LIDWALA CONSULTING ENGINEERS

ESKOM HENDRINA POWER STATION
NEW ASH DISPOSAL FACILITY

WASTE ASSESSMENT

Report No.: JW175/14/E699 – Rev 00

September 2014

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Acronyms and abbreviations used in this document:

ASLP	Australian Standard Leaching Procedure
DEA	Department of Environmental Affairs
DWS	Department of Water and Sanitation
DWAF	Department of Water Affairs and Forestry
LC	Leach concentration in mg/ℓ
LCT	Leach concentration threshold in mg/ℓ
mg/kg	Milligram per kilogram
mg/ℓ	Milligram per litre
TC	Total concentration in mg/kg
TCT	Total concentration threshold in mg/kg
TDS	Total dissolved salts
µS/cm	Micro Siemens per centimetre

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1. INTRODUCTION

1.1 Background

Lidwala Consulting Engineers (Pty) Ltd (Lidwala) was appointed by Eskom to identify, investigate and license a new ash disposal facility (or an expansion of the existing system) for the existing Hendrina Power Station located close to Hendrina in Mpumalanga, South Africa. The Hendrina Power Station employs a wet ash disposal method. Fly ash (also termed ashing ash) is deposited during day time in order to develop the day walls, while coarse ash is deposited during night time.

Lidwala appointed Jones & Wagener (J&W) to conduct a waste assessment to determine the type of waste for disposal purposes. Assessment of the ash is required for two purposes, namely to:

- Correctly assess the ash and hence the new ash disposal facility for licensing and environmental authorisation purposes, and
- Assist in the development an appropriate barrier design system for the facility, based on the outcome of the assessment of the ash.

For the assessment of the ash, a wet ash sample of the fly ash deposited onto the current waste disposal facility was used, as well as a seepage water sample. In addition, a dry fly ash and a coarse ash sample were also used.

1.2 Objectives

The objectives of this project were to classify the ash and seepage water in terms of the Department of Environmental Affairs' (DEA's) "National Norms and Standards for the Assessment of Waste for Landfill Disposal" (National Norms and Standards) of August 2013.

2. WASTE CLASSIFICATION FOR LANDFILL DISPOSAL (DEA, 2013A)

2.1 Overview of Classification System

The new waste classification system, which replaced the Department of Water Affairs and Forestry's 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 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).

A number of leach solutions can be used. 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 ash, is to be co-disposed with other non-organic wastes, 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, 2013a). 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.

For non-putrescible inorganic waste, such as the coal derived ash, 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).

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:

- 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[1];
- 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);

[1] [1]**If the TC of a chemical substance is >TCT2, and the concentration cannot be reduced to below the TCT2 limit, but the LC <LCT3, the waste is considered a Type 1 Waste**

- 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 , 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 classified 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)	6.0
Polychlorinated Biphenyls (PCBs)	1.0
Mineral Oil (C10 to C40)	500
Pesticides	
Aldrin + Dieldrin	0.050
DDT + DDD + DDE	0.050
2,4-D	0.050
Chlordane	0.050
Heptachlor	0.050

- Wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCTO 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, the waste is considered to be Type 1 Waste.

3. WET ASH ASSESSMENT

3.1 Samples

Initially four samples were collected for from the existing Hendrina Power Station ash disposal facility for analysis on 15 July 2014. One sample was collected from the ash water discharge pipe, while three samples were collected from the ash water seepage discharge pipes at the toe of the ash disposal facility.

Additional dry ash samples, fly and coarse ash, were collected on 28 August 2014 as the wet ash sample collected on 15 July 2014 did not contain sufficient ash solids in order to conduct the required TCs.

3.2 Analyses Conducted

Waterlab (Pty) Ltd in Pretoria conducted the following analytical work on the ash water sample.

- Separation of the solid ash fraction from the wet ash sample collected and determination of the percentage solids;
- Distilled water leach followed by ICP-OES analysis of the leach solution for the metals of concern. The total dissolved salts, chloride, sulfate, nitrate and fluoride concentrations were also determined from the distilled water leach solution;
- Aqua regia digestion of a solid sample and determination of the metals of concern in the solution by ICP-OES;
- Chromium VI determination;
- Paste pH of the ash sample;
- Final pH values of the leach solution.

The three ash water seepage samples collected at the toe of the existing ash disposal facility were combined to form a composite sample. The composite sample was then analysed for the inorganic chemical constituents listed in the National Norms and Standards.

An analysis of organic constituents was not performed on the samples as it is highly unlikely that any organics of concern will be present in the ash when being disposed of. Cyanide was also not analysed for.

The laboratory certificates are attached as Appendix A.

3.3 Ash Assessment

Coal Derived Ash

In order to determine the classification of the wet ash, the percentage contributions of the concentrations of the constituents in the liquid fraction and the distilled water leach concentrations were calculated based on the percentage liquids to solids – see **Table** 3-1. The corrected concentrations were then used for the assessment of the ash – see **Table** 3-2.

Based on the results obtained from the distilled water leach and total concentration analyses performed on the ash, the ash sample was assessed as a Type 3 waste requiring disposal on a waste disposal facility with a Class C barrier system provided there are no site specific risks that require a more conservative barrier system (DEA, 2013b). A Class C barrier system is the least stringent composite barrier system for

waste disposal facilities. The Type 3 waste classification was the result of the LC value of aluminium, boron, chromium VI, molybdenum Total Dissolved Salts (TDS) and sulfate concentrations exceeding their respective LCT0 values. In addition, the TCT0 values for arsenic, barium, copper, lead and nickel were also exceeded. Aluminium was added as one of the elements to be considered in the assessment due to aluminium silicates occurring in coal derived ashes. The same rules were used to establish the LCT for aluminium as per the National Norms and Standards, i.e., the SANS 241 drinking water standards were used as a basis for establishing the LCT value[2]. In addition, the calcium, magnesium, sodium and potassium concentrations were also determined should the Department of Water and Sanitation request that the Relative Abundance of Monovalent and Divalent Cations (RMD) ratio be determined. The RMD will only be required should geosynthetic clay liners be considered for the barrier system of the new ash disposal facility.

Ash Seepage Water

The ash seepage water reporting to the base of the ash disposal facility represents the actual threat to the receiving environment, especially the surface and groundwater. The ash seepage water was assessed as a Type 3 waste. The chemical constituents resulting in this outcome are aluminium, boron, TDS and sulfate – see **Table** 3-3.

[2] Aluminium is not considered a toxic element, but at concentrations above 0.50 mg/ℓ, aesthetic impacts may occur.

Table 3-1: Corrected concentrations for ash sample based on percentage contribution of ash carrier water and ash content

HENDRINA POWER STATION ASH							
Percentage solids	**2.90%**						
WATER LEACH							
	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**
Al, Aluminium	0.649	2.90%	0.019	0.336	97.10%	0.326	0.345
As, Arsenic	0.005	2.90%	0.000	0.005	97.10%	0.005	<0.010
B, Boron	0.179	2.90%	0.005	1.19	97.10%	1.16	1.161
Ba, Barium	0.261	2.90%	0.008	0.462	97.10%	0.449	0.456
Ca, Calcium	46	2.90%	1.334	596	97.10%	579	580
Cd, Cadmium	0.0015	2.90%	0.000	0.0025	97.10%	0.002	<0.005
Co, Cobalt	0.0125	2.90%	0.000	0.0125	97.10%	0.012	<0.025
Cr, Chromium - total	0.130	2.90%	0.004	0.088	97.10%	0.085	0.089
Cr VI, Chromium VI	0.138	2.90%	0.004	0.088	97.10%	0.085	0.089
Cu, Copper	0.0125	2.90%	0.000	0.0125	97.10%	0.012	<0.025
Hg, Mercury	0.0005	2.90%	0.000	0.0005	97.10%	0.000	<0.001
K, Potassium	0.5	2.90%	0.015	51	97.10%	49.521	49.5
Mg, Magnesium	1	2.90%	0.029	1.00	97.10%	0.971	1.000
Mn, Manganese	0.0125	2.90%	0.000	0.0125	97.10%	0.012	<0.025
Mo, Molydenum	0.036	2.90%	0.001	0.891	97.10%	0.865	0.866
Na, Sodium	2	2.90%	0.058	154	97.10%	149.534	150
Ni, Nickel	0.0125	2.90%	0.000	0.0125	97.10%	0.012	<0.025
Pb, Lead	0.005	2.90%	0.000	0.0100	97.10%	0.010	<0.020
Sb, Antimony	0.005	2.90%	0.000	0.005	97.10%	0.005	<0.010
Se, Selenium	0.005	2.90%	0.000	0.01	97.10%	0.010	0.010
V, Vanadium	0.105	2.90%	0.003	0.0125	97.10%	0.012	<0.025
Zn, Zinc	0.0125	2.90%	0.000	0.0125	97.10%	0.012	<0.025
TDS, Total dissolved solids	174	2.90%	5.046	2332	97.10%	2264	2269
Cl, Chloride	2.5	2.90%	0.073	156	97.10%	151	152
SO_4, Sulphate	44	2.90%	1.276	709	97.10%	688	690
NO_3, Nitrate	0.1	2.90%	0.003	2.7	97.10%	2.62	2.6
F, Fluoride	0.1	2.90%	0.003	1.4	97.10%	1.36	1.4
Note: In order to calcuate the % contibution of each phase, values less than (<) the limit of report (LOR) were divided by 2							

Table 3-2: De-ionised Water Leach Test and Total Concentration Results of Hendrina Power Station Ash versus LCT and TCT values

Elements & Chemical Substances	Hendrina Power Station Distilled Water Leach & Total Concentration					LCT0 (mg/ℓ)	TCT0 (mg/kg)		LCT1 (mg/ℓ)	TCT1 (mg/kg)		LCT2 (mg/ℓ)	TCT1 (mg/kg)		LCT3 (mg/ℓ)	TCT2 (mg/kg)	
	LC in mg/ℓ	TC in mg/kg*		Limit of Report for LC (mg/ℓ)													
		Fly Ash	Coarse Ash														
Al	0.345				Type 4 Waste	0.300		Type 3 Waste	15		Type 2 Waste	30		Type 1 Waste	120		Type 0 Waste
As	<0.010	<4.00	<4.00	0.010		0.01	5.8		0.50	500		1.0	500		4.0	2 000	
B	1.161	102	10	0.025		0.5	150		25	15 000		50	15 000		200	60 000	
Ba	0.456	608	144	0.025		0.7	62.5		35	6 250		70	6 250		280	25 000	
Ca	580																
Cd	<0.005	2.80	2.00	0.003		0.003	7.5		0.15	260		0.3	260		1.2	1 040	
Co	<0.025	12	<10	0.025		0.5	50		25	5 000		50	5 000		200	20 000	
Cr (total)	0.089	81	54	0.025		0.10	46 000		5	800 000		10	800 000		40		
Cr(VI)	0.089	<5.00	<5.00	0.010		0.05	6.5		2.5	500		5.0	500		20	2 000	
Cu	<0.025	15	<10	0.025		2.0	16		100	19 500		200	19 500		800	78 000	
Fe				0.025		2.0			100			200			800		
Hg	<0.001	0.80	<0.40	0.001		0.006	0.93		0.3	160		0.6	160		2.4	640	
K	49.5																
Mg	1.00			2													
Mn	<0.025	270	98	0.025		0.5	1 000		25	25 000		50	25 000		200	100 000	
Mo	0.866	<10	<10	0.025		0.07	40		3.5	1 000		7.0	1 000		28	4 000	
Na	150					200			10 000			20 000			80 000		
Ni	<0.025	40	32	0.025		0.07	91		3.5	10 600		7.0	10 600		28	42 400	
Pb	<0.020	<8.00	<8.00	0.010		0.01	20		0.5	1 900		1	1 900		4	7 600	
Sb	<0.010	6.80	<4.00	0.010		0.02	10		1.0	75		2	75		8	300	
Se	0.010	22	17	0.010		0.01	10		0.5	50		1	50		4	200	
V	<0.025	19	<10	0.025		0.2	150		10	2 680		20	2 680		80	10 720	
W				0.025													
Zn	<0.025	57	24	0.025		5.0	240		250	160 000		500	160 000		2000	640 000	
Inorganic Anions																	
TDS	2 269			10		1 000			12 500			25 000			100 000		
Chloride	152			5		300			15 000			30 000			120 000		
Sulfate as SO4	690			5		250			12 500			25 000			25 000		
NO3 as N	2.6			0.2		11			550			1 100			4 400		
Fluoride	1.4	147	72	0.2		1.5	100		75	10 000		50	10 000		600	40 000	
Cyanide				0.05		0.07	14		3.5	10 500		7.0	10 500		28	42 000	

	Not applicable
	Not analysed
	LC > LCT3 or TC > TCT2: Type 0 Wastes
	LCT2< LC ≤ LCT3 or TCT1 < TC ≤ TCT2 : Type 1 Wastes
	LCT1< LC ≤ LCT2 and TC ≤ TCT1: Type 2 Wastes
	LCT0 < LC ≤ LCT1 and TC ≤ TCT1: Type 3 Wastes
	LC ≤ LCT0 and TC ≤ TCT0: Type 4 wastes

Table 3-3: Ash Seepage Water Concentration Results of Hendrina Power versus LCT values

Elements & Chemical Substances	Hendrina Power Station Seepage Water: Composite Sample				LCT0 (mg/ℓ)	TCT0 (mg/kg)		LCT1 (mg/ℓ)	TCT1 (mg/kg)		LCT2 (mg/ℓ)	TCT1 (mg/kg)		LCT3 (mg/ℓ)	TCT2 (mg/kg)	
	Leach Concentration (LC) in mg/ℓ	Total Concentration (TC) in mg/kg	Limit of Report for LC (mg/ℓ)													
Al	0.479			Type 4 Waste	0.300		Type 3 Waste	15		Type 2 Waste	30		Type 1 Waste	120		Type 0 Waste
As	<0.010		0.010		0.01	5.8		0.50	500		1.0	500		4.0	2 000	
B	1.46		0.025		0.5	150		25	15 000		50	15 000		200	60 000	
Ba	0.090		0.025		0.7	62.5		35	6 250		70	6 250		280	25 000	
Ca	201															
Cd	<0.005		0.003		0.003	7.5		0.15	260		0.3	260		1.2	1 040	
Co	<0.025		0.025		0.5	50		25	5 000		50	5 000		200	20 000	
Cr (total)	<0.025		0.025		0.10	46 000		5	800 000		10	800 000		40		
Cr(VI)	<0.010		0.010		0.05	6.5		2.5	500		5.0	500		20	2 000	
Cu	<0.025		0.025		2.0	16		100	19 500		200	19 500		800	78 000	
Fe	0.074		0.025		2.0			100			200			800		
Hg	<0.001		0.001		0.006	0.93		0.3	160		0.6	160		2.4	640	
K	28															
Mg	<2		2													
Mn	0.340		0.025		0.5	1 000		25	25 000		50	25 000		200	100 000	
Mo	0.990		0.025		0.07	40		3.5	1 000		7.0	1 000		28	4 000	
Na	85				200			10 000			20 000			80 000		
Ni	<0.025		0.025		0.07	91		3.5	10 600		7.0	10 600		28	42 400	
Pb	<0.020		0.010		0.01	20		0.5	1 900		1	1 900		4	7 600	
Sb	<0.010		0.010		0.02	10		1.0	75		2	75		8	300	
Se	<0.020		0.010		0.01	10		0.5	50		1	50		4	200	
V	0.137		0.025		0.2	150		10	2 680		20	2 680		80	10 720	
W			0.025													
Zn	<0.025		0.025		5.0	240		250	160 000		500	160 000		2000	640 000	
Inorganic Anions																
TDS	1 064		10		1 000			12 500			25 000			100 000		
Chloride	76		5		300			15 000			30 000			120 000		
Sulfate as SO4	550		5		250			12 500			25 000			25 000		
NO3 as N	0.2		0.2		11			550			1 100			4 400		
Fluoride	0.2		0.2		1.5	100		75	10 000		50	10 000		600	40 000	
Cyanide			0.05		0.07	14		3.5	10 500		7.0	10 500		28	42 000	

	Not applicable
	Not analysed
	LC > LCT3 or TC > TCT2: Type 0 Wastes
	LCT2< LC ≤ LCT3 or TCT1 < TC ≤ TCT2 : Type 1 Wastes
	LCT1< LC ≤ LCT2 and TC ≤ TCT1: Type 2 Wastes
	LCT0 < LC ≤ LCT1 and TC ≤ TCT1: Type 3 Wastes
	LC ≤ LCT0 and TC ≤ TCT0: Type 4 wastes

4. DISCUSSION

Various classifications and assessments have been carried out on the Hendrina Power Station ash by others. These classifications did not exactly adhere to the procedures as stipulated in the National Norms and Standards and the Australian Standards as referred to in the National Norms and Standards. For instance in some instances not all the required inorganic leachable chemicals of concern as listed in the National Norms and Standards were analysed for and TCs were not determined. Although the assessments performed were not necessarily incorrect, there is a chance that the Department of Environmental Affairs and Department of Water and Sanitation (DWS) may reject the assessments on the basis that the minimum analyses were not carried out. This assessment report covers all the inorganic constituents requiring analysis as per the National Norms and Standards, and in addition, the correct procedures were followed, i.e., the liquid fraction was separated from the solid fraction and the two fractions were then analysed separately. In addition, some additional chemicals of interest were analysed for, such as aluminium, calcium, magnesium, potassium and sodium in order to calculate the Relative Abundance of Monovalent and Divalent Cations (RMD) ratio if so requested by the DWS. An analysis of organics were not carried out as it is highly unlikely that the wet ash will contain any organics due to the nature of the process.

When comparing the TDS values of the ash water sample with the seepage water, a significant reduction in the TDS occurs from the point where the ash carrier water is discharged on the beach of the ash disposal facility to where the water seeps out at the toe drains of the facility. J&W has observed similar reductions at other wet ash disposal facilities.

Based on the assessment carried out, the ash was assessed as a Type 3 waste requiring disposal on a waste disposal facility with a Class C barrier system. This barrier system is the least conservative composite barrier system currently accepted by the DWS – see **Figure 4-1**. As the ash seepage water has a low risk of impacting on the groundwater in the area (as was demonstrated by Infotox, Groundwater Square and Geostratum in their draft report Health-risk Based Assessment of the Hendrina Ash Dam Expansion Project, dated September 2013) (Van Niekerk et al, 2013) the installation of a Class C barrier system for the new wet ash disposal facility should be sufficient to protect the environment in the long term. A more conservative barrier system should, however, be considered for the return water dams.

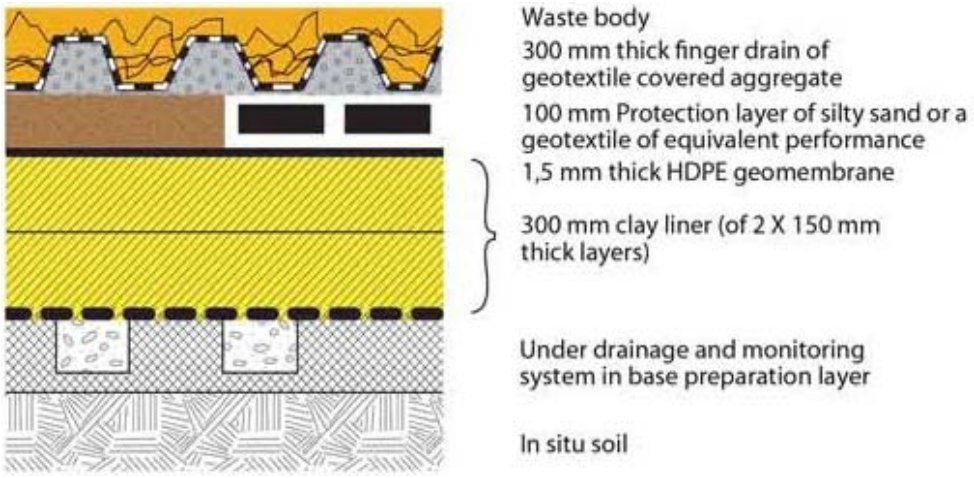

Figure 4-1: Class C landfill barrier system (DEA, 2013b)

5. RECOMMENDATIONS

The following recommendations are made:

- The intended barrier design of the new wet ash disposal facility for the Hendrina Power Station should be presented, discussed and agreed upon with the Department of Water and Sanitation prior to the design being submitted as part of the Waste Management Licence Application;
- A Class C barrier design, which is the barrier system recommended 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's National Norms and Standards or as agreed with the Department of Water Affairs.

6. REFERENCES

(i) 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.

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Appendix A

LABORATORY CERTIFICATES

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

Building D
The Woods
41 De Havilland Cresent
Persequor Techno Park
Meiring Naudé Drive
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SANAS Accredited Testing Laboratory
No. T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2014 - 07 - 18 **Date completed:** 2014 - 08 – 12

Project number: 132 **Report number: 47067** **Order number: E699/MVZ/26587**

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

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

Telephone: 011 519 0217 **Facsimile: 011 519 0201** **Mobile: 082 880 1250**

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification	
		HSW Composite	HWA1 Supernatant
Sample Number		11436	11437
pH – Value at 25°C	WLAB001	9.5	12.3
Total Dissolved Solids at 180°C *	WLAB003	1 064	2 332
Chloride as Cl	WLAB046	76	156
Sulphate as SO_4	WLAB046	550	709
Fluoride as F	WLAB014	0.2	1.4
Nitrate as N	WLAB046	0.2	2.7
Sodium as Na	WLAB015	85	154
Potassium as K	WLAB015	28	51
Calcium as Ca	WLAB015	201	596
Magnesium as Mg	WLAB015	<2	<2
Aluminium as Al	WLAB015	0.479	0.336
Antimony as Sb *	WLAB015	<0.010	<0.010
Arsenic as As *	WLAB015	<0.010	<0.010
Barium as Ba *	WLAB015	0.090	0.462
Boron as B *	WLAB015	1.46	1.19
Cadmium as Cd	WLAB015	<0.005	<0.005
Total Chromium as Cr	WLAB015	<0.025	0.088
Hexavalent Chromium as Cr^{6+} *	WLAB032	<0.010	0.088

Analyses continued on next page

Ard van de Wetering

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Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification	
		HSW Composite	HWA1 Supernatant
Sample Number		11436	11437
Cobalt as Co	WLAB015	<0.025	<0.025
Copper as Cu	WLAB015	<0.025	<0.025
Iron as Fe	WLAB015	0.074	<0.025
Lead as Pb	WLAB015	<0.020	<0.020
Manganese as Mn	WLAB015	0.340	<0.025
Mercury as Hg *	WLAB047	<0.001	<0.001
Molybdenum as Mo *	WLAB015	0.990	0.891
Nickel as Ni	WLAB015	<0.025	<0.025
Selenium as Se *	WLAB015	<0.020	<0.020
Vanadium as V *	WLAB015	0.137	<0.025
Zinc as Zn	WLAB015	<0.025	<0.025
% Balancing	---	90.4	95.8

*** = Not SANAS Accredited**

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

Ard van de Wetering

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CERTIFICATE OF ANALYSES
EXTRACTIONS AS 4439.3

Date received:	**18/07/2014**	**Date completed:**	**13/08/2014**
Project number:	**132** **Report number:** **47067**	**Order number:**	
Client name:	**Jones & Wagener**	**Contact person:**	**Marius van Zyl**
Address:	**PO Box 1434, Rivonia, 2128**	**Email:**	**vanzyl@jaws.co.za**
Telephone:	**011 519 0200**	**Cell:**	**082 880 1250**

Analyses	HWA 1 ash	
Sample Number	**11438**	
TCLP / Borax / Distilled Water	**Distilled Water**	
Ratio	**1:20**	
Units	**mg/ℓ**	**LCT0 mg/l**
Al, Aluminium	0.649	
As, Arsenic	<0.010	0.01
B, Boron	0.179	0.5
Ba, Barium	0.261	0.7
Ca, Calcium	46	
Cd, Cadmium	<0.003	0.003
Co, Cobalt	<0.025	0.5
$Cr_{Total,}$ Chromium Total	0.130	0.1
Cr(VI), Chromium (VI)	0.138	0.05
Cu, Copper	<0.025	2.0
Hg, Mercury	<0.001	0.006
K, Potassium	<1.0	
Mg, Magnesium	<2	
Mn, Manganese	<0.025	0.5
Mo, Molybdenum	0.036	0.07
Na, Sodium	2	
Ni, Nickel	<0.025	0.07
Pb, Lead	<0.010	0.01
Sb, Antimony	<0.010	0.02
Se, Selenium	<0.010	0.01
V, Vanadium	0.105	0.2
Zn, Zinc	<0.025	5
Inorganic Anions	**mg/ℓ**	
Total Dissolved Solids	174	1000
Chloride as Cl	<5	300
Sulphate as SO4	44	250
Nitrate as N	<0.2	11
Fluoride as F	<0.2	1.5
pH	11.0	
Paste pH	Insufficient sample	
Moisture % after filtration	17	
Solid %	2.9	

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CERTIFICATE OF ANALYSES

Digestion AS 4439.3

Date received:	**01/09/2014**			**Date completed:**	**10/09/2014**
Project number:	**132**	**Report number:**	**47749**	**Order number:**	**E699**

Client name:	**Jones & Wagener**	**Contact person:**	**Marius van Zyl**
Address:	**PO Box 1434, Rivonia, 2128**	**Email:**	vanzyl@jaws.co.za
Telephone:	**011 519 0200**	**Cell:**	**---**

Analyses	Hendrina Fly Ash Sample: 28 Aug 2014: HFA-1		Hendrina Coarse Ash Sample: 28 Aug 2014: HCA-1		
Sample Number	**15012**		**15013**		**TCT0 mg/kg**
Digestion	**Aqua Regia**		**Aqua Regia**		
Dry Mass Used (g)	**0.25**		**0.25**		
Volume Used (mℓ)	**100**		**100**		
Units	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	
As, Arsenic	<0.010	<4.00	<0.010	<4.00	5.8
B, Boron	0.256	102	0.026	10	150
Ba, Barium	1.52	608	0.361	144	62.5
Cd, Cadmium	0.007	2.80	0.005	2.00	7.5
Co, Cobalt	0.030	12	<0.025	<10	50
$Cr_{Total,}$ Chromium Total [s]	0.203	81	0.135	54	46000
Cr(VI), Chromium (VI) Total [s]	---	<5	---	<5	6.5
Cu, Copper	0.037	15	<0.025	<10	16
Hg, Mercury	0.002	0.8	<0.001	<0.4	0.93
Mn, Manganese	0.675	270	0.246	98	1000
Mo, Molybdenum	<0.025	<10	<0.025	<10	40
Ni, Nickel	0.100	40	0.081	32	91
Pb, Lead	<0.020	<8.00	<0.020	<8.00	20
Sb, Antimony	0.017	6.80	<0.010	<4.00	10
Se, Selenium	0.055	22	0.042	17	10
V, Vanadium	0.048	19	<0.025	<10	150
Zn, Zinc	0.142	57	0.060	24	240
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	
Total Fluoride [s] mg/kg	---	147	---	72	100