

Tronox Namakwa Sands, EOFS Waste Classification Study

Report Prepared for

Tronox Mineral Sands (Pty) Ltd



Report Number 548215



Report Prepared by



June 2020

Tronox Namakwa Sands, EOFS Waste Classification Study

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SRK Project Number 548215

June 2020

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Disclaimer

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1 Introduction and Scope of Report

Namakwa Sands is a heavy mineral sands mine operated by Tronox Mineral Sands (Pty) Ltd (Tronox). Namakwa Sands comprises the Mine at Brand-se-Baai (the Mine), a Mineral Separation Plant (MSP) near Koekenaap and a Smelter in Saldanha. The mine is split into a West Mine and an East Mine. Materials from both mines are processed at Primary Concentration Plants (PCP West and PCP East) to produce a heavy mineral concentrate (HMC), which is pumped to the Secondary Concentration Plant (SCP) which is also located at the Mine.

Waste products from primary processing at the PCP East include sand tailings (coarse material) and a finer residue called fines. Sand tailings are backfilled into the mining void(s), and residue is deposited in Residue Storage Facilities (RSFs). The East Mine is currently mining only the top Red Aeolian Sand (RAS) layer. However, Tronox is authorised to mine and process the deeper Orange Feldspathic Sand (OFS) resource underlying the RAS material at the East Mine. This project is called the East OFS (or EOFS) Project. In order for the East OFS Project to proceed, the PCP East must be upgraded, and the residue disposal plan modified. These modifications include the construction of Sand Tailings Facilities (STF's) and additional RSF for the fines.

In September 2019, Tronox appointed SRK Consulting (South Africa) (Pty) Ltd (SRK) to conduct a Waste Classification of the coarse Tailings and finer Fines materials which would be generated by the planned mining of the OFS deposit.

2 Scope of Work

The scope of work undertaken to classify the waste was as follows:

- Assist Tronox to prepare representative waste samples for chemical analysis;
- Submit samples to an appropriate laboratory for testing in accordance with the Waste Classification and Management Regulations (WCMR), Government Notice 634 (23 August 2013) and the Mineral and Petroleum Resources Development Act (Act 28 of 2002) (MPRDA);
- Interpret the laboratory results;
- Classify the waste in terms of the WCMR, Government Notice 634 (23 August 2013); and
- Prepare a report documenting the findings of the classification assessment and the design requirements of the disposal facility.

3 Waste Classification

Waste management in South Africa is currently governed by a number of pieces of legislation, including:

- The South African Constitution (Act 108 of 1996);
- The National Environmental Management Act (Act 107 of 1998);
- National Environmental Management: Waste Act, (Act 59 of 2008) (NEM:WA);
- Hazardous Substances Act (Act 5 of 1973);
- National Water Act (Act 36 of 1998); and
- MRPDA.

The Department of Environmental Affairs (DEA) revised the waste classification system in South Africa issued in terms of the NEM:WA. The WCMR were published in Government Gazette 634 on 23 August 2013. These regulations replaced the Minimum Requirements for Handling, Classification and Disposal of Waste (DWAF, 1998).

The NEM:WA was signed into an Act of Parliament in March 2009 and the Act took effect from 01 July 2009. In terms of NEM:WA, waste is divided into two classes based on the risk it poses - general waste and hazardous waste. The Act defines general and hazardous waste as follows:

- "General waste" means waste that does not pose an immediate hazard or threat to health or to the environment; and
- "Hazardous waste" means any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment.

In order to simplify, standardise or improve waste management in South Africa, the Minister of Environmental Affairs published the following regulations and National Norms & Standards in Government Gazette No 36784 dated 23 August 2013:

- R634 WCMR;
- R635 National Norms & Standards for the Assessment of Waste for Landfill Disposal; and
- R636 National Norms & Standards for Disposal of Waste to Landfill.

3.1 Application of the Waste Classification and Management Regulations

In terms of Regulation 7(2) of GN 635, the potential level of risk associated with disposal or downstream use of wastes must be assessed by following the prescribed and appropriate leach test protocols.

The procedures require the determination of both the Total Concentration (TC in mg/kg) and Leachable Concentration (LC in mg/L) of a particular contaminant in a waste to be assessed against the Total Concentration Thresholds (TCT) and the Leachable Concentration Thresholds (LCT) for particular contaminants in a waste. Various threshold levels for the TCT (TCT0, TCT1, TCT2) and LCT (LCT0, LCT1, LCT2 and LCT3) are provided which, in combination, determine the Risk Profile and corresponding waste types as set out below.

- **Type 4 Waste:** wastes with all determinand concentrations below the LCT0 and TCT0 values;
- **Type 3 Waste:** wastes with any determinand concentration above the LCT0 but below the LCT1 value and all determinand concentrations below the TCT1 values;
- **Type 2 Waste:** wastes with any determinand concentration above the LCT1 but below the LCT2 values, and all determinand concentrations below the TCT1 values;
- **Type 1 Waste:** wastes with any determinand concentration above the LCT2 but below the LCT3 values, or above the TCT1 but below the TCT2 values; and
- **Type 0 Waste:** wastes with any determinand concentration above the LCT3 or TCT2 values.

The waste type (Type 0 to 4) determined by the tests methodology described above is aligned with a set of minimum basal containment (liner) systems detailed in the GN 636 National Norms & Standards

for Disposal of Waste to Landfill to four landfill Classes. These landfill Classes (Class A, B, C and D) correspond to waste Types 0 to 4.

3.2 Application of the MRPDA

The MRPDA requires that waste streams from the mining sector be assessed for their chemical reactivity and stability. In the absence of national criteria, screening criteria prescribed by the Prediction Manual for Drainage Chemistry from Sulfidic Geological Materials (MEND, 2009) were used on the Acid Base Accounting (ABA) data to assess the potential for Acid Rock Drainage (ARD) generation. These classifications are based on the Modified Sobek ABA method and consider the Neutralisation Potential (NP)/Acid Potential (AP) ratio, which is also called the Net Potential Ratio (NPR). The criteria indicate the potential for ARD, and are based on NP/AP ratios as follows:

- **NP/AP < 1:** Potentially Acid Generating (PAG);
- **1 < NP/AP < 2:** Uncertain. Assuming no errors in the prediction of effective AP and NP, the maximum TNPR capable of generating ARD will be between 1 and 2. The classification of tests with TNPR between 1 and 2 may remain uncertain until the TNPR is refined by kinetic test;
- **NP/AP > 2:** Non-acid forming (NAF).

4 Methodology

4.1 Waste Sampling

Two samples, one of each of the waste materials were supplied to SRK by Tronox, following preparation by LDE. The samples were prepared to represent the conditions under which the material would be generated during normal operating conditions. No chemicals besides flocculant are used in processing. Seawater is, however used as process water, resulting in elevated salinity levels in waste streams. In addition, a sample of the local soil (non-ore material) was collected for comparative purposes by Tronox.

The samples were couriered to the SRK Cape Town office, where they were inspected, logged, homogenised prior to being split into the different laboratory aliquots.

4.2 Laboratory Methods

As defined in the Norms and Standards (GN 635), sub regulation 5(2a), wastes which will not be disposed of with putrescible waste (that contains organic matter capable of being decomposed by microorganisms) are to be leached in accordance with the Australian Standard Leaching Procedure (AS 4439.1, AS 4439.2 and AS 4439.3) using reagent water.

All analyses required for the classification of the waste samples in terms of GN 635 were submitted to by SANAS accredited Exova Jones Environmental Forensics in Somerset West. The acid base accounting and mineralogical analyses were performed by SANAS accredited M&L Laboratory Services in Johannesburg.

4.2.1 Acid-Base Accounting

The ABA test involves laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulfide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates). The values arising from the ABA are referred to as the Total Acid Potential (TAP) and the neutralisation potential (NP), respectively.

The TAP is calculated using the total sulfur content of the sample, where sulfide-sulfur is the only significant form of sulfur present. This calculation assumes that all of the sulfur measured in the sample occurs as pyrite (FeS_2) and that the pyrite reacts under oxidising conditions to generate acid.

By convention, the TAP is expressed as $\text{kg CaCO}_3/\text{t}$ to enable comparison with the NP and is calculated using the following formula: $\text{TAP (kg CaCO}_3/\text{t)} = (\text{total \%S}) \times 31.25$.

The use of the total sulfur to estimate the TAP is a conservative approach because some sulfur may occur in forms other than pyrite. Some sulfate-sulfur (e.g. gypsum) and native sulfur are non-acid generating sulfur forms, while other sulfate salts (e.g. jarosite) are acid generating.

The acid formed will react with acid neutralising minerals contained within the waste material to some extent. This inherent acid neutralisation is quantified in terms of the NP and was determined using the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react, and then titrated to pH 7.0 with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl . The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the TAP ($\text{kg CaCO}_3/\text{t}$).

The net-neutralisation potential (NNP) is a theoretical calculation commonly used to indicate if a material has the potential to produce acid. It represents the balance between the capacity of a sample to generate acid (TAP) and its capacity to neutralise acid (NP). The NNP is also expressed in units of $\text{kg CaCO}_3/\text{t}$ and is calculated as follows:

$$\text{NNP} = \text{TAP} - \text{NP}$$

If the TAP is less than the NP then the NNP is negative, which indicates that the sample may have sufficient NP to prevent acid generation. Conversely, if the TAP exceeds the NP then the NNP is positive, which indicates that the material may be acid generating.

The NP/TAP ratio is referred to as the Neutralisation Potential Ratio (NPR) and is used as a means of assessing the risk of acid generation from mine waste materials. A NPR <1 indicates potential acid generating material, and a NPR >1 indicates a NP exceeding TAP. Generally, a NPR of >3 indicates that there is a high probability that the material is not acid generating.

4.2.2 X-Ray Diffraction

The representative sample was milled in a tungsten carbide vessel and prepared according to the standardized PANalytical backloading system, which provides nearly random distribution of the particles.

The sample was analysed using a PANalytical X'Pert Pro powder diffractometer in $\theta - \theta$ configuration with an X'Celerator detector and variable divergence- and receiving slits with Fe filtered Co-K α radiation ($\lambda=1.789\text{\AA}$). The phases were identified using X'Pert Highscore plus software.

The relative phase amounts (weight per cent) were estimated using the Rietveld method (Autoquan Program). Amorphous phases, if present were not taken into consideration in the quantification.

5 Waste Assessment Results

5.1 Whole Rock Geochemistry

Elemental composition was carried out to identify the metals and metalloids in the tailings, fines and background soil samples. The purpose of these analyses is to quantify the total metal content of the material, and thereby determine the enrichment of potentially environmentally sensitive elements. It must be noted that the presence of a potential element of concern does not necessarily indicate a

potential impact on the receiving environment; however, it does indicate where to focus needs when assessing the potential for metal mobility.

One measure of enrichment of elements in the samples is the Geochemical Abundance Index (GAI). The GAI compares the actual concentration of an element in a sample with the median abundance for that element in the most relevant media (such as crustal abundance, soils or a particular rock type). The main purpose of the GAI is to provide an indication of any elemental enrichment that may be of environmental importance. The results of the whole rock analysis were compared to the average crustal abundance data of (Bowen, 1979) and (Berkman, 1976) and (Kabata-Pendias, 2001) for Boron.

The GAI is calculated from the following formula:

$$GAI = \log_2(C_n / 1.5 * B_n)$$

Where C_n is the concentration of the element in the sample and B_n is the crustal abundance of that element. The GAI values are truncated to integer increments 0 through to 6. A GAI of 0 indicates the element is present at a concentration similar to, or less than, the median abundance and a GAI of 6 indicates approximately a 100-fold, or greater, enrichment above median abundance. As a general guide, a GAI of 3 or above is considered significant, and such enrichment may warrant further examination to understand whether the concentrations present are mobile and, as such, represent a risk if leached into either surface water or groundwater.

The elemental composition and corresponding GAI values compared to global median soil values for the tailings, fines and background soil are given in **Error! Reference source not found..** Chromium, boron and zinc are enriched in the fines material, although this is largely a function of the relative distribution of the elements between the coarser grained tailings and fines (the relative enrichment of the fines corresponds to lower concentrations in the tailings). Notwithstanding the above, the GAI for these elements is 1, indicating a slight increase and is not considered significant.

Table 5-1: Trace Element Composition and GAI for the Tailings, Fines and Background Soil

	Global Soil median	FINES		TAILINGS		BGK Soil	
	mg/kg	Conc. mg/kg	GAI	Conc. mg/kg	GAI	Conc. mg/kg	GAI
Antimony	5	2	0	<1	0	<1	0
Arsenic	6	6.1	0	0.6	0	1.7	0
Barium	500	167	0	10	0	37	0
Cadmium	0.35	<0.1	0	<0.1	0	<0.1	0
Chromium	70	362.4	1	89.1	0	170.3	0
Cobalt	8	15.6	0	1.4	0	6.8	0
Copper	30	12	0	6	0	3	0
Lead	35	85	0	6	0	<5	0
Manganese	1000	991	0	57	0	290	0
Mercury	0.06	<0.1	0	<0.1	0	<0.1	0
Molybdenum	2	0.3	0	0.3	0	<0.1	0
Nickel	50	47.9	0	3.9	0	16	0
Selenium	0.4	<1	0	<1	0	<1	0
Vanadium	90	202	0	16	0	67	0
Boron	15	69.68	1	3.8	0	18.3	0
Zinc	90	305	1	18	0	21	0

5.2 Acid Base Accounting

Sulfide-sulfur is the primary source of acid, acidity and potentially deleterious elemental species (including mobilisation thereof in an acidic environment) in the drainage from the mining wastes. As

XRD analyses confirm the presence of sulfate phases, the total S concentration has been corrected for the concentration of sulfate -sulfur reported in the leachate analyses, with the concentration of sulfide sulfur being calculated by difference. The total acid potential (TAP) has been calculated using the concentration of sulfide sulfur.

The ABA analysis indicates the relative proportions of acid generating (TAP) and acid neutralising (NP) components of a sample. The results of the ABA tests are given in Table 5-2.

Table 5-2: Results of the ABA Analysis

Sample ID	Total S (%)	Sulfate S (%)	Sulfide S (%)	TAP CaCO ₃ kg/t	NP CaCO ₃ kg/t	NNP CaCO ₃ kg/t	NPR
FINES	0.37	0.15	0.22	6.81	38.00	31.19	5.580
TAILINGS	0.04	0.02	0.02	0.49	2.12	1.63	4.290

The neutralisation potential of the tailings material has been measured at 2.12 kg CaCO₃/t while the fines reported a neutralisation potential of 38.0 kg CaCO₃/t, resulting in a Net Neutralisation Potential (NNP) of 1.63 and 31.19 kg CaCO₃/t for the tailings and fines materials respectively.

Based on the NPR of >4 for the both the tailings and fines, these materials are both classified as **non-acid forming**.

5.3 Mineralogical Composition

The results of the X-Ray Diffraction (XRD) analysis are presented in Table 5-3. These results confirm that the major mineral phase present in the tailings are quartz and feldspars (microcline and plagioclase) as expected for a feldspathic sand. Halite is also identified as being present, although this reflects the use of seawater in the mineral separation process and is not likely to be present in the ore itself.

The mineralogy of the fines comprises quartz and clay minerals muscovite and kaolinite with minor basanite and goethite. Basanite, a calcium sulfate phase, is expected given arid environment and accumulation of soluble salts in the soil profile. Halite, was again identified in the sample, but at significantly high concentrations, reflecting the greater water retention in the fines material.

No minerals were identified which are commonly associated with chemically reactive or prone to oxidation and generation of acidic leachate. The only phase identified in the tailings samples which is associated with saline leachate is halite (sea salt). Halite is not present in the tailings material as discharged, but is reported in the mineralogical results as it is formed during the drying of the residual sea water saturated sample as part of the preparation procedure for XRD analyses.

These results of the mineralogical analysis confirm that the tailings material comprises of a **relatively inert mineral assemblage**.

Table 5-3: Results of the XRD Analysis

Sample id	Ideal formula	FINES	TAILINGS
Bassanite	$\text{CaSO}_4 \cdot \frac{1}{2}(\text{H}_2\text{O})$	1.42	-
Goethite	$\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$	1.55	-
Halite	NaCl	24.5	1.22
Kaolinite	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$	26.92	-
Microcline	KAlSi_3O_8	-	1.78
Muscovite	$\text{KAl}_3\text{Si}_3\text{O}_{10}(\text{OH})_2$	13.98	-
Plagioclase	$(\text{Na,Ca})(\text{Si,Al})_4\text{O}_8$	-	2.28
Quartz	SiO_2	31.63	94.72

5.4 Norms and Standards (GN 635)

The abridged results of the total and leachate analyses of the waste sample is given in Table 5-4 with the corresponding TCT and LCT levels. No target organic compounds were detected in either the total or leachate analyses for both samples. The unabridged analytical certificates are appended in Appendix A.

The results of the tailings analyses show that:

- The total concentrations of all determinands are below the respective TCT0 threshold concentrations; and
- The leachate concentrations of all determinands are below the respective LCT0 threshold concentrations.

The results of the fines analyses show that:

- The total concentrations of As, Ba, Pb, V and Zn exceed the TCT0 threshold concentrations but are below the TCT1 thresholds.
- The total concentrations of all other determinands are below the respective TCT0 threshold concentrations.
- The leachate concentrations of TDS and Cl exceed the LCT0 thresholds but are below the LCT1 thresholds.
- The leachable concentrations of all other determinands are below the respective LCT0 threshold concentrations.

The concentration of the arsenic, barium, lead, vanadium and zinc are all enriched in the fine fraction of the ore sands, and marginally exceed their respective TCT0 thresholds. The TCT0 thresholds have been obtained from the South African Norms and Standards for the management of Contaminated Land Soil Screening Values (SSV1) for the protection of potable water resources. The calculation of these SSV1 values assumes a potable water use within 100 m of the 'source' and accounts for groundwater soil leachate dilution factor of 20 and a conservative partition coefficient for the retardation of the determinand. The results of the leachate analyses provide a site-specific methodology for the calculation of the risk to groundwater resources.

The leachate concentrations for all these determinands are below the LCT0 thresholds, which are set equal to the South African drinking water standards. The leachate concentration data therefore confirms that, notwithstanding the total concentrations reported in the fines material, the leachate poses no unacceptable risks to potential human health via groundwater ingestion.

The concentrations of B, TDS and Cl in the leachate all exceed the LCT0 thresholds and are indicative of the contribution of the use of seawater¹ to the leachate generated by the fines material. The leachate concentrations are consistent with the results of the mineralogical analyses and geological environment, indicative of geochemically stable residual minerals.

Based on the results of the total and leachate concentrations reported, the tailings are classified as a **Type 4 Waste** while the **fines are classified as Type 3 Waste**.

Table 5-4 : Abridged Total and Leachate Concentration Results (all data in mg/kg)

Lab number	FINES		TAILINGS		BGK Soil		LCT0 mg/l	LCT1 mg/l	TCT0 mg/kg	TCT1 mg/kg
	TC	LC	TC	LC	TC	LC				
Antimony, Sb	2.00	<0.002	<1.00	<0.002	<1.00	<0.002	0.02	1.0	10	75
Arsenic, As	6.1	<0.003	0.60	0.004	1.70	0.004	0.01	0.5	5.8	500.0
Barium, Ba	167.0	0.090	10.00	0.013	37.00	0.027	0.7	35	63	6 250
Cadmium, Cd	<0.10	<0.001	<0.10	<0.001	<0.10	<0.001	0.003	0.15	7.5	260
Chromium (total)	362.40	0.004	89.10	0.002	170.30	0.004	0.05	2.5	46 000	800 000
Chromium (VI)	<0.30	<0.006	<0.30	<0.006	<0.30	<0.006	0.05	2.5	6.50	500
Cobalt, Co	15.60	<0.002	1.40	<0.002	6.80	<0.002	0.50	25	50	5 000
Copper, Cu	12.00	<0.007	6.00	0.020	3.00	<0.007	2.0	100	16.0	19 500
Lead, Pb	85.0	<0.005	6.00	<0.005	<5.00	<0.005	0.01	0.5	20	1 900
Manganese, Mn	991.00	0.231	57.00	0.038	290.00	0.025	0.50	25.0	1 000	25 000
Mercury, Hg	<0.10	<0.001	<0.10	<0.001	<0.10	<0.001	0.01	0.30	0.93	160
Molybdenum, Mo	0.30	<0.002	0.30	<0.002	<0.10	<0.002	0.07	3.5	40	1 000
Nickel, Ni	47.90	0.009	3.90	<0.002	16.00	<0.002	0.07	3.5	91	10 600
Selenium, Se	<1.00	<0.003	<1.00	<0.003	<1.00	<0.003	0.01	0.5	10	50
Vanadium, V	202.0	0.003	16.00	0.002	67.00	0.003	0.2	10	150	2 680
Boron	69.68	0.8	3.80	0.064	18.30	0.125	0.5	25	150	15 000
Zinc, Zn	305.0	0.988	18.00	0.158	21.00	0.009	5.0	250	240	160 000
TDS		1 374.0		437.00		168.000	1 000	12 500	-	-
Sulfate, SO ₄		228.30		36.30		20.600	250	12 500	-	-
Chloride, Cl		1 683.1		206.50		52.400	300	15 000	-	-
Nitrate as N		0.17		<0.05		0.080	11	550	-	-
Fluoride, F	4.60	<0.30	0.60	<0.30	1.30	<0.300	1.50	75	100	10 000
Cyanide, CN	<0.50	<0.01	<0.50	<0.01	<0.50	<0.010	0.07	3.5	14	10 500

5.5 Waste Cell Liner Requirements for Disposal

The standard containment barrier design and landfill disposal requirements for different waste types are detailed in the R636 National Norms & Standards for Disposal of Waste to Landfill. According to these requirements, the tailings material needs to be disposed of to a Class D landfill, designed in accordance with sub regulation 3(1)(a) of GN 636, as shown in Figure 5-1.

This class of landfill does not require an engineered synthetic liner or compacted clay layer. The design requirement is limited to the preparation of a 150 mm thick base layer.

The fines material needs to be disposed of to a Class C landfill, designed in accordance with sub regulation 3(1)(a) of GN 636, as shown in Figure 5-2.

¹ The concentration of B in seawater is typically between 4 – 5 mg/L

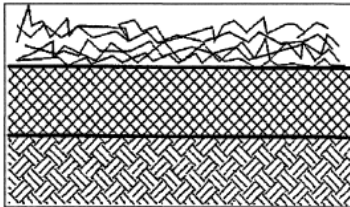

 <p>Waste body</p> <p>150mm Base preparation layer</p> <p>In situ soil</p>		
	EOFS Waste Classification Class D Landfill Design (Tailings)	Project No. 507228

Figure 5-1: Class D Inert Landfill Barrier Design (GN 636)

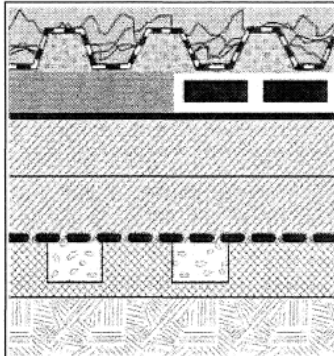

 <p>Waste body</p> <p>300 mm thick finger drain of geotextile covered aggregate</p> <p>100 mm Protection layer of silty sand or a geotextile of equivalent performance</p> <p>1,5 mm thick HDPE geomembrane</p> <p>300 mm clay liner (of 2 X 150 mm thick layers)</p> <p>Under drainage and monitoring system in base preparation layer</p> <p>In situ soil</p>		
	EOFS Waste Classification Class C Landfill Design (Fines)	Project No. 507228

Figure 5-2: Class C Inert Landfill Barrier Design (GN 636)

6 Conclusions and Recommendations

Based on the above results of the chemical and mineralogical characterisation the following conclusions are drawn:

- The GAI of all determinands in the Tailings and Fines are <3 and are therefore not considered to be significantly enriched relative to global soil mean or a sample of the local background soil.
- The GAI of 1 reported for chromium, boron and zinc in the fines material are largely a function of the relative distribution of the elements between the coarser grained tailings and fines (the relative enrichment of the fines corresponds to lower concentrations in the tailings).
- The mineralogy of the tailings and fines comprises a geochemically stable mineral assemblage.

Based on the results of the waste assessment in terms of the Norms & Standards for the Assessment of Waste for Landfill Disposal (GN 635), and requirements of the MRPDA regarding waste reactivity:

- The tailings material from the proposed EOFS expansion project is non-acid generating, inert, and classified as Type 4 waste.
- The tailings material needs to be disposed of to a Class D landfill (designed in accordance with sub regulation 3(1)(a) of GN 636), which does not require an engineered synthetic liner or compacted clay layer.
- The fines material from the proposed EOFS expansion project is non-acid generating, inert, and classified as Type 3 waste, due the elevated leachate concentrations of Cl, TDS and B.
- The fines material needs to be disposed of to a Class C landfill (designed in accordance with sub regulation 3(1)(a) of GN 636).

Stemming from these conclusions, the following recommendation is made:

- Based on the geochemical classification of both the tailings and fines material as inert, non-acid forming and with the GAI indicating no significant enrichment relative to the global soil median concentrations, a risk-based approach be followed to motivate for an alternative liner design for these facilities which would be protective of the groundwater resource.

Prepared by

SRK Consulting - Certified Electronic Signature

 548215/43992/Report
 7451-1554-3789-OBRI-12/06/2020
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Richard O'Brien M.SC. *Pr. Sci. Nat.*
 Principal Environmental Geochemist

Reviewed by

SRK Consulting - Certified Electronic Signature

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 7083-8638-6016-ENGE-12/06/2020
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Bruce Engelsman *Pr.Eng.Pr.CPM*
 Partner

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

Appendices

Appendix A: Analytical Certificates

SRK Consulting
Admin Building
Albion Spring
183 Main Road
Rondebosch 7700
South Africa

Attention :	Richard O'Brien
Date :	7th January, 2020
Your reference :	TRONOX MINE
Our reference :	Test Report 19/20946 Batch 1
Location :	Tronox, Brand Se Baai
Date samples received :	20th December, 2019
Status :	Final report
Issue :	1

Three samples were received for analysis on 20th December, 2019 of which three were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.

All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Analysis was undertaken at either Element Materials Technology UK, which is ISO 17025 accredited under UKAS (4225) or Element Materials Technology (SA) which is ISO 17025 accredited under SANAS (T0729) or a subcontract laboratory where specified.

NOTE: Under International Laboratory Accreditation Cooperation (ILAC), ISO 17025 (UKAS) accreditation is recognised as equivalent to SANAS (South Africa) accreditation.

Authorised By:



Simon Gomery BSc

Project Manager

Please include all sections of this report if it is reproduced

Element Materials Technology

Client Name: SRK Consulting
Reference: TRONOX MINE
Location: Tronox, Brand Se Baai
Contact: Richard O'Brien
EMT Job No: 19/20946

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

EMT Sample No.	1-2	3-4	5-6								Please see attached notes for all abbreviations and acronyms		
Sample ID	SLIMES TP1	TAILINGS TP1	EAST OFS TP1										
Depth													
COC No / misc													
Containers	J	J	J										
Sample Date	13/12/2019	13/12/2019	13/12/2019										
Sample Type	Soil	Soil	Soil										
Batch Number	1	1	1										
Date of Receipt	20/12/2019	20/12/2019	20/12/2019								LOD/LOR	Units	Method No.
Antimony	2	<1	<1								<1	mg/kg	TM30/PM15
Arsenic #	6.1	0.6	1.7								<0.5	mg/kg	TM30/PM15
Barium #	167	10	37								<1	mg/kg	TM30/PM15
Cadmium #	<0.1	<0.1	<0.1								<0.1	mg/kg	TM30/PM15
Chromium #	362.4 ^{AB}	89.1	170.3								<0.5	mg/kg	TM30/PM15
Cobalt #	15.6	1.4	6.8								<0.5	mg/kg	TM30/PM15
Copper #	12	6	3								<1	mg/kg	TM30/PM15
Lead #	85	6	<5								<5	mg/kg	TM30/PM15
Manganese #	991	57	290								<1	mg/kg	TM30/PM15
Mercury #	<0.1	<0.1	<0.1								<0.1	mg/kg	TM30/PM15
Molybdenum #	0.3	0.3	<0.1								<0.1	mg/kg	TM30/PM15
Nickel #	47.9	3.9	16.0								<0.7	mg/kg	TM30/PM15
Selenium #	<1	<1	<1								<1	mg/kg	TM30/PM15
Vanadium	202	16	67								<1	mg/kg	TM30/PM15
Boron (Aqua Regia Soluble)	69.68	3.80	18.30								<0.25	mg/kg	TM30/PM15
Zinc #	305	18	21								<5	mg/kg	TM30/PM15
VOC MS													
Chlorobenzene #	<3	<3	-								<3	ug/kg	TM15/PM10
Methyl Tertiary Butyl Ether #	<2	<2	-								<2	ug/kg	TM15/PM10
Benzene #	<3	<3	-								<3	ug/kg	TM15/PM10
Toluene #	<3	<3	-								<3	ug/kg	TM15/PM10
Ethylbenzene #	<3	<3	-								<3	ug/kg	TM15/PM10
Xylenes (sum of isomers) #	<8	<8	-								<8	ug/kg	TM15/PM10
1,2-Dichlorobenzene #	<4	<4	-								<4	ug/kg	TM15/PM10
1,4-Dichlorobenzene #	<4	<4	-								<4	ug/kg	TM15/PM10
1,1-Dichloroethene (1,1 DCE) #	<6	<6	-								<6	ug/kg	TM15/PM10
1,2-Dichloroethane (1,2 DCA) #	<4	<4	-								<4	ug/kg	TM15/PM10
1,2-Dichloroethene (cis & trans) #	<6	<6	-								<6	ug/kg	TM15/PM10
1,1,1-Trichloroethane #	<3	<3	-								<3	ug/kg	TM15/PM10
1,1,2-Trichloroethane #	<3	<3	-								<3	ug/kg	TM15/PM10
1,1,1,2-Tetrachloroethane #	<3	<3	-								<3	ug/kg	TM15/PM10
1,1,2,2-Tetrachloroethane #	<3	<3	-								<3	ug/kg	TM15/PM10
Trichlorobenzenes (1,2,3 & 1,2,4) #	<14	<14	-								<14	ug/kg	TM15/PM10
Carbon tetrachloride #	<4	<4	-								<4	ug/kg	TM15/PM10
Chloroform #	<3	<3	-								<3	ug/kg	TM15/PM10
Dichloromethane (DCM) #	<30	<30	-								<30	ug/kg	TM15/PM10
Methyl Ethyl Ketone (MEK)	<100	<100	-								<100	ug/kg	TM15/PM10
Styrene	<3	<3	-								<3	ug/kg	TM15_A/PM10
Tetrachloroethene (PCE) #	<3	<3	-								<3	ug/kg	TM15/PM10
Trichloroethene (TCE) #	<3	<3	-								<3	ug/kg	TM15/PM10
Vinyl Chloride	<2	<2	-								<2	ug/kg	TM15_A/PM10

Element Materials Technology

Client Name: SRK Consulting
Reference: TRONOX MINE
Location: Tronox, Brand Se Baai
Contact: Richard O'Brien
EMT Job No: 19/20946

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

EMT Sample No.	1-2	3-4	5-6								Please see attached notes for all abbreviations and acronyms		
Sample ID	SLIMES TP1	TAILINGS TP1	EAST OFS TP1										
Depth													
COC No / misc													
Containers	J	J	J										
Sample Date	13/12/2019	13/12/2019	13/12/2019										
Sample Type	Soil	Soil	Soil										
Batch Number	1	1	1										
Date of Receipt	20/12/2019	20/12/2019	20/12/2019								LOD/LOR	Units	Method No.
EPH (C10-C36)	<10	<10	-								<10	mg/kg	TM5/PM8
GRO C6-C9	<0.1	<0.1	-								<0.1	mg/kg	TM36/PM12
PCBs (Total vs Aroclor 1254)	<10	<10	-								<10	ug/kg	TM17/PM8
Total Phenols HPLC	<0.15	<0.15	-								<0.15	mg/kg	TM26/PM21
Natural Moisture Content	284.5	25.4	0.8								<0.1	%	PM4/PM0
Moisture Content (% Wet Weight)	74.0	20.2	0.8								<0.1	%	PM4/PM0
Fluoride	4.6	0.6	1.3								<0.3	mg/kg	TM173/PM20
Hexavalent Chromium [#]	<0.3	<0.3	<0.3								<0.3	mg/kg	TM38/PM20
Total Cyanide [#]	<0.5	<0.5	<0.5								<0.5	mg/kg	TM89/PM45
Phenols													
2,4,6-Trichlorophenol	<10	<10	-								<10	ug/kg	TM16/PM8
2,4-Dichlorophenol [#]	<10	<10	-								<10	ug/kg	TM16/PM8
2-Chlorophenol [#]	<10	<10	-								<10	ug/kg	TM16/PM8
PAHs													
Benzo(a)pyrene	<10	<10	-								<10	ug/kg	TM16/PM8
PAH 16 Total	<150	<150	-								<150	ug/kg	TM16/PM8
Phthalates													
Bis(2-ethylhexyl) phthalate	<100	<100	-								<100	ug/kg	TM16/PM8
Other semi volatiles													
2,4-Dinitrotoluene	<10	<10	-								<10	ug/kg	TM16/PM8
Hexachlorobutadiene [#]	<10	<10	-								<10	ug/kg	TM16/PM8
Nitrobenzene [#]	<10	<10	-								<10	ug/kg	TM16/PM8
Formaldehyde (water soluble)	<2	<2	-								<2	mg/kg	TM51/PM12

Element Materials Technology

Client Name: SRK Consulting
Reference: TRONOX MINE
Location: Tronox, Brand Se Baai
Contact: Richard O'Brien
EMT Job No: 19/20946

Report : ASLP (20:1)-Acetate pH 5 or 2.9

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

EMT Sample No.	1-2	3-4	5-6								Please see attached notes for all abbreviations and acronyms		
Sample ID	SLIMES TP1	TAILINGS TP1	EAST OFS TP1										
Depth													
COC No / misc													
Containers	J	J	J										
Sample Date	13/12/2019	13/12/2019	13/12/2019										
Sample Type	Soil	Soil	Soil										
Batch Number	1	1	1										
Date of Receipt	20/12/2019	20/12/2019	20/12/2019								LOD/LOR	Units	Method No.
Dissolved Antimony	<2	<2	<2								<2	ug/l	TM30/PM14
Dissolved Arsenic	<2.5	3.8	3.9								<2.5	ug/l	TM30/PM14
Dissolved Barium	90	13	27								<3	ug/l	TM30/PM14
Dissolved Boron	846	64	125								<12	ug/l	TM30/PM14
Dissolved Cadmium	<0.5	<0.5	<0.5								<0.5	ug/l	TM30/PM14
Dissolved Chromium	3.6	1.8	3.7								<1.5	ug/l	TM30/PM14
Dissolved Cobalt	<2	<2	<2								<2	ug/l	TM30/PM14
Dissolved Copper	<7	20	<7								<7	ug/l	TM30/PM14
Dissolved Lead	<5	<5	<5								<5	ug/l	TM30/PM14
Dissolved Manganese	231	38	25								<2	ug/l	TM30/PM14
Dissolved Mercury	<1	<1	<1								<1	ug/l	TM30/PM14
Dissolved Molybdenum	<2	<2	<2								<2	ug/l	TM30/PM14
Dissolved Nickel	9	<2	<2								<2	ug/l	TM30/PM14
Dissolved Selenium	<3	<3	<3								<3	ug/l	TM30/PM14
Dissolved Vanadium	3.0	2.4	2.8								<1.5	ug/l	TM30/PM14
Dissolved Zinc	988	158	9								<3	ug/l	TM30/PM14
EPH (C10-C36)	<10	<10	-								<10	ug/l	TM5/PM30
GRO (C6-C9)			-								<100	ug/l	TM36/PM88

Element Materials Technology

Client Name: SRK Consulting
Reference: TRONOX MINE
Location: Tronox, Brand Se Baai
Contact: Richard O'Brien
EMT Job No: 19/20946

Report : ASLP (20:1)-Acetate pH 5 or 2.9

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

EMT Sample No.	1-2	3-4	5-6								Please see attached notes for all abbreviations and acronyms		
Sample ID	SLIMES TP1	TAILINGS TP1	EAST OFS TP1										
Depth													
COC No / misc													
Containers	J	J	J										
Sample Date	13/12/2019	13/12/2019	13/12/2019										
Sample Type	Soil	Soil	Soil										
Batch Number	1	1	1										
Date of Receipt	20/12/2019	20/12/2019	20/12/2019								LOD/LOR	Units	Method No.
VOC MS													
Methyl Tertiary Butyl Ether	<0.1	<0.1	-								<0.1	ug/l	TM15/PM88
Vinyl Chloride	<0.1	<0.1	-								<0.1	ug/l	TM15/PM88
1,1-Dichloroethene (1,1 DCE)	<3	<3	-								<3	ug/l	TM15/PM88
Dichloromethane (DCM)	<20	<20	-								<20	ug/l	TM15/PM88
1,2-Dichloroethene (cis & trans)	<6	<6	-								<6	ug/l	TM15/PM88
Chloroform	<2	<2	-								<2	ug/l	TM15/PM88
1,1,1-Trichloroethane	<2	<2	-								<2	ug/l	TM15/PM88
Carbon tetrachloride	<2	<2	-								<2	ug/l	TM15/PM88
1,2-Dichloroethane	<2	<2	-								<2	ug/l	TM15/PM88
Benzene	<0.5	<0.5	-								<0.5	ug/l	TM15/PM88
Trichloroethene (TCE)	<3	<3	-								<3	ug/l	TM15/PM88
Toluene	<5	<5	-								<5	ug/l	TM15/PM88
1,1,2-Trichloroethane	<2	<2	-								<2	ug/l	TM15/PM88
Tetrachloroethene (PCE)	<3	<3	-								<3	ug/l	TM15/PM88
Chlorobenzene	<2	<2	-								<2	ug/l	TM15/PM88
1,1,1,2-Tetrachloroethane	<2	<2	-								<2	ug/l	TM15/PM88
Ethylbenzene	<1	<1	-								<1	ug/l	TM15/PM88
Xylenes (sum of isomers)	<3	<3	-								<3	ug/l	TM15/PM88
Styrene	<2	<2	-								<2	ug/l	TM15/PM88
1,1,2,2-Tetrachloroethane	<4	<4	-								<4	ug/l	TM15/PM88
1,4-Dichlorobenzene	<3	<3	-								<3	ug/l	TM15/PM88
1,2-Dichlorobenzene	<3	<3	-								<3	ug/l	TM15/PM88
Trichlorobenzenes (1,2,3 & 1,2,4)	<6	<6	-								<6	ug/l	TM15/PM88
Methyl Ethyl Ketone (MEK)	<100	<100	-								<100	ug/l	TM15/PM88
SVOC MS													
Phenols													
2-Chlorophenol	<3 _{AA}	<3 _{AA}	-								<1	ug/l	TM16/PM30
2,4-Dichlorophenol	<1.5 _{AA}	<1.5 _{AA}	-								<0.5	ug/l	TM16/PM30
2,4,6-Trichlorophenol	<3 _{AA}	<3 _{AA}	-								<1	ug/l	TM16/PM30
PAHs													
Benzo(a)pyrene	<3 _{AA}	<3 _{AA}	-								<1	ug/l	TM16/PM30
PAH 16 Total	<30 _{AA}	<30 _{AA}	-								<10	ug/l	TM16/PM30
Phthalates													
Bis(2-ethylhexyl) phthalate	<15 _{AA}	<15 _{AA}	-								<5	ug/l	TM16/PM30
Other SVOCs													
2,4-Dinitrotoluene	<1.5 _{AA}	<1.5 _{AA}	-								<0.5	ug/l	TM16/PM30
Hexachlorobutadiene	<3 _{AA}	<3 _{AA}	-								<1	ug/l	TM16/PM30
Nitrobenzene	<3 _{AA}	<3 _{AA}	-								<1	ug/l	TM16/PM30
PCBs (Total vs Aroclor 1254)	<0.2	<0.2	-								<0.2	ug/l	TM17/PM30

Element Materials Technology

Client Name: SRK Consulting
Reference: TRONOX MINE
Location: Tronox, Brand Se Baai
Contact: Richard O'Brien
EMT Job No: 19/20946

Report : ASLP (20:1)-Acetate pH 5 or 2.9

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

[illegible]

Client Name: SRK Consulting
Reference: TRONOX MINE
Location: Tronox, Brand Se Baai
Contact: Richard O'Brien

[illegible]

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating. Only analyses which are accredited are recorded as deviating if set criteria are not met.

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

EMT Job No.: 19/20946

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Limits of detection for analyses carried out on as received samples are not moisture content corrected. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Sufficient amount of sample must be received to carry out the testing specified. Where an insufficient amount of sample has been received the testing may not meet the requirements of our accredited methods, as such accreditation may be removed.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overestimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. The temperature of sample receipt is recorded on the confirmation schedules in order that the client can make an informed decision as to whether testing should still be undertaken.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.

Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

Please include all sections of this report if it is reproduced

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

Measurement Uncertainty

Measurement uncertainty defines the range of values that could reasonably be attributed to the measured quantity. This range of values has not been included within the reported results. Uncertainty expressed as a percentage can be provided upon request.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
>>	Results above calibration range, the result should be considered the minimum value. The actual result could be significantly higher, this result is not accredited.
*	Analysis subcontracted to an Element Materials Technology approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range
AA	x3 Dilution

AB	x5 Dilution
----	-------------

EMT Job No: 19/20946

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/S ANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
PM4	Gravimetric measurement of Natural Moisture Content and % Moisture Content at either 35°C or 105°C. Calculation based on ISO 11465 and BS1377.	PM0	No preparation is required.			AR	
TM5	Modified 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) within the range C8-C40 by GCFID. For waters the solvent extracts dissolved phase plus a sheen if present.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.			AR	No
TM5	Modified 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) within the range C8-C40 by GCFID. For waters the solvent extracts dissolved phase plus a sheen if present.	PM8	End over end extraction of solid samples for organic analysis. The solvent mix varies depending on analysis required.			AR	Yes
TM15	Modified USEPA 8260. Quantitative Determination of Volatile Organic Compounds (VOCs) by Headspace GC-MS.	PM10	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.			AR	Yes
TM15	Modified USEPA 8260. Quantitative Determination of Volatile Organic Compounds (VOCs) by Headspace GC-MS.	PM10	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes		AR	Yes
TM15	Modified USEPA 8260. Quantitative Determination of Volatile Organic Compounds (VOCs) by Headspace GC-MS.	PM88	A 20:1 ratio of deionised water to as received soil, is leached for 18 hours with zero headspace.			AR	No
TM16	Modified USEPA 8270. Quantitative determination of Semi-Volatile Organic compounds (SVOCs) by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.			AR	No
TM16	Modified USEPA 8270. Quantitative determination of Semi-Volatile Organic compounds (SVOCs) by GC-MS.	PM8	End over end extraction of solid samples for organic analysis. The solvent mix varies depending on analysis required.			AR	Yes
TM16	Modified USEPA 8270. Quantitative determination of Semi-Volatile Organic compounds (SVOCs) by GC-MS.	PM8	End over end extraction of solid samples for organic analysis. The solvent mix varies depending on analysis required.	Yes		AR	Yes
TM17	Modified US EPA method 8270. Determination of specific Polychlorinated Biphenyl congeners by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.			AR	No

EMT Job No: 19/20946

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/ANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM17	Modified US EPA method 8270. Determination of specific Polychlorinated Biphenyl congeners by GC-MS.	PM8	End over end extraction of solid samples for organic analysis. The solvent mix varies depending on analysis required.			AR	Yes
TM20	Modified BS 1377-3: 1990/USEPA 160.3 Gravimetric determination of Total Dissolved Solids/Total Solids	PM0	No preparation is required.			AR	No
TM26	Determination of phenols by Reversed Phased High Performance Liquid Chromatography and Electro-Chemical Detection.	PM0	No preparation is required.			AR	No
TM26	Determination of phenols by Reversed Phased High Performance Liquid Chromatography and Electro-Chemical Detection.	PM21	As received solid or water samples are extracted in Methanol: Sodium Hydroxide (0.1M NaOH) (60:40) by orbital shaker.			AR	Yes
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.			AR	No
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM15	Acid digestion of dried and ground solid samples using Aqua Regia refluxed at 112.5 °C. Samples containing asbestos are not dried and ground.			AD	Yes
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM15	Acid digestion of dried and ground solid samples using Aqua Regia refluxed at 112.5 °C. Samples containing asbestos are not dried and ground.	Yes		AD	Yes
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID. MTBE by GC/FID co-elutes with 3-methylpentane if present and therefore can give a false positive. Positive MTBE results can be confirmed using GCMS.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.			AR	Yes
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID. MTBE by GC/FID co-elutes with 3-methylpentane if present and therefore can give a false positive. Positive MTBE results can be confirmed using GCMS.	PM88	A 20:1 ratio of deionised water to as received soil, is leached for 18 hours with zero headspace.			AR	No
TM38	Soluble Ion analysis using Discrete Analyser. Modified US EPA methods 325.2 (Chloride), 375.4 (Sulphate), 365.2 (o-Phosphate), 353.1 (TON), 354.1 (Nitrite), 350.1 (NH4+) comparable to BS ISO 15923-1, 7196A (Hex Cr)	PM0	No preparation is required.			AR	No

EMT Job No: 19/20946

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/ANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM38	Soluble Ion analysis using Discrete Analyser. Modified US EPA methods 325.2 (Chloride), 375.4 (Sulphate), 365.2 (o-Phosphate), 353.1 (TON), 354.1 (Nitrite), 350.1 (NH4+) comparable to BS ISO 15923-1, 7196A (Hex Cr)	PM20	Extraction of dried and ground or as received samples with deionised water in a 2:1 water to solid ratio using a reciprocal shaker for all analytes except hexavalent chromium. Extraction of as received sample using 10:1 ratio of 0.2M sodium hydroxide to soil for hexavalent chromium using a reciprocal shaker.	Yes		AR	Yes
TM51	Formaldehyde determination by reaction with Ammonium Ions and acetylacetone which is analysed spectrophotometrically. This is a colourimetric determination based on ISO 15373:200 method A.	PM0	No preparation is required.				
TM51	Formaldehyde determination by reaction with Ammonium Ions and acetylacetone which is analysed spectrophotometrically. This is a colourimetric determination based on ISO 15373:200 method A.	PM112	As received soils are extracted with deionised water in a 4:1 ratio			AR	Yes
TM89	Modified USEPA method OIA-1667. Determination of cyanide by Flow Injection Analyser. Where WAD cyanides are required a Ligand displacement step is carried out before analysis.	PM0	No preparation is required.			AR	No
TM89	Modified USEPA method OIA-1667. Determination of cyanide by Flow Injection Analyser. Where WAD cyanides are required a Ligand displacement step is carried out before analysis.	PM45	As received solid samples are extracted with 1M NaOH by orbital shaker for Cyanide, Sulphide and Thiocyanate analysis.	Yes		AR	Yes
TM173	Analysis of fluoride by ISE (Ion Selective Electrode) using modified ISE method 340.2	PM0	No preparation is required.			AR	No
TM173	Analysis of fluoride by ISE (Ion Selective Electrode) using modified ISE method 340.2	PM20	Extraction of dried and ground or as received samples with deionised water in a 2:1 water to solid ratio using a reciprocal shaker for all analytes except hexavalent chromium. Extraction of as received sample using 10:1 ratio of 0.2M sodium hydroxide to soil for hexavalent chromium using a reciprocal shaker.			AR	Yes
NONE	No Method Code	PM80	A 20:1 ratio of leaching fluid to as received soil, is leached for 18 hours. The client can choose to use any of the following leaching fluids a) deionised water b) pH5 c) pH 5/pH2.9 depending on pH of sample d) pH9.2			AR	No
NONE	No Method Code	PM88	A 20:1 ratio of deionised water to as received soil, is leached for 18 hours with zero headspace.				No
TM15_A	Modified USEPA 8260. Quantitative Determination of Volatile Organic Compounds, Vinyl Chloride & Styrene by Headspace GC-MS.	PM10	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.			AR	Yes



M & L LABS

Certificate/Report

RESULTS REPORTED RELATED ONLY TO ITEMS TESTED

COMPANY NAME : SRK CONSULTING –CAPE TOWN

ADDRESS : POSTNET SUITE NO 206 PRIVATE BAG X18 RONDEBOSCH 7700

SUBJECT : ANALYSIS OF 2 SOLID SAMPLES

MARKED : AS BELOW

INSTRUCTED BY : RICHARD O'BRIEN

ORDER NO. : TRONOX

RECEIVED ON : 18/12/2019

LAB NO(S) : E022249-E022250

DATE ANALYSED : 13/02/2020

ACID-BASE ACCOUNTING

Analysis on the dried and milled samples:

<u>SAMPLE MARKS:</u>	<u>LAB NO:</u>	<u>Total Sulphur, S</u> <u>%</u>	<u>Total Acidity</u> <u>Potential as</u> <u>CaCO₃ kg/ton</u>	<u>Gross Neutralisation</u> <u>Potential as CaCO₃</u> <u>kg/ton</u>	<u>Net Neutralisation</u> <u>Potential as CaCO₃</u> <u>kg/ton</u> <u>(By Difference)</u>
SLIMES TP1	E022249	0.370	11.5	38	26.5
TAILINGS TP1	E022250	0.040	1.25	2.12	0.87

Method Reference:

Lawrence, R.W., Polling, G.P. and Marchant, P.B., 1989. Investigation of predictive techniques or acid mine drainage, Report on DSS Contract No. 23440-7-9178/01-SQ, Energy Mines and Resources, Canada, MEND Report 1.16.1(a). Sobek, A.A., Schuller, W.A., Freeman, J.R. and Smith, R.M., 1978. Field and Laboratory Methods Applicable to Overburden and Mine soils, EPA 600/2-78-054, 203 pp.



Certificate/Report

RESULTS REPORTED RELATED ONLY TO ITEMS TESTED

ANALYSIS

Qualitative and Quantitative XRD (mineralogy)

- The samples were prepared according to the standardized Panalytical backloading system, which provides nearly random distribution of the particles.
- The samples were analyzed using a PANalytical Aeris powder diffractometer in $\theta-\theta$ configuration with an X'Celerator detector and fixed divergence- and receiving slits with Fe filtered Co-K α radiation ($\lambda=1.789\text{\AA}$). The phases were identified using X'Pert Highscore plus software.
- The relative phase amounts (weight %) were estimated using the Rietveld method (Autoquan Program). The quantitative results are listed below.

Mineral	General Formula
Bassanite	CaSO ₄ (H ₂ O) _{0.5}
Goethite	Fe ₂ O ₃ .H ₂ O
Halite	NaCl
Kaolinite	Al ₄ (OH) ₈ (Si ₄ O ₁₀)
Microcline	KAlSi ₃ O ₈
Muscovite	KAl ₃ Si ₃ O ₁₀ (OH) ₂
Plagioclase	(Na,Ca)(Si,Al) ₄ O ₈

SAMPLE ID	SLIMES TP1	TAILINGS TP1
	<u>E022249</u>	<u>E022250</u>
	wt%	wt%
Bassanite	1.42	-
Goethite	1.55	-
Halite	24.5	1.22
Kaolinite	26.92	-
Microcline	-	1.78
Muscovite	13.98	-
Plagioclase	-	2.28
Quartz	31.63	94.72

Note: The results were supplied by a sub-contracting laboratory.

 Authorised Signature

EXTRACT OF THE BUREAU VERITAS GENERAL TERMS AND CONDITIONS OF BUSINESS

This extract of the Bureau Veritas general terms and conditions of business ("**General Conditions**") shall govern all services, including (but not limited to) laboratory test work, surveys, sampling, site investigations, consultations and opinions, performed for any individual or juristic person (the "**Client**") by M and L Laboratory Services Proprietary Limited, its subsidiary companies and their employees, agents, consultants and subcontractors (collectively referred to as the "**Company**"), whether in terms of a specified contract or not. For the purpose of these General Conditions, the Company and the Client shall collectively be referred to as the "**Parties**" and individually as a "**Party**".

1. QUOTATIONS

Any quotations for Services submitted by the Company to the Client shall be based on information supplied to the Company by the Client and will not under any circumstances be binding on the Company if such information is incorrect or incomplete in any manner.

2. INSTRUCTIONS

The Client will provide the Company with clear and precise written instructions, documents, information and samples prior to the performance of the Services. The Company will not be liable for any error, omission or inaccuracy in the reports or certificates produced by it to the extent that the Company has been given erroneous or incomplete information by the Client. The reports and certificates produced by the Company reflect the findings of the Company at the time of performance of the Services only.

3. SAMPLE MATERIAL

The Client will ensure that all samples/materials submitted by it for test work of any nature are clearly marked and identifiable. Should it be necessary for the Company to carry out any sample preparation, preliminary experimental work, or research prior to carrying out the Services, the Client will be liable for any charges in respect thereof. Unless the Client otherwise instructs in writing, the Company may retain, return to the Client, destroy or dispose of all excess samples, material, specimens or exhibits provided by the Client to the Company as soon as the Services are completed and the results have been reported to the Client. Any destruction or disposal shall exclude normal amounts of reserve sample material which the Company shall retain for a period of three months from date of completion of the Services. If the Client requires the Company to return any samples or materials to it or a third party, all costs associated therewith, including associated telecommunication costs, will be borne and paid for the Client.

4. FEES AND TERMS OF PAYMENT

In consideration for the provision of the Services by the Company, the Client shall pay the fees calculated in accordance with the Company's tariff of fees at the time, copies of which may be requested by the Client at any time. In the event of any changes in the Company's fees, the Company shall provide written notification thereof to the Client within a reasonable time prior to such new fees becoming effective. If the Client does not have an account with the Company, the Client shall be required to pay the whole or part of the fees before the Company will commence the Services or release the results, as the case may be. The Client will pay each valid invoice submitted to it by the Company in full and in cleared funds within 30 days of the date of the invoice. The Company shall be entitled to charge Interest at 2% per month on any amounts not paid on the due date.

5. LIABILITY AND INDEMNITY

Neither Party shall be liable to the other Party for any consequential, indirect, incidental or special losses or damages of any nature whatsoever and howsoever arising. Without prejudice to the foregoing, the total liability of the Company arising out of or in connection with this Agreement or in relation to the Services shall be limited to the fee paid or payable by the Client to the Company for the Services that gave rise to the Company's liability to the Client, if any. The Client indemnifies the Company and holds it harmless against all claims made by third parties for losses, damages or expenses of whatsoever nature and howsoever arising relating to the performance, purported performance or non-performance of any Services to the extent that the aggregate of such claims for any one Service exceeds the limitation of liability set out in this clause 5.

6. PROVISION OF THE SERVICES

The Company shall provide the Services with reasonable care, skill and diligence as expected of a competent body experienced in performing services of a similar nature and under similar circumstances. If the Client is aware of any apparent inaccuracy in any results reported by the Company in respect of the Services, the Client shall immediately advise the Company accordingly, and allow the Company a reasonable opportunity to check such results and amend them if necessary.

7. PUBLICATION OF RESULTS

Any reports or certificates issued by the Company are intended for the exclusive use of the Client and shall not be published, used for advertising purposes, copied or replicated for distribution to any person or entity or otherwise publicly disclosed without the prior written consent of the Company.

8. ALTERATIONS OF TERMS

No employee, agent or representative of the Company is authorised to alter or waive any of the terms contained in these General Conditions unless in writing and signed by or on behalf of the Parties. The performance of any test shall further be subject to any additional special

conditions as the Company may impose from time to time. If such special conditions differ from any provisions set out herein, such special conditions shall, to the extent of such difference, take precedence.

9. LAW OF SOUTH AFRICA

These General Conditions shall be governed by and construed in accordance with the laws of the Republic of South Africa. The Parties irrevocably consent to the jurisdiction of the South Gauteng High Court, Johannesburg, if any dispute or claim arises out of or in connection with this Agreement.

For full business terms and conditions please click or visit http://portal.bureauveritas.co.za/downloads/conditions_ml.pdf

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