ZITHOLELE CONSULTING (PTY) LTD

WASTE ASSESSMENT OF POWER STATION ASH AND REVERSE OSMOSIS PLANT EFFLUENT FROM THE CAMDEN POWER STATION

Report No.: JW164/11/D116 - REV 8

October 2014

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Acronyms and abbreviations used in this document:

ARL	Acceptable Risk Level. (ARL = 0.1 x LC_{50})
ARLP	South African Acid Rain Leach Procedure
ASLP	Australian Standard Leaching Procedure
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
G:L:B$^+$	General waste landfill receiving more than 500 tonnes of waste per day with a barrier system containing a leachate detection and collection layer
H:H	Hazardous waste disposal facility suitable for the disposal of all Hazard Group 1, 2, 3, 4 and general wastes. Comply with the most conservative design as indicated in the DWAF's Minimum Requirements
H:h	Hazardous waste disposal facility suitable for the disposal of all Hazard Group 3 and 4 wastes, and general wastes. Comply with the second most conservative design as indicated in the DWAF's Minimum Requirements
LC	Leach concentration in mg/ℓ
LCT	Leach concentration threshold in mg/ℓ
LC_{50}	The concentration at which 50% of test organisms will die after a certain exposure time
mg/kg	Milligram per kilogram
mg/ℓ	Milligram per litre
RO	Reverse osmosis
TC	Total concentration in mg/kg
TCT	Total concentration threshold
TCLP	Toxic characteristic leach procedure
TDS	Total dissolved salts
µS/cm	Micro Siemens per centimetre

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CONTENTS PAGE

List of Tables

List of Photo's & Figures

APPENDICES

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1. INTRODUCTION

1.1 Background

Zitholele Consulting (Pty) Ltd is currently in the process of conducting an Environmental Impact Assessment (EIA) and Waste Licence Application for a new wet ash disposal facility for the Camden Power Station. The new ash disposal site will be approximately 100 hectares in size with a further 25 hectares for associated infrastructure. The power station also operates a Reverse Osmosis (RO) plant in order to reduce the positive water balance of the ash water system. This plant generates an effluent, which is added to the ash water circuit.

The assessment of the ash from the wet-ash deposition process at Camden Power Station is required for input into both the EIA and Waste Licence Application Report. In addition, the ash assessment is required to determine its environmental risk profile and hence the barrier design criteria applicable to the new ash disposal facility. Assessment of the RO effluent was also requested in order to establish its risk profile, but it forms an integral part of the ash water system.

The ash was originally classified in terms of both the Department of Water Affairs and Forestry's (DWAF's) "*Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste*" of 1998 (DWAF, 1998a) and the Department of Environmental Affairs' draft "*National Environmental Management: Waste Act (Act 59 of 2008). Draft Standard for Assessment of Waste for Landfill Disposal"* (DEA, 2011). The outcome of this classification is dealt with in Jones & Wagener's report no JW164/11/D116 - REV 3 dated September 2012.

In January 2014 J&W was requested by Zitholele Consulting to update the classifications based on the DEA's "*National Norms and Standards for the Assessment of Waste for Landfill Disposal*" (National Norms and Standards) (DEA, 2013a). The National Norms and Standards were promulgated in August 2013 and replaced the Minimum Requirements waste classification system. This report contains the results of the waste assessments.

1.2 Objectives

The objective was to assess the Camden Power Station's wet ash and RO plant effluent in terms of the DEA's Norms and Standards of 2013 for disposal purposes. The analytical results of the tests performed in 2012 on the wet ash were used for this assessment. The original assessment of the RO plant effluent was based on theoretical values

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provided, but for this revised assessment, chemical analyses were made available for some of the constituents listed in the National Norms and Standards.

2. DEA WASTE ASSESSMENT SYSTEM

The new waste assessment system, which replaced the Department of Water Affairs' Minimum Requirements classification system on 23 August 2013, focuses on the long term storage (in excess of 90 days) and disposal of waste on land or in waste disposal facilities. The system is based on the Australian State of Victoria's waste classification system for disposal, which uses the Australian Standard Leaching Procedure (ASLP) to determine the Leachable Concentrations (LCs) of pollutants (DEA, 2013a).

For waste to be disposed of with putrescible organic matter, an acetic acid leach solution is used. This leach solution is very similar to the US EPA TCLP leach solution used in the now outdated Minimum Requirements, except that the pH is 5.0, instead of pH 4.93. In cases where a waste has a high pH, and following an acid neutralisation capacity test, a pH 2.9 leach solution must be used.

In cases where non-organic waste, such as the power station ash, is to be co-disposed with other non-organic waste, a basic 0.10 M sodium tetraborate decahydrate (borax) solution of pH 9.2 ± 0.10 should be used in addition to the acetic acid leach (DEA, 2012a). The objective of the sodium tetraborate test is to identify contaminants that are leached above the various Leachable Concentration Thresholds (LCTs) trigger values at a high pH[1].

For non-putrescible inorganic waste to be disposed of without any other wastes (mono-disposal scenario), reagent water (distilled water) is used as a leach agent.

In addition to the above, the Total Concentrations (TCs) of the constituents of concern need to be determined and compared to specified Total Concentration Threshold (TCT) values (DEA, 2013a)[2].

The number of potentially hazardous substances in the new classification system has been significantly reduced from that listed in the old Minimum Requirements of 1998 and brought in line with the potentially hazardous substances being used in other parts of the world to classify waste for disposal purposes. However, if a generator is aware of a hazardous substance other than those listed by the DEA, they are obliged to indicate and analyse for this.

Once the analytical results are known, the waste is classified in line with the following approach:

[1] LCT1 limits have, where possible, been derived from the lowest value of the standard for human health effects listed for drinking water (LCT0) in South Africa (DWAF, SANS) by multiplying with a Dilution Attenuation Factor (DAF) of 50 as proposed by the Australian State of Victoria, "Industrial Waste Resource Guidelines: Solid Industrial Waste Hazard Categorisation and Management", June 2009 (www.epa.vic.gov.aus). If no standard was available in South Africa then the limits given by the WHO or other appropriate drinking water standard, such as those published in the California Regulations have been used.
LCT2 limits were derived by multiplying the LCT1 value with a factor of 2, and the LCT3 limits have been derived by multiplying the LCT2 value with a factor of 4. The factors applied represents a conservative assessment of the decrease in risk achieved by the increase in environmental protection provided by more comprehensive liner designs in higher classes of landfill and landfill operating requirements.

[2] TCT1 limits were derived from the land remediation values for commercial/industrial land determined by the Department of Environmental Affairs' "Framework for the Management of Contaminated Land". The TCT2 limits were derived by multiplying TCT1 by a factor of 4, as used by the Environmental Protection Agency, Australian State of Victoria

- Wastes with any element or chemical substance concentration above the LCT3 or TCT2 values (LC > LCT3 or TC > TCT2) are Type 0 Wastes. Type 0 wastes (extremely hazardous waste), require treatment/stabilisation before disposal;
- Wastes with any element or chemical substance concentration above the LCT2 but below LCT3 values, or above the TCT1 but below TCT2 values (LCT2 < LC ≤ LCT3 or TCT1 < TC ≤ TCT2), are Type 1 Wastes (highly hazardous waste, which must be disposed of on a Class A landfill constructed with the most conservative barrier system);
- Wastes with any element or chemical substance concentration above the LCT1 but below the LCT2 values and all concentrations below the TCT1 values (LCT1 < LC ≤ LCT2 and TC ≤ TCT1) are Type 2 Wastes (moderate hazardous waste, which must be disposed of on a Class B landfill);
- Wastes with any element or chemical substance concentration above the LCT0 but below LCT1 values and all concentrations below the TCT1 values (LCT0 < LC ≤ LCT1 and TC ≤ TCT1) are Type 3 Wastes (low hazardous waste, which must be disposed of on a Class C landfill);
- Wastes with all elements and chemical substance concentration levels for metal ions and inorganic anions below the LCT0 and TCT0 values (LC ≤ LCT0 and TC ≤ TCT0), as well as below the limits for organics and pesticides as in **Table 2-1**, are Type 4 Wastes (near inert wastes, which must be disposed of on sites with some base preparation, but no formal barrier system):

Table 2-1: Organic limits for wastes to be assessed as Type 4 wastes.

Chemical Substances in Waste	Total Concentration (mg/kg)
Organic constituents	
Total organic carbon (TOC)	30 000 (3%)
Benzene, toluene, ethyl benzene and xylenes (BTEX)	6
Polychlorinated Biphenyls (PCBs)	1
Mineral Oil (C10 to C40)	500
Pesticides	
Aldrin + Dieldrin	0.05
DDT + DDD + DDE	0.05
2,4-D	0.05
Chlordane	0.05
Heptachlor	0.05

- Wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 waste, irrespective of the total concentration of elements or chemical substances in the waste, provided that:

- All chemical substance concentration levels are below the total concentration limits for organics and pesticides in the **Table 2-1**;
- The inherent physical and chemical character of the waste is stable and will not change over time; and,
- The waste is disposed of to landfill without any other waste.

- Wastes with the TC of an element or chemical substance above the TCT2 limit, and where the concentration cannot be reduced to below the TCT2 limit, but the LC for the particular element or chemical substance is below the LCT3 limit, is considered to be Type 1 Wastes (DEA, 2013a).

3. TESTS CONDUCTED

Camden Power Station supplied representative samples of dry ash, two wet ash samples, namely a fine ash [dusting ash] and coarse ash [ashing ash], and ash disposal site leachate (toe seepage water) – see **Photo 1**. The samples were then sent to the SGS Laboratory in Randburg for various leach analyses, total concentration (TC) determination and quantitative x-ray diffraction (XRD) analysis to determine the mineralogy.

The SGS laboratory subjected the dry ash to a Minimum Requirements' Acid Rain Leach Procedure (ARLP). The ARLP leach procedure was used in the 1998 Minimum Requirements waste classification system where a waste is mono-disposed or stored or where it is co-disposed with other inorganic waste types not containing any decomposable compounds.

The dry ash sample was also subjected to a total extraction procedure in order to determine the TCs of the various elements.

In addition, the dry ash sample was subjected to a XRD analysis to determine the mineralogy.

Following the new DEA assessment system for the mono storage and disposal of a waste, solids were firstly separated from the liquid fraction and the percentage solids determined. The solids fractions were then subjected to a deionised (DI) (South African Standard Leach Procedure) water leach test, where after the leach solution was analysed for various metals and other inorganic constituents. The water fractions of the two wet ash samples were also analysed for the various metals and inorganic constituents listed in the National Norms and Standards. The organic components listed in the National Norms and Standards were not analysed for as it is highly unlikely that organics will occur in the wet ash at concentrations above the LCT0 and TCT0 values of the National Norms and Standards.)

The two wet ash samples provided were termed dusting ash, that is the fine ash-water mixture used to develop the outer walls of the current ash disposal facility and ashing ash, the coarse ash-water mixture. The coarse ash is deposited in the middle of the ash disposal facility. It is noted that the effluent from the RO plant is added to the ash water system.

A sample of leachate collected at the toe of the ash disposal facility (seepage water) was also analysed for various inorganic constituents.

The certificates of the results of the various tests conducted on the ash and leachate are included in **Appendix A**.

Although a sample of effluent from the RO plant was requested for analyses at the time, the plant was not operative on the day that the ash samples were collected. Theoretical

values for the various constituents of concern were provided by Eskom Camden Power Station and these values were used in the initial classification. However, for this updated classification, Mrs I. Hodgson of the Camden Power Station provided some analyses performed on the RO plant effluent to J&W on 20 February 2014 and also determined the conductivity of the effluent on 20 February 2014 – see **Appendix B**. The conductivity of the effluent was verbally reported as 3 309 µS/cm (330.9 mS/m*).* For the assessment of the effluent, the 70% water recovery rate results were used, which provides a more concentrated effluent, therefore the more conservative scenario was used for the assessment. In addition, the RO plant effluent was analysed in November of 2012 by Waterlab for a different waste assessment exercise and that analytical information has now also been used in this assessment – see **Appendix B** for lab certificate.

For the assessment of the wet ash in terms of the DEA's National Norms and Standards the analytical results from the ARLP were ignored. Only the results obtained from the DI water leach and the TCs were used for the assessment of the wet ash.

Photo 1: **Four samples used in the assessment of the Camden Power Station Ash, Ash Carrier Water and Ash Disposal Facility Seepage Water (Leachate)**

4. CAMDEN POWER STATION ASH AND REVERSE OSMOSIS EFFLUENT ASSESSMENT

4.1 Wet Ash

In order to assess the wet dusting ash (fine ash) and wet ashing ash (coarse ash) for disposal, the percentage contributions of the concentrations of the constituents in the liquid fractions (which also contains a percentage of RO plant effluent) and the leach concentrations were calculated based on the percentage liquids to solids – see **Table 4-1** and **Table 4-3**. The corrected concentrations were then used for the classification – see **Table 4-2** and **Table 4-4**. This method is in line with the Australian leach procedure methodology, which was adopted in the South African National Norms and Standards. Based on the corrected concentrations, both the dusting and ashing ash are assessed as Type 3 wastes.

In addition, the concentrations of the listed constituents were also determined on the ash seepage water collected at the base of the existing ash disposal facility. Based on these concentrations, the ash is also assessed as a Type 3 waste. It is noted that the TDS of the seepage water (764 mg/ℓ) is significantly lower than the average TDS of the dusting and ashing ash water fractions (1 424 mg/ℓ). The ash has a significant adsorption capacity for certain salts, while significant amounts of calcium sulfate will also precipitate out in the ash body.

Type 3 wastes should be disposed of on waste disposal facilities with Class C landfill barrier systems.

4.2 RO Plant Effluent

Based on the theoretical and actual concentrations provided for the RO plant effluent, the effluent is classified as a Type 3 liquid waste – see **Table 4-6.** The effluent is classified as a Type 3 waste due to the concentrations of TDS, chloride, sulphate, fluoride, lead, boron, total chromium, chromium VI, molybdenum and selenium being above their respective LCT0 values. The theoretical values supplied by Eskom are indicated in red in **Table 4-6.**

Table 4-1: Corrected concentrations for dusting ash sample based on % contribution of ash carrier water and fine ash (dusting ash) content

DUSTING SAMPLE							
Percentage solids	**48.30%**						
WATER LEACH: DUSTING SAMPLE							
	Solid Phase			**Water Phase**			**Leach Concentration**
Element/Compound	**mg/ℓ**	**Contribution Factor**	**Corrected concentration in mg/ℓ**	**mg/ℓ**	**Contribution Factor**	**Corrected concentration in mg/ℓ**	**mg/ℓ**
As, Arsenic	0.0015	0.483	0.0007245	0.0015	0.517	0.0007755	0.0015
B, Boron	0.2	0.483	0.0966	0.11	0.517	0.05687	0.15347
Ba, Barium	0.84	0.483	0.40572	1.3	0.517	0.6721	1.07782
Cd, Cadmium	0.001	0.483	0.000483	0.001	0.517	0.000517	0.001
Co, Cobalt	0.001	0.483	0.000483	0.001	0.517	0.000517	0.001
Cr, Chromium - total	0.11	0.483	0.05313	0.15	0.517	0.07755	0.13068
Cr VI, Chromium VI	0.11	0.483	0.05313	0.15	0.517	0.07755	0.13068
Cu, Copper	0.002	0.483	0.000966	0.002	0.517	0.001034	0.002
Hg, Mercury	0.0003	0.483	0.0001449	0.00005	0.517	0.00002585	0.00017075
Mn, Manganese	0.0015	0.483	0.0007245	0.0015	0.517	0.0007755	0.0015
Mo, Molydenum	0.067	0.483	0.032361	0.19	0.517	0.09823	0.130591
Ni, Nickel	0.0035	0.483	0.0016905	0.0035	0.517	0.0018095	0.0035
Pb, Lead	0.002	0.483	0.000966	0.002	0.517	0.001034	0.002
Sb, Antimony	0.0035	0.483	0.0016905		0.517	0	0.0016905
Se, Selenium	0.002	0.483	0.000966	0.002	0.517	0.001034	0.002
V, Vanadium	0.045	0.483	0.021735	0.0021	0.517	0.0010857	0.0228207
Zn, Zinc	0.005	0.483	0.002415	0.005	0.517	0.002585	0.005
TDS, Total dissolved salts	272	0.483	131.376	1992	0.517	1029.864	1161.24
Cl, Chloride	2.1	0.483	1.0143	120	0.517	62.04	63.0543
SO_4, Sulphate	13	0.483	6.279	210	0.517	108.57	114.849
NO_3, Nitrate	1.5	0.483	0.7245	0.64	0.517	0.33088	1.05538
F, Fluoride	0.3	0.483	0.1449	0.73	0.517	0.37741	0.52231
Note: In order to calcuate the % contibution of each phase, values less than (<) the limit of report (LOR) were divided by 2							

Table 4-2: De-ionised Water Leach Test Results of Camden Power Station Ash (TC Dry Ash, LC Dusting sample)

Chemical Species	Camden Power Station Ash: Dusting Ash				LCT0	TCT0		LCT1	TCT1		LCT2	TCT1		LCT3	TCT2	
	Deionised Water Leach (LC)	Total Concentration (TC)	Limit of Report for LC													
	mg/ℓ	mg/kg	mg/ℓ		mg/ℓ	mg/kg		mg/ℓ	mg/kg		mg/ℓ	mg/kg		mg/ℓ	mg/kg	
As	0.0015	13	0.0030	TYPE 4 WASTE	0.010	5.8	TYPE 3 WASTE	0.50	500	TYPE 2 WASTE	1.0	500	TYPE 1 WASTE	4.0	2 000	TYPE 0 WASTE
B	0.15	NA	0.220		0.50	150		25	15 000		50	15 000		200	60 000	
Ba	1.1	716	0.030		0.70	62.5		35	6 250		70	6 250		280	25 000	
Cd	0.0010	<0.020	0.0020		0.003	7.5		0.15	260		0.30	260		1.2	1 040	
Co	0.0010	16	0.0020		0.50	50		25	5 000		50	5 000		200	20 000	
Cr	0.13	113	0.040		0.10	46 000		5.0	800 000		10	800 000		40		
Cr(VI)	0.13	NA	0.010		0.050	6.5		2.5	500		5.0	500		20	2 000	
Cu	0.0020	59	0.0040		2.0	16		100	19 500		200	19 500		800	78 000	
Hg	0.00017	<3.0	0.00010		0.006	0.93		0.30	160		0.6	160		2.4	640	
Mn	0.0015	488	0.060		0.50	1 000		25	25 000		50	25 000		200	100 000	
Mo	0.13	5.2	0.020		0.070	40		3.5	1 000		7.0	1 000		28	4 000	
Ni	0.0035	51	0.0070		0.070	91		3.5	10 600		7.0	10 600		28	42 400	
Pb	0.0020	41	0.0040		0.010	20		0.50	1 900		1.0	1 900		4.0	7 600	
Sb	0.0017	0.89	0.0070		0.02	10		1.00	75		2.00	75		8.00	300	
Se	0.0020	<2.0	0.0040		0.010	10		0.50	50		1.0	50		4.0	200	
V	0.023	68	0.0030		0.20	150		10	2 680		20	2 680		80	10 720	
Zn	0.0050	314	0.080		5.0	240		250	160 000		500	160 000		2 000	640 000	
TDS	1 161		21		1 000			12 500			25 -000	N/A		100 000	N/A	
Chloride	63		0.50		300			15 000			30 000	N/A		120 000	N/A	
Sulphate as SO_4	115		0.40		250			12 500			25 000	N/A		100 000	N/A	
NO_3 as N	1.1		0.40		11			550			1 100	N/A		4 400	N/A	
Fluoride	0.52	NA	0.30		1.5	100		75	10 000		150	10 000		600	40 000	

NA	Not analysed
N/A	Not available
	LC ≤ LCT0 and TC ≤ TCT0: Type 4 wastes
	LCT0 < LV ≤ LCT1 and TC ≤ TCT1: Type 3 Wastes
	LCT1< LC ≤ LCT2 and TC ≤ TCT1: Type 2 Waste
	LCT2< LC ≤ LCT3 or TCT1 < TC ≤ TCT2: Type 1 Wastes
	LC > LCT3 or TC > TCT2: Type 0

Table 4-3: Corrected concentrations for ashing sample based on % contribution of ash carrier water and ashing (coarse) ash content

ASHING SAMPLE (Wet)							
Percentage solids	**6.37%**						
WATER LEACH: ASHING SAMPLE							
	Solid Phase			**Water Phase**			**Leach Concentration**
Element/Compound	**mg/ℓ**	**Contribution Factor**	**Corrected concentration in mg/ℓ**	**mg/ℓ**	**Contribution Factor**	**Corrected concentration in mg/ℓ**	**mg/ℓ**
As, Arsenic	0.012	0.064	0.00076	0.0015	0.9363	0.0014	0.0022
B, Boron	0.39	0.064	0.025	1.1	0.9363	1.03	1.1
Ba, Barium	0.059	0.064	0.0038	0.34	0.9363	0.32	0.32
Cd, Cadmium	0.0024	0.064	0.00015	0.0010	0.9363	0.00094	0.0011
Co, Cobalt	0.0027	0.064	0.00017	0.0010	0.9363	0.00094	0.0011
Cr, Chromium - total	0.0075	0.064	0.00048	0.029	0.9363	0.027	0.028
Cr VI, Chromium VI	0.0050	0.064	0.00032	0.030	0.9363	0.028	0.028
Cu, Copper	0.0020	0.064	0.00013	0.0020	0.9363	0.0019	0.0020
Hg, Mercury	0.00015	0.064	0.0000096	0.0012	0.9363	0.0011	0.0011
Mn, Manganese	0.0097	0.064	0.00062	0.0015	0.9363	0.0014	0.0020
Mo, Molydenum	0.012	0.064	0.00076	0.18	0.9363	0.17	0.17
Ni, Nickel	0.0035	0.064	0.00022	0.0035	0.9363	0.0033	0.0035
Pb, Lead	0.0020	0.064	0.00013	0.0020	0.9363	0.0019	0.0020
Sb, Antimony	0.0035	0.064	0.00022		0.9363	0	0.00022
Se, Selenium	0.0020	0.064	0.00013	0.0094	0.9363	0.0088	0.0089
V, Vanadium	0.022	0.064	0.0014	0.020	0.9363	0.019	0.020
Zn, Zinc	0.0050	0.064	0.00032	0.0050	0.9363	0.0047	0.0050
TDS, Total dissolved solids	64	0.064	4.1	856	0.9363	801	806
Cl, Chloride	1.7	0.064	0.11	97	0.9363	91	91
SO_4, Sulphate	19	0.064	1.2	380	0.9363	356	357
NO_3, Nitrate	0.28	0.064	0.018	3.2	0.9363	3.0	3.0
F, Fluoride	0.025	0.064	0.0016	0.74	0.9363	0.69	0.69
Note: In order to calcuate the % contibution of each phase, values less than (<) the limit of report (LOR) were divided by 2							

Table 4-4: De-ionised Water Leach Test Results of Camden Power Station Ash (TC Dry Ash, LC Ashing sample)

	Camden Power Station Ash: Ashing Sample																	
Chemical Species	Deionised Water Leach (LC)	Total Concentration (TC)	Limit of Report for LC		LCT0	TCT0		LCT1	TCT1		LCT2	TCT1		LCT3	TCT2			
	mg/ℓ	mg/kg	mg/ℓ		mg/ℓ	mg/kg		mg/ℓ	mg/kg		mg/ℓ	mg/kg		mg/ℓ	mg/kg			
As	0.0022	13	0.0030	TYPE 4 WASTE	0.010	5.8	TYPE 3 WASTE	0.50	500	TYPE 2 WASTE	1.0	500	TYPE 1 WASTE	4.0	2 000	TYPE 0 WASTE		
B	1.1	NA	0.220		0.50	150		25	15 000		50	15 000		200	60 000			
Ba	0.32	716	0.030		0.70	62.5		35	6 250		70	6 250		280	25 000			
Cd	0.0011	<0.020	0.0020		0.003	7.5		0.15	260		0.30	260		1.2	1 040			
Co	0.0011	16	0.0020		0.50	50		25	5 000		50	5 000		200	20 000			
Cr	0.028	113	0.040		0.10	46 000		5.0	800 000		10	800 000		40				
Cr(VI)	0.028	NA	0.010		0.050	6.5		2.5	500		5.0	500		20	2 000			
Cu	0.0020	59	0.0040		2.0	16		100	19 500		200	19 500		800	78 000			
Hg	0.0011	<3.0	0.00010		0.006	0.93		0.30	160		0.60	160		2.40	640			
Mn	0.0020	488	0.060		0.50	1 000		25	25 000		50	25 000		200	100 000			
Mo	0.17	5.2	0.020		0.070	40		3.5	1 000		7.0	1 000		28	4 000			
Ni	0.0035	51	0.0070		0.070	91		3.5	10 600		7.0	10 600		28	42 400			
Pb	0.0020	41	0.0040		0.010	20		0.50	1 900		1.0	1 900		4.0	7 600			
Sb	0.00022	0.89	0.0070		0.020	10		1.00	75		2.00	75		8.00	300			
Se	0.0089	<2.0	0.0040		0.010	10		0.50	50		1.0	50		4.0	200			
V	0.020	68	0.0030		0.20	150		10	2 680		20	2 680		80	10 720			
Zn	0.0050	314	0.080		5.0	240		250	160 000		500	160 000		2 000	640 000			
TDS	806		21		1 100			12 500			25 000			100 000				
Chloride	91		0.50		300			15 000			30 000			120 000				
Sulphate as SO_4	357		0.40		250			12 500			25 000			100 000				
NO_3 as N	3.0		0.40		11			550			1 100			4 400				
Fluoride	0.69	NA	0.30		0 1.5	100		75	10 000		150	10 000		600	40 000			

NA	Not analysed
N/A	Not available
	LC ≤ LCT0 and TC ≤ TCT0: Type 4 wastes
	LCT0 < LV ≤ LCT1 and TC ≤ TCT1: Type 3 Wastes
	LCT1< LC ≤ LCT2 and TC ≤ TCT1: Type 2 Waste
	LCT2< LC ≤ LCT3 or TCT1 < TC ≤ TCT2: Type 1 Wastes
	LC > LCT3 or TC > TCT2: Type 0

Table 4-5: Ash Seepage Water Concentrations versus LCT values

	Camden Power Station Ash: Seepage Water																
Chemical Species	Seepage water (LC)	Total Concentration (TC)	Limit of Report for LC		LCT0	TCT0		LCT1	TCT1		LCT2	TCT1		LCT3	TCT2		
	mg/ℓ	mg/kg	mg/ℓ		mg/ℓ	mg/kg		mg/ℓ	mg/kg		mg/ℓ	mg/kg		mg/ℓ	mg/kg		
As	0.0049	NA	0.0030	TYPE 4 WASTE	0.010	5.8	TYPE 3 WASTE	0.50	500	TYPE 2 WASTE	1.0	500	TYPE 1 WASTE	4.0	2 000	TYPE 0 WASTE	
B	2.50	NA	0.220		0.50	150		25	15 000		50	15 000		200	60 000		
Ba	0.063	NA	0.030		0.70	62.5		35	6 250		70	6 250		280	25 000		
Cd	<0.002	NA	0.0020		0.003	7.5		0.15	260		0.30	260		1.2	1 040		
Co	<0.002	NA	0.0020		0.50	50		25	5 000		50	5 000		200	20 000		
Cr	0.0051	NA	0.0030		0.10	46000		5.0	800 000		10	800 000		40			
Cr(VI)	<0.01	NA	0.010		0.050	6.5		2.5	500		5.0	500		20	2 000		
Cu	<0.004	NA	0.0040		2.0	16		100	19 500		200	19 500		800	78 000		
Hg	0.00042	NA	0.00010		0.006	0.93		0.3	160		0.6	160		2.4	640		
Mn	<0.003	NA	0.0030		0.50	1 000		25	25 000		50	25 000		200	100 000		
Mo	0.19	NA	0.020		0.070	40		3.5	1 000		7.0	1 000		28	4 000		
Ni	<0.007	NA	0.0070		0.070	91		3.5	10 600		7.0	10 600		28	42 400		
Pb	<0.004	NA	0.0040		0.010	20		0.50	1 900		1.0	1 900		4.0	7 600		
Sb	NA	NA	0.0070		0.02	10		1.00	75		2.0	75		8.00	300		
Se	0.0047	NA	0.0040		0.010	10		0.50	50		1.0	50		4.0	200		
V	<0.001	NA	0.001		0.20	150		10	2 680		20	2 680		80	10 720		
Zn	<0.01	NA	0.01		5.0	240		250	160 000		500	160 000		2 000	640 000		
TDS	764		21		1 000			12 500			25 000	N/A		100 000	N/A		
Chloride	160		0.50		300			15 000			30 000	N/A		120 000	N/A		
Sulphate as SO_4	450		0.40		250			12 500			25 000	N/A		100 000	N/A		
NO_3 as N	<0.1		0.10		11			550			1 100	N/A		4 400	N/A		
Fluoride	<0.05	NA	0.30		1.5	100		75	10 000		150	10 000		600	40 000		

NA	Not analysed
N/A	Not available
	LC ≤ LCT0 and TC ≤ TCT0: Type 4 wastes
	LCT0 < LV ≤ LCT1 and TC ≤ TCT1: Type 3 Wastes
	LCT1< LC ≤ LCT2 and TC ≤ TCT1: Type 2 Wastes
	LCT2< LC ≤ LCT3 or TCT1 < TC ≤ TCT2 : Type 1 Wastes
	LC > LCT3 or TC > TCT2: Type 0 Wastes

Table 4-6: Concentrations of Constituents of the RO Plant Effluent versus LCT values

	Camden Power Station																	
Chemical Species	Effluent from RO Plant(LC) Theoretical and Actual	Effluent from RO Plant(LC) Actual (Nov 2012)	Limit of Report for LC		LCT0	TCT0		LCT1	TCT1		LCT2	TCT1		LCT3	TCT2	
	mg/ℓ	mg/kg	mg/ℓ		mg/ℓ	mg/kg		mg/ℓ	mg/kg		mg/ℓ	mg/kg		mg/ℓ	mg/kg	
As	N/A	<0.010	0.010		0.010	5.8		0.50	500		1.0	500		4.0	2 000	
B	N/A	3.13	0.025		0.50	150		25	15 000		50	15 000		200	60 000	
Ba	0.0250	0.207	0.025		0.70	62.5		35	6 250		70	6 250		280	25 000	
Cd	<0.0050	<0.005	0.005		0.003	7.5		0.15	260		0.30	260		1.2	1 040	
Co	<0.0050	<0.025	0.025		0.50	50		25	5 000		50	5 000		200	20 000	
Cr	0.10	0.148	0.025		0.10	46 000		5.0	800 000		10	800 000		40		
Cr(VI)	N/A	0.071	0.010		0.050	6.5		2.5	500		5.0	500		20	2 000	
Cu	<0.0050	<0.025	0.025		2.0	16		100	19 500		200	19 500		800	78 000	
Hg	0.0040	<0.001	0.001		0.006	0.93		0.03	160		0.6	160		2.4	640	
Mn	<0.005	<0.025	0.025		0.50	1 000		25	25 000		50	25 000		200	100 000	
Mo	0.10	1.64	0.025A		0.070	40		3.5	1 000		7.0	1 000		28	4 000	
Ni	<0.0050	<0.025	0.025		0.070	91		3.5	10 600		7.0	10 600		28	42 400	
Pb	0.27	<0.020	0.020		0.010	20		0.50	1 900		1.0	1 900		4.0	7 600	
Sb	N/A	<0.010	0.010		0.02	10		1.00	75		2.00	75		8.00	300	
Se	N/A	0.050	0.020		0.010	10		0.50	50		1.0	50		4.0	200	
V	0.10	<0.025	0.025		0.20	150		10	2 680		20	2 680		80	10 720	
Zn	<0.0050	<0.025	0.025		5.0	240		250	160 000		500	160 000		2 000	640 000	
TDS	2 150*	3 398	Not given		1 000			12 500			25 000	N/A		100 000	N/A	
Chloride	380	283	Not given		300			15 000			30 000	N/A		120 000	N/A	
Sulphate as SO_4	2 080	1 811	Not given		250			12 500			25 000	N/A		100 000	N/A	
NO_3 as N	3.32	3.0	0.20		11			550			1 100	N/A		4 400	N/A	
Fluoride	3.47	3.70	0.20		1.5	100		75	10 000		150	10 000		600	40 000	
	TYPE 4 WASTE				TYPE 3 WASTE			TYPE 2 WASTE			TYPE 1 WASTE			TYPE 0 WASTE		

NA	Not analysed
N/A	Not available
	Values in red are theoretical
*	Calculated TDS at 60% clean water recovery rate using a µS/cm to mg/ℓ conversion factor of 0.65
	LC ≤ LCT0 and TC ≤ TCT0: Type 4 wastes
	LCT0 < LV ≤ LCT1 and TC ≤ TCT1: Type 3 Wastes
	LCT1< LC ≤ LCT2 and TC ≤ TCT1: Type 2 Waste
	LCT2< LC ≤ LCT3 or TCT1 < TC ≤ TCT2: Type 1 Wastes
	LC > LCT3 or TC > TCT2: Type 0

5. DISCUSSION AND CONCLUSIONS

In terms of the DEA's National Norms and Standards, the Camden ash was subjected to a TC extract and DI water leaches. Two samples were used in the assessment, namely dusting ash (fine ash) and ashing ash (course) ash. In addition, the water leaching from the base or toe of the existing ash disposal facility was also analysed and compared to the respective LCT values. The seepage water was therefore also classified in terms of the National Norms and Standards, as it is seen as the actual risk posed by the ash disposal facility to the receiving environment.

The DI water leach scenario is applicable in the case that ash is mono-disposed or stored in the environment at a permanent storage facility, i.e., the waste is stored for longer than 90 days. Based on the DI water leach results, and taking the concentrations of the water fractions of the wet ash samples into account, both the dusting and ashing ash samples are classified as Type 3 wastes requiring disposal on a landfill with a Class C barrier system – see **Figure 5-1**.

This barrier system is considered appropriate for the wet ash disposal facility provided the drainage layer on top of the barrier system contains drainage pipes of adequate size, spacing and strength to ensure atmospheric pressure within the drainage application for the service life of the ash disposal facility (DEA, 2013b). It should be noted that the National Norms and Standards require that the disposal of liquid waste must be phased out over a period of six years from the date that the National Norms and Standards were promulgated. If the authorities insist on this approach, it may have significant cost implications for the Camden Power Station, which was not designed as a dry ash power plant. Therefore it is recommended that agreement be reached with the authorities on the long term management scenario of the ash disposal facility prior to the barrier system being designed.

The RO plant effluent is also classified as a Type 3 waste. This effluent is added to the ash water circuit. A Class C landfill barrier is considered appropriate for the wet ash and RO plant effluent disposal facility. As with the wet ash only disposal scenario, it is a requirement that liquid waste should be disposed of in hazardous lagoon facilities, but provided the drainage layer on top of the Class C barrier system contains drainage pipes of adequate size, spacing and strength to ensure atmospheric pressure within the drainage application for the service life of the ash disposal facility, the co-disposal scenario is considered appropriate.

It has been shown that ash has significant capacity to adsorb and precipitate salts, which is also the case at Camden. The TDS of the ashing water (average of the dusting and ashing ash water fraction values is 1 424 mg/ℓ) has a significantly higher TDS value than that of the seepage water reporting at the toe of the existing wet ash disposal facility (764 mg/ℓ) – see **Table 4-1**, **Table 4-3** and **Table 4-5.** The adding of the RO plant effluent into the ash water circuit can therefore be regarded as treatment of the RO effluent and the ash carrier water itself.

It is important to note that the disposal of brines or wastes with a high salt content (TDS > 5% [5 grams per 100 mℓ]) and a leachable concentration for TDS of more than 100 000 mg/ℓ needs to be phased out within eight (8) years from the date of promulgation of the National Norms and Standards (DEA, 2013b). However, the effluent from the RO plant at Camden has a TDS of only 2 150 mg/ℓ (0.215% [0.215 grams per 100 mℓ), therefore it does not comply with the definition of a brine as given in the National Norms and Standards. Therefore the requirement of phasing out the disposal of the Camden RO plant effluent is not applicable as the TDS is lower than 5%. In addition, the RO plant

effluent is added to the ash carrier water system and as a result a significant percentage of the salt is adsorbed/precipitated in the ash body itself.

Table 5-1 below summarises the assessment of the wet ash and RO plant effluent and also indicates the recommended barrier systems for the various disposal scenarios.

Table 5-1: Waste Type and Recommended Class of Landfill Required

Waste	Type of Waste	Recommended Barrier System
Ash + Ash Carrier Water	Type 3: Low Risk Waste	Class C
Ash + Ash Carrier Water + RO Plant Effluent	Type 3: Low Risk Waste	Class C

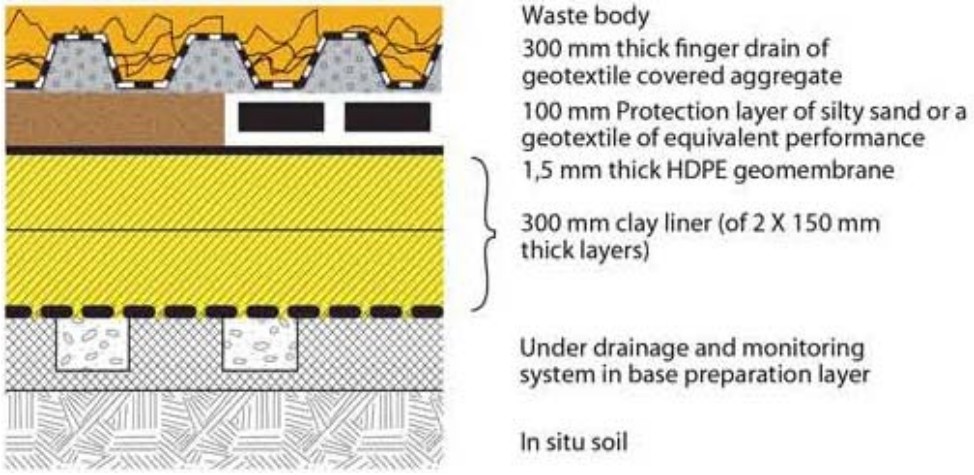

Figure 5-1: Class C landfill barrier system (DEA, 2013b)

6. RECOMMENDATIONS

The following recommendations are made:

- The intended barrier design of the new wet ash disposal facility for Camden Power Station should be presented, discussed and agreed upon with the Department of Water and Sanitation prior to the design being developed;
- A Class C barrier design, which is the recommended barrier system by J&W, for the new wet ash disposal facility should incorporate a drainage layer on top of the barrier system containing drainage pipes of adequate size, spacing and strength to ensure atmospheric pressure within the drainage application for the service life of the ash disposal facility as per the DEA National Norms and Standards or as agreed with the Department of Water and Sanitation.

7. REFERENCES

i. Department of Water Affairs and Forestry, 1998a. Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, Second Edition. Department of Water Affairs, Pretoria.

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iv. Department of Environmental Affairs, 2013a. National norms and standards for the assessment of waste for landfill disposal. R635 of 23 August 2013, Government Gazette 36784 of 23 August 2013, Government Printer, Pretoria.

v. Department of Environmental Affairs, 2013b. National norms and standards for disposal of waste to landfill. R636 of 23 August 2013, Government Gazette 36784 of 23 August 2013, Government Printer, Pretoria.

vi. Legge, K., 2011. *Verbal communication.* Department of Water Affairs.

viii. Hodgskin, I., 2011. *Verbal communication*. Eskom, Camden Power Station.

Marius van Zyl
Project Manager

Tolmay Hopkins
Reviewer

John Glendinning
Project Director

8 October 2014

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Appendix A

SGS SOUTH AFRICA: LABORATORY CERTIFICATES

ANALYTICAL REPORT

CLIENT DETAILS

Contact	Marius Van Zyl
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Address	P.O. Box 1434 Rivonia 2128
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Facsimile	011 519 0201
Email	vanzyl@jaws.co.za
Project	**11521195**
Order Number	**DI66/MVZ/19829**
Samples	3
Sample matrix	WATER

LABORATORY DETAILS

Laboratory	SGS South Africa (Pty) Limited
Address	259 Kent Avenue Ferndale, 2194
Telephone	+27 (0)11 781 5689
Laboratory Manager	Mark Baird (acting)
SGS Reference	JB11-01869 R0
Report Number	0000001519
Date Received	2011/09/12 10:00:46AM
Date Reported	2011/09/30 09:26:12AM

COMMENTS

The document is issued in accordance with SANAS's accreditation requirements.
Accredited for compliance with ISO/IEC 17025. SANAS accredited laboratory T0107.

Samples filtered prior to analysis.

SIGNATORIES

Gladness Radebe
Technical Supervisor/Technical Signatory

Sarah Newton
Technical Consultant/Technical Signatory

Parameter	Units	LOR	Sample Number Sample Name JB11-01869.001 Seepage Water	JB11-01869.002 Ashing Water	JB11-01869.003 Dusting Water
pH in water Method: ME-ANA-AN-016					
pH		0.10	8.4	11.4	12.2
Conductivity - Water Method: ME-ANA-AN-007					
Conductivity	mS/m	2.0	160	190	740
Total Dissolved Solids (TDS) in water Method: ME-ANA-AN-011					
Total Dissolved Solids	mg/l	21.0	764	856	1992
Anions by Ion Chromatography Method: ME-ANA-AN-AN014					
Fluoride	mg/l	0.050	<0.050	0.74	0.73
Chloride	mg/l	0.050	160	97	120
Nitrate	mg/l	0.10	<0.10	3.2	0.64
Sulphate	mg/l	0.050	450	380	210
Ammonia as N by UV Method: APHA4500_NH3					
Ammonia*	mg/l	0.050	<0.050	<0.050	0.066
Hexavalent Chromium by UV-VIS Method: ME-ANA-AN-018					
Hexavalent Chromium*	mg/l	0.010	<0.010	0.030	0.15
ICP-OES Metals in Water (Dissolved) Method: ME-ANA-AN-027					
Silver	mg/l	0.0020	0.0037	0.0041	0.026
Aluminium	mg/l	0.020	<0.020	1.2	0.19
Boron	mg/l	0.0050	2.5	1.1	0.11
Barium	mg/l	0.0020	0.063	0.34	1.3
Beryllium	mg/l	0.00010	-1.30551E-	-2.85557E-	-6.56818E-
Calcium	mg/l	0.50	110	190	760
Iron	mg/l	0.050	<0.050	<0.050	<0.050
Potassium	mg/l	0.20	39	27	68
Lithium	mg/l	0.0050	0.61	0.85	3.8
Magnesium	mg/l	0.010	8.7	0.072	<0.010
Sodium	mg/l	0.50	240	160	210
Silicon	mg/l	1.0	1.7	7.6	<1.0
Strontium	mg/l	0.0010	3.9	3.6	39
Titanium	mg/l	0.0050	<0.0050	<0.0050	0.0098
Vanadium	mg/l	0.0010	<0.0010	0.020	0.0021
Zinc	mg/l	0.010	<0.010	<0.010	<0.010
ICP-MS Metals (Dissolved) Method: ME-ANA-AN-026					
Arsenic	mg/l	0.0030	0.0049	<0.0030	<0.0030
Bismuth	mg/l	0.0010	<0.0010	<0.0010	<0.0010
Cadmium	mg/l	0.0020	<0.0020	<0.0020	<0.0020
Cobalt	mg/l	0.0020	<0.0020	<0.0020	<0.0020
Chromium	mg/l	0.0030	0.0051	0.029	0.15
Copper	mg/l	0.0040	<0.0040	<0.0040	<0.0040
Mercury	mg/l	0.00010	0.00042	0.0012	<0.00010
Manganese	mg/l	0.0030	<0.0030	<0.0030	<0.0030
Molybdenum	mg/l	0.0070	0.19	0.18	0.19
Nickel	mg/l	0.0070	<0.0070	<0.0070	<0.0070
Lead	mg/l	0.0040	<0.0040	<0.0040	<0.0040
Selenium	mg/l	0.0040	0.0047	0.0094	<0.0040
Tin	mg/l	0.0070	<0.0070	<0.0070	<0.0070

METHOD SUMMARY

JB11-01869 R0

Report number 0000001519
Client reference: **11521195**

METHOD	METHODOLOGY SUMMARY

FOOTNOTES

IS	Insufficient sample for analysis.
LNR	Sample listed, but not received.
*	This analysis is not covered by the scope of accreditation.
^	Performed by outside laboratory.
LOR	Limit of Reporting
↑↓	Raised or Lowered Limit of Reporting

QFH	QC result is above the upper tolerance
QFL	QC result is below the lower tolerance
-	The sample was not analysed for this analyte

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Unless otherwise indicated, samples were received in containers fit for purpose.

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T0107

ANALYTICAL REPORT (Amended)

CLIENT DETAILS

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Telephone	011 519 0200
Facsimile	011 519 0201
Email	vanzyl@jaws.co.za
Project	**11521198**
Order Number	**DI66/MVZ/19829**
Samples	2
Sample matrix	SOIL

LABORATORY DETAILS

Laboratory	SGS South Africa (Pty) Limited
Address	259 Kent Avenue Ferndale, 2194
Telephone	+27 (0)11 781 5689
Laboratory Manager	Mark Baird (acting)
SGS Reference	JB11-01870 R0
Report Number	0000001540
Date Received	2011/09/12 11:20:06AM
Date Reported	2011/10/03 11:26:35AM

COMMENTS

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This report/certificate is a re-issued copy and replaces the originally issued document dated 2011-09-30. The reason for re-issue is that percent solids results were omitted from the original report.

Filter cake samples not dried prior to testing.

Sample(s) leached using deionised water. Results reported on leachate.

SIGNATORIES

Gladness Radebe
Technical Supervisor/Technical Signatory

Sarah Newton
Technical Consultant/Technical Signatory

ANALYTICAL REPORT

JB11-01870 R0

Report number 0000001540
Client reference: **11521198**

Parameter	Units	LOR	Sample Number: JB11-01870.001 Sample Name: Ashing Ash Sample Matrix: Ash sample	Sample Number: JB11-01870.002 Sample Name: Dusting Ash Sample Matrix: Ash sample
Moisture Method:				
Solids content*	%	0.050	6.37	48.3
South African Standard Leach Procedure Method: AS 4439.3				
Final pH	-	-	10.9	11.8
Conductivity - Water Method: ME-ANA-AN-007				
Conductivity	mS/m	2.0	24	160
Total Dissolved Solids (TDS) in water Method: ME-ANA-AN-011				
Total Dissolved Solids	mg/l	21.0	64	272
Anions by Ion Chromatography Method: ME-ANA-AN-AN014				
Fluoride	mg/l	0.050	<0.050	0.30
Chloride	mg/l	0.050	1.7	2.1
Nitrate	mg/l	0.10	0.28	1.5
Sulphate	mg/l	0.050	19	13
Hexavalent Chromium by UV-VIS Method: ME-ANA-AN-018				
Hexavalent Chromium*	mg/l	0.010	<0.010	0.11
Ammonia as N by UV Method: APHA4500_NH3				
Ammonia*	mg/l	0.050	<0.050	<0.050
ICP-OES Metals in Water (Dissolved) Method: ME-ANA-AN-027				
Silver	mg/l	0.0020	<0.0020	<0.0020
Aluminium	mg/l	0.020	1.6	4.4
Boron	mg/l	0.0050	0.39	0.20
Barium	mg/l	0.0020	0.059	0.84
Beryllium	mg/l	0.00010	<0.00010	<0.00010
Calcium	mg/l	0.50	28	130
Iron	mg/l	0.050	<0.050	<0.050
Potassium	mg/l	0.20	0.45	1.0
Lithium	mg/l	0.0050	0.011	0.068
Magnesium	mg/l	0.010	0.46	0.018
Sodium	mg/l	0.50	3.5	5.0
Silicon	mg/l	1.0	7.1	4.3
Strontium	mg/l	0.0010	0.41	2.1
Titanium	mg/l	0.0050	<0.0050	<0.0050
Vanadium	mg/l	0.0010	0.022	0.045
Zinc	mg/l	0.010	<0.010	<0.010
ICP-MS Metals (Dissolved) Method: ME-ANA-AN-026				
Arsenic	mg/l	0.0030	0.012	<0.0030
Bismuth	mg/l	0.0010	0.0020	<0.0010
Cadmium	mg/l	0.0020	0.0024	<0.0020
Cobalt	mg/l	0.0020	0.0027	<0.0020
Chromium	mg/l	0.0030	0.0075	0.11
Copper	mg/l	0.0040	<0.0040	<0.0040
Mercury	mg/l	0.00010	0.00015	0.00030
Manganese	mg/l	0.0030	0.0097	<0.0030
Molybdenum	mg/l	0.0070	0.012	0.067
Nickel	mg/l	0.0070	<0.0070	<0.0070

			Sample Number	JB11-01870.001	JB11-01870.002
			Sample Name	Ashing Ash	Dusting Ash
			Sample Matrix	Ash sample	Ash sample
Parameter	**Units**	**LOR**			
ICP-MS Metals (Dissolved)	**Method: ME-ANA-AN-026 (continued)**				
Lead	mg/l	0.0040		<0.0040	<0.0040
Antimony	mg/l	0.0070		<0.0070	<0.0070
Selenium	mg/l	0.0040		<0.0040	<0.0040
Tin	mg/l	0.0070		<0.0070	<0.0070

METHOD SUMMARY

JB11-01870 R0

Report number 0000001540
Client reference: **11521198**

METHOD	METHODOLOGY SUMMARY

FOOTNOTES

IS	Insufficient sample for analysis.
LNR	Sample listed, but not received.
*	This analysis is not covered by the scope of accreditation.
^	Performed by outside laboratory.
LOR	Limit of Reporting
↑↓	Raised or Lowered Limit of Reporting

QFH	QC result is above the upper tolerance
QFL	QC result is below the lower tolerance
-	The sample was not analysed for this analyte

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Unless otherwise indicated, samples were received in containers fit for purpose.

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SGS ***Environmental*** Services ***Randburg*** is accredited by ***SANAS*** and conforms to the requirements of ISO/IEC 17025 for specific test or calibrations as indicated on the scope of accreditation to be found at http://sanas.co.za.

T0107

ANALYTICAL REPORT

CLIENT DETAILS

Contact	Marius Van Zyl
Client	Jones & Wagener (Pty) Ltd
Address	P.O. Box 1434 Rivonia 2128
Telephone	011 519 0200
Facsimile	011 519 0201
Email	vanzyl@jaws.co.za
Project	**11521199**
Order Number	**DI66/MVZ/19829**
Samples	1
Sample matrix	SOIL

LABORATORY DETAILS

Laboratory	SGS South Africa (Pty) Limited
Address	259 Kent Avenue Ferndale, 2194
Telephone	+27 (0)11 781 5689
Laboratory Manager	Mark Baird (acting)
SGS Reference	JB11-01871 R0
Report Number	0000001521
Date Received	2011/09/12 11:49:42AM
Date Reported	2011/09/30 09:33:06AM

COMMENTS

The document is issued in accordance with SANAS's accreditation requirements.
Accredited for compliance with ISO/IEC 17025. SANAS accredited laboratory T0107.

Filter cake samples not dried prior to testing.

Sample(s) leached using ARLP leachate. Results reported on leachate.

SIGNATORIES

Gladness Radebe
Technical Supervisor/Technical Signatory

Sarah Newton
Technical Consultant/Technical Signatory

	Sample Number	JB11-01871.001
	Sample Name	Dusting Ash
Parameter	**Units**	**LOR**	

Acid Rain Leaching Procedure (ARLP) Method:

Final pH*	-	-	7.9

Conductivity - Water Method: ME-ANA-AN-007

Conductivity	mS/m	2.0	120

Total Dissolved Solids (TDS) in water Method: ME-ANA-AN-011

Total Dissolved Solids	mg/l	21.0	528

Anions by Ion Chromatography Method: ME-ANA-AN-AN014

Fluoride	mg/l	0.050	<0.050
Chloride	mg/l	0.050	2.5
Nitrate	mg/l	0.10	15
Sulphate	mg/l	0.050	180

Hexavalent Chromium by UV-VIS Method: ME-ANA-AN-018

Hexavalent Chromium*	mg/l	0.010	0.40

Ammonia as N by UV Method: APHA4500_NH3

Ammonia*	mg/l	0.050	<0.050

ICP-OES Metals in Water (Dissolved) Method: ME-ANA-AN-027

Silver	mg/l	0.0020	<0.0020
Aluminium	mg/l	0.020	0.069
Boron	mg/l	0.0050	2.3
Barium	mg/l	0.0020	0.21
Beryllium	mg/l	0.00010	<0.00010
Calcium	mg/l	0.50	200
Iron	mg/l	0.050	<0.050
Potassium	mg/l	0.20	1.4
Lithium	mg/l	0.0050	0.073
Magnesium	mg/l	0.010	45
Sodium	mg/l	0.50	5.4
Silicon	mg/l	1.0	11
Strontium	mg/l	0.0010	2.6
Titanium	mg/l	0.0050	0.023
Vanadium	mg/l	0.0010	0.38
Zinc	mg/l	0.010	<0.010

ICP-MS Metals (Dissolved) Method: ME-ANA-AN-026

Arsenic	mg/l	0.0030	0.080
Bismuth	mg/l	0.0010	<0.0010
Cadmium	mg/l	0.0020	<0.0020
Cobalt	mg/l	0.0020	<0.0020
Chromium	mg/l	0.0030	0.40
Copper	mg/l	0.0040	<0.0040
Mercury	mg/l	0.00010	0.0020
Manganese	mg/l	0.0030	0.049
Molybdenum	mg/l	0.0070	0.14
Nickel	mg/l	0.0070	0.014
Lead	mg/l	0.0040	<0.0040
Antimony	mg/l	0.0070	0.013
Selenium	mg/l	0.0040	0.026
Tin	mg/l	0.0070	<0.0070

METHOD SUMMARY

JB11-01871 R0

Report number 0000001521
Client reference: **11521199**

METHOD	METHODOLOGY SUMMARY

FOOTNOTES

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T0107

ANALYTICAL REPORT

CLIENT DETAILS

Contact	Marius Van Zyl
Client	Jones & Wagener (Pty) Ltd
Address	P.O. Box 1434 Rivonia 2128
Telephone	011 519 0200
Facsimile	011 519 0201
Email	vanzyl@jaws.co.za
Project	(Not specified)
Order Number	**DI66/MVZ/19829**
Samples	1
Sample matrix	SOIL

LABORATORY DETAILS

Laboratory	SGS South Africa (Pty) Limited
Address	259 Kent Avenue Ferndale, 2194
Telephone	+27 (0)11 781 5689
Laboratory Manager	Mark Baird (acting)
SGS Reference	JB11-01881 R0
Report Number	0000001593
Date Received	2011/09/13 12:15:20PM
Date Reported	2011/10/10 11:32:03AM

COMMENTS

Whilst SGS laboratories conform to ISO/IEC 17025 standards, results of analysis in this report fall outside of the current scope of accreditation.

Testing subcontracted to SGS Booysens.

Mineralogy results contained in their report, MIN 0911/192, appended.

SIGNATORIES

Gladness Radebe
Technical Supervisor/Technical Signatory

Sarah Newton
Technical Consultant/Technical Signatory

Report number 0000001593
Client reference: **DI66/MVZ/19829**

		Sample Number	**JB11-01881.001**
		Sample Name	**Dry Ash**
		Sample Matrix	**Soil**
Parameter	**Units**	**LOR**	
SUB_Mineralogy Method: SUB			
XRD scan	No unit	-	MIN 0911/192
SUB_SGS Booysens Method: SUB_BOOY			
Silver	ppm	0.020	<0.020
Aluminium	%	0.010	11
Arsenic	ppm	1.0	13
Barium	ppm	5.0	720
Beryllium	ppm	0.10	5.6
Bismuth	ppm	0.040	1.2
Calcium	%	0.010	3.5
Cadmium	ppm	0.020	<0.020
Chromium	ppm	1.0	110
Cobalt	ppm	0.10	16
Copper	ppm	0.50	59
Iron	%	0.010	6.9
Mercury	ppm	3.0	<3.0
Potassium	%	0.010	0.50
Lithium	ppm	1.0	180
Magnesium	%	0.010	0.82
Manganese	ppm	5.0	490
Molybdenum	ppm	0.050	5.2
Sodium	%	0.010	0.12
Nickel	ppm	0.50	51
Phosphorus	ppm	50	1100
Lead	ppm	0.50	41
Sulphur	%	0.010	0.20
Antimony	ppm	0.050	0.89
Selenium	ppm	2.0	<2.0
Silicon	%	0.10	19
Tin	ppm	0.30	4.4
Strontium	ppm	0.50	1000
Titanium	%	0.010	0.71
Vanadium	ppm	1.0	68
Zinc	ppm	1.0	310
Zirconium	ppm	0.50	250

METHOD SUMMARY

JB11-01881 R0

Report number 0000001593
Client reference: **DI66/MVZ/19829**

METHOD	METHODOLOGY SUMMARY

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ANALYTICAL REPORT

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Client	Jones & Wagener (Pty) Ltd
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Telephone	011 519 0200
Facsimile	011 519 0201
Email	vanzyl@jaws.co.za
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Technical Supervisor/Technical Signatory

Sarah Newton
Technical Consultant/Technical Signatory

Report number 0000001593
Client reference: **DI66/MVZ/19829**

		Sample Number	**JB11-01881.001**
		Sample Name	**Dry Ash**
		Sample Matrix	**Soil**
Parameter	**Units**	**LOR**	
SUB_Mineralogy Method: SUB			
XRD scan	No unit	-	MIN 0911/192
SUB_SGS Booysens Method: SUB_BOOY			
Silver	ppm	0.020	<0.020
Aluminium	%	0.010	11
Arsenic	ppm	1.0	13
Barium	ppm	5.0	720
Beryllium	ppm	0.10	5.6
Bismuth	ppm	0.040	1.2
Calcium	%	0.010	3.5
Cadmium	ppm	0.020	<0.020
Chromium	ppm	1.0	110
Cobalt	ppm	0.10	16
Copper	ppm	0.50	59
Iron	%	0.010	6.9
Mercury	ppm	3.0	<3.0
Potassium	%	0.010	0.50
Lithium	ppm	1.0	180
Magnesium	%	0.010	0.82
Manganese	ppm	5.0	490
Molybdenum	ppm	0.050	5.2
Sodium	%	0.010	0.12
Nickel	ppm	0.50	51
Phosphorus	ppm	50	1100
Lead	ppm	0.50	41
Sulphur	%	0.010	0.20
Antimony	ppm	0.050	0.89
Selenium	ppm	2.0	<2.0
Silicon	%	0.10	19
Tin	ppm	0.30	4.4
Strontium	ppm	0.50	1000
Titanium	%	0.010	0.71
Vanadium	ppm	1.0	68
Zinc	ppm	1.0	310
Zirconium	ppm	0.50	250

METHOD SUMMARY

JB11-01881 R0

Report number 0000001593
Client reference: **DI66/MVZ/19829**

METHOD	METHODOLOGY SUMMARY

FOOTNOTES

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Internet: www.sgs.com

Sarah Newton

SGS Environmental Services SA
P.O. Box 82582
Southdale
2135

TEST REPORT

Lab Ref	LA117646
Client Ref	**JB11 - 01881**
Project	DEFAULT
Product Code	SOLIDS
Status	Final
Received	14/09/11
Reported	10/10/11
Samples	2
First Sample	1881 - 001
Last Sample	WASTE ROCK
Pages	10

Notes

Technical Signatory Name: ..... ***Signature:***.....

Technical Signatory Name: ..... ***Signature:***.....

Technical Signatory Name: ..... ***Signature:***.....

On behalf of: SGS South Africa

The results in the following analytical report pertain to this laboratory for preparation and/or analysis as requested by SGS Environmental Services SA.

The analytical results reported herein refer to the samples as received and are based on a dry basis where applicable.

SGS South Africa (Pty) Ltd
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Internet: www.sgs.com

Lab Ref LA117646
Client Ref **JB11 - 01881**
Project DEFAULT
Reported 10/10/11
Status Final

TEST REPORT

	WtRec	Al	Ba	Ca	Cr	Cu
Scheme	**WGH79**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**
Units	**g**	**%**	**ppm**	**%**	**ppm**	**ppm**
Detection Limit	**0.01**	**0.01**	**5**	**0.01**	**1**	**0.5**
1881 - 001	**34.50**	**10.5**	**716**	**3.50**	**113**	**59.4**
WASTE ROCK	**-**	**0.28**	**94**	**0.03**	**22**	**14.6**
GEOSTATS		**4.34**	**36**	**1.13**	**1750**	**3880**
LKSD-3SA		**5.67**	**638**	**1.49**	**-**	**-**
OREAS 100A		**5.58**	**417**	**1.05**	**39**	**183**
OREAS 101A		**5.78**	**180**	**1.23**	**39**	**-**
BLANK		**<0.01**	**<5**	**<0.01**	**<1**	**<0.5**
1881 - 001		**10.8**	**777**	**3.63**	**119**	**62.4**

- not analysed / -- element not determined / I.S. insufficient sample / L.N.R. listed not received / U.T.D. Unable To Determine

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Internet: www.sgs.com

Lab Ref LA117646
Client Ref **JB11 - 01881**
Project DEFAULT
Reported 10/10/11
Status Final

TEST REPORT

	Fe	K	Li	Mg	Mn	Na
Scheme	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**
Units	**%**	**%**	**ppm**	**%**	**ppm**	**%**
Detection Limit	**0.01**	**0.01**	**1**	**0.01**	**5**	**0.01**
1881 - 001	**6.86**	**0.50**	**181**	**0.82**	**488**	**0.12**
WASTE ROCK	**0.72**	**0.08**	**<1**	**<0.01**	**128**	**0.02**
GEOSTATS	**4.75**	**3.41**	**9**	**0.52**	**5230**	**1.60**
LKSD-3SA	**4.01**	**2.02**	**27**	**1.14**	**1410**	**1.97**
OREAS 100A	**4.21**	**3.79**	**20**	**0.85**	**579**	**0.14**
OREAS 101A	**10.4**	**2.26**	**44**	**1.24**	**1020**	**0.08**
BLANK	**<0.01**	**<0.01**	**<1**	**<0.01**	**<5**	**<0.01**
1881 - 001	**7.03**	**0.52**	**188**	**0.86**	**508**	**0.12**

- not analysed / -- element not determined / I.S. insufficient sample / L.N.R. listed not received / U.T.D. Unable To Determine

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Lab Ref LA117646
Client Ref **JB11 - 01881**
Project DEFAULT
Reported 10/10/11
Status Final
Page

TEST REPORT

	P	S	Sr	Ti	V	Zn
Scheme	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**
Units	**ppm**	**%**	**ppm**	**%**	**ppm**	**ppm**
Detection Limit	**50**	**0.01**	**0.5**	**0.01**	**1**	**1**
1881 - 001	**1130**	**0.20**	**1010**	**0.71**	**68**	**314**
WASTE ROCK	**210**	**0.04**	**<0.5**	**0.01**	**3**	**39**
GEOSTATS	**460**	**0.96**	**43.7**	**0.21**	**45**	**5230**
LKSD-3SA	**1110**	**-**	**237**	**-**	**-**	**-**
OREAS 100A	**510**	**0.06**	**22.5**	**-**	**-**	**41**
OREAS 101A	**-**	**0.13**	**10.0**	**-**	**-**	**101**
BLANK	**<50**	**<0.01**	**<0.5**	**<0.01**	**<1**	**5**
1881 - 001	**1190**	**0.22**	**1050**	**0.74**	**77**	**336**

- not analysed / -- element not determined / I.S. insufficient sample / L.N.R. listed not received / U.T.D. Unable To Determine

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Lab Ref LA117646
Client Ref **JB11 - 01881**
Project DEFAULT
Reported 10/10/11
Status Final

TEST REPORT

	Zr	Ag	As	Be	Bi	Cd
Scheme	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**
Units	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Detection Limit	**0.5**	**0.02**	**1**	**0.1**	**0.04**	**0.02**
1881 - 001	**254**	**<0.02**	**13**	**5.6**	**1.24**	**<0.02**
WASTE ROCK	**54.2**	**<0.02**	**2**	**0.1**	**0.31**	**<0.02**
GEOSTATS	**68.2**	**48.0**	**13**	**-**	**-**	**-**
LKSD-3SA	**-**	**2.87**	**27**	**1.8**	**-**	**-**
OREAS 100A	**121**	**-**	**-**	**-**	**-**	**-**
OREAS 101A	**91.0**	**-**	**-**	**-**	**-**	**-**
BLANK	**<0.5**	**<0.02**	**<1**	**<0.1**	**<0.04**	**<0.02**
1881 - 001	**275**					
1881 - 001		**<0.02**	**13**	**5.8**	**1.25**	**<0.02**

- not analysed / -- element not determined / I.S. insufficient sample / L.N.R. listed not received / U.T.D. Unable To Determine

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Lab Ref LA117646
Client Ref **JB11 - 01881**
Project DEFAULT
Reported 10/10/11
Status Final

TEST REPORT

	Co	Mo	Ni	Pb	Sb	Se
Scheme	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**	**ICM40B**
Units	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Detection Limit	**0.1**	**0.05**	**0.5**	**0.5**	**0.05**	**2**
1881 - 001	**16.4**	**5.18**	**51.3**	**41.4**	**0.89**	**<2**
WASTE ROCK	**1.6**	**3.71**	**5.3**	**7.6**	**0.17**	**<2**
GEOSTATS	**2070**	**-**	**4030**	**1.21%**	**11.3**	**-**
LKSD-3SA	**29.0**	**-**	**46.7**	**29.3**	**1.36**	**-**
OREAS 100A	**16.4**	**20.7**	**-**	**13.4**	**-**	**-**
OREAS 101A	**47.0**	**20.5**	**-**	**21.3**	**-**	**-**
BLANK	**<0.1**	**<0.05**	**<0.5**	**<0.5**	**0.09**	**<2**
1881 - 001	**16.6**	**5.22**	**52.0**	**41.7**	**0.90**	**<2**

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Lab Ref LA117646
Client Ref **JB11 - 01881**
Project DEFAULT
Reported 10/10/11
Status Final

TEST REPORT

	Sn	Hg	Si
Scheme	**ICM40B**	**IMS12B**	**ICP90A**
Units	**ppm**	**ppm**	**%**
Detection Limit	**0.3**	**3**	**0.1**
1881 - 001	**4.4**	**<3**	**19.2**
WASTE ROCK	**0.5**	**<3**	**20.8**
GEOSTATS	**-**		
LKSD-3SA	**-**		
OREAS 100A	**-**		
OREAS 101A	**-**		
BLANK	**<0.3**		
BLANK		**<3**	
SARM5			**-**
BLANK			**<0.1**
1881 - 001			**19.9**
BCS176/2			**1.27**
1881 - 001		**<3**	
CCU-1C		**30**	
GXR-1		**4**	
1881 - 001	**4.4**		

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TEST REPORT

APPENDIX A - METHODS

METHOD NUMBER	METHOD DESCRIPTION	SCHEME CODE
ME-ZA-[MINANA]-[BYZ(FAS)]AN-001	Au by Lead Fusion followed by Atomic Absorption analysis or Gravimetric analysis	FAALA01, FAALA01D, FAGLA01, FAGLA02, FAGLA03, FAGLA04, FAGLA05
ME-ZA-[MINANA]-[BYZ(FAS)]AN-002	Au, Pt, Pd by Lead Fusion followed by	FAI313
ME-ZA-[MINANA]-[BYZ(FAS)]AN-003	Pt, Pd, Rh, Ru, Ir by Nickel Sulphide, ICP-OES finish	FAI363
ME-ZA-[MINANA]-[BYZ(XRF)]AN-001	Major Element Oxides by Borate fusion XRF	XRF79V, XRF79C
ME-ZA-[MINANA]-[BYZ(XRF)]AN-002	Base Metals by Potassium Pyrosulphate Fusion XRF	XRF77R
ME-ZA-[MINANA]-[BYZ(AAS)]AN-001	Acid Soluble Cu and Ni by Acid digestion and analysis by AAS	AAS13C
ME-ZA-[MINANA]-[BYZ(LEC)]AN-001	Total Sulphur and Carbon by Leco Combustion Infrared Detection	CSALA01, CSALA06
ME-ZA-[MINANA]-[BYZ(ICM)]AN-001	Total & Dissolved metals by ICP-OES & ICP-MS	ICP84T & IMS84T
ME-ZA-[MINANA]-[BYZ(XRF)]AN-003	Uranium Oxide, pressed powder analysis using XRF spectrometer	XRF75G
ME-ZA-[MINANA]-[BYZ(FAS)]AN-005	Rh by Pd fusion by ICP-OES finish	FAI353
ME-ZA-[MINANA]-[BYZ(WET)]AN-001	Chloride by Potentiometric titration	CLA27V

- not analysed / -- element not determined / I.S. insufficient sample / L.N.R. listed not received / U.T.D. Unable To Determine

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METHOD DESCRIPTION	SCHEME CODE
Silver (Ag) by Fire Assay, gravimetric finish	FAGLA02
Trace elements by pressed pellet, XRF	XRF75G
Sulphide Sulphur (S2-) by Leco	CSA08V
Elemental sulphur (S°) by gravimetric finish	CSA12V
Aqueous sulphate (SO4) by Dionex	CLA31V
Sulphate (SO4) on solids by Dionex	CSA11V
Carbonate (CO3) by LECO	CSA02V
Graphite carbon by LECO	CSA10V
Organic carbon by LECO	CSA03V
pH determination	ISE06T
Conductivity (EC) determination	ISE09V
Total Hardness as CaCO3 (calc from ICP Ca, Mg analyses)	ICP84B
Anions by IC (F, Cl, NO2, NO3, SO4)	CLA31V
Ammonia (NH3) by spectroquant	CLA23V
Phosphate (PO4) by colourmetric analysis	CLA22V
Chemical Oxygen Demand (COD) by spectroquant	CLA24V
Suspended solids (TSS)	PHY18V
Total dissolved solids (TDS), gravimetric finish (180 °C)/Electrometric, conductivity meter	ISE10V
Alkalinity by titration	CLA28V
Chloride (Cl) by titration (solutions)	CLA27V
Chloride (Cl) by titration (solids)	CLA04E
Fluoride (F) by ISE (solutions)	ISE07W
Fluoride (F) by ISE (solids)	ISELA01
Acid Base Accounting (ABA)	CLA41V
Net acid generation (NAG) test (incl. S species)	CLA43V
Short term leach testing (ARLP, TCLP, SPLP, etc)	CLA40V
Deionised water (DI) leach (2 hours, L:S=10)	Leach
Cyanide (CN) species - Free, WAD & Total	CLA25V
Thiocyanate (SCN) by IC	CLA31V
Metals by AAS (solutions)	AAS84T
Gold (Au) in CN solutions by AAS	SOL81T
Silver (Ag) by acid digestion, AAS	AAS14E
Arsenic (As) by Aqua Regia digestion, AAS	AAS11C
Multi Acid digestion, AAS finish	AAS40D
Acid soluble Cu, Co by Sulphuric Acid leach, AAS	AAS72C
Aqua Regia digestion, ICP-OES finish	ICP13E
Multi Acid digestion, ICP-OES finish	ICP40D
Sodium Peroxide fusion, ICP-OES finish	ICP91B

- not analysed / -- element not determined / I.S. insufficient sample / L.N.R. listed not received / U.T.D. Unable To Determine

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TEST REPORT

METHOD DESCRIPTION	SCHEME CODE
Semi quantative ICP-OES +ICP-MS scan, Aqua Regia digestion	ICM12B
As, Hg, Se, Te by Aqua Regia digestion, ICP-MS finish	IMS12Q
Multi Acid digestion, semi quantative scan, ICP-OES + ICP-MS	ICM40B
Multi acid digestion, ICP-MS	IMS40B
Rare Earth Elements (REE) by Na2O2 fusion, ICP-MS	IMS90A
Free acid titration	CLA15F
Chloride (Cl) by manual titration (Metallurgical)	CLA26V
As 3+ by titration	CLA32V
As 5+ by calculation	CLA32V
Lime (CaO) by titration	CLA07C
Lime (CaO), calculation after AAS analysis	CLA07C
Ferrous (Fe2+) iron by titration (solids)	CLA34V
Ferrous (Fe2+) iron by titration (solutions)	CLA34V
Ferric (Fe3+) iron by diff (incl. Fe total, Fe2+) - solids	CLA34V
Ferric (Fe3+) iron by diff (incl. Fe total, Fe2+) - solutions	CLA35V
Iron (Fe) by titration (solids)	CLA35V
Tin (Sn) by titration (solids)	CON14V
Zinc (Zn) by EDTA titration (solids)	CON12V
Hexavalent chromium (Cr6+) in solutions	CLA21V
Manganese (Mn) by back titration	CON15V
Vanadium (V) by titration	CON16V
Chrome (Cr) by back titration	CON10B
Relative Density/Specific Gravity (by Le Chatelier flask)	PHY04V
Bulk density	PHY21V
Relative Density/Specific Gravity (by Helium pyncometer)	PHY03V
Grain density	PHY20V
Moisture (105 °C)	PHY08D
Ash/LOI (1050 °C)	PHY01K

- not analysed / -- element not determined / I.S. insufficient sample / L.N.R. listed not received / U.T.D. Unable To Determine

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TEST REPORT

SGS South Africa (Pty) Ltd.
58 Melville Street
Booysens
Johannesburg

Sarah Newton
SGS Environmental Services
259 Kent Avenue
Randburg

MINERALOGICAL REPORT No: MIN 0911/192

Work Requested By: Sarah Newton

On Behalf Of: SGS Environmental

Date issued: 05 October 2011

Investigator: O.D Mosinyi

Analysis of Sample 1881-001 by XRD

O.D. Mosinyi — **Mineralogist**

L.L. Coetzee — **Manager: Mineralogy**

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1. INTRODUCTION

Sarah Newton, on behalf of SGS Environmental Services, submitted one sample for X-ray diffraction mineralogical examination. The sample was labelled 1881-001, a dry ash sample.

2. METHODOLOGY

The sample was pulverized and analysed by X-ray diffraction utilising a Panalytical X'pert Pro Diffractometer employing Co-Kα radiation. Data interpretation was by means of Panalytical Highscore Plus analytical software, in conjunction with the PDF2 database. The XRD analysis was used to identify and quantify the crystalline phases present in the sample.

3. RESULTS

3.1 X-ray Diffraction Analyses

The crystalline phases that were detected by XRD are listed below in Table 1, and the diffractogram for the sample is shown in figure 1. There were four crystalline phases that were detected by XRD. These were mullite which made up 45.2%,of the sample, and quartz which also accounted for 45.2 % of the sample, calcite accounted for 6.5 % of the sample and lastly magnetite accounted for 3.1 % of the sample.

Table 1: Crystalline phases as determined by X-ray Diffraction

Mineral	Approx. Formula	01881-001 Mass %
Mullite	$Al_6Si_2O_{13}$	45.2
Quartz	SiO_2	45.2
Calcite	$CaCO_3$	6.5
Magnetite	Fe_3O_4	3.1

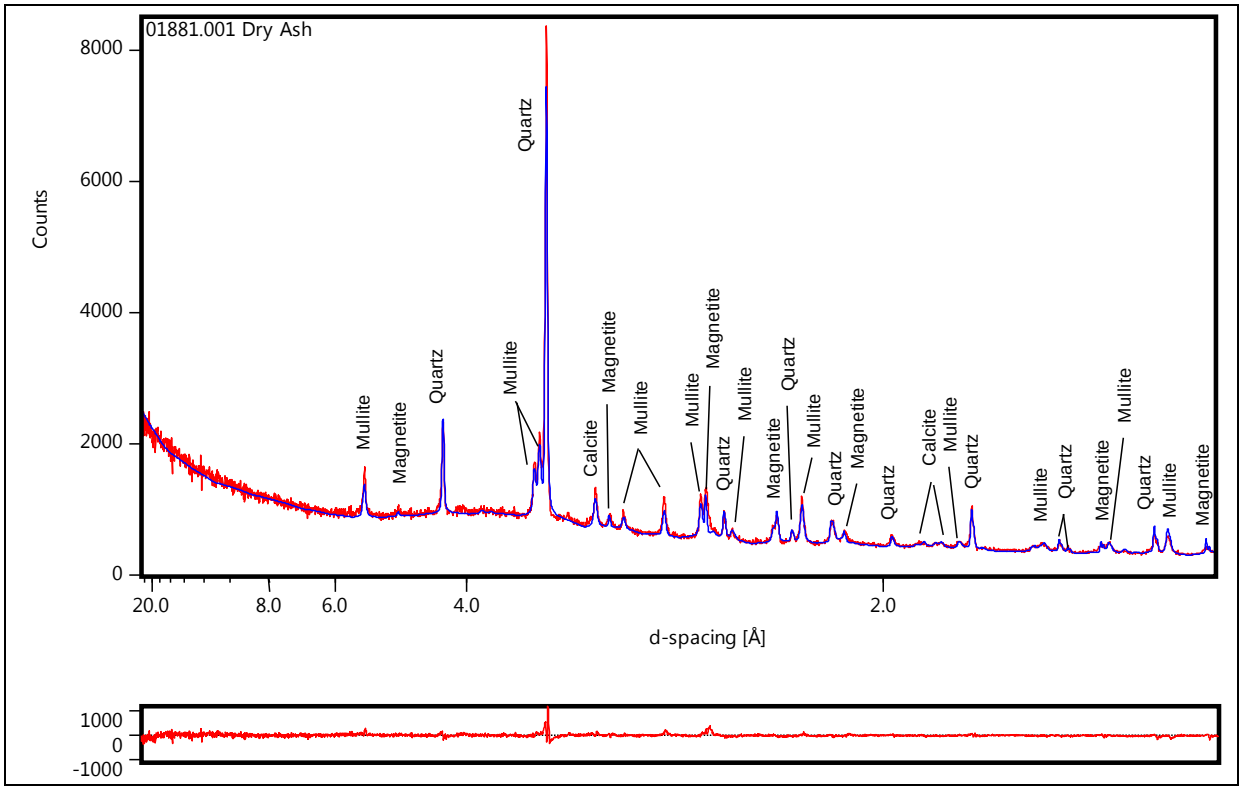

Figure 1: X-ray Diffractogram showing the composition of the sample 1881-001.The diffractogram in red shows the measured pattern, while the blue shows the calculated pattern obtained as part of the Rietveld refinement. The lower red pattern shows the difference between the measured and calculated pattern.

Appendix B

CHEMICAL ANALYSES CONDUCTED ON THE REVERSE OSMOSIS EFFLUENT

Laboratory Number T0055

Central Water Laboratory

Final Task Report

Report Reference

WL2012-010221

Date	**2012/07/09**
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Attention	Irma Hodgskin
Client Name	Camden Power Station
Address	Piet Retief Road
Fax	017 827 8115
Telephone	017 827 8007

Report Title WMC

TEST RESULTS FOR THE ANALYSIS OF WATER SAMPLES

Number of Samples 1

Description of Samples Acceptable

Date Registered 29-June-2012

Date Reported 09-July-2012

Task Comments:

Approved By : _____

Cody Makhuba

Snr Technician

011 629 5596

Date : _____

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Opinions and interpretations expressed herein are outside the scope of SANAS accredition,

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Eskom Holdings Reg No 2002/015527/06

Eskom Central Water Laboratory Test Results

Laboratory Number T0055

Sample ID 3906049 SAMPLE 1 RO BRINE	WMC-2012-06-29/13	WL2012-010221
Component	**Unit**	**Value**
Alkalinity Total	mg/l CaCO3	29.1
Aluminium as Al	mg/l	0.07
Barium as Ba	mg/l	0.25
Calcium as Ca	mg/l	640
Chloride as Cl	mg/l	380.00
Iron as Fe	mg/l	0.01
Flouride as F	mg/l	3.47
Magnesium as Mg	mg/l	0.60
Manganese as Mn	mg/l	<0.005
Sodium as Na	mg/l	570
Nitrate as N	mg/l	3.32
pH @ 25 ℃		7.12
Ortho Phosphate as PO4	mg/l	<0.090
Silica as SiO2	mg/l	22
Sulphate as SO4	mg/l	2080
Strontium as Sr	mg/l	15

The analyses were performed using the following methods:

Alkalinity Total	**ESKOM METHOD NO 304**	**Accredited**
Aluminium ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Barium ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Calcium ICP (mg/l)	**ESKOM METHOD NO 415**	**Accredited**
Chloride IC (mg/l)	**ESKOM METHOD NO 307**	**Accredited**
Flouride IC (mg/l)	**ESKOM METHOD NO 307**	**Not Accredited**
Iron ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Magnesium ICP (mg/l)	**ESKOM METHOD NO 415**	**Accredited**
Manganese ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Nitrate as N IC (mg/l)	**ESKOM METHOD NO 307**	**Accredited**
Ortho Phosphate as PO4(mg/l)	**ESKOM METHOD NO 72**	**Not Accredited**
pH @ 25 ℃	**ESKOM METHOD NO 300A**	**Accredited**
Silica as SiO2 ICP (mg/l)	**ESKOM METHOD NO 417**	**Not Accredited**
Sodium ICP (mg/l)	**ESKOM METHOD NO 415**	**Accredited**
Strontium ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Sulphate IC (mg/l)	**ESKOM METHOD NO 307**	**Accredited**

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4. With the exception of all microbiological analyses, unless otherwise stated, sampling is not carried out by the laboratory.

5. All water samples are preserved according to procedure P511 unless otherwise stated.

6. Unless otherwise specified all analyses on water samples give the dissolved constituents.

End of the Report

Laboratory Number T0055

Central Water Laboratory

Final Task Report

Report Reference

WL2012-010199

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Attention	Irma Hodgskin
Client Name	Camden Power Station
Address	Piet Retief Road
Fax	017 827 8115
Telephone	017 827 8007

Report Title WMC

TEST RESULTS FOR THE ANALYSIS OF WATER SAMPLES

Number of Samples 5

Description of Samples ACCEPTABLE

Date Registered 12-June-2012

Date Reported 25-June-2012

Task Comments:

Approved By : _____

Cody Makhuba

Snr Technician

011 629 5596

Date : _____

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Eskom Holdings Reg No 2002/015527/06

Eskom Central Water Laboratory Test Results

Laboratory Number T0055

Sample ID 3860564	WMC-2012-06-12/91	WL2012-010199
Brine water sample		
Component	**Unit**	**Value**
Alkalinity Total	mg/l CaCO3	26.7
Aluminium as Al	mg/l	0.67
Barium as Ba	mg/l	0.30
Calcium as Ca	mg/l	480
Chloride as Cl	mg/l	330.00
Iron as Fe	mg/l	<0.005
Flouride as F	mg/l	3.64
Magnesium as Mg	mg/l	0.73
Manganese as Mn	mg/l	0.01
Sodium as Na	mg/l	420
Nitrate as N	mg/l	3.14
pH @ 25 ℃		6.54
Ortho Phosphate as PO4	mg/l	<0.090
Silica as SiO2	mg/l	18
Sulphate as SO4	mg/l	2100
Strontium as Sr	mg/l	13

Sample ID 3860565	WMC-2012-06-12/92	WL2012-010199
Raw Feed water sample		
Component	**Unit**	**Value**
Alkalinity Total	mg/l CaCO3	132
Aluminium as Al	mg/l	0.94
Barium as Ba	mg/l	0.18
Calcium as Ca	mg/l	180
Chloride as Cl	mg/l	130.00
Iron as Fe	mg/l	<0.005
Flouride as F	mg/l	1.47
Magnesium as Mg	mg/l	0.18
Manganese as Mn	mg/l	0.01
Sodium as Na	mg/l	170
Nitrate as N	mg/l	1.35
pH @ 25 ℃		10.52
Ortho Phosphate as PO4	mg/l	<0.090
Silica as SiO2	mg/l	8.8
Sulphate as SO4	mg/l	610
Strontium as Sr	mg/l	4.8

Eskom Central Water Laboratory Test Results

Laboratory Number T0055

Sample ID 3860566 Maddox Out water sample	WMC-2012-06-12/93	WL2012-010199
Component	**Unit**	**Value**
Alkalinity Total	mg/l CaCO3	13.6
Aluminium as Al	mg/l	0.21
Barium as Ba	mg/l	0.10
Calcium as Ca	mg/l	180
Chloride as Cl	mg/l	130.00
Iron as Fe	mg/l	0.02
Flouride as F	mg/l	1.48
Magnesium as Mg	mg/l	0.24
Manganese as Mn	mg/l	0.01
Sodium as Na	mg/l	160
Nitrate as N	mg/l	1.36
pH @ 25 ℃		5.97
Ortho Phosphate as PO4	mg/l	<0.090
Silica as SiO2	mg/l	7.2
Sulphate as SO4	mg/l	730
Strontium as Sr	mg/l	4.8

Sample ID 3860567 Gac Out water sample	WMC-2012-06-12/94	WL2012-010199
Component	**Unit**	**Value**
Alkalinity Total	mg/l CaCO3	15.1
Aluminium as Al	mg/l	0.25
Barium as Ba	mg/l	0.14
Calcium as Ca	mg/l	180
Chloride as Cl	mg/l	130.00
Iron as Fe	mg/l	<0.005
Flouride as F	mg/l	1.46
Magnesium as Mg	mg/l	0.25
Manganese as Mn	mg/l	0.01
Sodium as Na	mg/l	160
Nitrate as N	mg/l	1.35
pH @ 25 ℃		5.81
Ortho Phosphate as PO4	mg/l	<0.090
Silica as SiO2	mg/l	7.4
Sulphate as SO4	mg/l	730
Strontium as Sr	mg/l	4.7

Eskom Central Water Laboratory Test Results

Laboratory Number T0055

Sample ID 3860568	WMC-2012-06-12/95	WL2012-010199
Pertmate Product water sample		
Component	**Unit**	**Value**
Alkalinity Total	mg/l CaCO3	3.7
Aluminium as Al	mg/l	0.04
Barium as Ba	mg/l	<0.005
Calcium as Ca	mg/l	1.9
Chloride as Cl	mg/l	5.28
Iron as Fe	mg/l	<0.005
Flouride as F	mg/l	0.08
Magnesium as Mg	mg/l	<0.005
Manganese as Mn	mg/l	0.01
Sodium as Na	mg/l	6.9
Nitrate as N	mg/l	0.27
pH @ 25 ℃		5.75
Ortho Phosphate as PO4	mg/l	<0.090
Silica as SiO2	mg/l	0.16
Sulphate as SO4	mg/l	5.59
Strontium as Sr	mg/l	0.05

The analyses were performed using the following methods:

Alkalinity Total	**ESKOM METHOD NO 304**	**Accredited**
Aluminium ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Barium ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Calcium ICP (mg/l)	**ESKOM METHOD NO 415**	**Accredited**
Chloride IC (mg/l)	**ESKOM METHOD NO 307**	**Accredited**
Flouride IC (mg/l)	**ESKOM METHOD NO 307**	**Not Accredited**
Iron ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Magnesium ICP (mg/l)	**ESKOM METHOD NO 415**	**Accredited**
Manganese ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Nitrate as N IC (mg/l)	**ESKOM METHOD NO 307**	**Accredited**
Ortho Phosphate as PO4(mg/l)	**ESKOM METHOD NO 72**	**Not Accredited**
pH @ 25 ℃	**ESKOM METHOD NO 300A**	**Accredited**
Silica as SiO2 ICP (mg/l)	**ESKOM METHOD NO 417**	**Not Accredited**
Sodium ICP (mg/l)	**ESKOM METHOD NO 415**	**Accredited**
Strontium ICP (mg/l)	**ESKOM METHOD NO 412**	**Accredited**
Sulphate IC (mg/l)	**ESKOM METHOD NO 307**	**Accredited**

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3. While every endeavour will be made to ensure that a test is representative and accurately performed, and that the report is accurate and the quoted results and conclusions drawn from the test, its officers shall in no way be liable for any error made in carrying out the test or for erronous statement, whether in fact or opinion, contained in a report persuant to a test.

4. With the exception of all microbiological analyses, unless otherwise stated, sampling is not carried out by the laboratory.

5. All water samples are preserved according to procedure P511 unless otherwise stated.

6. Unless otherwise specified all analyses on water samples give the dissolved constituents.

End of the Report

Camden Projected Brine Quality

		Feed	PERMEATE	BRINE
FLOW RATE	**m3/hr**		145	36
Component	**Unit**	**Average**		
ALUMINIUM	mg/l	0.9	0.001	0.1
AMMONIA (AS N)	mg/l	0	0	0
BARIUM (AS BA)	mg/l	0.2	0	0.99
BERYLLIUM	mg/l	<.005	0	<.005
BORON (AS B)	mg/l	2.3	0.5	1.4
C.O.D	mg/l	61	0.1	3
CADMIUM	mg/l	<.005	0	<.005
CALCIUM (AS CA)	mg/l	177	1.57	877.02
CHLORIDE (AS CL)	mg/l	160	3.06	785.93
CHROMIUM	mg/l	0.03	0	0.1
COBALT (AS CO)	mg/l	<.005	0	<.005
CONDUCTIVITY (AT 25C	US/CM	2010		
TOTAL DISSOLVED SOLIDS	mg/l		16.88	7476.65
COPPER	mg/l	<.005	0	<.005
CYANIDE (AS CN)	mg/l	<.025	0	<.025
FATS, OILS AND GREASE	mg/l	1.3	0	0.1
FLUORIDE (AS F)	mg/l	0	0	0
IRON	mg/l	0.06	0	0.3
LEAD	mg/l	0.05	0	0.27
MAGNESIUM	mg/l	0.27	0	1.34
MANGANESE	mg/l	0.01	0	0.05
MERCURY	ug/l	1.03	0	4
MOLYBDENUM	mg/l	0.33	0	0.1
NICKEL	mg/l	<.005	0	<.005
NITRATE (AS NO3)	mg/l N	<.02	0	<.02
ORTHO PHOSPHATE (AS PO4)	mg/l	0	0	0
OXYGEN ABSORBED (AS O2)	mg/l	0.85		
PH	PH @25C	11.03	5.1	7.2
PHENOLS (AS PHENOL)	mg/l	0.01	0	0.03
POTASSIUM	mg/l	34	0.64	167.1
SODIUM	mg/l	210	3.51	1385.38
STRONTIUM	mg/l	4.9	0.04	24.28
SULPHATE (AS SO4)	mg/l	760	7.19	4009.28
SUSPENDED SOLIDS	mg/l	10.7	0	1
TOTAL ALKALINITY (AS CACO3)	mg/l	113.8	1	404
TOTAL HARDNESS (AS CACO3)	mg/l	442	4	2197
TOTAL PHOSPHATE (AS P)	mg/l	0	0	0
VANDIUM	mg/l	0.04	0	0.1
ZINC	mg/l	<.005	0	<.005

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SANAS Accredited Testing Laboratory
No. T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2012 - 11 - 08 **Date completed:** 2012 - 11 – 16

Project number: 132 **Report number: 37483** **Order number: D756/MVZ/22281**

Client name: Jones & Wagener Consulting Civil Engineers **Contact person: Mr. M. van Zyl**

Address: P.O. Box 1434 Rivonia 2128 **e-mail: vanzyl@jaws.co.za**

Telephone: 011 519 0200 **Facsimile: 011 519 0201** **Mobile: 082 604 5137**

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification: Camden			
		Demin Plant: Clarifier Blow-down	Cooling Water Blow Down	RO Plant Brine	De Jagers Pan Water
Sample Number		15500	15501	15502	15503
Total Dissolved Solids at 180°C *	WLAB003	60	984	3 398	1 308
Chloride as Cl *	WLAB046	8	81	283	133
Sulphate as SO_4	WLAB046	10	371	1 811	668
Fluoride as F	WLAB014	<0.2	1.3	3.7	1.2
Nitrate as N *	WLAB046	<0.2	4.4	3.0	1.3
Aluminium as Al	WLAB015	0.398	2.52	0.289	1.17
Antimony as Sb *	WLAB015	<0.010	<0.010	<0.010	<0.010
Arsenic as As *	WLAB015	<0.010	<0.010	<0.010	<0.010
Barium as Ba *	WLAB015	0.084	0.151	0.207	0.139
Boron as B *	WLAB015	<0.025	0.489	3.13	1.71
Cadmium as Cd	WLAB015	<0.005	<0.005	<0.005	<0.005
Total Chromium as Cr	WLAB015	<0.025	<0.025	0.148	0.051
Hexavalent Chromium as Cr^{6+} *	WLAB032	<0.010	<0.010	0.071	0.048
Trivalent Chromium as Cr^{3+} *	---	<0.025	<0.025	0.077	<0.025
Cobalt as Co	WLAB015	<0.025	<0.025	<0.025	<0.025
Copper as Cu	WLAB015	<0.025	0.743	<0.025	<0.025
Iron as Fe	WLAB015	0.355	2.95	<0.025	<0.025
Lead as Pb	WLAB015	<0.020	<0.020	<0.020	<0.020
Manganese as Mn	WLAB015	1.65	0.452	<0.025	<0.025
Mercury as Hg *	WLAB047	<0.001	<0.001	<0.001	<0.001
Molybdenum as Mo *	WLAB015	<0.025	<0.025	1.64	0.436
Nickel as Ni	WLAB015	<0.025	<0.025	<0.025	<0.025
Selenium as Se *	WLAB015	<0.020	<0.020	0.050	<0.020
Strontium as Sr *	WLAB015	0.034	0.829	13	4.93
Thallium as Tl *	WLAB015	<0.025	<0.025	<0.025	<0.025
Vanadium as V *	WLAB015	<0.025	<0.025	<0.025	<0.025
Zinc as Zn	WLAB015	<0.025	0.364	<0.025	<0.025

*** = Not SANAS Accredited**

Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this Laboratory.

A van de Wetering

Technical Signatory

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