namibia, Mozambique, Kenya and Botswana.

SELECTED CONFERENCE PROCEEDINGS

- Vivier, J.J.P and Van Der Walt, I.J. (2011a) When is groundwater data enough for decision-making? GSSA Groundwater Division. Groundwater Conference 2011. CSIR, Pretoria, South Africa
- Vivier, J.J.P and Van Der Walt, I.J. (2011b) If All Models are Wrong, How Can It Be Useful For Decision-Making? GSSA Groundwater Division. Groundwater Conference 2011. CSIR, Pretoria, South Africa

- Vivier, J.J.P. (2013) Determination of sustainable groundwater yield: a systems management approach based on the minimum groundwater balance. Groundwater Conference 2013. Durban, South Africa

SPECIALITY FIELDS

- Development of mine water solutions and management strategies with optimization of mine water flow and mass (water quality) balances.
- Value engineering through optimization of systems models to inform design criteria.
- Mine dewatering and cost-benefit modelling.
- Water supply from groundwater resources and determination of assured yield.
- Hydrogeochemistry of mine wastes, environmental risk assessments through source-pathway-receptor analysis.
- Integration of hydrogeological specialist fields; statistical data analysis, numerical modelling, hydrogeochemistry, mine waste assessments and optimization towards value engineering.
- Quantification of regional, basin scale groundwater potential using systems models and reserve determinations. Development of the GYMR model for regional groundwater component of the water Reserve studies.
- Mine water and regional water resources management and assurance of supply. Development of systems models for management and decision-making purposes. Statistical modelling for water supply assurance levels and risk assessments
- Integration of groundwater flow models with environmental assessments and financial models for the purposes of project feasibility studies and sustainability assessments.
- Decision-making and sustainability assessments using systems thinking and modelling.
- Evaluation of groundwater specialist studies in the mining industry, which includes water supply, mine dewatering design and groundwater pollution. Experience in pre-feasibility studies (PFS) and Definitive Feasibility Studies.
- Characterization of aquifers with a focus on management of regional groundwater systems.
- Groundwater flow and contaminant transport modelling. Groundwater flow, and radionuclide transport (pollution) modelling at nuclear waste facilities.
- Environmental hydrogeological impact and risk assessments.
- Groundwater management for water supply and environmental management programs (EMP's).

Artesium Consulting Services (Pty) Ltd
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Building 4e
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Meiring Naude Rd
Pretoria
0001

CURRICULUM VITAE

Wiehan Swanepoel
(B.sc Hons)

PERSONAL DETAILS

Nationality:	South African
Date of birth:	14 January 1994
Residential address:	127 Haymeadow Crescent, Faerie Glen, Pretoria 0081
Mobile:	+27 72 085 3409
Identity number:	9401145027083
Languages:	Afrikaans, English

QUALIFICATIONS

Matric (2012) Afrikaanse Hoërskool Sasolburg.
B.Sc. Geology and Geography (2014 - 2016) North West University
B.Sc. Honors Geohydrology (2017) North West University

EMPLOYMENT HISTORY

April 2021 – Present: Artesium Consulting Services	Junior Hydrogeologist
October 2018 – March 2021 – GCS Water and Environmental Consultants	Junior Hydrogeologist
November 2017 – September 2018 – GCS, SRK, BlueWave	Student Hydrogeologist

PROFESSIONAL SKILSS AND EXPERIENCE

Wiehan Swanepoel has 3 years' experience in Hydrogeological data collection, fieldwork management, geophysical surveys, aquifer testing programmes, water supply investigations, wellfield development and risk assessments. Involved in multiple studies locally and internationally across multiple sectors such as mining, industrial, Environmental, oil and gas and specialist investigations.

Experience in data analysis of various hydrogeological methods, such as aquifer testing data, geophysical data, geological data and long term monitoring data.

Experienced in analytical groundwater modelling, statistical methods and GIS based methods, using software such as QGIS, ArcMaps, Strater, Surfer, AQTESOLV, FC(fracture Characterisation) and Micrsoft Office (Excel, Word, PowerPoint and Access) .

INTERNATIONAL EXPERIENCE

- Mozambique: Seepage Detection and Mitigation of a TSF wall using geophysical methods to determine preferential pathways.
- Namibia: Groundwater Characterisation in Monitoring boreholes for a Copper Smelter. The investigation included, geophysics, drilling supervision, borehole profiling and development of a monitoring network with specific depth sampling to mitigate the arsenic pollution occurring.
- Democratic Republic of the Congo (DRC): Multiple Groundwater Supply Investigations, including desktop study, geophysical surveys, drilling supervision, aquifer testing, safe yield calculation, groundwater reserve determination and technical reporting. (2018 – 2021)

Artesium Consulting Services (Pty) Ltd
Reg no 2021/447309/07

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0001

Curriculum Vitae

Petrus Arnoldus Hoffman
Hydrogeologist
pietah007@gmail.com
+27 72 597 6459
19 High Street
Waterkloof
Pretoria
South Africa

1. Qualifications

Masters in Environmental Management. University of the Free State, Bloemfontein Campus, 2014 – 2015
Dissertation title: *Area selection of game species around pans on a game ranch in the Western Free State.*

BSc. **Hons.** Hydrogeology, University of the Free State, Bloemfontein Campus, 2016
Subjects: *Hydrogeochemistry, Groundwater Modelling, Geophysics, Mining Geohydrology, Groundwater Hydraulics and Groundwater Management.*

BSc. Agriculture, University of the Free State, Bloemfontein Campus, 2010 – 2013

Matric, Grey College class of 2009

2. Professional Work Experience

September 2020– Present Hydrogeologist
Artesium (Pty) Ltd, Pretoria, South Africa

I started working for Artesium Consulting Services (Pty) Ltd in September 2020. Artesium offers a wide variety of hydrogeological solutions to numerous groundwater related challanges. Services include hydrological and hydrogeological facets of pre-feasibility, feasibility, scoping, environmental impact assessment and mining right applications. I also conduct practical fieldwork; which includes sampling, aquifer testing, geophysical surveys and geological interpretations.
I furthermore conduct analytical- and numerical groundwater models, micro-, macro-, and trend analyses of data and processing thereof which includes statistical analysis- including GIS-based methods and aquifer test analysis, waste assessments and classifications, risk- and impact assessments, proposals, and reporting. I utilise software such as FEFLOW, AquaChem, AqteSolve, FC (Flow Characteristic), Wish, Surfer, ArcGIS, QGIS and Office (Excel, Word, PowerPoint, Access) to assist me with the decision-making process during each project. I have extensive consulting experience throughout Africa and have been involved in various diamond, copper, chrome, PGMs, coal projects in South Africa, and other countries including the Democratic Republic of Congo, Botswana, Mozambique and Lesotho.

March 2019 – August 2020 Hydrogeologist
Exigo Sustainability, Pretoria, South Africa

I was employed as a Hydrogeologist with Exigo from March 2019 to August 2020. I have experience working with numerous groundwater assessments across various industries, including mining, environmental, and specialized investigations. Additionally, I have also been involved with all hydrological and hydrogeological facets of pre-feasibility, feasibility, scoping, environmental impact assessment, mining right applications. I have also conducted practical fieldwork for Exigo; which includes sampling, aquifer testing, geophysical surveys and geological interpretations.

At Exigo, I have gained experience with analytical- and numerical groundwater modelling, micro-, macro-, and trend analyses of data and processing thereof which includes statistical analysis- including GIS-based methods and aquifer test analysis, waste assessments and classifications, risk- and impact assessments, proposals, and reporting. I have utilised software such as FEFLOW, AquaChem, AqteSolve, FC (Flow Characteristic), Wish, Surfer, ArcGIS, QGIS and Office (Excel, Word, PowerPoint, Access) to assist me with the decision-making process during each project. I have extensive consulting experience throughout Africa and have been involved in various diamond, copper, chrome, PGMs, coal projects in South Africa, and other countries including the Democratic Republic of Congo, Botswana and Mozambique.

August 2018– February 2019 Sub Unit Manager for the monitoring unit
GCS (Pty) Ltd, Johannesburg, South Africa

Responsibilities included the management of various water and dust monitoring studies in South Africa as well as Southern Africa. Additional responsibilities include marketing, writing proposals, maintaining good client relationships as well as logistical arrangements.

November 2016 – July 2018 Hydrogeologist
GCS (Pty) Ltd, Johannesburg, South Africa

Responsibilities included fieldwork as well as report writing within the following disciplines: geophysics, drilling supervision, aquifer testing, water and soil sampling, bathymetric surveys, contaminated site management as well as maintaining good client relationships. Conducted work in South Africa, Nigeria, Mozambique, the Democratic Republic of the Congo (DRC) and Lesotho.

January 2016 – October 2016 Student Hydrogeologist
Institute for Groundwater Studies (IGS), Bloemfontein, South Africa

Conducted fieldwork for the Institute for Groundwater Studies (IGS), which included borehole water level monitoring, sampling and aquifer testing at various coal mines in the Mpumulanga Province, South Africa.

January 2014 – December 2015 Research Assistant
Centre for Environmental Management, Bloemfontein, South Africa

Responsibilities included water quality monitoring within the Modder River as well conducting research on numerous projects conducted by the Centre for Environmental Management (CEM) which include projects related to the potential impact of fracking on groundwater and the environment within South Africa.

3. Key Areas of Expertise

Analytical and numerical groundwater modelling	FEFLOW, Excel
Geo- and hydrochemical assessments	AquaChem, Waste classification, Trend analysis
Geographical Information Systems	Spatial analysis, conceptual design for modelling
Geophysical Investigations	Resistivity, EM-34, Geotron Magnetometer
Aquifer Charcterization	Aqtesolv, FC

4. Major Projects

Below is a list describing some of the major projects that I have worked on:

Lucara Botswana Karowe Diamond Mine Underground Feasibility Study

Period: 2018 - 2019

Value: USD 1 168 000

Lucara Botswana's Karowe Diamond Mine (KDM) initiated a feasibility study to expand mining of the diamond-bearing kimberlite underground beyond the current open pit's life. KDM is situated approximately 25 km south of the renowned Debswana diamond mine, Orapa, Botswana. The study included numerous site visits, drilling

supervision, pumping tests, straddle packer tests, hydro- and geochemical analyses, geochemical modelling- and waste assessments, life of mine options and financial modelling, analytical and numerical groundwater modelling, and dynamic mine water and mass balances. I was part of a multi-disciplinary team that accomplished these aforementioned tasks and was either directly responsible for numerous tasks or assisted the responsible person/s.

Sibanye Stillwater Hydrogeological investigation into a proposed TSF expansion

Period: 2019 – ongoing

Value: R 300 000

Sibanye Stillwater is investigating the feasibility of expanding the current TSF at its Marikana operations by means of backfilling the existing mine voids with tailings material and then constructing two TSF's above the backfilled voids. The scope of work includes an in-depth hydrochemical and geochemical investigation as well as a numerical groundwater model to simulate potential impacts and the extent thereof. I was the project leader and manager responsible for the completion of the aforementioned tasks.

Kriel Colliery Groundwater, Bathymetric & Pit Lake Investigation

Period: 2017 - 2018

Value: R 280 000

The study included the investigation of 4 pit lakes which involved profiling the pit lakes and collection of water samples. The pit lake investigation was aimed at determining if the pit lakes are an environmentally stable option for mine closure. A bathymetric survey was also conducted, which included the processing of the acquired data including interpolation to generate surface contours and elevations, as well as cross-section profiles and segmented volumetric calculations of each body. I was the project leader and manager responsible for the completion of the aforementioned tasks.

Vale Moatize Mine Waste Dump Piezometers and Monitoring Wells Installation in Mozambique

Period: 2017

Value: R 1 396 450

The overall objectives of the study are to install piezometers and monitoring boreholes in the vicinity of the Moatize Mine waste dump facility, as well as to determine the specifications for a scavenger well pump to intercept seepage from the Tailings Storage Facility's (TSF) toe area. The scope of work included: Drilling and Installation of Piezometers and Monitoring Wells; Development of Piezometers and Monitoring Wells; assisting with the installation of VWP's, Falling Head- and Pumping-Testing; Groundwater sampling; and Data Analysis and Reporting. I was directly responsible for the aforementioned tasks numerous tasks or assisted the responsible person/s.

Siting of Water Supply Boreholes for Boss Mining at Luita in the DRC.

Period: 2017

Value: USD 22 624

Boss Mining – ERG Africa investigated the groundwater resource potential to meet the Luita plant raw water makeup requirement. The study included site visits, a hydrocensus, water level and groundwater inflow analyses as well as a geophysical investigation to identify potential drill targets. I was responsible for the completion of the aforementioned tasks.

5. References

Dr. Koos Vivier
Managing Director
KC Vivier (Pty) Ltd
Telephone number: +27 64 512 4776

Prof. Danie Vermeulen
Dean of Natural and Agricultural Sciences
University of the Free State
Telephone number: +27 72 321 6111

Mr. Paul Lourens
Lecturer
Institute for Groundwater Studies
University of the Free State
Telephone number: +27 82 879 5993

Mr. Kobus Troskie
Water resources manager
GCS (Pty) Ltd
Telephone number:+27 82 336 0069

APPENDIX C: DECLERATION OF INDEPENDENCE

Artesium Consulting Services (Pty) Ltd
Reg no 2021/447309/07

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Declaration of Independence

Project: Transalloys FeCr TSF Geochemical Waste Assessment

Artesium Consulting Services (Pty) Ltd (ACS) declares that:

- The company and it specialists involved acts as an independent specialist in this Waste Assessment;
- ACS and the project team will perform the work related to this Waste Assessment in an objective manner, even if the results are not favorable to the client;
- No circumstances may compromise the objectivity in performing this work;
- The specialists have expertise and are qualified in conducting the work related to this Waste Assessment;
- ACS undertake to disclose to the client all information in their possession that reasonably has or may have the potential of influencing any decision making;
- ACS has no, and will not engage in conflicting interests in the undertaking of this Waste Assessment;
- ACS does not have and will not have any vested interest (either business, financial, personal or other) in the clients business other than remuneration for work performed in terms of the regulations.

Name: Wiehan Swanepoel **Position:** Hydrogeologist **Date:** 12 August 2021

Signature: 

Name: Pieta Hoffman **Position:** Director / Hydrogeologist **Date:** 12 August 2021

Signature: 

Name: Koos Vivier **Position:** Managing Director / Senior Hydrogeologist **Date:** 12 August 2021

Signature: 

APPENDIX D: REDCO SAMPLING REPORT

TRANSALLOYS (PTY) LTD

ENGINEERING DESIGN AND REPORT FOR THE CLOSURE AND REHABILITATION OF THE FECR WASTE MANAGEMENT FACILITY AT TRANSALLOYS (PTY) LTD

Sample report

Project: TA007

21 June 2021

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1 INTRODUCTION

Transalloys is located approximately 14 km west of eMalahleni and approximately 90 km east of Pretoria. The scope of the works is to evaluate and design an appropriate closure of the FeCr dump which compliment the closure plan of the mine.

Figure 1: Transalloys Location

The FeCr Waste Management Facility is located between two larger facilities (see Figure 2). The FeCr Waste management facility has not been in use since 2008 and is a Geomembrane lined facility surrounded with an HDPE lined drain in which the underdrainage and penstock pipe discharges.

At the date of the sample, 10 June 2021, no water was seeping through the large pipes, assuming from the penstocks. Dripping from three (3) of the smaller pipes however were observed. It is assumed that the dripping is from the drainage pipes installed at the base of the facility on top of the liner.

Figure 2: FeCr Waste Management Facility Location

Figure 3: Large Penstock Pipes

Figure 4: Seeping drainage pipes

Figure 5: Seeping drainage pipe

In order to determine the appropriate capping for the closure of the FeCr Waste Management Facility, it is important to understand the waste classification, restraints and geometry of the facility. Sampling therefore was required to determine the waste classification and in turn the risk analysis for the design of a suitable closure capping.

2 SAMPLING

Samples were taken on 10 June 2021. Various samples from the toe and top of the facility were taken to represent a global overview of the facility and the various chemicals that could exist within the facility. Sampling of the tailings were extremely difficult to do by hand as the tailings has already consolidated to a very hard material which could not be easily excavated by hand. Machine equipment were not possible as no easy access to the facility exist and the facility is surrounded by a deep HDPE lined channel.

The sampling points are indicated in
Figure 6 below and the coordinates of the various samples is indicated in Table 2.

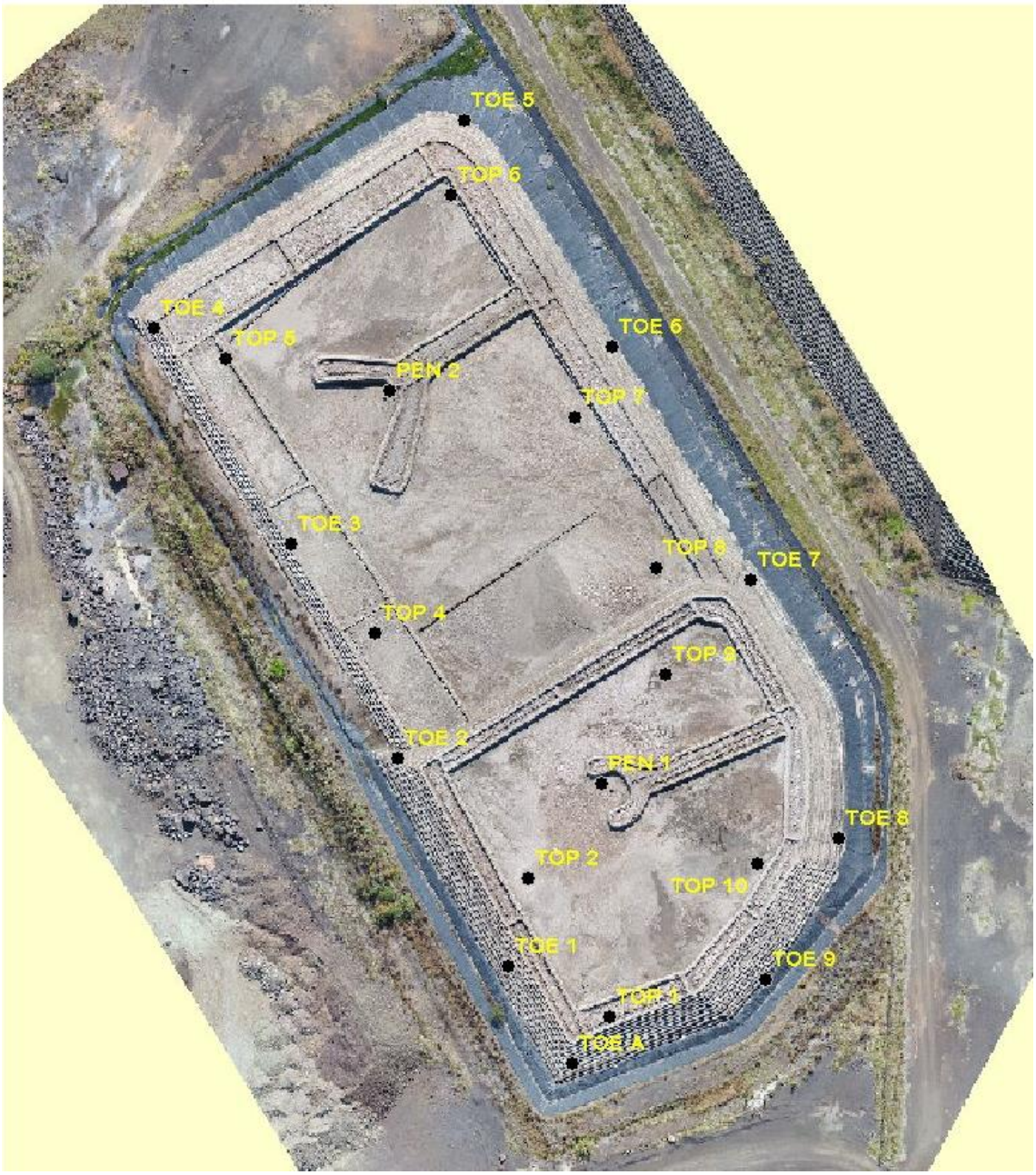


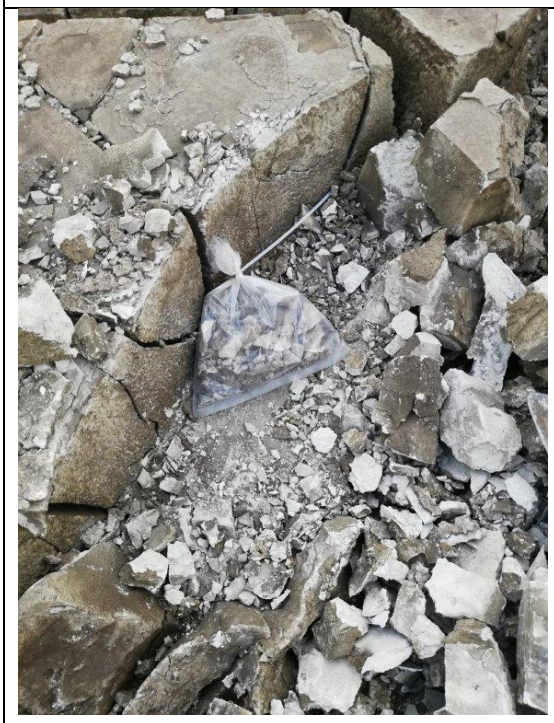
Figure 6: Sample locations

Table 1: Sample points and coordinates

Sample No.	Unique Sample Number	Coordinates		
		Y	X	Z
Top 1	TA007/TP01	25°53.433' S	29°07.392' E	1527
Top 2	TA007/TP02	25°53.420' S	29°07.353' E	1527
Top 3	TA007/TP03			
Top 4	TA007/TP04	25°53.396' S	29°07.337' E	1524
Top 5	TA007/TP05	25°53.370' S	29°07.321' E	1524
Top 6	TA007/TP06	25°53.355' S	29°07.345' E	1525
Top 7	TA007/TP07	25°53.376' S	29°07.358' E	1524
Top 8	TA007/TP08	25°53.390' S	29°07.367' E	1523
Top 9	TA007/TP09	25°53.400' S	29°07.368' E	1528
Top 10	TA007/TP10	25°53.418' S	29°07.378' E	1528
Toe 1	TA007/T01	25°53.428' S	29°07.351' E	1522
Toe 2	TA007/T02	25°53.408' S	29°07.339' E	1524
Toe 3	TA007/T03	25°53.388' S	29°07.328' E	1520
Toe 4	TA007/T04	25°53.367' S	29°07.314' E	1519
Toe 5	TA007/T05	25°53.348' S	29°07.347' E	1520
Toe 6	TA007/T06	25°53.369' S	29°07.362' E	1519
Toe 7	TA007/T07	25°53.391' S	29°07.377' E	1520
Toe 8	TA007/T08	25°53.416' S	29°07.386' E	1524
Toe 9	TA007/T09	25°53.429' S	29°07.378' E	1517

The table below indicate photographs of the sample hole for each of the samples taken.

Table 2: Photographs of sample points

Top 1	Top 2
	
Top 4	**Top 5**
	

Top 6	Top 7
	
Top 8	Top 9
	

Toe 1	Toe 2
	
Toe 3	Toe 4
	

Toe 5	Toe 6
	
Toe 7	Toe 8
	
Toe 9	

3 REQUIREMENTS

A waste classification and risk analysis are required to determine the appropriate capping design which is in line with the final closure plan. The samples are to be tested by Artesium Consulting Services (Pty) Ltd and a waste classification and risk analysis is to be provided according to the following objectives:

- Determine the geochemical characteristics of the tailings material that may impact the surrounding environment.
- Evaluate the hydrochemical monitoring data of the site.

The scope for the analysis includes the following:

- Handling and compositing representative tailings samples received from Redco Services.
- Analysis of 2 tailings representative samples (leach test, Closed vessel microwave digestion).
- Waste assessment in terms of current legislation (GNR 635 and GNR 636).
- Hydrochemical data analysis and incorporation thereof into the waste assessment on a risk based approach.
- GIS spatial analysis and maps
- Reporting