ZITHOLELE CONSULTING

KUSILE AND KENDAL POWER STATIONS
ASH DISPOSAL FACILITIES
WASTE CLASSIFICATION REPORT

Report No.: JW030/13/D121 - Rev 2

March 2013

Jones & Wagener
Consulting Civil Engineers
59 Bevan Road PO Box 1434 Rivonia 2128 South Africa
Tel: 00 27 (0)11 519 0200 Fax: 00 27 (0)11 519 0201 email: post@jaws.co.za

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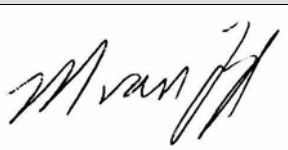
Prepared	Project Director	M van Zyl	27/03/2013	
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SYNOPSIS

Zitholele Consulting was appointed by Eskom to identify, investigate and licence the long term ash disposal facility for the new Kusile Power Station. Zitholele Consulting appointed Jones & Wagener Consulting Civil Engineers (J&W) to classify the ash to be generated by Eskom's Kusile Power Station.

More recently, Zitholele Consulting was also appointed to extend and licence the existing ash disposal facility of the Kendal Power Station, as well as identifying and licencing a new ash disposal facility for the station.

The Kendal Power Station employs a dry ash disposal method. The Kusile Power Station will use a similar methodology. For this waste classification ash from the Kendal Power Station was used because Kusile will use coal from similar coal fields and hence the ash qualities should be similar.

Classification of the ash is required for two purposes, namely to;

- Correctly classify the ash disposal facilities for licensing purposes, and
- Develop an appropriate barrier design for the facilities, based on the outcome of the classification of the ash, in order to protect the water environment.

The classification of the ash is not the only aspect that will determine the eventual barrier (liner) design of the waste disposal facilities. Site specific conditions, such as the vulnerability of the ground and surface water resources, will also play an important role in the design of the barrier system.

The objectives of this project were to classify the ash in terms of the:

- The Department of Water Affairs and Forestry's (the DWAF's) "*Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste*", Second Edition (DWAF, 1998) (Minimum Requirements) and the Department of Environmental Affairs letters dated June 2009. The Minimum Requirements is the current official waste classification system, but will be replaced once the envisaged draft waste classification regulations are promulgated.
- The Department of Environmental Affairs' (DEA's) draft waste classification regulations published for comment in August 2012 in terms of the provisions of the National Environmental Management: Waste Act, Act 59 of 2008.
- Regulations promulgated in terms of Section 36 of the National Nuclear Regulator Act, Act 47 of 1999, (NNRA) to establish whether or not the ash disposal facilities also have to be licensed in terms of the provisions of the NNRA.

The following tests were carried out on the Kendal Ash Sample:

- South African Acid Rain Leach (ARLP) extract of the Kendal ash sample and analysis of the inorganic and organic constituents. This was required to classify the ash in terms of the current Minimum Requirements waste classification procedure. This methodology is used for the Minimum Requirements classification.
- Total extraction (aqua regia digestion) analysis of the ash sample, including both inorganic and organic constituents. The total extraction analysis is required for the draft waste classification system.

- Australian de-ionised water leach of the dry ash and analysis of the leach solution. This was required to classify the waste in terms of the DEA's draft waste classification regulations for disposal purposes. The de-ionised leach analysis is required in cases where waste types are mono-disposed.
- Radioactivity analysis for gross alpha/beta-activity and for selected radionuclides in the uranium and thorium decay series.

In terms of the Minimum Requirements methodology the Kendal coal derived ash is classified as a Hazard Group 1 waste or an Extreme Hazard waste. This was due to the leachable concentration of chromium VI detected in the ARLP leach solution. In terms of the Minimum Requirements, a Hazard Group 1 waste should be disposed of on a landfill with a type H:H barrier system.

In terms of the DEA's draft waste classification system, the ash is classified as a Type 3 waste (low hazard waste), which requires disposal on a landfill with a Class C barrier system. This classification was the result of the leachable concentration of boron and the total concentration of barium and fluoride in the ash.

The difference in the two very varied results of the two classifications is because of the chosen trigger values. In terms of the Minimum Requirements, a waste is classified as a Hazard Group 1 waste in the case that the chromium VI exceeds a concentration of 0.020 mg/ℓ and the leach solution used is acidic. In the case of the DEA's draft waste classification regulations various chromium VI trigger values are given and a waste is only highly hazardous in the case that the leachable chromium VI concentration is above 5.0 mg/ℓ, while it is moderately hazardous above 2.5 mg/ℓ and low hazardous above 0.05 mg/ℓ[1][2]. In the case of the DEA's draft waste regulations, different levels of protection are assigned for the different concentration levels. The higher the leachable concentration (or total concentration) of a pollutant, the higher the level of protection that must be provided. This approach is in line with waste disposal practices elsewhere in the world.

Although the ash is classified as a Hazard Group 1 waste in terms of the Minimum Requirements, a H:H barrier system is considered too conservative for the relatively low concentration of chromium VI detected in the ARLP leach solution, i.e., it is lower than the drinking water standard of 0.050 mg/ℓ.

A more appropriate barrier system for the Kusile and Kendal Power Station ash disposal facilities would be a Class C barrier system, provided that the leachate head on the barrier system can be maintained at equal or less than 300 mm and the drainage piping system on the barrier is of adequate size, spacing and strength to ensure atmospheric pressure within the drainage system for the service life of the landfill. Class C landfill barrier systems are very similar in design to the current G:L:B$^+$ landfills, with the major difference being the HDPE (plastic) layer added to the barrier system (replacing 2 x 150 mm clay layers). This composite barrier system (HDPE and clay) is considered appropriate for the dry ash disposal facilities. In order to verify that a Class C barrier system will be sufficient in protecting the environment in the long-term, it is recommended that source-pathway-receptor modelling is undertaken at the chosen ash disposal facility sites.

The ash, based on the literature research, is not classified as a carcinogen even though it contains 14.15% quartz. The ash is also not classifiable as a teratogen or mutagen.

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[1] **In the case that the chromium VI concentration is above 20 mg/ℓ, the waste needs to be treated in order to reduce it to below 5.0 mg/ℓ before it can be disposed.**

[2] **The SANS 241-1 2011 drinking water standard for chromium VI is 0.050 mg/ℓ.**

From a radio activity perspective, it was found that:

- The ash is below the limit set for material to be considered as radioactive.
- Assuming very conservative conditions (people working on the ash for 7.6 hours per day), the potential radiological impact is below the regulatory criteria for the radiological protection of members of the public.

In this radioactivity exposure assessment a scenario in which members of the public construct dwellings on top of the ash disposal facilities was not considered. It is, however, recommended that human settlements not be allowed on the ash disposal facilities during operation and after closure.

Based on the findings and the conclusions reached, it is recommended that:

- Source-pathway-receptor modelling be undertaken using the chromium VI concentration as input to verify whether or not a Class C barrier system, with a design to ensure atmospheric pressure within the drainage system for the service life of the landfill, will be sufficient to protect the receiving water environment.
- The ash disposal facilities be licenced as an H:H waste disposal facilities as per the Minimum Requirements waste classification system.
- Human settlements are not allowed on top of the ash disposal facilities either during operation or after closure.
- With regard to impacts that may be caused by airborne ash dust:
  - The ash disposal facility should have gentle slopes to minimise the generation of airborne dust,
  - Ash should be moistened before disposal in order to minimise dust generation,
  - Progressive capping, including vegetation, of the ash disposal facility must be undertaken where the final disposal height has been achieved,
- Dust generation should be monitored around the site for:
  - Respirable dust ($PM_{2.5}$ and PM_{10}); and
  - Settable dust[3].

M van Zyl

[3] The air quality monitoring system will be established from the air quality modelling study being undertaken.

Acronyms and abbreviations:

Acronym / abbreviations	Definition
ARL	Acceptable Risk Level. (ARL = 0.1 x LC_{50})
ARLP	South African Acid Rain Leach Procedure
ASLP	Australian Standard Leaching Procedure
B^-	Landfills constructed without a leachate detection and collection layer
BA	Basic Assessment
DEA	Department of Environmental Affairs
Bq/gram	Becquerel per gram
DI	Deionised
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EIA	Environmental Impact Assessment
$G:L:B^+$	General waste landfill receiving more than 500 tonnes of general waste per day with a barrier system containing a leachate detection and collection layer
$G:L:B^-$	General waste landfill receiving more than 500 tonnes of general waste per day without a liner system containing a leachate detection and collection layer
$G:M:B^-$	General waste landfill receiving more than 150 but less than 500 tonnes of general waste per day without 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
LC_{50}	The concentration at which 50% of test organisms will die after a certain exposure time to a chemical compound or element
m^3	Cubic metres

Acronym / abbreviations	Definition
M	molar
mg/kg	milligram per kilogram
mg/ℓ	milligram per litre
µm	micrometre
TC	Total concentration in mg/kg
TCLP	Toxic Characteristic Leach Procedure
TDS	Total Dissolved Salts
>	Greater than

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Jones & Wagener
Consulting Civil Engineers
59 Bevan Road PO Box 1434 Rivonia 2128 South Africa
Tel: 00 27 (0)11 519 0200 Fax: 00 27 (0)11 519 0201 email: post@jaws.co.za

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1. INTRODUCTION

1.1 Background

Zitholele Consulting was appointed by Eskom to identify, investigate and licence the long term ash disposal facility for the new Kusile Power Station. Zitholele Consulting appointed Jones & Wagener (J&W) to classify the ash to be generated by Eskom's Kusile Power Station.

More recently, Zitholele Consulting was also appointed to extend and licence the existing ash disposal facility of the Kendal Power Station, as well as identify and licence a new ash disposal facility for the station.

The Kendal Power Station employs a dry ash disposal method. The Kusile Power Station will use a similar methodology.

Classification of the ash is required for two purposes, namely:

- Correctly classify the ash disposal facilities for licensing purposes, and
- Assist in the development an appropriate barrier design system for the facilities, based on the outcome of the classification of the ash.

For this classification Kendal Power Station ash was used as it was indicated that the Kusile Power Station will generate ash of a similar quality based on the coal for the two power stations sourced from similar coal fields.

1.2 Objectives

The objectives of this project were to classify the ash in terms of:

- The Department of Water Affairs and Forestry's (the DWAF's) "*Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste*", Second Edition (DWAF, 1998) (Minimum Requirements) and the Department of Environmental Affairs letters dated June 2009. Based on the classification, a monthly ash disposal rate was also calculated. The Minimum Requirements is the current official waste classification system, but will be replaced once the draft waste classification regulations are promulgated.
- The Department of Environmental Affairs' (DEA's) draft waste classification regulations published for comment in August 2012 in terms of the provisions of the National Environmental Management: Waste Act, Act 59 of 2008. The ash was classified in terms of this system, as the ash disposal facility may only be

constructed when the new classification system is in place, and Mr K. Legge of the Department of Water Affairs indicated that the new landfill barrier systems must be implemented once the new classification system is in place (K. Legge, 2011).

- Regulations promulgated in terms of Section 36 of the National Nuclear Regulator Act, Act 47 of 1999, (NNRA) to establish whether or not the ash disposal facilities also have to be licensed in terms of the provisions of the NNRA.

1.3 Historic overview

The ash generated by the Kendal Power Station was previously classified by Dr D. Baldwin of En-Chem Consultants cc. This work was carried out on behalf of Eskom for the Environmental Team Panel B Consultants in November 2008. The classification was carried out for the short term ash disposal facility of the new Kusile Power Station (En-Chem, 2008).

Using the South African Acid Rain Leach Procedure (ARLP) it was found that none of the elements tested for in the ARLP leach solution, leached at concentrations higher than their Acceptable Risk Levels (ARLs) and therefore the ash was classified as non-toxic (general) by En-Chem Consultants. For this waste classification, Kendal Power Station ash samples were also used (En-Chem Consultants, 2008).

2. METHODOLOGY

2.1 Phase 1: Sample Collection and Analysis

2.1.1 Samples Collected

Zitholele Consulting collected two representative fresh ash samples from the Kendal Power Station. One sample was collected in a glass bottle and was dated 16 November 2012. The other sample was collected in a plastic bucket and was dated 17 November 2012. The sample collected in the glass bottle was used for the organic analyses, while the one collected in the plastic bucket was used for the inorganic analyses.

A sample from the plastic bucket was collected for the radio-activity analyses to be carried out by NECSA.

J&W delivered the ash samples to the Waterlab on 23 November 2012. The sample for the radioactivity analyses was delivered to NECSA on 26 November 2012.

2.1.2 Tests Conducted

In order to classify the ash for disposal purposes, the following tests were carried out on the samples obtained:

- Total extraction (aqua regia digestion) analysis of the ash sample, including both inorganic and organic constituents.
- South African Acid Rain Leach (ARLP) extract of the ash sample and analysis of the inorganic and organic constituents. This was required to classify the ash in terms of the current Minimum Requirements waste classification procedure.

- Australian de-ionised water leach of the dry ash and analysis of the leach solution. This was required to classify the waste in terms of the DEA's draft waste classification regulations for disposal purposes.
- Radiological analysis by NECSA for gross alpha/beta-activity and for selected radionuclides in the uranium and thorium decay series.

2.2 Phase 2: Interpretation of Laboratory Results

J&W classified the ash as listed in the objectives given in Section 1.2 above. A statement has also been included on the carcinogenity, mutagenity and teratogenity of the ash.

The Kendal Power Station ash was also classified in accordance with the DEA's 2012 draft waste classification regulations pertaining to the disposal of waste.

The ash was not classified in terms of SANS 10234. This particular project focused on the classification of the ash for disposal purposes. A statement was, however, made with regard to the obvious health and safety risks posed by ash.

The laboratory certificates of the results of the various tests that were conducted are attached in **Appendix A**.

3. MINIMUM REQUIREMENTS (DWAF, 1998) WASTE CLASSIFICATION

3.1 Minimum Requirements Methodology

The Kendal ash sample was classified in terms of the Minimum Requirements (DWAF, 1998a) and the letter from the DEA, titled "Waste Delisting Procedure", signed by their Director General, dated 17 June 2009 (DEAT, 2009). Information from an earlier letter, dated 2008, was also considered (DEAT, 2008). The waste classification in this report is therefore in compliance with the Minimum Requirements as amended by the DEA. The ash was classified based on the leach results of the ARLP.

The ARLP is used in cases where non-organic waste, such as the ash, is not co-disposed with wastes containing organic material, which may decompose to generate organic acids, or in the case that a non-organic waste is mono-disposed.

The concentrations of the hazardous substances in the leach solutions were compared to the Acceptable Risk Levels (ARLs) for the aquatic environment as listed in the Minimum Requirements or as identified by J&W. The ARL, expressed in parts per million (ppm) or mg/ℓ = 0.1 x LC_{50} (mg/ℓ)[4]. Where the concentration in the leach solution is greater than (>) the ARL, the waste is classified as hazardous for that particular substance. The most hazardous substance dictates the Hazard Rating of the waste. Four Hazard Rating classes are specified in the Minimum Requirements ranging from Hazard Group 1 (Extreme Hazard) to Hazard Group 4 (Low Hazard).

Furthermore, the monthly loading rate, i.e., the amount of waste that can be disposed of in tons/hectare/month, can be calculated for the ash based on the Minimum Requirements methodology:

[4] The factor of 0.1 is calculated from a cross section of typical dose response data, with a typical slope of dose response curves. From an exposure 10 times lower than the LC_{50}, approximately 0,00034% or one in 300 000 of a population exposed to the contaminant, is likely to die (DWAF, 1998a).

Monthly loading rate = Allowable dose per month (g/ha/month) / Concentration in leach solution, where allowable dose per month = ARL/0.66 x 1000 [5]

The allowable maximum load per hectare for lined waste disposal facilities can again be calculated from the dose as:

Total load (ton/hectare) = 100 x dose (g/ha/month)/mg of most hazardous substance per kilogram of waste

or, for unlined waste disposal facilities, as:

Total load (ton/hectare) = 10 x dose (g/ha/month)/mg of most hazardous substance per kilogram of waste

A waste can be delisted to general waste in cases where the:

- Concentration in the leach solution < ARL for Hazard Group 2, 3 or 4 substances, or
- Concentration in the leach solution < 0.10 x Hazard Group 1, or
- An allowable load of [(ARL/0.66)/(Measured concentration)] is not exceeded.

3.2 Primary Waste Classification (Hazard Rating) of Kendal Ash Sample

Based on the Minimum Requirements approach, a waste is first categorised based on the industry type. In this case the ash is from a power plant, where electricity is generated.

The ash from the Kendal Power Station is provisionally classified as hazardous. This is because the Minimum Requirements classifies the energy sector, specifically the production of electricity from coal, as an industrial sector which may generate hazardous waste (DWAF, 1998a).

3.3 Secondary Waste Classification or Hazard Rating

Based on the chemical analysis obtained from ARLP leach solution, the ash is classified as a Hazard Group 1 waste. This is due to chromium VI having been detected in the ARLP solution at a concentration higher than its ARL value of 0.020 mg/ℓ - see **Table 3-1**. None of the other elements and organic compounds tested for was detected in the leach solution at a concentration higher than its respective ARL value.

The results indicate that disposal of the ash should be onto a facility that complies with the barrier (liner) performance requirements of an H:H waste disposal facility – see **Figure 3-1**. An H:H waste disposal facility complies with the most stringent design requirements as per the Minimum Requirements. It may be possible to delist the ash for disposal on a G:L:B^+ lined waste disposal facility **Figure 3-12** based on the actual disposal rate.

The monthly loading or disposal rate for the ash, based on the ARLP results for chromium VI, is presented in **Table 3-2**. Based on the concentration of hexavalent chromium present in the ash – only 417 tons may be disposed of per hectare on G:L:B^+ waste disposal facility per month. The total loading rate will be a hundred (100) times the monthly loading rate, which is therefore 41 700 tonnes per hectare. It was indicated

[5] The factor 0.66 is derived from the ratio of the substance in a weight of underground body of water (DWAF, 1998). A correction factor of a 1000 was applied by the DWAF to obtain g/ha/month instead of mg/ha/month – this was never fully explained in the Minimum Requirements.

that Kusile will generate in the order of 7.1 million tonnes of ash per annum and that the life of the long term disposal facility should be in the order of 60 years, therefore over a 60 year period, 426 million tonnes of ash will be generated. At a maximum disposal rate of only 41 700 tonnes per hectare, the G:L:B$^+$ landfill will have to be in the order of a 10 215 hectares in size, which will be completely impracticable. On the other hand, a waste disposal facility constructed with an H:H barrier system will be highly expensive. Therefore, in order to protect the environment and also make the disposal facility affordable, it is recommended that an improved G:L:B$^+$ liner system (a Class C barrier system – see **Figure 4-1**) be considered and that the liner system be designed in a manner that will prevent build-up of leachate on the drainage layer in excess of 300 mm. This liner design scenario should be tested by source-pathway-receptor modelling to verify that this liner system will be sufficient to protect the water environment in the long term.

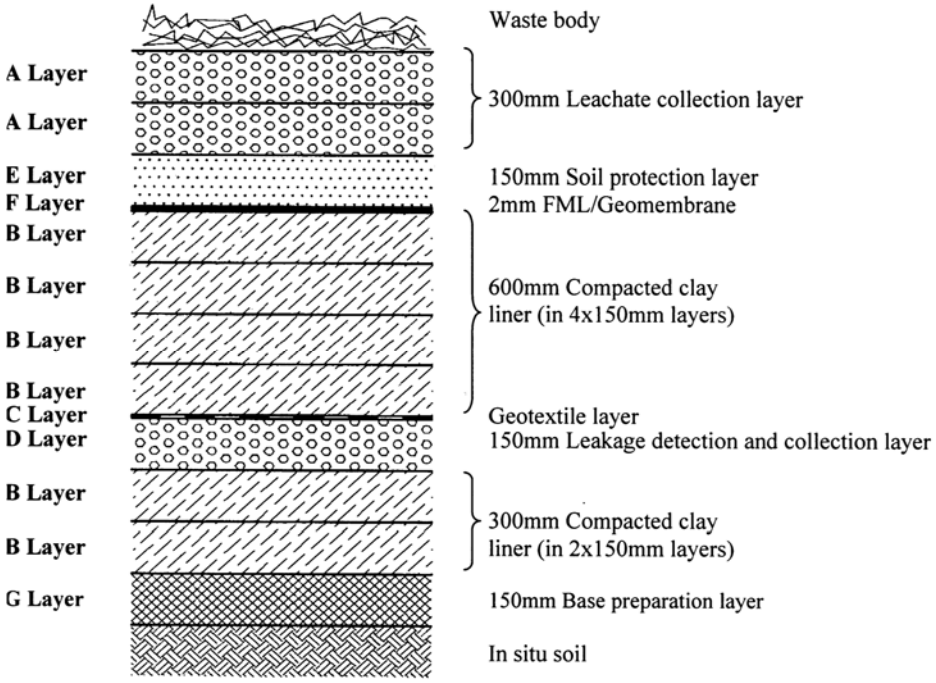

Figure 3-1: H:H Landfill Barrier System (DWAF, 1998b)

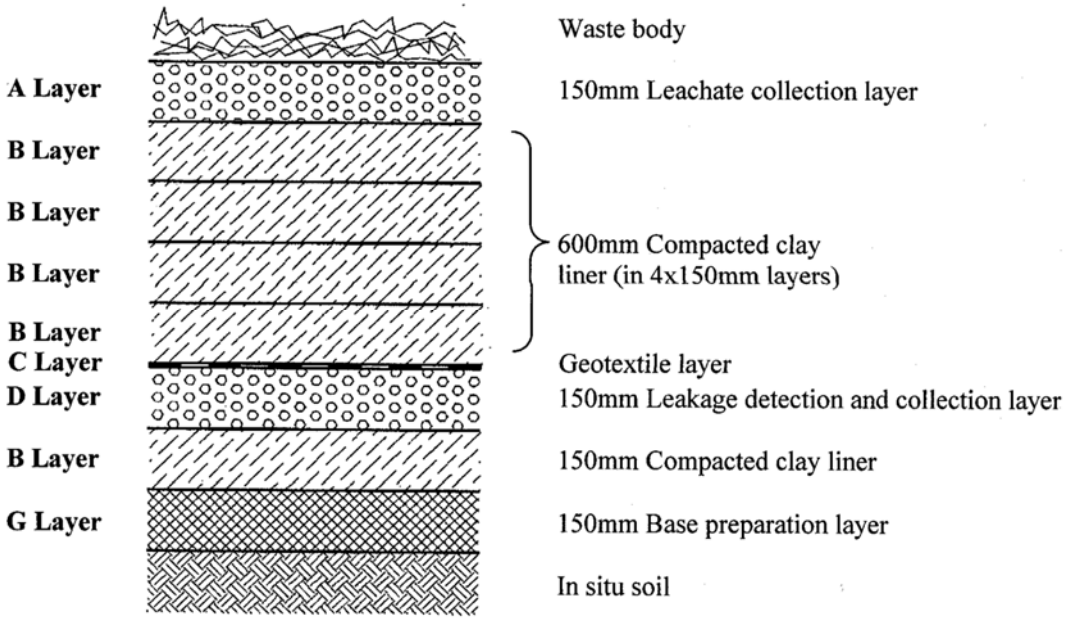

Figure 3-2: G:L:B$^+$ Landfill Barrier System (DWAF, 1998b)

Table 3-1: Results of ARLP Leaches Compared to ARL Values

Chemical Substance	Kendal Ash (mg/ℓ)	Detection Limit (mg/ℓ)	ARL (mg/ℓ)	Hazard Group
1,2 Dichloroetane	<0.002	<0.002	6.5	3
1,1,2 Trichloroetane	<0.002	<0.002	8.2	3
1,2,3 Trichlorobenzene	<0.002	<0.002	0.28	2
1,4 Dichlorobenzene	<0.002	<0.002	3.37	3
2,4,5 Trichlorophenol	<0.002	<0.002	0.050	1
Aluminium (Al)	0.013	<0.001	10	4
Antimony (Sb)	0.007	<0.001	0.070	2
Arsenic (As)	0.064	<0.001	0.43	2
Barium (Ba)	0.138	<0.001	7.8	3
Benzene	<0.002	<0.002	2.2	3
Benzo(a)pyrene	<0.0001	<0.0001	0.010	1
Cadmium (Cd)	0.0001	<0.0001	0.031	1
Carbon tetrachloride	<0.005	<0.005	0.10	2
Chloroform	<0.005	<0.005	0.10	2
Chromium (Cr) (total)	0.086	<0.025	4.7	3
Chromium VI (Cr VI)	0.072	<0.001	0.020	1
Cobalt (Co)	0.002	<0.001	6.9	3
Copper (Cu)	<0.001	<0.001	0.10	2
Cresols	<0.002	<0.002	0.40	2
Cyanide	<0.05	<0.05	0.0053	1
Ethylbenzene	<0.002	<0.002	1.20	2
Fluoride	0.60	<0.01	1	3
Hexachlorobenzene	<0.001	<0.001	0.030	1
Hexachlorobutadiene	<0.002	<0.002	0.010	1
Iron (Fe)	<0.010	<0.010	9.0	3
Lead (Pb)	<0.001	<0.001	0.10	2
Isopropylbenzene	<0.002	<0.002	2.2	3
Manganese (Mn)	0.011	<0.001	0.30	2
Mercury (Hg)	0.0002	<0.0001	0.022	1
Naphthalene	<0.002	<0.002	0.38	2
Phenol	<0.002	<0.002	2.3	3
Selenium (Se)	0.016	<0.010	0.26	2
Strontium (Sr)	1.08	<0.001	18.0	3
Tetrachloroethane	NA	<0.010	3.70	3

Chemical Substance	Kendal Ash (mg/ℓ)	Detection Limit (mg/ℓ)	ARL (mg/ℓ)	Hazard Group
Tetracholoroethylene	<0.010	<0.010		
Titanium (Ti)	<0.001	<0.001	0.73	2
Vanadium (V)	0.188	<0.001	1.3	3
Xylene	<0.002	<0.002	1.1	3
Zinc (Zn)	0.002	<0.001	0.70	2
NA	Not analysed			
	TCLP > ARL Hazard Group 1			
	TCLP > ARL Hazard Group 2			
	TCLP > ARL Hazard Group 3			
	TCLP > ARL: Hazard Group 4			

Table 3-2: Monthly loading rate based on Chrome VI leach concentration

KUSILE & KENDAL POWER STATION: MONTHLY ASH LOADING RATE IN TONNES PER HECTARE	
	KendalAsh
Concentration of chromium VI (ppm) in ARLP ash leach	0.072
Load for element in g/ha/month from Minlmum Requirements	30
Load in kg/ha/month	416667
Load in tons/ha/month for H:H	**417**
The monthly disposal rate is calculated by dividing the ARL by 0.66, which gives the load for the element in g/ha/month. The monthly load of the waste is then calculated by dividing the load (in g/ha/month) with the concentration of the component in the leach solution (ppb).	

4. DEA WASTE CLASSIFICATION

4.1 Introduction

Although the Minimum Requirements waste classification system is currently still the official waste classification system, the ash sample was also classified in terms of the draft DEA waste classification system for disposal purposes (DEA, 2012). The reason for this being that by the time that the new Kusile ash disposal facility is constructed, the new waste classification regulations would in all likelihood have been promulgated. Mr K. Legge of the Department of Water Affairs indicated that in such cases, the new classification system and landfill barrier design system should be adhered to (Legge, 2011). The same applies to the extension of the existing and the envisaged new ash disposal facility of the Kendal Power Station.

4.2 Overview of Draft Classification System

The draft classification system focuses on the long term disposal of waste (longer than 90 days) 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, 2012a).

For the ASLP a number of leach solutions can be used. For waste to be disposed of with organic matter, an acetic acid leach solution is used. This leach solution is very similar to the currently used USEPA TCLP leach solution, 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 is to be co-disposed with other non-organic waste, a basic 0.10 M sodium tetraborate decahydrate solution of pH 9.2 ± 0.10 should be used in addition to the TCLP (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.

For non-putrescible waste to be disposed of without any other wastes (mono-disposal scenario), reagent water (deionised water [DI]) must be used as a leach agent.

In addition to the above, the TCs of the constituents of concern must also be determined and compared to specified total concentration threshold (TCT) values.

The number of potentially hazardous substances in the new classification system has been significantly reduced from that listed in the 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 <u>any</u> element or chemical substance concentration above the LCT3 or TCT2 values (LC > LCT3 or TC > TCT2) are Type 0 Wastes. Type 0 wastes require treatment/stabilisation before disposal[6];
- Wastes with <u>any</u> 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;
- Wastes with <u>any</u> element or chemical substance concentration above the LCT1 but below the LCT2 values and <u>all</u> concentrations below the TCT1 values (LCT1 < LC ≤ LCT2 and TC ≤ TCT1) are Type 2 Wastes;
- 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;
- 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 following limits for organics and pesticides, are Type 4 Wastes:

[6] **If the TC of a chemical substance is > TCT2, and the concentration cannot be reduced by waste avoidance, re-use, recycling or recovery, or it is not economically feasible e.g. due to very small quantities, the waste must be stabilised to a minimum of LC < LCT2, and will then be considered a Type 1 Waste.**

Chemical Substances in Waste	Total Concentration (mg/kg)
Organic constituents	
Total organic carbon (TOC)	30 000 (3%)
Benzene, toluene, ethylbenzene, 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

4.3 Kusile and Kendal Ash Classification

Based on the results obtained from the distilled water leach and analyses performed on the leach solution, the ash sample is classified 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 – see **Table 4-1** and **Figure 4-1**. The Type 3 waste classification was the result of the LC value of boron (B) exceeding its LC0 value of 0.50 mg/ℓ, and the TC value of barium (Ba) and fluoride (F) exceeding their respective TC0 values – see **Table 4-1**.

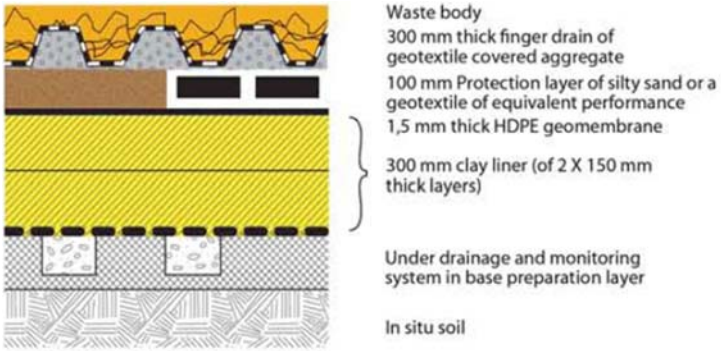

Figure 4-1: Class C landfill barrier system (DEA, 2012b)

Table 4-1: Distilled Water (LC) and Total Concentration (TC) results of Kendal Power Station Ash Sample

Elements & Chemical Substances	Kendal Power				LC0	TCT0		LC1	TCT1		LCT2	TCT1		LCT3	TCT2	
	Distilled Water leach concentration (LC) (mg/ℓ)	Total concentration (TC) (mg/kg)	Limit of Report for LC (mg/ℓ)		(mg/ℓ)	(mg/kg)		(mg/ℓ)	(mg/kg)		(mg/ℓ)	(mg/kg)		(mg/ℓ)	(mg/kg)	
Metal Ions																
As	<0.010	<2.00	0.010		0.01	5.8		0.50	500		1.0	500		4.0	2 000	
B	0.733	82	0.025		0.5	150		25	15 000		50	15 000		200	60 000	
Ba	0.044	570	0.025		0.7	62.5		35	6 250		70	6 250		280	25 000	
Cd	<0.005	2.80	0.005		0.003	7.5		0.15	260		0.3	260		1.2	1 040	
Co	<0.025	<5.00	0.025		0.5	50		25	5 000		50	5 000		200	20 000	
Cr	<0.025	33	0.025		0.05	46 000		2.5	800 000		5.0	800 000		20		
Cr(VI)	0.028(1)	NA	0.010		0.05	6.5		2.5	500		5.0	500		20	2 000	
Cu	<0.025	<5.00	0.025		2.0	16		100	19 500		200	19 500		800	78 000	
Hg	<0.001	<0.200	0.001		0.006	0.93		0.3	160		0.6	160		2.4	640	
Mn	<0.025	190.40	0.025		0.5	1 000		25	25 000		50	25 000		200	100 000	
Mo	<0.025	<5.00	0.025		0.07	40		3.5	1 000		7.0	1 000		28	4 000	
Ni	<0.025	<5.00	0.025		0.07	91		3.5	10 600		7.0	10 600		28	42 400	
Pb	<0.010	<2.00	0.020		0.01	20		0.5	1 900		1	1 900		4	7 600	
Sb	<0.010	<2.00	0.010		0.02	10		1.0	75		2	75		8	300	
Se	<0.010	<2.00	0.020		0.01	10		0.5	50		1	50		4	200	
V	0.049	<5.00	0.025		0.2	150		10	2 680		20	2 680		80	10 720	
Zn	<0.025	35	0.025		5.0	240		250	160 000		500	160 000		2000	640 000	
Inorganic Anions																
TDS	80		10	Type 4 Waste	1000		Type 3 Waste	12 500		Type 2 Waste	25 000		Type 1 Waste	100 000		Type 0 Waste
Chloride	<5		5		300			15 000			30 000			120 000		
Sulphate as SO_4	36		5		250			12 500			25 000			25 000		
NO_3 as N	<0.2		0.2		11			550			1 100			4 400		
Fluoride	0.40	112	0.01		1.5	100		75	10 000		50	10 000		600	40 000	
Cyanide	<0.05	<0.05	0.05		0.07	14		3.5	10 500		7.0	10 500		28	42 000	
Organics																
Benzene	<0.002	<0.80	0.002					0.01	10		0.02	10		0.08	40	
Benzo(a)pyrene	<0.0001	<0.040	0.0001					0.035	1.7		0.070	1.7		0.28	6.8	
Carbon tetrachloride	<0.005	<2.00	0.005					0.20	4		0.40	4		1.6	16	
Chlorobenzene	<0.002	<0.80	0.002					5.0	8 800		10	8 800		40	35 200	
Chloroform	<0.005	<0.80	0.005					15	700		30	700		120	2 800	
2-Chlorophenol	<0.002	<0.80	0.002					15	2 100		30	2 100		120	8 400	
Di (2-ethylhexyl) phthalate	<0.010	<0.80	0.010					0.50	40		1	40		4	160	
1,2-Dichlorobenzene	<0.002	<0.80	0.002					5	31 900		10	31 900		40	127 600	
1,4-Dichlorobenzene	<0.002	<0.80	0.002					15	18 400		30	18 400		120	73 600	
1,2-Dichloroethane	<0.002	<0.80	0.002					1.5	3.7		3	3.7		12	14.8	
1,1-Dichloroethylene (1,1-Dichloroethene)	<0.010	<4.00	0.010					0.35	150		0.7	150		2.8	600	
1,2-Dichloroethylene	<0.010	<4.00	0.010					2.5	3 750		5.0	3 750		20	15 000	
Dichloromethane	<0.020	<8.00	0.020					0.25	16		0.5	16		2	64	
2,4-Dichlorophenol	<0.002	<0.80	0.002					10	800		20	800		80	3 200	
2,4-Dinitrotoluene	<0.001	<0.40	0.001					0.065	5.2		0.13	5.2		0.52	20.8	

Elements & Chemical Substances	Kendal Power			LC0 (mg/ℓ)	TCT0 (mg/kg)	LC1 (mg/ℓ)	TCT1 (mg/kg)	LCT2 (mg/ℓ)	TCT1 (mg/kg)	LCT3 (mg/ℓ)	TCT2 (mg/kg)
	Distilled Water leach concentration (LC) (mg/ℓ)	Total concentration (TC) (mg/kg)	Limit of Report for LC (mg/ℓ)								
Ethyl benzene	<0.002	<0.80	0.002			3.5	540	7	540	28	2 160
Formaldehyde	<0.050	<2.0	0.050			25	2 000	50	2 000	200	8 000
Hexachlorobutadiene	<0.002	<0.80	0.002			0.03	2.8	0.06	2.8	0.24	5.4
Methyl ethyl ketone (butanone)	<0.001	<0.001	0.001			100	8 000	200	8 000	800	32 000
MTBE (Methyl t-butyl ether)	<0.005	<2.00	0.005			2.5	1 435	5.0	1 435	20	5 740
Nitrobenzene	<0.001	<0.40	0.001			1	45	2	45	8	180
PAHs (total)	<0.002	<0.80	0.002				50		50		200
Petroleum hydrocarbons (C6 to C9)	<0.025	<10.0	0.025				650		650		2 240
Petroleum hydrocarbons (C10 to C36)	<0.010	<4.0	0.010				10 000		10 000		40 000
Phenols (Total non-halogenated)	<0.020	<8.00	0.020			7	560	14	560	56	2 600
Polychlorinated biphynels (PCBs)	<0.005	<2.00	0.005			0.025	12	0.050	12	0.20	48
Styrene	<0.005	<2.00	0.005			1.0	120	2	120	8	480
1,1,1,2-Tretrachloroethane	<0.010	<4.00	0.010			5	400	10	400	40	1 600
1,1,2,2-Tretrachloroethane	<0.010	<4.00	0.010			0.65	5.0	1.3	5.0	5.3	20
Tetrachloroethylene	<0.010	<4.00	0.010			0.25	200	0.50	200	2	800
Toluene	<0.010	<4.00	0.010			35	1 150	70	1 150	280	4 600
Trichlorobenzenes (Total)	<0.002	<0.80	0.010			3.5	3 300	7.0	3 300	28	13 200
1,1,1-Trichloroethane	<0.005	<2.00	0.005			15	1 200	30	1 200	120	4 800
1,1,2-Trichloroethane	<0.005	<2.00	0.005			0.6	48	1	48	4	192
Trichloroethylene	<0.010	<4.00	0.010			0.25	11 600	2	11 600	8	46 400
2,4,6-Trichlorophenol	<0.002	<0.80	0.002			10	1 770	20	1 770	80	7 080
Vinyl chloride	<0.001	<1.0	0.001			0.015	1.5	0.03	1.5	0.12	6.0
Xylenes (total)	<0.005	<0.100	0.005			25	890	50	890	200	3.560
Pesticides											
Aldrin + Dieldrin	<0.001	<0.04	<0.001		0.05	0.015	1.2	0.03	1.2	0.03	4.8
DDT + DDD + DDE	<0.001	<0.04	<0.001		0.05	1	50	2	50	2	200
2.4-D	<0.001	<0.04	<0.001		0.05	1.5	120	3	120	3	480
Chlordane	<0.001	<0.04	<0.001		0.05	0.05	4	0.1	4	0.1	16
Heptachlor	<0.001	<0.04	<0.001		0.05	0.015	1.2	0.03	1.2	0.03	4.8

	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 < LV ≤ LCT1 and TC ≤ TCT1: Type 3 Wastes
	LC ≤ LCT0 and TC ≤ TCT0: Type 4 wastes
(1)	Waterlab indicated that due to analytical noise, it is possible that the total chromium could be less than chromium VI. They have repeated the analysis.

5. CARCINOGENIC, TERATOGENIC AND MUTAGENIC CHARACTERISTICS OF THE ASH

The DEA requires that a declaration be given with regard to the carcinogenic, mutagenic and teratogenic characteristics of the Kendal ash (DEA, 2009).

This assessment and declaration are based on a desktop study of available information and detailed source-pathway-receptor analysis and modelling was not undertaken. In addition, no testing of the ash sample was undertaken to establish the carcinogenic, mutagenic or teratogenic characteristics. The assessment is based on information obtained from literature sources, such as the International Association for Research on Cancer (IARC), the World Health Organisation, US National Institute for Occupational Safety and Health (NIOSH), the US EPA and the Minimum Requirements, etc.

The ash contains elements which fall into the Group 1, Group 2 and Group 3 carcinogens as identified by the IARC – see **Table 5-1**. The ash contains in the order of 14.15% quartz (crystalline silica), based on the XRD analysis. Silica quartz has been classified as a Group 1 carcinogen by the IARC. In terms of the SANS 10234 rules, the ash would be classifiable as a Category 1 carcinogen, i.e., the ash contains more than 0.1% of a Group 1 carcinogen (SABS, 2008).

However, despite the above, no medical evidence could be found that coal derived ash is actually classifiable as carcinogenic. From the literature study, it would appear that the respirable fractions of the silica are coated with amorphous alumina-silicate and thus renders the silica significantly less hazardous (Y. Nathan et al, 2009). Therefore coal ash, including bottom and fly-ash, is currently classified as a non-hazardous waste in the European Union, State of Maryland and Ireland, USA (EU, 2000 and Maryland Dept. of Health, 2007). The ash is therefore not classified as a carcinogen.

No evidence could be found that the ash is teratogenic or mutagenic either.

The above does not mean that the ash may not pose health hazards. In order to minimise the impact of the ash on the environment and human health it is recommended that:

- The ash disposal facility should have gentle slopes to minimise the generation of airborne dust,
- The ash should be moistened before disposal in order to minimise dust generation,
- Irrigation of the ash body should be done in order to minimise the generation of windblown dust,
- Progressive capping, including vegetation, of the ash disposal facility must be undertaken where the final disposal height and landform has been achieved,
- The base of the landfill should be constructed with a suitable barrier and seepage water management system to prevent significant seepage of leachate from the site (based on the outcome of the above recommended modelling),
- Dust deposition should be monitored around the site for:
    - Respirable dust (PM2.5 and PM10); and
    - Settable dust monitoring

The air quality monitoring points and frequency should be determined in the air quality impact assessment.

Table 5-1: Elements detected in the ARLP leach solution and their carcinogenic, mutagenic and teratogenic characteristics

Element or Compound	Carcinogenic and Mutagenic	Teratogenic	Percentage in waste stream (%)	Comments / Notes
Aluminium (Al)	Group 1	No	1.3×10^{-6}	Aluminium is a Group 1 carcinogen in aluminium production processes in the case that volatile aluminium is inhaled. It will not be applicable to the ash.
Antimony (Sb)	Group 2B - Antimony trioxide Group 3 – Antimony trisulphide	No	7.0×10^{-7}	Antimony trioxide and antimony trisulphide have been assigned a Group 2B (possibly carcinogenic to humans) and 3 (not classifiable as to its carcinogenicity to humans) classifications respectively (IARC, 2012). From the experimental work conducted, it would appear that most of the research focused on exposure compounds by inhalation due to the fact that antimony is recovered by roasting processes (IARC).
Barium (Ba)	No	No	1.38×10^{-5}	The World Health Organisation (WHO) reports that there is no evidence that barium is carcinogenic or mutagenic. (WHO, 2008).
Cadmium (Cd)	No	No	5×10^{-5}	Cadmium and cadmium compounds have been identified as Group 1 carcinogens (IARC, 2012). However, there is no evidence of carcinogenicity by the oral route and no clear evidence of the genotoxicity of cadmium (WHO, 2008).
Chromium III (Cr III)	No	No	8.6×10^{-6}	Chromium III has been identified as a Group 3 carcinogen (IARC, 2012). This category is used most commonly for agents for which the evidence of carcinogenicity is inadequate in humans and inadequate or limited in experimental animals. Chromium III is a dietary requirement and is known to enhance the action of insulin, a hormone critical to the metabolism and storage of carbohydrate, fat, and protein in the body.
Chromium VI (Cr VI)	Group 1	No	7.2×10^{-6}	Chromium VI is a Group 1 carcinogen (IARC, 2012). Most evidence regarding the carcinogenicity is related to lung cancer with some evidence of gastrointestinal sites (IARC, 2005). Based on the evidence of lung cancer in humans, chromium VI was classified as Group 1.
Cobalt (Co)	Group 2B	No	2×10^{-7}	Cobalt sulfate and other soluble cobalt (II) salts have been assigned a Group 2B carcinogenic classification by the IARC, which means that soluble cobalt is possibly carcinogenic to humans (IARC, 2012). This category is used for agents for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals (IARC, 2006).

Element or Compound	Carcinogenic and Mutagenic	Teratogenic	Percentage in waste stream (%)	Comments / Notes
Fluoride (F)	No	No	-	
Manganese (Mn)	No	No	-	
Mercury (Hg)	Group 3	No	2×10^{-8}	Mercury and inorganic mercury compounds have been classified as Group 3 carcinogens, therefore not classifiable as to its carcinogenicity to humans (IARC, 2012). This category is used most commonly for agents for which the evidence of carcinogenicity is inadequate in humans and inadequate or limited in experimental animals (IARC, 2006).
Selenium (Se)	Group 3	No	1.6×10^{-6}	Selenium and selenium compounds have been assigned a Group 3 carcinogenic classification by the IARC (IARC, 2012), therefore not classifiable as to its carcinogenicity to humans. Selenium is an essential element for humans, with a recommended daily intake of about 1 mg/kg of body weight for adults (WHO 2008).
Quartz (SiO_2)	Group 1	No	14.15	Quartz (SiO_2) is a Group 1 carcinogen (IARC, 2012). However, despite this, no medical evidence could be found that coal derived ash is classifiable as carcinogenic. It would appear that the respirable fractions of the silica are coated with amorphous alumina-silicate and thus renders the silica significantly less hazardous (Y. Nathan et al, 2009).
Strontium (Sr)	No	No	-	Group 1 in the case of Strontium 90, which is a radioactive material (IARC, 2012).
Vanadium (Va)	Group 2B	No	1.88×10^{-5}	Vanadium pentoxide has been assigned Group 2B classification by the IARC (IARC, 2012).

6. RADIOACTIVITY OF THE ASH

It was agreed that radioactivity analyses of the ash will be conducted and therefore an ash sample was analysed at NECSA for radioactivity.

The potassium-40, gross alpha and gross beta results are presented in **Table 6-1**. The results for each nuclide analysed for are attached as **Appendix B**.

The results indicate that the ash is excluded from regulatory control. None of the individual nuclides and their progeny analysed for had activities above 0.50 Bq/gram, while the total radioactivity of the ash was significantly below the 1000 Bq/gram, which would trigger regulatory control. The radioactivity of potassium-40 was also well below 50 Bq/gram regulatory control value.

In terms of the potential impact on public health, J&W sub-contracted Dr J J van Blerk of Aquisim Consulting to conduct a first order assessment based on the results obtained. Dr Van Blerk's report is attached as **Appendix C** and is summarised below.

For the assessment conducted by Aquisim, the following assumptions were made, namely:

- Members of the public are exposed to the material for a period of 2 000 hours per annum (7.6 hours per day for 260 days per annum - equal to the period normally used for worker radiological safety assessments, such as tailings dam operators).
- During this exposure period, an adult member of the public inhales 1 850 m^3 of air (or 0.93 m^3/hour, which is the average breathing rate for and adult during sleeping, sitting, and for light and heavy exercise). For this study it was assumed that the respirable dust load is 1 x 10^{-4} grams/m^3.

For these assumed conditions, the inhalation dose to adult members of the public will be in the order of 7.0 µSv/annum for the sample analysed, while the external gamma radiation for an adult member of the public (2 000 hours on top of the facility) would be in the order of 197 µSv/annum.

The external gamma radiation dose will decrease linearly with a decrease in exposure period, while the exposure with distance away from the facility will decrease exponentially (i.e., at a small distance away from the facility, the dose will decrease to insignificant levels).

Based on the assessment conducted, Dr Van Blerk concluded that:

- The material is below the limit set for material to be considered as radioactive,
- Assuming very conservative conditions, the potential radiological impact is below the regulatory criteria for the radiological protection of members of the public.

Dr Van Blerk did not consider a scenario where members of the public constructed dwellings on top of the ash disposal facilities, which is unlikely as the sites will not be open for the public. Nevertheless, it is recommended that human settlements must not be allowed on the ash disposal facilities during operation and after closure of the disposal facility.

Table 6-1: Summary of radiological results

Radioactivity in Bq/gram(1)	Kendal Ash	Exclusion Level
^{40}K (Potassium-40)	0.296	50(2)
Gross alpha	2.510	_
Gross beta	1.220	_
Total radioactivity (alpha + beta	**3.730**	**1000**
1: The values in the NECSA report are reported as Bq/kg and were converted to Bg/gram to be in line with the values as stipulated in the legislation (Dept of Minerals and Energy, 2006). 2: For material to be used in the building industry the potassium 40 level must not exceed 10 Bq/gram.		

7. DISCUSSION AND CONCLUSIONS

In terms of the Minimum Requirements methodology the Kendal coal derived ash is classified as a Hazard Group 1 waste or an Extreme Hazard waste. This is due to the leachable amount of chromium VI which was detected in the ARLP leach solution. In terms of the Minimum Requirements, a Hazard Group 1 waste should be disposed of on a landfill with a type H:H barrier system.

In terms of the DEA's draft waste classification system, the ash is classified as a Type 3 waste (low hazard waste) which requires disposal on a landfill with a Class C barrier system. This classification was the result of the leachable concentration of boron and the total concentration of barium and fluoride in the ash.

The difference in the two very varied results of the two classifications is because of the chosen trigger values. In terms of the Minimum Requirements, a waste is classified as a Hazard Group 1 waste in the case that the chromium VI exceeds a concentration of 0.020 mg/ℓ and the leach solution used is acidic, which will result in a more conservative classification than when a deionised water leach is used. In the case of the DEA's draft waste classification regulations various chromium VI trigger values are given and a waste is only highly hazardous in the case that the leachable chromium VI concentration is above 5.0 mg/ℓ, while it is moderately hazardous above 2.5 mg/ℓ and low hazardous above 0.05 mg/ℓ[7][8]. In the case of the DEA's draft waste regulations, different levels of protection are assigned for the different concentration levels. The higher the leachable concentration (or total concentration) of a pollutant, the higher the level of protection that must be provided, i.e., the more conservative the barrier systems become. This approach is in line with waste disposal practices elsewhere in the world.

Therefore, although the ash is classified as a Hazard Group 1 waste in terms of the Minimum Requirements, an H:H barrier system is considered too conservative for the

[7] **In the case that the chromium VI concentration is above 20 mg/ℓ, the waste needs to be treated in order to reduce it to below 5.0 mg/ℓ before it can be disposed.**

[8] **The SANS 241-1 2011 drinking water standard for chromium VI is 0.050 mg/ℓ.**

relatively low concentration of chromium VI detected in the ARLP leach solution of 0.072 mg/ℓ.

The Kusile and Kendal Power Station ash should therefore be disposed of on facilities that has been designed and constructed as a Class C landfills (DEA, 2012b). Class C landfills are very similar in design to the current G:L:B$^+$ landfills, with the major difference being the HDPE layer added to the barrier system replacing 2 x 150 mm clay layers. This composite barrier system (HDPE and clay) is considered appropriate for the dry ash disposal facilities, provided the seepage water (leachate) head can be maintained at equal or less than 300 mm on top of the HDPE barrier layer and the drainage piping system on the barrier is of adequate size, spacing and strength to ensure atmospheric pressure within the drainage system for the service life of the landfill. In order to verify that a Class C barrier system will be sufficient in protecting the environment in the long-term, it is recommended that source-pathway-receptor modelling be undertaken.

The ash, based on the literature research, is not classified as a carcinogen even though it contains 14.15% quartz. The ash is also not classifiable as a teratogen or mutagen.

From a radioactivity perspective, it was found that:

- The ash is below the limit set for material to be considered as radioactive, and therefore the National Nuclear Regulator Act, Act 47 of 1999, is not applicable.
- Assuming very conservative conditions (people working on the ash for 7.6 hours per day), the potential radiological impact is below the regulatory criteria for the radiological protection of members of the public.

8. RECOMMENDATIONS

Based on the findings of this study, it is recommended that:

- Source-pathway-receptor modelling be undertaken using the chromium VI concentration as input to verify whether or not a Class C barrier system, with a design to ensure atmospheric pressure within the drainage system for the service life of the landfill, will be sufficient to protect the receiving water environment.
- The ash disposal facilities will have to be licenced as H:H waste disposal facilities in terms of the Minimum Requirements waste classification system.
- Human settlements are not allowed on top of the ash disposal facilities either during operation or after closure.
- The head of leachate on the barrier system should not be allowed to be greater than 300 mm,
- With regard to impacts that may be caused by airborne ash dust:
    - The ash disposal facility should have gentle slopes to minimise the generation of airborne dust,
    - Ash should be moisturised before disposal in order to minimise dust generation,
    - Progressive capping, including vegetation, of the ash disposal facility must be undertaken where the final disposal height has been achieved,
- Dust generation should also be monitored around the site for:

- Respirable dust ($PM_{2.5}$ and PM_{10}); and
- Settable dust[9].

9. REFERENCES

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M. van Zyl
Technical Director

L Potter
Environmental Scientist

[9] The air quality monitoring system will be established from the air quality modelling study being undertaken.

3 April 2013

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APPENDIX A

WATERLAB LABORATORY CERTIFICATES

WATERLAB (PTY) LTD

Building D, The Woods,
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received: 2012-11-23 **Date completed: 2013-01-09**
Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Mr. M. van Zyl**
Address: P.O. Box 1434 Rivonia 2128 **Email: vanzyl@jaws.co.za**
Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Cell: 082 880 1250**

Analyses	Sample Identification	
	Kendall Ash Sample	
Sample number	17069	
TCLP / Acid Rain / Distilled Water / H_2O_2	Acid Rain	
Dry Mass Used (g)	50	
Volume Used (mℓ)	1000	
Units	mg/ℓ	mg/kg
Fluoride as F	0.6	12
Hexavalent Chromium	0.072	1.44
Total Cyanide	<0.05	<1.00
ICP-MS Quant	See attached report 37722 ICP-MS Acid Rain	
Organics	See attached report 37722 Organics Acid Rain	

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

E. Botha
Geochemistry Project Manager

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
Pretoria

P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] – Acid Rain

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Volatile Organic Compound – Acid Rain		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**x1**	
Benzene	**ug/l**	<2
Carbon Tetrachloride	**ug/l**	<5
Chloroform	**ug/l**	<5
1,4-Dichlorobenzene	**ug/l**	<2
1,2-Dichloroethane	**ug/l**	<2
Ethylbenzene	**ug/l**	<2
Hexachlorobutadiene	**ug/l**	<2
Isopropylbenzene	**ug/l**	<2
Naphthalene	**ug/l**	<2
1,1,2-Trichloroethane	**ug/l**	<5
Xylene (Total)	**ug/l**	<5
1,2,3 Trichlorobenzene	**ug/l**	<2
Tetrachloroethylene	**ug/l**	<10

Organic Analyses: Semi Volatile Organic Compound		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**x1**	
Benzo(a)pyrene	**ug/l**	<0.1
Hexachlorobenzene	**ug/l**	<1

Organic Analyses: Phenols		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**x1**	
Cresols	**ug/l**	<2
2,4,5-Trichlorophenol	**ug/l**	<2
Phenol	**ug/l**	<2

[s] = Analyses performed by a Sub-contracted Laboratory

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSES

ICP-MS QUANTITATIVE ANALYSIS [s]

Date received:	**23-11-2012**	**Date Completed:**	**09-01-2013**
Project number:	**132**	**Report number:**	**37722**

Client name:	**Jones & Wagener Consulting Civil Engineers**	**Contact person:**	**Mr. M. van Zyl**
Adress:	**P.O. Box 1434, Rivonia, 2128**	**Email:**	**vanzyl@jaws.co.za**
Telephone:	**011 - 519 - 0200**	**Facsimile:**	**011 - 519 - 0201**

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

[s]= Results obtained form subcontracted laboratory

Sample Id	Sample Number	Al	Al	As	As	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Kendall Ash Sample	17069	0.013	0.267	0.064	1.28	0.138	2.77

Sample Id	Sample Number	Cd	Cd	Co	Co	Cr	Cr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.0001	<0.002	<0.001	<0.020	<0.001	<0.020
Kendall Ash Sample	17069	0.0001	0.002	<0.001	<0.020	0.068	1.36

Sample Id	Sample Number	Cu	Cu	Fe	Fe	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.010	<0.200	<0.0001	<0.002
Kendall Ash Sample	17069	<0.001	<0.020	<0.010	<0.200	0.0002	0.004

Sample Id	Sample Number	Mn	Mn	Pb	Pb	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Kendall Ash Sample	17069	0.011	0.223	<0.001	<0.020	0.007	0.133

Sample Id	Sample Number	Se	Se	Sr	Sr	Tl	Tl
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Kendall Ash Sample	17069	0.016	0.316	1.08	22	<0.001	<0.020

Sample Id	Sample Number	V	V	Zn	Zn
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020
Kendall Ash Sample	17069	0.188	3.76	0.002	0.043

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P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received: 2012-11-23 **Date completed: 2013-01-09**
Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Mr. M. van Zyl**
Address: P.O. Box 1434 Rivonia 2128 **Email: vanzyl@jaws.co.za**
Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Cell: 082 880 1250**

Analyses	Sample Identification	
	Kendall Ash Sample	
Sample number	17069	
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water	
Dry Mass Used (g)	250	
Volume Used (mℓ)	1000	
pH Value at 25˚C	9.0	
Units	mg/ℓ	mg/kg
Fluoride as F	0.6	2.4
Hexavalent Chromium	0.096	0.384
Total Cyanide	<0.05	<0.20
ICP-MS Quant	See attached report 37722 ICP MS Distilled Water (4)	

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

E. Botha
Geochemistry Project Manager

WATERLAB (PTY) LTD

Building D, The Woods,
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received: 2012-11-23 | **Date completed: 2012-12-12**
Project number: 132 | **Report number: 37722** | **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS | **Contact person: Mr. M. van Zyl**
Address: P.O. Box 1434 Rivonia 2128 | **Email: vanzyl@jaws.co.za**
Telephone: 011 - 519 - 0200 | **Facsimile: 011 - 519 - 0201** | **Cell: 082 880 1250**

Analyses	Sample Identification	
	Kendall Ash Sample	
Sample number	17069	
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water	
Dry Mass Used (g)	50	
Volume Used (mℓ)	1000	
Units	mg/ℓ	mg/kg
Total Dissolved Solids at 180°C	80	1 600
Chloride as Cl	<5	<100
Sulphate as SO_4	36	720
Nitrate as N	<0.2	<4.0
Fluoride as F	0.4	8.0
Total Cyanide as CN	<0.05	<1.00
Mercury as Hg	<0.001	<0.020
Hexavalent Chromium as Cr^{6+}	0.028	0.560
ICP-OES Quant	See attached report 37722 ICP DW	
Organic Analyses (DW 1:20 Leach) [s]	See attached report 37722 Organics Distilled Water	
X-ray Diffraction [s]	See attached report 37722 XRD	

Sample number	17069	
TCLP / Acid Rain / Distilled Water / H_2O_2	Aqua Regia	
Dry Mass Used (g)	0.5	
Volume Used (mℓ)	100	
Units	mg/ℓ	mg/kg
Mercury as Hg	<0.001	<0.200
Total Cyanide as CN(Solid) ppm	<0.05	
Total Fluoride as F [s] (Solid) ppm	112	
ICP-OES Quant	See attached report 37722 ICP AQR	
Total Organics (solid) [s]	See attached report 37722 Organics Totals	

[s]= Results obtained from subcontracted laboratory

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

E. Botha
Geochemistry Project Manager

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CERTIFICATE OF ANALYSES

ICP-OES - QUANT

Date received:	**23-11-2012**	**Date Completed:**	**12-12-2012**
Project number:	**132**	**Report number:**	**37722**

Client name:	**Jones & Wagener Consulting Civil Engineers**	**Contact person:**	**Mr. M. van Zyl**
Adress:	**P.O. Box 1434, Rivonia, 2128**	**Email:**	**vanzyl@jaws.co.za**
Telephone:	**011 - 519 - 0200**	**Facsimile:**	**011 - 519 - 0201**

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

Sample Id	Sample number	As	As	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.025	<0.500	<0.025	<0.500
Kendall Ash Sample	17069	<0.010	<0.200	0.733	15	0.044	0.880

Sample Id	Sample number	Cd	Cd	Co	Co	Cr	Cr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.005	<0.100	<0.025	<0.500	<0.025	<0.500
Kendall Ash Sample	17069	<0.005	<0.100	<0.025	<0.500	<0.025	<0.500

Sample Id	Sample number	Cu	Cu	Mn	Mn	Mo	Mo
		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
Kendall Ash Sample	17069	<0.025	<0.500	<0.025	<0.500	<0.025	<0.500

Sample Id	Sample number	Ni	Ni	Pb	Pb	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.010	<0.200	<0.010	<0.200
Kendall Ash Sample	17069	<0.025	<0.500	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample number	Se	Se	V	V	Zn	Zn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.025	<0.500	<0.025	<0.500
Kendall Ash Sample	17069	<0.010	<0.200	0.049	0.980	<0.025	<0.500

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

Building D
The Woods
41 De Havilland Cresent
Persequor Techno Park
Meiring Naudé Drive
Pretoria

P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Distilled Water Leach

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Volatile Organic Compound (DW leach)		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Benzene	**ug/l**	<2
Carbon Tetrachloride	**ug/l**	<5
Chlorobenzene	**ug/l**	<2
Chloroform	**ug/l**	<5
1,2-Dichlorobenzene	**ug/l**	<2
1,4-Dichlorobenzene	**ug/l**	<2
1,2-Dichloroethane	**ug/l**	<2
Ethylbenzene	**ug/l**	<2
Hexachlorobutadiene	**ug/l**	<2
Isopropylbenzene	**ug/l**	<2
MTBE	**ug/l**	<5
Naphthalene	**ug/l**	<2
Styrene	**ug/l**	<5
1,1,1,2-Tetrachloroethane	**ug/l**	<10
1,1,2,2-Tetrachloroethane	**ug/l**	<10
Toluene	**ug/l**	<10
1,1,1-Trichloroethane	**ug/l**	<5
1,1,2-Trichloroethane	**ug/l**	<5
Xylenes total	**ug/l**	<5
1,2,4 Trichlorobenzene	**ug/l**	<2
1,2,3 Trichlorobenzene	**ug/l**	<2
Dichloromethane	**ug/l**	<20
1,1-Dichloroethylene	**ug/l**	<10
1,2-Dichloroethylene	**ug/l**	<10
Tetrachloroethylene	**ug/l**	<10
Trichloroethylene	**ug/l**	<10

E. Botha
Geochemistry Project Manager

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The Woods
41 De Havilland Cresent
Persequor Techno Park
Meiring Naudé Drive
Pretoria

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Persequor Park, 0020
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Fax: +2712 – 349 – 2064
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CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Distilled Water Leach

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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Organic Analyses: Polars		
Analyses in mg/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
2-Butanone	**mg/l**	<1
Vinyl Chloride	**mg/l**	<1

Organic Analyses: Semi Volatile Organic Compound		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Benzo(a)pyrene	**ug/l**	<0.1
Di (2 ethylhexyl) Phthalate	**ug/l**	<10
Hexachlorobenzene	**ug/l**	<1
Nitrobenzene	**ug/l**	<1
2,4 Dinitrotoluene	**ug/l**	<1
Hexachloroethane	**ug/l**	<1
Total PAH's	**ug/l**	<2

Organic Analyses: Phenols		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Cresols	**ug/l**	<2
2-Chlorophenol	**ug/l**	<2
2,4-Dichlorophenol	**ug/l**	<2
Pentachlorophenol	**ug/l**	<2
2,4,5-Trichlorophenol	**ug/l**	<2
2,4,6-Trichlorophenol	**ug/l**	<2
Phenols (total,non-halogenated)	**ug/l**	<20

E. Botha
Geochemistry Project Manager

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Persequor Techno Park
Meiring Naudé Drive
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P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
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CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Distilled Water Leach

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: PCB		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Ballsmitters Totals	**ug/l**	<5

Organic Analyses: TPH		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Petroleum H/Cs,C6-C9	**ug/l**	<25
Petroleum H/Cs,C10 to C36	**ug/l**	<10

Organic Analyses: Formaldehyde		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Formaldehyde	**ug/l**	<50

E. Botha
Geochemistry Project Manager

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The Woods
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Pretoria

P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Distilled Water Leach

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Pesticides		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Adrin	**ug/l**	<0.1
Dieldrin	**ug/l**	<0.1
DDT	**ug/l**	<0.1
DDE	**ug/l**	<0.1
DDD	**ug/l**	<0.1
Heptachlor	**ug/l**	<0.1
Chlordane	**ug/l**	<0.1
2,4 Dichlorophenoxyacetic Acid	**ug/l**	<0.1

[s] = Analyses performed by a Sub-contracted Laboratory

E. Botha
Geochemistry Project Manager

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSES

ICP-OES - QUANT

Date received: 23-11-2012
Project number: 132

Date Completed: 09-01-2013
Report number: 37722

Client name: Jones & Wagener Consulting Civil Engineers
Adress: P.O. Box 1434, Rivonia, 2128
Telephone: 011 - 519 - 0200

Contact person: Mr. M. van Zyl
Email: vanzyl@jaws.co.za
Facsimile: 011 - 519 - 0201

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

Sample Id	Sample number	As	As	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<2.00	<0.025	<5.00	<0.025	<5.00
Kendall Ash Sample	17069	<0.010	<2.00	0.410	82	2.85	570

Sample Id	Sample number	Cd	Cd	Co	Co	Cr	Cr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.005	<1.00	<0.025	<5.00	<0.025	<5.00
Kendall Ash Sample	17069	0.014	2.80	<0.025	<5.00	0.167	33

Sample Id	Sample number	Cu	Cu	Mo	Mo	Mn	Mn
		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
Kendall Ash Sample	17069	<0.025	<5.00	<0.025	<5.00	0.952	190.400

Sample Id	Sample number	Ni	Ni	Pb	Pb	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<0.010	<2.00	<0.010	<2.00
Kendall Ash Sample	17069	<0.025	<5.00	<0.010	<2.00	<0.010	<2.00

Sample Id	Sample number	Se	Se	V	V	Zn	Zn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<2.00	<0.025	<5.00	<0.025	<5.00
Kendall Ash Sample	17069	<0.010	<2.00	<0.025	<5.00	0.177	35

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The Woods
41 De Havilland Cresent
Persequor Techno Park
Meiring Naudé Drive
Pretoria

P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Totals

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Volatile Organic Compound (Total)		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Benzene	**ug/kg**	<40
Carbon Tetrachloride	**ug/kg**	<100
Chlorobenzene	**ug/kg**	<40
Chloroform	**ug/kg**	<100
1,2-Dichlorobenzene	**ug/kg**	<40
1,4-Dichlorobenzene	**ug/kg**	<40
1,2-Dichloroethane	**ug/kg**	<40
Ethylbenzene	**ug/kg**	<40
Hexachlorobutadiene	**ug/kg**	<40
Isopropylbenzene	**ug/kg**	<40
MTBE	**ug/kg**	<100
Naphthalene	**ug/kg**	<40
Styrene	**ug/kg**	<100
1,1,1,2-Tetrachloroethane	**ug/kg**	<200
1,1,2,2-Tetrachloroethane	**ug/kg**	<200
Toluene	**ug/kg**	<200
1,1,1-Trichloroethane	**ug/kg**	<100
1,1,2-Trichloroethane	**ug/kg**	<100
Xylenes total	**ug/kg**	<100
1,2,4 Trichlorobenzene	**ug/kg**	<40
1,2,3 Trichlorobenzene	**ug/kg**	<40
Dichloromethane	**ug/kg**	<400
1,1-Dichloroethylene	**ug/kg**	<200
1,2-Dichloroethylene	**ug/kg**	<200
Tetrachloroethylene	**ug/kg**	<200
Trichloroethylene	**ug/kg**	<200

E. Botha
Geochemistry Project Manager

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
Pretoria

P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Totals

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Polars		
Analyses in mg/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
2-Butanone	**mg/kg**	<1
Vinyl Chloride	**mg/kg**	<1

Organic Analyses: Semi Volatile Organic Compound		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Benzo(a)pyrene	**ug/kg**	<2
Di (2 ethylhexyl) Phthalate	**ug/kg**	<200
Hexachlorobenzene	**ug/kg**	<20
Nitrobenzene	**ug/kg**	<20
2,4 Dinitrotoluene	**ug/kg**	<20
Hexachloroethane	**ug/kg**	<20
Total PAH's	**ug/kg**	<40

Organic Analyses: Phenols		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Cresols	**ug/kg**	<40
2-Chlorophenol	**ug/kg**	<40
2,4-Dichlorophenol	**ug/kg**	<40
Pentachlorophenol	**ug/kg**	<40
2,4,5-Trichlorophenol	**ug/kg**	<40
2,4,6-Trichlorophenol	**ug/kg**	<40
Phenols (total,non-halogenated)	**ug/kg**	<400

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Persequor Techno Park
Meiring Naudé Drive
Pretoria

P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Totals

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: PCB		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Ballsmitters Totals	**ug/kg**	<100

Organic Analyses: TPH		
Analyses in mg/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Petroleum H/Cs,C6-C9	**mg/kg**	<0.5
Petroleum H/Cs,C10 to C36	**mg/kg**	<0.2

Organic Analyses: Formaldehyde		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X40**	
Formaldehyde	**ug/kg**	<50

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

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The Woods
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Persequor Techno Park
Meiring Naudé Drive
Pretoria

P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Totals

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Pesticides		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Adrin	**ug/l**	<2
Dieldrin	**ug/l**	<2
DDT	**ug/l**	<2
DDE	**ug/l**	<2
DDD	**ug/l**	<2
Heptachlor	**ug/l**	<2
Chlordane	**ug/l**	<2
2,4 Dichlorophenoxyacetic Acid	**ug/l**	<2

[s] = Analyses performed by a Sub-contracted Laboratory

E. Botha
Geochemistry Project Manager

WATERLAB (PTY) LTD

Building D, The Woods,
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
X-RAY DIFFRACTION

Date received: 2012-11-23 | **Date completed: 2012-12-12**
Project number: 132 | **Report number: 37722** | **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS | **Contact person: Mr. M. van Zyl**
Address: P.O. Box 1434 Rivonia 2128 | **Email: vanzyl@jaws.co.za**
Telephone: 011 - 519 - 0200 | **Facsimile: 011 - 519 - 0201** | **Cell: 082 880 1250**

Composition (%) [s]		
Kendall Ash Sample		
17069		
Mineral	Amount (weight %)	Error
Amorphous	55.48	1.2
Calcite	3.54	0.36
Mullite	26.84	0.99
Quartz	14.15	0.57

Note:

The material submitted was scanned after addition of 20 % Si for quantitative determination of amorphous content and micronizing in a McCrone micronizing mill using a back loading preparation method.
It was analysed with a PANalytical Empyrean diffractometer with PIXcel detector and fixed slits with Fe filtered Co-K_ radiation.
The phases were identified using X'Pert Highscore plus software.
The relative phase amounts (weight %) were estimated using the Rietveld method.
Errors are on the 3 sigma level in the column to the right of the amount (in weight per cent).

Comment:

- In case the results do not correspond to results of other analytical techniques, please let me know for further fine tuning of XRD results.
- Errors reported for phases occurring in minor amounts are sometimes larger than that of the quantity reported, indicating the possible absence of those phases.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group.

E. Botha
Geochemistry Project Manager

APPENDIX B

RADIOACTIVITY ANALYSIS REPORT

RadioAnalysis
Building 1600
P O Box 582
Pretoria 0001

Telephone: + 27 12 305 5527
Facsimile: + 27 12 305 5944

Contact: ***Mr M van Zyl***
Company: ***Jones & Wagener***
Address: ***PO Box 1434***
Rivonia
2128

Date: ***18 March 2013***
Report number: ***RA-13828-01***
Pages: ***3***
Your reference: ***DIZI/MvZ/22291***

Analysis Report

Radioactivity analysis of solids

Compiled by: ***D Kotze***

Checked by: ***M Raven***

1. SERVICE

Analysis solid samples for gross alpha/beta-activity and for selected radionuclides in the uranium and thorium decay series.

Number of samples received: 1

The samples were received on: 26 November 2012

2. SAMPLE PREPARATION AND ANALYSIS

Method	Description	Completed	Assayer	Verified by
WIN-114	**Dry sample, mill to homogenise**	20/12/2012	E Mothlabane	J Smit
WIN-138	**Gross alpha/beta analysis**	14/02/2012	N Yawa	E Nhlapo
WIN-167	**U and Th by neutron activation analysis**	15/03/2013	A Sathekge	M Raven
WIN-101	^{226}Ra, ^{228}Ra, ^{228}Th, ^{40}K by gamma analysis	18/02/2013	D Matshidiso	M Raven
WIN-158	**^{210}Pb by low energy gamma analysis**	06/02/2013	D Matshidiso	M Raven

Results indicated in **bold in this report were obtained from methods that are not included in the SANAS Schedule of Accreditation fo this laboratory*

3. RESULTS

3.1 Results are attached as an appendix to this report.

3.2 Results report are related only to sample portions tested.

3.3 The method for gross alpha/beta-activity is intended to merely be a screening technique and gives only a first order estimate of total activities. Errors associated with unavoidable differences between particle energies of the calibration standards and samples, are not accounted for in the reported uncertainty which is mainly based on counting statistics. The reported uncertainty may therefore be an underestimation of the true uncertainty.

4. QUALITY ASSURANCE

4.1 RadioAnalysis is a SANAS accredited laboratory (Testing Laboratory T0111) based on ISO/IEC Standard 17025. All analytical methods are documented in the RadioAnalysis Quality System.

4.2 Results in this report were obtained from one or more individual test reports produced by accredited or non-accredit methods.

- Test reports containing results obtained from methods included in the SANAS Schedule of Accreditation, are verified and signed by SANAS Technical Signatories for those methods.
- Test reports containing results obtained from methods not included in the SANAS Schedule of Accreditation, are verified and signed by qualified competent analysts for those methods.
- The individual test reports are available upon request

4.3 The compiler is the Technical Expert for all the methods.

4.4 The compiled report is checked by a person other than the compiler for accuracy of data transcription.

4.5 The RadioAnalysis Laboratory keeps the original signed hard copy of this report on record for three years.

APPENDIX 1: ANALYTICAL RESULTS

Activity concentrations of nuclides

Unit: Bq/kg

Field code	**Kendall Power Station**		
Lab code	**RA-13828X001**		
Nuclide	**Value**	**Unc.**	**MDA**
^{238}U	**164**	**3**	**0.43**
^{234}U	**166**	**3**	**0.44**
^{226}Ra	158	8	16
^{210}Pb	**183**	**27**	**81**
^{235}U	**7.56**	**0.13**	**0.020**
^{232}Th	**148**	**9**	**2.4**
^{228}Ra	197	13	25
^{228}Th	176	10	19
^{40}K	296	34	70
Gross alpha	**2510**	**190**	**350**
Gross beta	**1220**	**20**	**38**

*Results indicated in **bold** in this report were obtained from methods that are not included in the SANAS Schedule of Accreditation for this laboratory*

Notes:

1. If a measured value (**Value** column) was recorded, it is reported regardless if the value is less than the minimum detectable activity concentration (**MDA** column) or even if the value is negative. In the case where a value could not be obtained, a less than MDA ("< MDA") will be indicated.
2. The reported uncertainty (**Unc.** column) is quoted at 1 sigma (or coverage factor k = 1). The uncertainty is calculated mainly from counting statistics and it is not the standard deviation obtained from replicate measurements. No uncertainty value is reported of a less than MDA ("< MDA") is indicated in the **Value** column.
3. The minimum detectable activity concentration (**MDA** column) is calculated with a 95% confidence level.
4. A values is reported with 3 significant digits if it is greater than the MDA value and the associated uncertainty will be reported the same precision. If a value is less than the MDA, the value and its associated uncertainty are reported with 2 significant digits regardless their respective magnitudes. A MDA value is always reported with 2 significant digits.

APPENDIX C

AQUISIM REPORT

Technical Memorandum

AquiSim Consulting (Pty) Ltd

P O Box 51777, Wierda Park, 0149, South Africa

Telephone: + (27) (0)12 654-0212
Facsimile: + (27) (0)866 89-6006
E-mail: aquisim@netactive.co.za

To:	Marius van Zyl	**Date:**	26 March 2013
cc:		**Project No:**	ASC-1037B
From:	Japie van Blerk	**File No:**	01
RE:	**INTERPRETATION OF FULL SPECTRUM RADIOLOGICAL ANALYSIS: KENDAL POWER STATION**		

National Legislation

Materials and residues that contain naturally occurring radionuclides (i.e., radionuclides associated with the U-238, Th-232 and U-235 decay series) are generally referred to as Naturally Occurring Radioactive Material (NORM).

The legal limit in South Africa for material to be classified as radioactive is 0.5 $Bq.g^{-1}$ (nuclide specific). The protection of human health and the environment from adverse effects associated with exposure to ionizing radiation is regulated in terms of the National Nuclear Regulator Act (NNRA) (Act 47 of 1999) and the Nuclear Energy Act (NEA) (Act No. 46 of 1999).

The NNRA established the National Nuclear Regulator (NNR) as the statutory body responsible for regulating the nuclear industry, as well as NORM associated with the mining and mineral processing industry. Due to the presence of naturally occurring radionuclides, NORM has the potential to impact negatively on the health of humans that are exposed to these material.

In terms of its mandate, the NNR must publish requirements, guidelines, and standards for the protection of persons, property, and the environment against exposure to ionizing radiation that are consistent with international requirements and guidelines. Regulation No. 388 (dated 28 April 2006) defines regulations regarding safety standards and regulatory practices promulgated by the NNR. This means that material containing natural occurring radionuclides can only be regarded as radioactive if any of the radionuclides in the 238, U-234, U-235, and Th-232 decay series is above the exemption level of 0.5 $Bq.g^{-1}$.

The regulatory protection criteria defined in Regulation No. 388 for the protection of members of the public is consistent with international guidelines provided by the IAEA and ICRP. In terms of Regulation No. 388 the following limits apply:

- The annual effective dose limits for members of the public from all authorised actions is 1 mSv.
- No action may be authorised which would give rise to any member of the public receiving a radiation dose from all authorised actions exceeding 1 mSv in a year.

Consistent with international guidelines, the regulation makes provision for the application of a dose constraint for authorised actions to ensure optimisation of radiation protection. The following is stated (Section 4.5.2):

> Where applicable in terms of the prior safety assessment, the optimisation of protection must be subject to dose constraints specific to the authorised action, which must not exceed values that can cause the relevant dose limits to be exceeded and which ensure as far as practicable that doses are restricted by application of the ALARA principle on a source-specific basis rather than by dose limits (Section 4.5.2.1).
>
> For members of the public, the dose constraint applicable to the average member of the critical group within the exposure population is 0.25 mSv per year specific to the authorised action unless otherwise agreed by the Regulator on a case-by case basis, taking into account the dose limit specified for exposure of members of the public from all sources (Section 4.5.2.2).

Full Spectrum RadioAnalytical Results

Full spectrum results of an ash samples analysed at the Necsa RadioAnalytical Laboratories (Sanas Accredited) are available and listed in Table 1. From the results it is clear that all nuclides are below the exemption criteria of 0.5 $Bq.g^{-1}$ (or 500 $Bq.kg^{-1}$). This means that the material is not considered as radioactive material *per se*.

Table 1 Summary of the Necsa full spectrum radiological analysis (RA-13828, dated 18 March 2013) of an ash sample from the Kendal Power Station.

Nuclide	Kendal Power Station (RA-13828X001)		
	Value	Uncertainty	MDA
	$Bq.kg^{-1}$		
U-238	1.64E+02	3.00E+00	4.30E-01
U-234	1.66E+02	3.00E+00	4.40E-01
Ra-226	1.58E+02	8.00E+00	1.60E+01
Pb-210	1.83E+02	2.70E+01	8.10E+01
U-235	7.56E+00	1.30E-01	2.00E-02
Th-232	1.48E+02	9.00E+00	2.40E+00
Ra-228	1.97E+02	1.30E+01	2.50E+01
Th-228	1.76E+02	1.00E+01	1.90E+01
K-40	2.96E+02	3.40E+01	7.00E+01
Gross α	2.51E+03	1.90E+02	3.50E+02
Gross β	1.22E+03	2.00E+01	3.80E+01

Radiological Impact to Members of the Public

In order to assess the potential radiological impact to members of the public, information in terms of how these people interact with the material is needed (e.g. period exposed to the material, inhalation of dust particles containing the material, inadvertent ingestion of the material, etc.). This information is not available at present.

As an alternative, conservative assumption can be made regarding some of these parameters, to estimate the potential radiological impact under the assumed conditions. For this purpose, the following assumptions are made:

- Members of the public are exposed to the material for a period of 2000 hours per annum (equal to the period normally used for worker radiological safety assessments, such as tailings dam operators).
- During this exposure period, an adult member of the public inhale 1850 m^3 of air (or 0.93 $m^3.h^{-1}$, which is the average breathing rate during sleeping, sitting, light and heavy exercise). For this purpose it is assume that the inhalable dust load is 1E-04 $g.m^{-3}$.

For these assumed conditions, the inhalation dose to an adult members of the public will be in the order of 7 $\mu Sv.a^{-1}$ for the sample, while the external gamma radiation (normally referred to as ground shine) for an adult member of the public (2000 hour exposure period) would be in the order of 197 $\mu Sv.a^{-1}$. The external gamma radiation dose will decrease linearly with a decrease in exposure period, while the exposure with distance away from the facility will decrease exponentially (i.e., a small distance away from the facility, the dose will decrease to insignificant levels).

Conclusion

The material is below the limit set for material to be considered as radioactive. Assuming very conservative conditions (e.g. exposure for a period of 2000 hours per annum) the potential radiological impact to members of the public is below the regulatory criteria for the radiological protection of members of the public. It should be noted, however, that the assumed conditions does not consider the possibility for members of the public residing on top of the facility for extended periods of time, in which case additional exposure conditions would need to be considered (e.g. radon exhalation and the subsequent built-up of radon inside a house). It is not known whether such conditions is a possibility or realistic in this case.

Please do not hesitate to contact me if something is unclear.

Best Regards

JJ van Blerk (Sent electronically)
DIRECTOR: AquiSim Consulting (Pty) Ltd.