



October 2012

SYNERGISTICS ENVIRONMENTAL SERVICES

Classification and Characterisation of Komati Power Station Fly Ash

Submitted to:
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REPORT

Report Number. 12614666-11683-1

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1.0 INTRODUCTION

Synergistics Environmental Services appointed Golder Associates Africa (Pty) Ltd (Golder) to characterise and classify fly ash generated by Komati Power station. The classification and characterisation are needed to determine the liner requirements for disposal of the ash.

This report details the approach, analytical results, waste classification and liner requirements for disposal of the Fly Ash.

2.0 SAMPLING AND ANALYSES

Two Fly ash samples were collected by a Golder representative at two different positions at the Komati Power Station. One sample was a representative fresh fly ash (S3) sample collected at the plant, and the other was a representative fly ash sample collected from the disposal site (Unit B). The samples were submitted to Waterlab (a SANAS accredited laboratory) for the following analyses:

- Acid rain leach procedure (ARLP) extraction followed by:
 - Semi-quantitative 33 element ICP scan;
 - Cations and anions including Ca, Na, K, Mg, SO₄, Cl, F, NH₄, NO₃ and pH;
- Deionised water (1:20) extraction followed by:
 - Semi-quantitative 33 element ICP scan;
 - Cations and anions including Ca, Na, K, Mg, SO₄, Cl, F, NH₄, NO₃ and pH;
- *Aqua regia* digestion followed by:
 - Semi-quantitative 33 element ICP scan; and
 - Cations and anions including Ca, Na, K, Mg, SO₄, Cl, F, NH₄, NO₃ and pH.

3.0 WASTE CLASSIFICATION

Waste classification in this report is based on both the Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste (Second Edition, 1998; Department of Water Affairs and Forestry) (MRs) and the draft Waste Classification and Management Regulations (WCMR) (GN 614 of 2012) published for comment in August 2012.

Since the WCMR is not yet enforceable and further here to the fact that the MRs will remain in force for a further 18 months (once the WCMR has been promulgated), both classification systems have been followed, the results of which are presented in this report

3.1 SANS 10234 as per WCMR

In terms of Regulation 4(1) of the WCMR, all waste generators must ensure that the wastes they generate are classified in accordance with SANS 10234 within ninety (90) days of generation.

The SANS 10234 covers the harmonised criteria for classification of potentially hazardous substances and mixtures, including wastes, in terms of its intrinsic properties/hazards. The classification criteria include:

- Physical hazards (flammability, corrosiveness, etc.);
- Health hazards (toxicity, carcinogenicity, etc.); and
- Environmental hazards (aquatic toxicity, bioaccumulation, etc.).

Table 1 indicate the different hazard classes for waste according to SANS 10234. The classification of the waste streams is based on the general characteristics of the waste as well as analytical results.



CLASSIFICATION OF KOMATI FLY ASH

The Fly Ash is not explosive, flammable, oxidising and does not release toxic gases when in contact with water or acid. Therefore, it is not classified as hazardous in terms of Classes 1 – 4 of SANS 10234.

Potential health hazards include:

- Irritation (or inflammation) of the skin, eyes, mucous membranes and respiratory tract;
- Corrosiveness – destroys living tissue on contact or cause irreversible damage;
- Harmful or toxic when ingested, inhaled or on dermal contact;
- Mutagenic – cause mutation of genetic material;
- Carcinogenic – cause cancer or increase the rate of occurrence; and
- Toxic for reproduction.

Based on analytical results of the Fly Ash, the only constituent that could pose any of these health hazards were soluble Cr, assumed to be in the Cr(VI) form due to its solubility. Cr(VI) is a carcinogen, therefore the Fly Ash is classified as a Class 10 hazardous waste in terms of SANS 10234.

Environmental hazard is based on toxicity to the aquatic ecosystem and distinguishes between acute and chronic toxicity and further relates to bioaccumulation and biodegradation. Based on the chemical analyses of the Fly Ash (see sections 3.2 and 3.3.2), potential constituents which may pose a hazard to the aquatic environment under acidic conditions and due to its solubility, include B, Ba, Cr, Mg and Sr. Therefore, the Fly Ash is classified as hazardous (Class 12 (Ecotoxicity)) in terms of SANS 10234.

Table 1: Hazard classes according to SANS 10234

Class 1	Explosive	Class 7	Harmful
Class 2A	Highly Flammable	Class 8	Toxic
Class 2B	Flammable	Class 9	Mutagenic
Class 3	Oxidising	Class 10	Carcinogen
Class 4	Substances that release toxic gases in contact with water or acid	Class 11	Toxic for reproduction
Class 5	Irritant	Class 12	Ecotoxic
Class 6	Corrosive		

3.2 Hazard rating as per MRs

The Hazard Rating is used to classify waste into any of the four Hazard Rating levels. The four Hazard Ratings are ranked according to a logarithmic progression, whereby Extreme Hazard is 10 times more toxic than High Hazard and 1000 times more toxic than Low Hazard:

- Hazard Rating 1 (Extreme Hazard): Contains significant concentrations of extremely toxic substances, including certain carcinogens, teratogens and infectious wastes;
- Hazard Rating 2 (High Hazard): Highly toxic characteristics which are not persistent, including certain carcinogens;
- Hazard Rating 3 (Moderate Hazard): Moderately toxic or containing substances that are potentially highly harmful to human health or to the environment, but are not persistent; and
- Hazard Rating 4 (Low Hazard): Contains potentially harmful substances in concentrations that in most instances would represent only a limited threat to human health or to the environment.



CLASSIFICATION OF KOMATI FLY ASH

At a certain concentrations in the environment any compound (excluding certain carcinogens and teratogens) will be classified in any one of the above four Hazard Ratings.

A summary of the analytical results, Contaminants of Concern (COCs) detected at concentrations higher than the detection limits of the ARLP extract (compared to the Acceptable Risk Levels (ARLs)) are presented in Table 2 together with the hazard rating and the maximum load calculations. Values indicated in red exceeded the ARLs. The detailed analytical certificates are in Appendix A.

Table 2: Analytical results of acid rain extracts of Fly Ash compared to ARL (mg/l)

CoCs	ARL	Fly Ash S3	Fly Ash Unit B
Ag	2	<0.025	<0.025
Al	10	0.202	0.213
As	0.43	0.038	0.114
B	7.8	5.286	5.508
Ba	7.8	0.183	0.072
Be	7.8	<0.025	<0.025
Ca	ng	279	130
Cd	0.031	<0.005	<0.005
Co	6.9	<0.025	<0.025
Cr	0.02	1.09	0.827
Cu	0.1	<0.025	<0.025
Fe	9	<0.025	<0.025
K	ng	1.9	<1.0
Li	0.14	0.141	0.14
Mg	10	154	159
Mn	0.3	0.044	<0.025
Mo	55	0.122	0.196
Na	ng	4	<2
Ni	0.62	0.058	0.048
Pb	0.1	<0.020	<0.020
Sb	0.07	<0.010	<0.010
Se	0.26	0.043	0.027
Si	1000	8	7
Sn	0.042	<0.025	<0.025
Sr	1	2.465	2.354
Ti	0.731	<0.025	<0.025
V	1.3	0.707	1.009
Zn	0.7	<0.025	<0.025
Hazard rating		HR1(Cr(VI))	HR1 (Cr(VI))
Max load (t/ha/month)		2.8	3.7



These results indicate the following:

- The Komati Fly Ash has elevated Cr, Mg and Sr concentrations, exceeding the ARL detailed in the MRs;
- Since Cr(III) is an insoluble constituent, it is assumed that the soluble Cr in the acid rain extract is in the Cr(VI) form. Therefore, the Fly Ash has a HR1 hazard rating due to the elevated Cr(VI) concentrations; and
- The Fly Ash has to be disposed on a H:H designed landfill, except when the monthly load is less than 2.8 tonnes when it can be disposed on a correctly engineered and authorised G:L:B⁺ landfill site with a leachate collection system.

3.3 Type of waste as per WCMR

In terms of Regulation 13(1) of the WCMR, the potential level of risk associated with disposal or downstream use of wastes must be determined by following the prescribed and appropriate leach test protocols as detailed in GN 613 of 2012, published for comment in August 2012. The results must be assessed against the four levels of thresholds for leachable and total concentrations, which in combination, determines the Risk Profile of the waste.

The terminology relevant to the WCMR is as follows:

- LC = means the leachable concentration of a particular contaminant in a waste, expressed as mg/l;
- TC = means the total concentration of a particular contaminant in a waste, expressed as mg/kg;
- LCT = means the leachable concentration thresholds for particular contaminants in a waste (LCT0, LCT1, LCT2 and LCT3); and
- TCT = means the total concentration thresholds for particular contaminants in a waste (TCT0, TCT1, TCT2).

Figure 1 shows the flow diagram of the process to be followed to determine the waste type destined for disposal or downstream use. According to this process, the waste needs to be analysed to determine total and leachable concentrations of potential CoCs. The results are then compared to the threshold values to determine the waste type (Type 0 – Type 4).

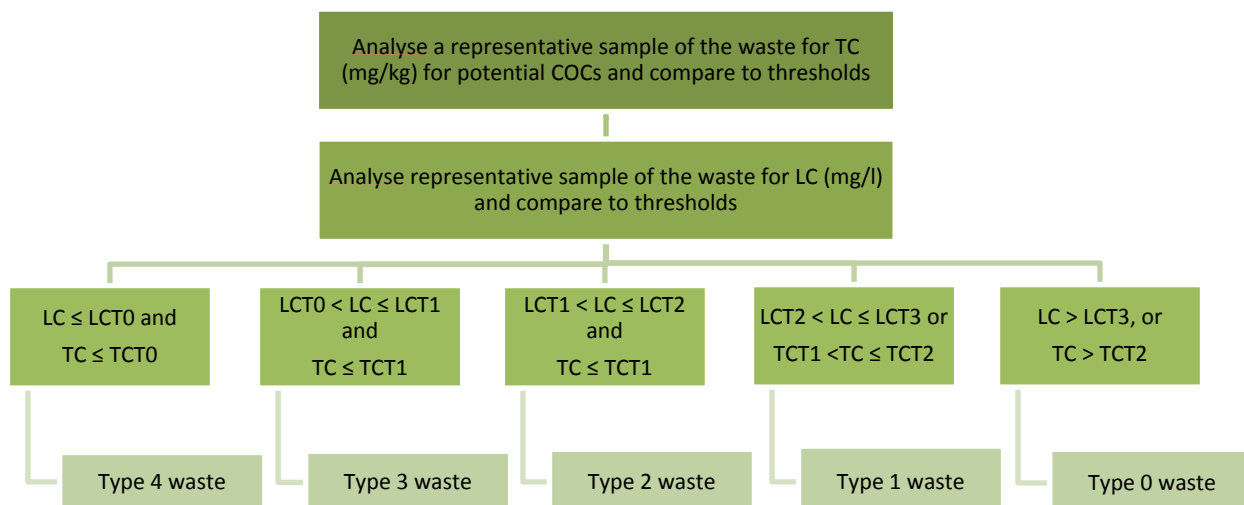


Figure 1: Flow diagram for determination of the waste type based on the WCMR



CLASSIFICATION OF KOMATI FLY ASH

3.3.1 Total concentrations

The total concentrations (*aqua regia* extract) of the waste samples compared to the TCT levels are presented in Table 3. This is a summary of the results and includes only elements which were detected at concentrations higher than the detection limit. The detailed analytical certificates are appended in Appendix A.

Values indicated in green exceeded the TCT0 threshold level. These results show that:

- The total Arsenic (As) concentration in the Unit B sample exceeded the TCT0, while the As in the S3 sample were below the reporting limit;
- The total Barium (Ba) in both samples exceeded the TCT0 threshold level;
- The total Lead (Pb) in sample S3 was equal to the TCT0 and in Unit B sample it was 1 mg/kg higher than TCT0;
- Therefore, based on the total concentrations of CoCs according to the methodology detailed in the WCMR, the Komati Fly Ash is a Type 3 waste and can be disposed on a G:L:B⁺ landfill site.

Table 3: Analytical results of *aqua regia* digestion of Fly Ash compared to TCT levels

CoCs	TCT0	TCT1	TCT2	Fly Ash S3	Fly Ash Unit B
	mg/kg				
Al	ng			22200	28600
As	5.8	500	2000	<2.00	6.6
B	150	15000	60000	50	64
Ba	62.5	6250	25000	554	411
Ca	ng			34000	46000
Cr	46000	800000	N/A	61	94
Fe	ng			11000	12000
K	ng			460	500
Li	ng			6.4	7.8
Mg	ng			9000	9800
Mn	1000	25000	100000	245	286
Mo	40	1000	4000	19	15
Na	ng			<40	55
Ni	91	10600	42400	22	21
Pb	20	1900	7600	20	21
Si	ng			1760	1720
Sr	ng			754	681
Ti	ng			1688	2000
V	150	2680	10720	<5.00	29
Zn	240	160000	640000	146	202
Waste type				Type 3	Type 3



3.3.2 Leachable concentrations

The analytical results of the deionised water extract were compared to the LCT levels to assess the risk profile of the waste samples based on leachable concentrations of CoCs (Table 4). Levels indicated in green exceeded the LCT0 level.

These results indicate the following:

- Elevated soluble B in sample S3;
- Slightly elevated soluble Ba concentration in the sample from Unit B, only just exceeding the LCT0 level;
- The soluble Cr concentration in both samples exceeded the LCT0 threshold;
- Based on the leachable concentrations of CoCs in the Fly Ash and the methodology detailed in the WCMR, the Fly Ash is a Type 3 waste and can be disposed on a G:L:B⁺ landfill site.

Table 4: Analytical results of deionised water extract of Fly Ash compared to LCT levels

CoCs	LCT0	LCT1	LCT2	LCT3	Fly Ash S3	Fly Ash Unit B
mg/l						
Al	ng				11	1.712
B	0.5	25	50	200	1.059	0.04
Ba	0.7	35	70	280	0.328	0.722
Ca	ng				124	281
Cr	0.05	2.5	5	20	0.347	0.145
K	ng				1.8	<1.0
Li	ng				0.075	0.082
Mo	0.07	3.5	7	28	0.052	0.043
Na	ng				3	<2
SO ₄	250	12500	25000	100000	71	14
F	1.5	75	150	600	0.3	0.6
pH	ng				11.5	12.1
Waste type					Type 3	Type 3

4.0 LINER REQUIREMENTS FOR DISPOSAL

4.1 Minimum Requirements

Since the Fly Ash has a HR1 hazard rating due to the elevated Cr concentration in the acid rain extract, the material must be disposed on a H:H designed landfill.

4.2 WCMR

The standard containment barrier design and landfill disposal requirements for different types of waste, as detailed in the draft Standards for Disposal of Waste to Landfill (GN 615 of 2012), are presented in Table 5. According to these requirements the Fly Ash disposal area need a Class C liner as a minimum (Figure 4).



CLASSIFICATION OF KOMATI FLY ASH

Table 5: Landfill disposal requirements detailed in the Standard for Disposal of Waste to Landfill

Waste Type	Landfill Disposal Requirements
Type 0	The disposal of Type 0 waste to landfill is not allowed . The waste must be treated and re-assessed in terms of the <i>Standard for Assessment of Waste for Landfill Disposal</i> to determine the level of risk associated with disposing the waste to landfill.
Type 1	Type 1 waste may only be disposed of at a Class A landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a Hh / HH landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2 nd Ed., DWAF, 1998) (Figure 2).
Type 2	Type 2 waste may only be disposed of at a Class B landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2 nd Ed., DWAF, 1998) (Figure 3).
Type 3	Type 3 waste may only be disposed of at a Class C landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2 nd Ed., DWAF, 1998) (Figure 4).
Type 4	Disposal allowed at a landfill with a Class D landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a GSB- landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2 nd Ed., DWAF, 1998).

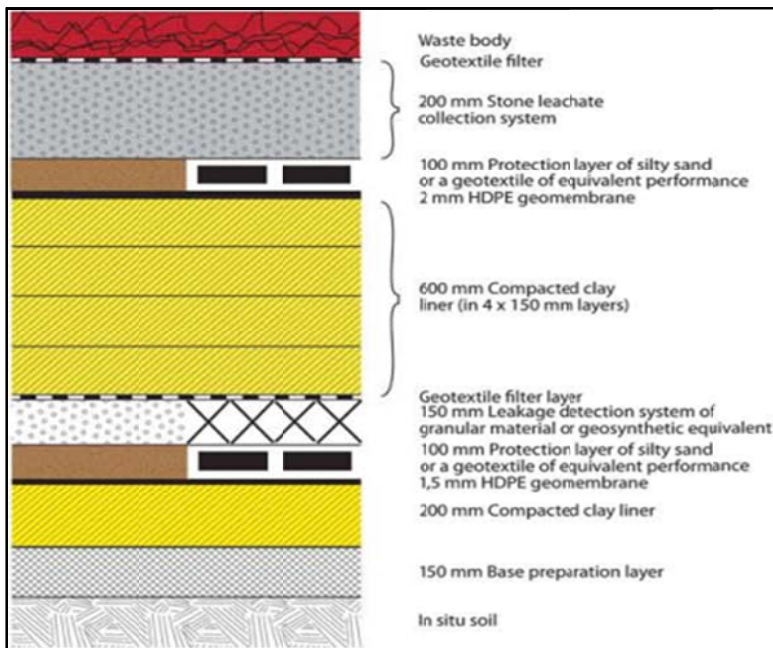


Figure 2: Class A landfill liner system (proposed)

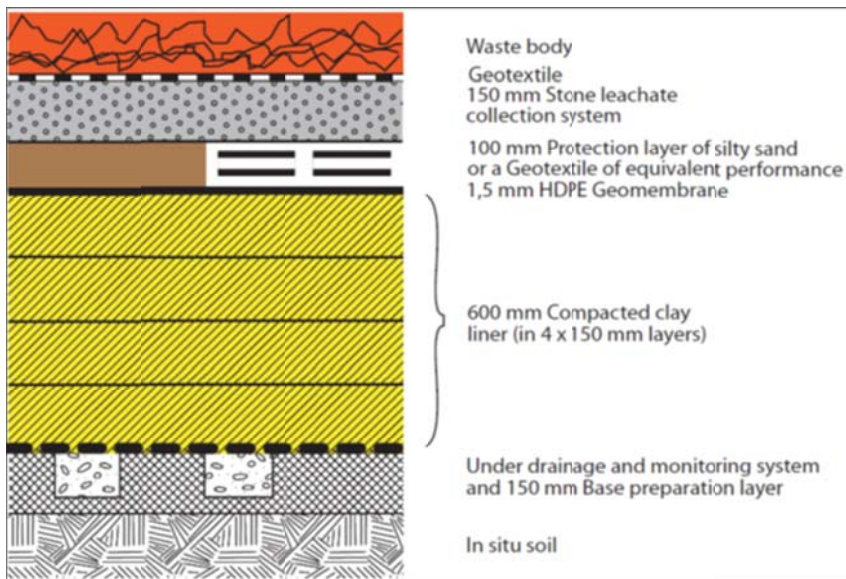


Figure 3: Class B landfill liner system (proposed)

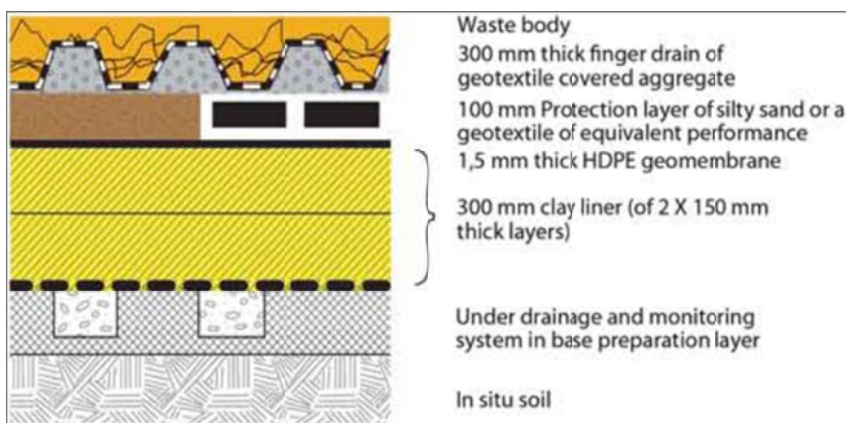


Figure 4: Class C landfill liner system (proposed)

5.0 CONCLUSION

The analytical results obtained during this investigation showed the following:

- According to the Minimum Requirements, the Komati Fly Ash has a HR1 rating due to elevated soluble Cr concentration in the acid rain extract, while the concentrations of Mg and Sr were also higher than ARLs. Therefore, the Fly Ash has to be disposed on hazardous landfill (H:H) (Figure 2);
- Based on the draft WCMR, the Fly Ash is classified as a Type 3 waste which can be disposed on a landfill site with a Class C barrier system (WCMR) (Figure 4) or a G:L:B⁺ landfill site (MRs).



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Currently, the Minimum Requirements are still enforceable while the WCMR is in draft and not promulgated yet. Therefore, at this point in time, the Fly Ash must be disposed of on a facility designed at H:H standards or correctly engineered and authorised G:L:B⁺ landfill site with a leachate collection system (provided that the total load for the CoC's are not exceeded) until such time that the WCMR has been promulgated. From the date of promulgation of the WCMR onwards Fly Ash can be disposed of on a G:L:B⁺ implying that if G:L:B⁺ facility could be identified at this point in time for acceptance of Fly Ash, this practice could proceed and will be fully compliant also in terms of the WCMR once promulgated.

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APPENDIX A

Laboratory Results

WATERLAB (PTY) LTD
CERTIFICATE OF ANALYSES

12614666

ICP-OES - SCAN

Date received: 2012/10/12
Project number: 159

Date Completed: 2012/10/19
Report number: 37114

Client name: Golder Associates Africa
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Telephone: 012 366 0100

Contact person: Elize Herselman
Email: eherselman@golder.co.za

Extract	Sample Dry Mass	Volume	Mass (g/l)	Factor
Distilled Water	50	1000	50	20

Sample Id	Sample number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.100	<2.00	<0.010	<0.200
Fly Ash S3	13520	<0.025	<0.500	11	220	<0.010	<0.200
Fly Ash Unit B	13521	<0.025	<0.500	1.71	34	<0.010	<0.200

Sample Id	Sample number	B	B	Ba	Ba	Be	Be
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	1.06	21	0.328	6.56	<0.025	<0.500
Fly Ash Unit B	13521	0.040	0.800	0.722	14	<0.025	<0.500

Sample Id	Sample number	Bi	Bi	Ca	Ca	Cd	Cd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<2	<40	<0.005	<0.100
Fly Ash S3	13520	<0.025	<0.500	124	2480	<0.005	<0.100
Fly Ash Unit B	13521	<0.025	<0.500	281	5620	<0.005	<0.100

Sample Id	Sample number	Co	Co	Cr	Cr	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	<0.025	<0.500	0.347	6.94	<0.025	<0.500
Fly Ash Unit B	13521	<0.025	<0.500	0.145	2.90	<0.025	<0.500

Sample Id	Sample number	Fe	Fe	K	K	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<1.0	<20	<0.025	<0.500
Fly Ash S3	13520	<0.025	<0.500	1.8	36	0.075	1.50
Fly Ash Unit B	13521	<0.025	<0.500	<1.0	<20	0.082	1.64

Sample Id	Sample number	Mg	Mg	Mn	Mn	Mo	Mo
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<2	<40	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	<2	<40	<0.025	<0.500	0.052	1.04
Fly Ash Unit B	13521	<2	<40	<0.025	<0.500	0.043	0.860

Sample Id	Sample number	Na	Na	Ni	Ni	P	P
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<2	<40	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	3	60	<0.025	<0.500	<0.025	<0.500
Fly Ash Unit B	13521	<2	<40	<0.025	<0.500	<0.025	<0.500

Sample Id	Sample number	Pb	Pb	S	S	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.020	<0.400	<0.100	<2.00	<0.010	<0.200
Fly Ash S3	13520	<0.020	<0.400	34	680	<0.010	<0.200
Fly Ash Unit B	13521	<0.020	<0.400	9.77	195	<0.010	<0.200

Sample Id	Sample number	Se	Se	Si	Si	Sn	Sn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.020	<0.400	<0.2	<4.0	<0.025	<0.500
Fly Ash S3	13520	<0.020	<0.400	1.6	32	<0.025	<0.500
Fly Ash Unit B	13521	<0.020	<0.400	1.5	30	<0.025	<0.500

Sample Id	Sample number	Sr	Sr	Ti	Ti	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	1.55	31	<0.025	<0.500	<0.025	<0.500
Fly Ash Unit B	13521	2.64	53	<0.025	<0.500	<0.025	<0.500

Sample Id	Sample number	W	W	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Fly Ash Unit B	13521	<0.025	<0.500	<0.025	<0.500	<0.025	<0.500

WATERLAB (PTY) LTD
CERTIFICATE OF ANALYSES

12614666

ICP-OES - SCAN

Date received: 2012/10/12
Project number: 159

Date Completed: 2012/10/19
Report number: 37114

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Email: eherselman@golder.co.za

Extract	Sample Dry Mass	Volume	Mass (g/l)	Factor
Aqua Regia	0.5	100	5	200

Sample Id	Sample number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<0.100	<20	<0.010	<2.00
Fly Ash S3	13520	<0.025	<5.00	111	22200	<0.010	<2.00
Fly Ash Unit B	13521	<0.025	<5.00	143	28600	0.033	6.60

Sample Id	Sample number	B	B	Ba	Ba	Be	Be
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<0.025	<5.00	<0.025	<5.00
Fly Ash S3	13520	0.249	50	2.77	554	<0.025	<5.00
Fly Ash Unit B	13521	0.318	64	2.06	411	<0.025	<5.00

Sample Id	Sample number	Bi	Bi	Ca	Ca	Cd	Cd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<2	<400	<0.005	<1.00
Fly Ash S3	13520	<0.025	<5.00	170	34000	<0.005	<1.00
Fly Ash Unit B	13521	<0.025	<5.00	230	46000	<0.005	<1.00

Sample Id	Sample number	Co	Co	Cr	Cr	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<0.025	<5.00	<0.025	<5.00
Fly Ash S3	13520	<0.025	<5.00	0.306	61	<0.025	<5.00
Fly Ash Unit B	13521	<0.025	<5.00	0.471	94	<0.025	<5.00

Sample Id	Sample number	Fe	Fe	K	K	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<1.0	<200	<0.025	<5.00
Fly Ash S3	13520	55	11000	2.3	460	0.032	6.40
Fly Ash Unit B	13521	60	12000	2.5	500	0.039	7.80

Sample Id	Sample number	Mg	Mg	Mn	Mn	Mo	Mo
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<2	<400	<0.025	<5.00	<0.025	<5.00
Fly Ash S3	13520	45	9000	1.22	245	0.094	19
Fly Ash Unit B	13521	49	9800	1.43	286	0.077	15

Sample Id	Sample number	Na	Na	Ni	Ni	P	P
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<2	<400	<0.025	<5.00	<0.025	<5.00
Fly Ash S3	13520	<2	<400	0.112	22	13	2600
Fly Ash Unit B	13521	0.277	55	0.105	21	16	3200

Sample Id	Sample number	Pb	Pb	S	S	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.020	<4.00	<0.100	<20	<0.010	<2.00
Fly Ash S3	13520	0.101	20	12	2400	<0.010	<2.00
Fly Ash Unit B	13521	0.105	21	10	2000	<0.010	<2.00

Sample Id	Sample number	Se	Se	Si	Si	Sn	Sn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.020	<4.00	<0.200	<40	<0.025	<5.00
Fly Ash S3	13520	<0.020	<4.00	8.8	1760	<0.025	<5.00
Fly Ash Unit B	13521	<0.020	<4.00	8.6	1720	<0.025	<5.00

Sample Id	Sample number	Sr	Sr	Ti	Ti	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<0.025	<5.00	<0.025	<5.00
Fly Ash S3	13520	3.77	754	8.44	1688	<0.025	<5.00
Fly Ash Unit B	13521	3.40	681	10	2000	0.144	29

Sample Id	Sample number	W	W	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<0.025	<5.00	<0.025	<5.00
Fly Ash S3	13520	<0.025	<5.00	0.731	146	0.212	42
Fly Ash Unit B	13521	<0.025	<5.00	1.01	202	0.212	42

WATERLAB (PTY) LTD
CERTIFICATE OF ANALYSES

12614666

ICP-OES - SCAN

Date received: 2012/10/12
Project number: 159

Date Completed: 2012/10/19
Report number: 37114

Client name: Golder Associates Africa
Address: PO Box 6001, Halfway House, 1685
Telephone: 012 366 0100

Contact person: Elize Herselman
Email: eherselman@golder.co.za

Extract	Sample Dry Mass	Volume	Mass (g/l)	Factor
Acid Rain	50	1000	50	20

Sample Id	Sample number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.100	<2.00	<0.010	<0.200
Fly Ash S3	13520	<0.025	<0.500	0.202	4.04	0.038	0.760
Fly Ash Unit B	13521	<0.025	<0.500	0.213	4.26	0.114	2.28

Sample Id	Sample number	B	B	Ba	Ba	Be	Be
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	5.29	106	0.183	3.66	<0.025	<0.500
Fly Ash Unit B	13521	5.51	110	0.072	1.44	<0.025	<0.500

Sample Id	Sample number	Bi	Bi	Ca	Ca	Cd	Cd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<2	<40	<0.005	<0.100
Fly Ash S3	13520	<0.025	<0.500	279	5580	<0.005	<0.100
Fly Ash Unit B	13521	<0.025	<0.500	130	2600	<0.005	<0.100

Sample Id	Sample number	Co	Co	Cr	Cr	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	<0.025	<0.500	1.09	22	<0.025	<0.500
Fly Ash Unit B	13521	<0.025	<0.500	0.827	17	<0.025	<0.500

Sample Id	Sample number	Fe	Fe	K	K	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<1.0	<20	<0.025	<0.500
Fly Ash S3	13520	<0.025	<0.500	1.9	38	0.141	2.82
Fly Ash Unit B	13521	<0.025	<0.500	<1.0	<20	0.140	2.80

Sample Id	Sample number	Mg	Mg	Mn	Mn	Mo	Mo
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<2	<40	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	154	3080	0.044	0.880	0.122	2.44
Fly Ash Unit B	13521	159	3180	<0.025	<0.500	0.196	3.92

Sample Id	Sample number	Na	Na	Ni	Ni	P	P
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<2	<40	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	4	80	0.058	1.16	0.706	14
Fly Ash Unit B	13521	<2	<40	0.048	0.960	0.995	20

Sample Id	Sample number	Pb	Pb	S	S	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.020	<0.400	<0.100	<2.00	<0.010	<0.200
Fly Ash S3	13520	<0.020	<0.400	85	1700	<0.010	<0.200
Fly Ash Unit B	13521	<0.020	<0.400	75	1500	<0.010	<0.200

Sample Id	Sample number	Se	Se	Si	Si	Sn	Sn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.020	<0.400	<0.2	<4.0	<0.025	<0.500
Fly Ash S3	13520	0.043	0.860	8.0	160	<0.025	<0.500
Fly Ash Unit B	13521	0.027	0.540	7.0	140	<0.025	<0.500

Sample Id	Sample number	Sr	Sr	Ti	Ti	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	2.47	49	<0.025	<0.500	0.707	14
Fly Ash Unit B	13521	2.35	47	<0.025	<0.500	1.01	20

Sample Id	Sample number	W	W	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Fly Ash S3	13520	0.099	1.98	<0.025	<0.500	<0.025	<0.500
Fly Ash Unit B	13521	0.125	2.50	<0.025	<0.500	<0.025	<0.500



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CERTIFICATE OF ANALYSES TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received: 2012-10-12
Project number: 159

Report number: 37114

Date completed: 2012-10-19
Order number: 47238

Client name: Golder Associates Africa
Address: P.O. Box 6001, Halfway House, 1685
Telephone: 012 366 0100

Contact person: Me. E. Herselman
Email: eherselman@golder.co.za
Facsimile: (012) 366 0111

Analyses	Sample Identification			
	Fly Ash S3		Fly Ash Unit B	
Sample number	13520		13521	
TCLP / Acid Rain / Distilled Water / H ₂ O ₂	Acid Rain		Acid Rain	
Dry Mass Used (g)	50		50	
Volume Used (mℓ)	1000		1000	
pH Value at 25°C	7.8		8.5	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Chloride as Cl	<5	<100	<5	<100
Sulphate as SO ₄	160	3 200	151	3 020
Nitrate as N	<0.2	<4.0	<0.2	<4.0
Fluoride as F	0.3	6.0	0.7	14
Ammonia as N	<0.2	<4.0	<0.2	<4.0
ICP-OES Scan	See attached report 37114 ICP AR		See attached report 37114 ICP AR	

Please note: The blank was subtracted from all leach results, except pH

E. Botha
Geochemistry Project manager

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Telephone: 012 366 0100

Contact person: Me. E. Herselman
Email: eherselman@golder.co.za
Facsimile: (012) 366 0111

Analyses	Sample Identification			
	Fly Ash S3		Fly Ash Unit B	
Sample number	13520		13521	
TCLP / Acid Rain / Distilled Water / H ₂ O ₂	Distilled Water		Distilled Water	
Dry Mass Used (g)	50		50	
Volume Used (mℓ)	1000		1000	
pH Value at 25°C	11.5		12.1	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Chloride as Cl	<5	<100	<5	<100
Sulphate as SO ₄	71	1 420	14	280
Nitrate as N	<0.2	<4.0	<0.2	<4.0
Fluoride as F	0.3	6.0	0.6	12
Ammonia as N	<0.2	<4.0	<0.2	<4.0
ICP-OES Scan	See attached report 37114 ICP DW		See attached report 37114 ICP DW	

Analyses	Sample Identification			
	Fly Ash S3		Fly Ash Unit B	
Sample number	13520		13521	
TCLP / Acid Rain / Distilled Water / H ₂ O ₂	Aqua Regia		Aqua Regia	
Dry Mass Used (g)	0.5		0.5	
Volume Used (mℓ)	100		100	
ICP-OES Scan	See attached report 37114 ICP AQR		See attached report 37114 ICP AQR	

Please note: The blank was subtracted from all leach results, except pH.

E. Botha
Geochemistry Project manager

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