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Inertization, Utilization, and Safe Disposal of Incineration Residues

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INERTIZATION, UTILIZATION, AND SAFE DISPOSAL OF INCINERATION RESIDUES

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ABSTRACT

INERTIZATION, UTILIZATION, AND SAFE DISPOSAL OF INCINERATION RESIDUES

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Combustion of coal or Municipal Solid Waste (MSW) causes air pollution and produces solid residues which contain high levels of toxic elements. The toxic characteristics of residues generated from combustion of MSW in waste-to-energy plants are strictly controlled by Federal and State Waste Management Regulations. According to Resource Conservation and Recovery Act (RCRA), residue generated from combustion of MSW is considered hazardous and must be tested according to EPA Toxic Characteristics Leaching Procedure (TCLP) Method 1311 and suitably treated for its safe disposal to landfills. Experiments with various treatment chemicals as primary independent variable had earlier been conducted by several agencies and facilities. The author has successfully developed two new cost-effective solutions for stabilizing heavy metals in MSW residues to cover the gap between the leachability concentrations of toxic elements observed in residues and the leachability toxicity limits as per EPA's regulatory threshold. These methods include treating MSW residue fly ash (FA) with 2% dolomitic lime by weight, or by injecting aqueous (39% concentration) sodium sulfide at a controlled rate. The extensive full scale experimental study was carried out at 240 t/day capacity Hampton/NASA waste-to-energy mass burn MSW Incinerator (MSWI). This process has showed savings to the extent of $150,000 per year by treating the plant's combustion residues with aqueous sodium sulfide over the use of dolomitic lime for ash treatment.

Results of the prior studies for treatment of toxic wastes have been synthesized and a randomized experimental plan has been planned for conducting this research. Thus valid and defensible results have been obtained that show repeatability of the identified treatment method in varying operating conditions of the combustion process. The research plans and experimental design methods are detailed in section 1.16 of Chapter 1. The treatment method invented has also shown better control of the leachability of toxic heavy metals than previously used chemical treatment methods. Comparative study showing the level of leachability of toxic heavy metals with different treatment methods are detailed in Chapter 5.

The best management practices for use and disposal of such wastes have been discussed.

Key words: Municipal Solid Waste (MSW); Resource Recovery and Conservation Act (RCRA); Toxic Characteristics Leaching Procedure (TCLP); Combined Ash (CA); Scrubber Dryer Absorber (SDA)

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This thesis is dedicated to my wife Sandhya who always supported and stood by me during all these years of studies and hard work.

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NOMENCLATURE

AAS	Atomic Absorption Spectrometry
ANC	Acid Neutralization Capacity
APC	Air Pollution Control
BTU	British thermal unit
BA	Bottom Ash
CFR	Code of Federal Regulations
DEQ	Department of Environmental Quality
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
FA	Fly ash
IAWG	International Ash Working Group
LDR	Land Disposal Restrictions
LOI	Loss on ignition
L/S	Liquid-solid ratio
mg/L	milligrams per liter
mg/kg	milligrams per kilogram
mm	millimeter
MSW	Municipal Solid Waste
MSWI	Municipal Solid Waste Incinerator
ppm	part per million
RCRA	Resource Conservation and Recovery Act
RDF	Refuse Derived Fuel
TCLP	Toxicity Characteristic Leaching Procedure
W-t-E	Waste-to-Energy

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CHAPTER 1: INTORDUCTION

1.1 MUNICIPAL SOLID WASTE GENERATION AND UTILIZATION

The garbage generated by households and commercial establishments and managed by local governments is known as municipal solid waste (MSW). MSW is collected and recycled, incinerated, or disposed of in MSW landfills. These types of landfills are generally called sanitary landfills. In the United States the largest component of the MSW stream is paper and card board products (26.6%), with food (14.9%) and yard trimmings (13.3%) the second and third most predominant components (EPA, 2016). Domestic sewage and other municipal wastewater treatment sludges, demolition and construction debris, agricultural and mining residues, and wastes from industrial processes are excluded from the definition of MSW.

Due to substantial increase in populations and consequent increase in generation combustion of MSW and recovery through recycling have increasingly become common MSW management practices worldwide. European Union (EU) countries generate an average of 524 kg of MSW per person per year, while in the US about 730 kg of MSW is generated person/year. In EU27 block 40% of the MSW generated is landfilled, 20% is incinerated, 17% is composted and 23% is recycled. Some northern countries in the EU such as Denmark, Sweden, the Netherlands, and Germany are most advanced in terms of environmental management of their waste and Germany is the foremost among them as less than 5% of the total MSW generated in Germany is landfilled while it recycles 40% of its waste.

Over 250 million tons of MSW is generated in the United States each year, with each citizen generating about 4.4 lbs. of waste per day on an average. Waste recycling including combustion of solid waste that has already been created and collected is considered the best management strategy. Thus the waste is utilized as a secondary raw material and a fuel for production of energy. Incineration of MSW with energy recovery is one the important component of recycling in EPA's Integrated Solid Waste Management (ISWM) program. According to US EPA's Advancing Sustainable Materials Management 2014 Fact Sheet, 12.8 % of MSW generated in U.S. is combusted for energy recovery (Figure 1).

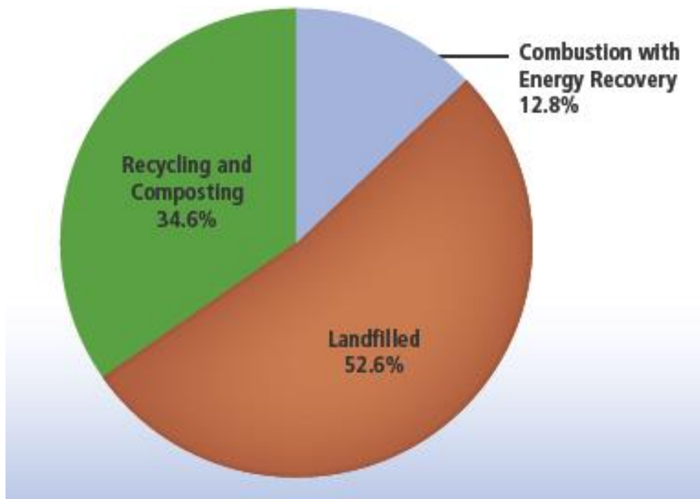


Figure 1 Management of MSW in the United States, 2014

Source: EPA Advancing Sustainable Materials Management: 2014 Fact Sheet

EPA implements solid-waste management programs by setting national goals, providing leadership and technical assistance, and developing educational materials. EPA's Integrated Solid Waste Management (ISWM) program aims at four main components: (1) source reduction and reuse, (2) recycle, (3) energy recovery, and (4) treatment and disposal (EPA, ISWM 2016).

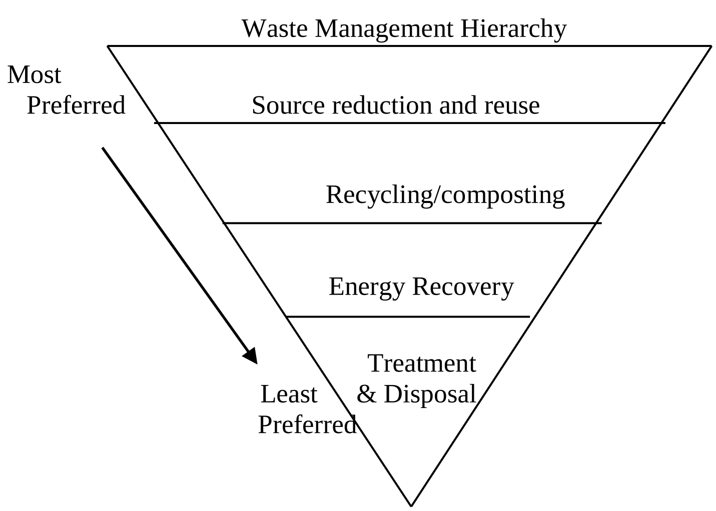


Figure 2 EPA's Sustainable Waste Management Hierarchy

Source reduction in this hierarchical approach to waste management takes top priority and aims to decrease the volume and toxicity of waste and to increase the useful life of products. As per *EPA Sustainable Materials Management: Non-Hazardous Materials and Waste Management Hierarchy* source reduction can:

- *Save natural resources,*
- *Conserve energy,*
- *Reduce pollution,*
- *Reduce the toxicity of our waste, and*
- *Save money for consumers and businesses alike.*

Recycling is the next favored strategy followed by reuse that includes composting and energy recovery through combustion. Landfilling is the least favored option and is to be used for the final disposal of non-recyclables and noncombustible materials. The goal such an integrated management hierarchy is to use a combination of all these methods to handle the MSW stream safely and effectively with the least adverse impact on human health and the environment.

1.2 INCINERATION OF MUNICIPAL SOLID WASTE

Incineration of MSW was initially taken up for disposal of residential waste as an alternative to burying it in landfills and the energy released from the combustion of MSW has also been utilized in some form or the other from early times. However, it was during early 1970's that the incineration of MSW for energy generation was taken up as an organized industry. These facilities came to called Waste-to Energy (W-t-E) or Energy-from-Waste (E-f-W) facilities. Incineration of waste reduces it by about 90% by volume and by about 60-65% by weight. The environmental policies of most of the developed countries call for avoiding disposal in landfills as much as possible.

Worldwide there are presently over 1600 waste-to-energy plants operating at various capacities. One plant currently being built in the Shenzhen megacity of China would be the world's largest waste-to-energy plant with a capacity to burn 5,000 tons of trash every day. However, much progress in this regard could not be made in the United States which currently has only 85 such plants in operation. In the US conventional fossil fuels contribute most towards energy generation. Only about 12.8 % of the municipal waste generated in the US is used for energy generation while the most of it is still landfilled (Figure 1). According to U.S. Energy Information Administration 67% of the electricity produced in in the United States during 2015 was from fossil fuel sources, with coal and natural gas contributing equally, about 33% of it each, and the rest provided by nuclear, wind, hydroelectric and renewables like MSW.

Out of these sources for generation of power, the residues from combustion of coal as well as from MSW incineration contain toxic compounds that create serious environmental hazards. The residue ash from combustion of MSW can leach toxic heavy metals to the ground water if the toxicity is not controlled within permissible limits before its disposal and storage in the landfills.

The coal combustion residues (CCRs) are stored in mono-fills and impoundments and the concentrations of potentially toxic compounds in the coal ash have been determined below the hazardous limits by EPA. But recent accidental spills of CCRs from impoundments in Kingston, Tennessee and the Dan River, North Carolina have raised serious questions about the negative impacts to the ground waters around the impoundments where the coal combustion residues are discharged without any pollution prevention measures. Although about 45% of coal combustion residues generated are recycled for environmentally safer and beneficial applications, the rest 55% are still unsafely stored in impoundments which have the potential to pollute the ground water due to accidental spills and leaching into the surroundings.

Soon after the inception of waste-to-energy facilities public and political concerns were raised regarding the environmental impacts of burning MSW as it produces toxic pollutants that are released to the atmosphere and the residue ashes generated from combustion of MSW contain hazardous heavy metals that have potential to cause groundwater pollution when these residues are landfilled. As a result all countries promulgated progressively higher air emission standards as well as stricter controls on residue ash before its disposal in landfills.

The paper examines various technologies used to control discharge of potentially harmful elements from MSW combustion residues when disposed of in landfills and presents two viable treatment methods as proved by applied research to mitigate the potential negative environmental impacts MSW incineration (MSWI) residues and provides evidence to the effectiveness of the solutions presented in the context of W-t-E plants operating in the US. The solutions can be applied to reduce the current environmental impacts from the disposal of incineration residues from MSW and can possibly be improved further to deliver better performance. The paper intends to validate the solutions to the practice-based problems in order to deal with the detrimental effects of disposal of incineration residues and is expected to contribute to the body of knowledge in this field.

1.3 UTILIZATION OF MSW AS FUEL

Municipal solid waste is very heterogeneous in characteristics constituting of several organic and inorganic elements and their compounds. Most of the environmental problems of waste disposal are related to the chemicals in the waste. During the incineration process organic components in the waste are oxidized to H_2O, CO_2, NO_x, and CO while the inorganic mineral compounds are either volatilized or remain as solid particles that are trapped in various residue streams. The solid combustion residues in the furnace are collected as bottom ash (BA) which is first quenched in a water trench and then conveyed through an incline conveyor to ash collection area. Before collection the BA is generally passed through a screen to separate oversized unburnt portions and also through a metal separation device –a conveyor passing over a magnet or a rotating magnetic drum picking up ferrous and non-ferrous items in the residue ash.

The volatilized mineral compounds are either discharged to atmosphere with flue gases along with oxidized organics or are sorbed with alkaline sorbent and then condensed out on the fly ash particles collected through particulates collecting devices: Electro Static Precipitators (ESP) or Fabric Filters (FFs) or a combination of both. The prominent sorbent slurry sprayed in the Spray Drier Absorber (SDA) for absorbing acid gases in the flue gas stream is high calcium hydrated lime $CaOH_2$. Other additives like activated carbon and selective non-catalytic reduction (SCNR) agents are used for treatment of dioxins and mercury and for NOx control, respectively. These chemicals along with SDA and ESP/FFs train constitute what is called the Air Pollution Control (APC) device. The dry ash particles collected in the SDA hopper and in the particulate collecting equipment ESP/FFs is called fly ash (FA) which when combined with the courser BA is collectively called as combined ash (CA). It has generally been found that fly ash contains higher concentrations of toxic inorganic heavy metals than bottom ash.

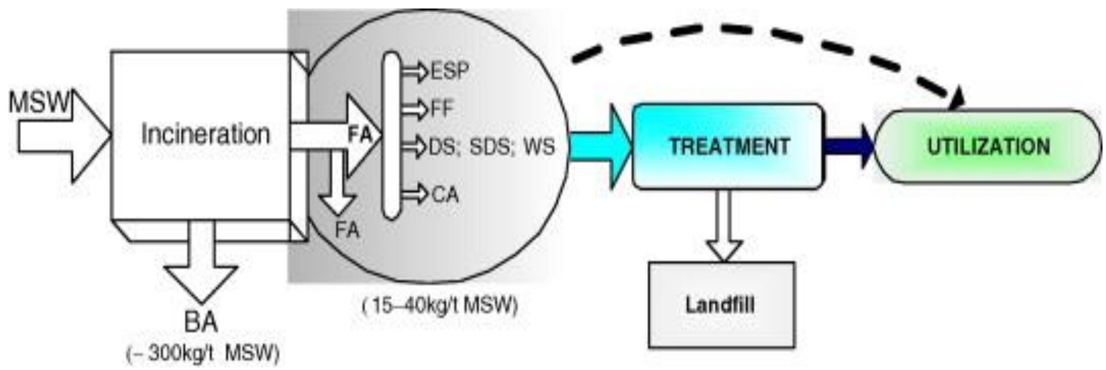


Figure 3 Management of residue from MSW incineration
Hjelmar, O., 1996

1.4 MSW COMBUSTION TECHNOLOGIES

Two basic technologies are used for incineration of MSW. One is called mass burn (MB) technology which consumes the waste in as-received condition without processing the incoming waste in any manner. The other technology which is also very commonly used is called refuse-derived fuel (RDF) technology in which the refuse is processed in several steps that include breaking open, shredding, screening, and separation of glass and metal etc. Some facilities even use modified RDF technology by densifying the fluffed and fine refuse into briquettes. This technology is called Densified Refuse-derived fuel (DRDF) technology. Each technology has its advantages and disadvantages. The RDF/DRFDF technology increases the heating value of fuel by 25 to 30% but it is very labor and maintenance intensive. The two technologies are discussed in detail in the next sections.

The combined residue from MSW combustion is considered hazardous and must be tested according to EPA Toxic Characteristic Leachability Procedure (TCLP) Method 1311 as provided in SW-846 guidance manual for meeting the leachability limits of heavy metals into ground water before its safe disposal to sanitary landfills as non-toxic waste or for recycling as secondary material. The EPA TCLP Test Method 1311 is given in Appendix A.

Each ton of municipal solid waste incinerated in a mass burn unit would generate about 2% to 4% (40 -80 lb.) of hazardous waste. The residues collected in APC system include the particulate matter captured after the acid gas treatment device, this waste can either be solid or liquid slurry depending on the type of air pollution control equipment used which may be dry, semi-dry or a wet process.

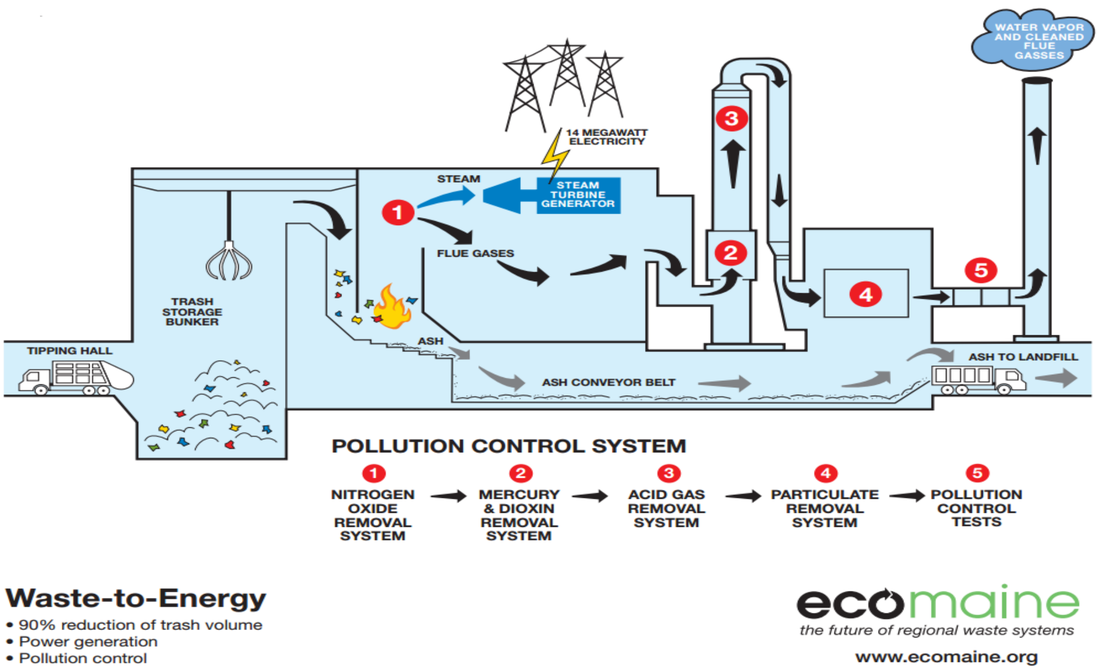


Figure 4 Schematic of a mass burn MSW incineration process

Source: Basic Information about Energy Recovery from Waste, EPA Archives

1.5 MASS BURN COMBUSTION TECHNOLOGY

Mass burn (MB) is the dominant waste-to-energy technology in which MSW is combusted on moving grates in “as-received” condition. It is the simplest technology that has been in use for several decades. The MSW is combusted as-received without any pre-processing of fuel; only very large and hazardous objects are pulled out from the refuse pile. In large mass-burn facilities refuse up to 150 tons per hour is fed into the hoppers. The refuse moves down the feed hopper by gravity and is then pushed into the furnace by heavy-duty feed rams that are hydraulically operated. The fuel is processed through 2 or 3 sections of moving stokers that are set at a gradient. The process takes about an hour and quite a high degree of combustion is achieved. Primary combustion air is injected through the grates and tuyers and the secondary air flows through nozzles above the grates to help in combustion of unburnt carbon inn the flue gases before they exit the furnace.

The technology has now attained a high degree of development. Good combustion practice and state-of-the-art dedicated digital controls (DDCs) have resulted in higher rate of capture or destruction of pollutants, like sulfur, chlorine, carbon mono oxide, dioxins, furans, volatile metals, and particulate matter.

1.6 RDF COMBUSTION TECHNOLOGY

Refuse-Derived-Fuel (RDF) technology is a simple advancement over the MB process. The refuse is shredded, crushed in hammer mill, and screened through trommel into a less heterogeneous fuel which is subsequently subjected to separation and recycling of unburnable materials, like metal and glass. The easily accessible recyclable materials are manually picked up from slow-moving conveyors, while some ferrous metals are later recovered through magnetic rotating drums and non-ferrous metals are captured by eddy-current separators. The pre-processing of municipal solid waste increases the calorific value of the fuel and hence the capacity of the combustion units. While average higher heating value (HHV) of “as-received” MSW used in MB process is 4,500 BTU/lb, pre-processing of solid waste as refuse-derived-fuel (RDF) increases the HHV of MSW by about 25% to approximately 6,500 BTU/lb.

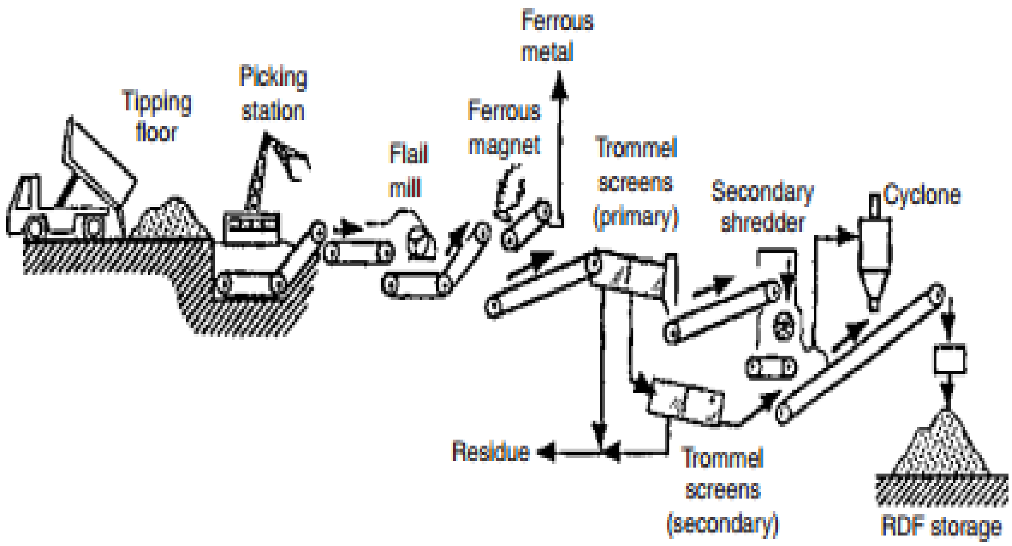


Figure 5 RDF Processing Diagram
Source: Charles O. Velzy, Leaonard M. Grillo, Waste-to-Energy, Taylor and Francis, 2007

In preparing RDF the pre-processing of MSW is carried out in several steps as shown the flow diagram below.

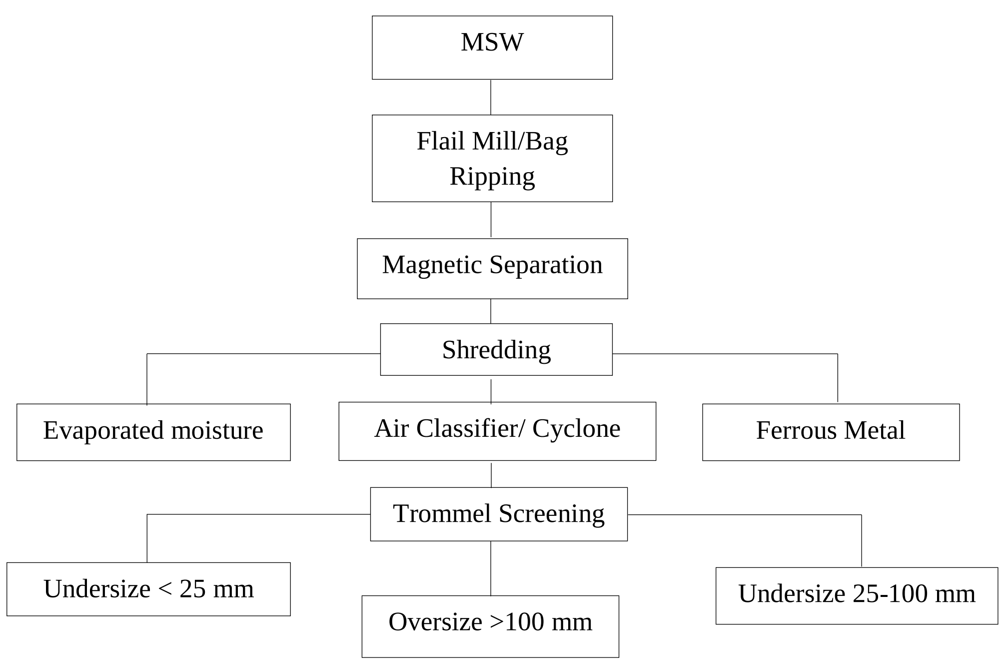


Figure 6 Schematic of pre-processing of MSW in RDF process

There are, however, several disadvantages of RDF technology. Major problems are encountered when explosive objects like propane gas cylinders go undetected through the incoming solid wastes and cause explosions when processed through giant hammer rotated at high speeds. Shredders and hammer mills are now equipped with explosion-containment devices above their chambers but sometimes explosions put the equipment out of order for long periods of time requiring extensive maintenance.

Waste-to-Energy Research Technology Council (WTERT), Earth Engineering Center, Columbia University developed a new generation of high-torque, low-speed shredders equipped with mechanisms to detect and discard large and metallic objects in order to avoid this type of catastrophic problems. The technology has been used in newer RDF plants like South East Massachusetts (SEMASS) facility (NAWTEC, 2000). Because RDF process is equipped with a series of pre-processing equipment mentioned and with multiple set of conveyors, the process becomes prone to breakdowns and hence is very labor and maintenance-intensive. About twice the size of labor force is needed to operate an RDF plant than that for a MB plant.

When examined from the point of view of reaction kinetics, when the highly heterogeneous MSW is shredded to smaller uniform size during pre-processing in RDF plants, its heat and mass transfer rates are increased. The homogenized fuel allows for easier access of primary air from underneath the stoker grates thus increasing the drying, volatilizing, and higher combustion rates in the RDF furnace. The secondary combustion occurring in suspension is also higher than in MB system.

A study of the design of an RDF plant operated by South East Massachusetts (SEMASS) utilizing RDF technology and two mass burn units Union County Stoker WTE and Brescia Stoker WTE was conducted by Earth Engineering Center, Columbia University. Both these plants are operated by Covanta Energy. The study was conducted to determine the difference in rates of combustion per unit surface area of grates between the two types of technologies based on the respective physical dimensions, MSW feed rates, and air injected in these plants. The results of the study are shown in the Table 1.

Table 1 MB and RDF WTE COMBUSTION PLANT DESIGNS

SEMASS: South Eastern Massachusetts (RDF-type plant of COVANTA)

Source: Themelis, N.J. and Saman Reshadi, *Potential for Reducing the Capital Cost of WTE Facilities*, NAWTEC (2000)

	Mass-Burn Union County Stoker WTE, USA (1994)	Mass-Burn Brescia Stoker WTE, Italy (1998)	RDF SEMASS semi-suspension combustion (1988)
Capacity, tons/day (per unit)	480	792	910
Heating value of fuel, MJ/kg	11	11.3	11.63
Process gas volume, Nm^3 /hour	125,300	135,000	208,500
Process gas volume/ton, dry Nm^3	5,653	4,100	5,500
Length of grate, m	7.5	8	6
Width of grate & furnace, m	7.8	12.8	10
Grate area, m^2	58.5	102.4	60
Grate productivity, tons/day/m^2	8.2	7.7	15.2
Heat generation rate, MW (Thermal)	55.5	94.2	11.4
Heat flux released on grate, MW/m	0.95	0.92	1.86
Length of furnace, m	6.5	5	6
Furnace cross section, m^2	51	64	60
Velocity of gas in combustion chamber, m/s	2.7	2.3	3.8
Reynolds number in furnace (@ $900^{O}C$)	100,000	66,000	130,000
Furnace height, m	19	22	30
Average gas residence time, s	7.0	9.5	7.9
Waterwall surface area, m^2	543	783	960
Heat flux at waterwall (50% load), MW/m^2	0.05	0.06	0.06

The study indicated that the grate productivity in terms of tons/day/m^2 of RDF plant was 83% higher than the Union County MB plant in USA, and it was 96% higher as compared to the

Brescia Stoker MB WTE facility in Italy. Grate productivity is measured in terms of tons of MSW processed/day/ unit grate area (m^2) as given in above study. Higher grate productivity in RDF plant was expected due to higher rate of combustion because of pre-shedding of the refuse and more efficient furnace design.

1.7 CHARACTERIZATION OF MSW RESIDUES

The MSW incineration residue characteristically contains high concentrations of salts, heavy metals, and organic trace pollutants. Typical concentrations of heavy metals in the bottom ash portion of residue ashes generated in a Municipal Solid Waste Incinerator (MSWI) are shown in the following table (Journal of Hazardous Materials 47, 1996).

Table 2 Heavy metal compositions in bottom ash from all types of incinerators and in fly ash, Dry/semidry, and wet APC system residues from mass burn incinerators

Heavy metal	Range for bottom ash	Range for fly ash	Range for dry/semidry APC system residues	Range for wet APC system residue without fly ash
As	0.12-190	37-320	18-530	41-210
Ba	400-3000	330-3100	51-14000	55-1600
Cd	0.30-71	50-450	140-300	150-1400
Cr	23-3200	140-1100	73-570	80-560
Hg	0.02-7.80	0.70-30	0.10-51	2.20-2300
Pb	98-14000	5300-26000	2500-10000	3300-22000
Se	0.05-10	0.40-31	0.70-29	-
Si	91000-330000	95000-210000	36000-120000	78000

All concentrations are in mg/Kg

Adopted from Municipal solid waste combustion ash: State-of-the-knowledge, Carlton C. Wiles, Journal of the Hazardous Materials 47, 1996

1.8 COMAPARISONS OF MASS BURN AND RDF ASH CHARACTERISITICS

As indicated in Section 2.2 RDF Combustion Technology, the grate productivity in terms of tons/day/m^2 of RDF plants is greater than that of plants that are constructed with mass burn systems. The better combustion rate of RDF systems results in higher productivity and also results in lower CO_2 emissions and thus in lower pollution of the environment from greenhouse gases (GHGs).

However, due to higher energy required to process raw MSW into RDF the overall system efficiency of RDF plants is lower than that of MB plants. As per the system used by EPA to work out the combustion system efficiency from conversion of MSW to energy (most of the WTE plants in the United States produce electricity) the total system efficiency has been estimated as 17.8% for MB and 16.3% for RDF (US EPA, Combustion). These data are provided in Appendix A.

The bottom ash from combustion of RDF, which is more homogeneous and less coarse than “as-received” raw MSW, has found some possibilities for its utilization in road paving and mixed with other materials for cement production.

1.9 CHEMICAL COMPOSITIONS OF ASH FROM MASS-BURN AND RDF SYSTEMS

A study presented during North American Waste-to-Energy Conference (NAWTEC) in 1997 indicated chemical composition of reside ash from the two main MSWI technologies, mass burn and RDF, are shown in the Table 3.

Table 3 Comparisons of chemical compositions (wt%) of ash from mass burn (MSW) and RDF

Inorganic Oxides	MB		RDF	
	Bottom ash (%)	Fly ash (%)	Bottom ash (%)	Fly ash (%)
CaO	34.678	16.901	44.668	19.546
SiO_2	18.653	12.481	19.861	20.186
Al_2O_3	13.973	5.946	13.392	10.897
Fe_2O_3	27.053	48.341	10.327	43.978
ZnO	-	13.336	5.325	3.528
MgO	5.492	-	4.577	1.590
Cr_2O_3	-	2.926	1.836	0.164
Total percentage	99.850	99.932	99.987	99.890

Data source: Chang N. B., Wang H. P., Huang W. L., Lin K. S., Y.H. Chang, Comparison between MSW Ash and RDF Ash from Incineration Process, Fifth North American Waste-To-Energy Conference, 1997

1.10 HEAVY METALS IN RESIDUES FROM MASS-BURN AND RDFCOMBUSTION

According to the same study by NAWTEC the Toxic Characteristic Leaching Procedure (TCLP) analysis of heavy metals in bottom ash and fly ash from MB MSW and RDF has indicated that although the concentration of Pb falls below the TCLP standards, leaching of Cd remains higher than TCLP standards for residue ash from both MB MSW and RDF (NAWTEC, 1997). It was inferred that the BA generated from burning MSW in “as-received” condition and as RDF can be classified as non-hazardous, but both types of fly ash are required to be treated due to higher contents of toxic metals. The results are shown in the table below.

Table 4 TCLP analysis of bottom and fly ash from combustion of MB and RDF

Toxic metals/pH	Mass Burn MSW		RDF		TCLP Standards
	Bottom ash	Fly ash	Bottom ash	Fly ash	
As (mg/L)	ND < 0.001	ND < 0.001	ND < 0.001	ND < 0.001	5.00
Cd (mg/L)	0.01 – 0.02	4.60 – 4.67	0.05 – 0.06	2.60 – 2.61	1.00
Cu (mg/L)	0.03 – 0.40	22.30 – 22.40	0.39 – 0.40	9.62 – 9.66	15.00
Cr (mg/L)	0.03 - 0.04	ND < 0.02	0.12 - 0.13	0.04 - 0.06	5.00
Hg (mg/L)	ND < 0.002	ND < 0.002	ND < 0.002	ND < 0.002	0.20
Pb (mg/L)	ND < 0.03	9.48 – 9.65	0.11 – 0.12	0.03 – 0.05	5.00
Zn (mg/L)	1.50 – 1.60	5.22 – 5.34	16.10 – 16.30	21.50 – 21.80	25.00
pH	11.8	5.6	10.2	5.0	

As shown in Table 4 all 7 toxic metals extracted from the bottom ash of MB and burning RDF exhibit relatively lower concentrations as compared to fly ash. The extracted metals from the fly ash in the RDF incineration process generally exhibit relatively lower concentrations than that of MB, still these concentrations are higher than the regulatory limits and therefore the ashes are classified as hazardous materials. The extractable cadmium concentrations are beyond the regulatory levels in both MB and RDF plants. The substantial differences require the fly ash or combined ash, if the ash generator disposal program includes other streams of ashes, from both combustion technologies to be treated by either solidification, stabilization, evaporation or vitrification techniques that are discussed later in this paper.

Some kind of pre-treatment is therefore inevitably required for both types of MSW incinerators in order to improve their environmental characteristics and possibilities of reuse. Various treatment methods used are discussed in this paper. These can be broadly categorized as separation process, solidification and stabilization by additives or use of chemicals, and thermal methods.

1.11 STUDY SITE FOR THIS RESEARCH

The WTE facility Hampton/NASA Steam Plant located at NASA Langley Research Center in Hampton, Virginia has been chosen for purpose of studying the treatment methods for plants utilizing MSW as combustion fuel for generation of steam and electricity. The facility's letter authorizing the use of data from various tests and methods used for control of leachability of heavy metals in its residue ash is attached at Appendix C.

This facility has been in operation since 1980. It operates two municipal waste combustors, each combusting 120 tons per day (total 240 tons/day) of MSW to recover steam energy for supply to nearby NASA center.

Municipal waste combustors (MWCs) that feed 250 tons or less of MSW per day are classified as Class II facilities according to EPA municipal solid waste incineration (MSWI) classifications. The MSW combustion residues are considered hazardous as EPA's Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions (LDR) and as covered by the Code for Federal regulations 40CFR 261 governing all hazardous wastes. Accordingly the MSW combustion residues have to be tested for the following RCRA Subpart C –Characteristics of Hazardous Waste before their reuse or disposal to landfill:

1. § 40CFR 261. 21 Characteristic of Ignitability
2. § 40CFR 261. 22 Characteristic of Corrosivity
3. § 40CFR 261. 23 Characteristic of Reactivity, and
4. § 40CFR 261. 24 Toxicity characteristic

The toxicity of the MSW residue is tested by EPA TCLP Method 1311. The residue ash generated at Hampton/NASA Steam Plant has always met with the TCLP regulatory limits without requiring any treatment of its combustion residue until it modified its Air Pollution Control (APC) system during late 2005 to meet EPA's new air emission guidelines (EG).

The Hampton/NASA Steam Plant follows a standardized procedure for collection of a random representative residue ash sample for TCLP testing. The procedure is included in Appendix B of this paper.

Most of the combustion process residue is BA which is quenched in a wet bottom trench and then conveyed through an incline conveyor to the vibrating screen. Ferrous metal is removed by a rotating drum magnet and the scrubber ash and APC system fly ash is mixed with the bottom ash after conditioning with boiler process water. Before mixing with bottom ash the finer fly ash is subjected to chemical treatment. Initial treatment chemical used during early 2006 was a proprietary product. An alternative chemical dolomitic lime was later used starting in November 2008.

A snapshot (Figure 7) of the flue gas cleaning (in scrubber) and fabric filter particulate collection system is shown below. The sorbent of choice for flue gas scrubbing to remove sulfur dioxide and HCL (a hazardous air pollutant) is high calcium hydrated lime. This is followed by a set of particulate collection equipment, for example fabric filters in case of Hampton plant.

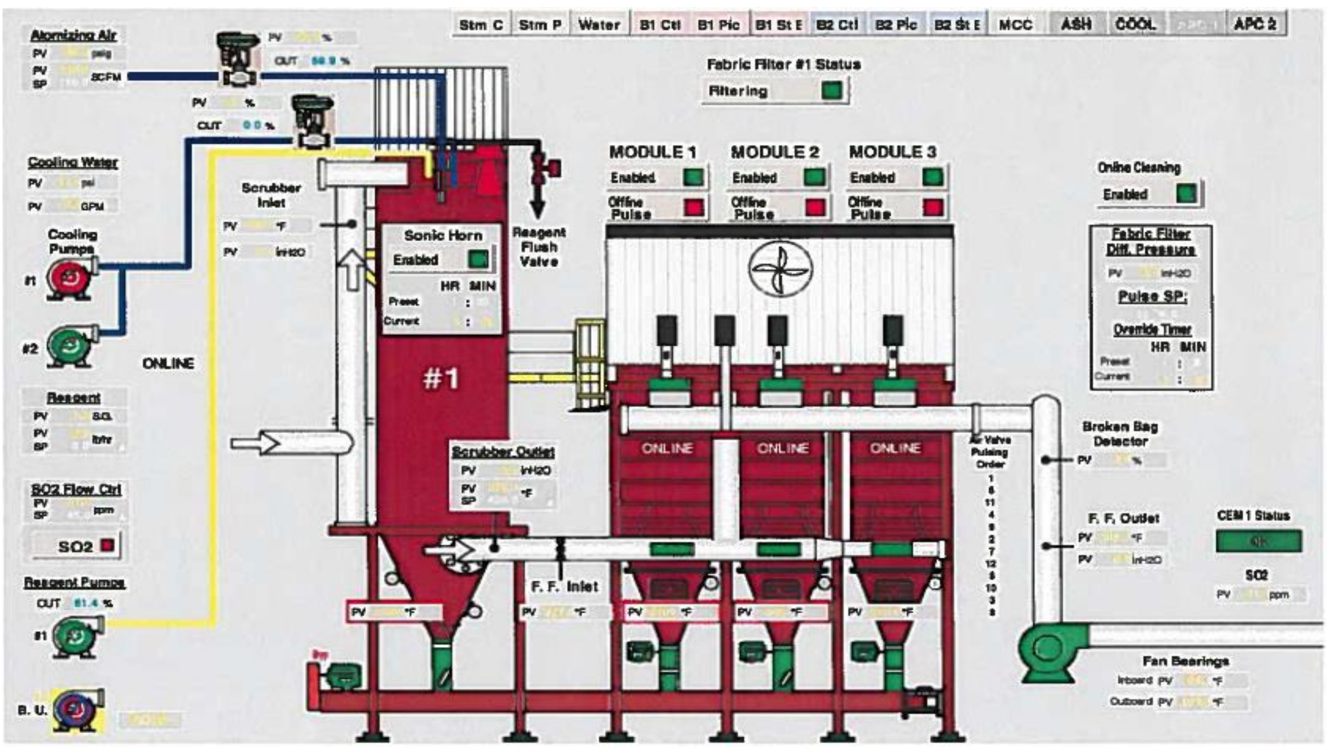


Figure 7 Hampton/NASA Steam Plant modified Air Pollution Control System

Most of the lead, cadmium and other TCLP metals leave the boilers with flue gas and are condensed in scrubber and then captured in the fabric filters in air pollution control residues. These fine dry residues are conveyed through a set of enclosed conveyors at gradient to mix these residues with the coarser bottom ash. Before mixing these residues are treated with heavy metal stabilizing chemical and conditioned with hot boiler process water.

A snap shot of scrubber and fly ash conveying system and its treatment is shown in Figure 8.

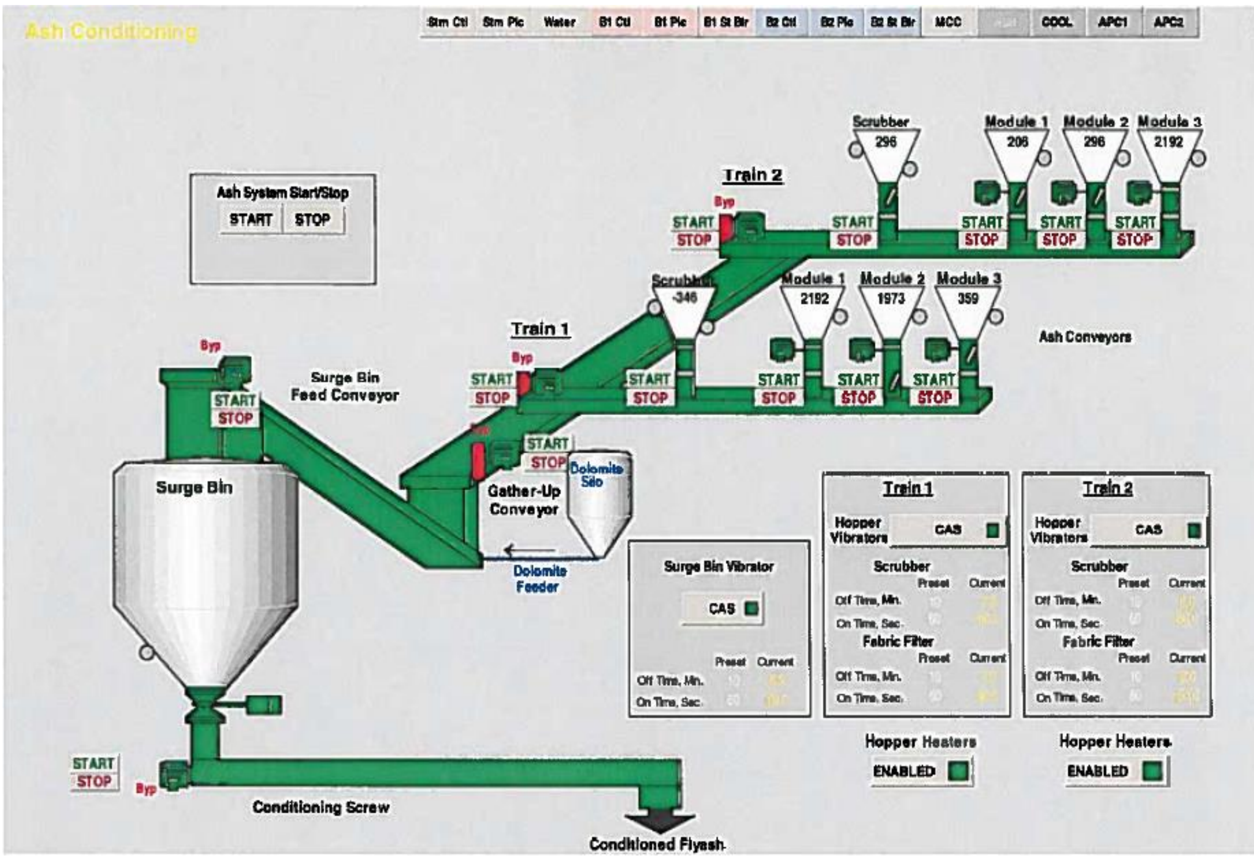


Figure 8 Scrubber and fly ash conveying system residue ash and its treatment

1.12 MASS FLOWS IN GRATE OPERATED MB INCINERATION PLANTS

Grate furnaces, mostly reciprocating type, are generally a preferred option with waste incineration because of their ability to handle high feed inputs. These grates are able to feed untreated as-received MSW of any particle size and shape. The air emissions and combustion residues from grate furnaces are distributed into various fractions. These fractions lie in certain range and show some variations depending on the type of air pollution control (APC) system used and on the feeding capacities of different types of MSW incinerators, but still broadly follow a set pattern.

The air emissions from state-of-the-art MSW plants normally constitute 68 -70% of various gases, 24 -26 % moisture, and about 5% solid particles of various metal compounds and aerosols.

The bottom residues are divided in the following fractions as percentages of refuse feed:

Table 5 Normal percent fractions of MSW combustion residue

Constituent of bottom residue	% of refuse feed	% of total ash
1. Furnace bottom ash (BA) including grate siftings	27.0%	80.1%
2. Scrubber ash and Fabric Filter ash: Fly ash (FA)	3.3%	9.8%
Sub-total of combined ash (BA + FA = CA)		89.9%
3. Waste water	2.0%	5.9%
4. Scrap metal (post combustion separation)	1.4%	4.2%
Total	33.7%	100.0%

The above fractions have been arrived at based on the studies as the one shown in the figure below and it matches with the generally accepted fact that the refuse feed when combusted in a municipal solid waste incinerator (MSWI) is reduced to about 10 - 12% in volume and to about one third (33%) in weight (Vehlow, 2012).

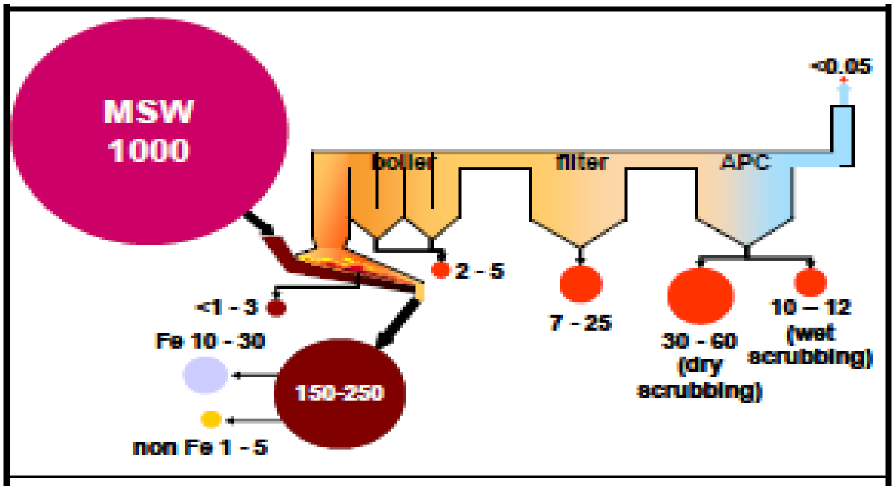


Figure 9 Fractions of MSW Incineration residues per 1000 kg refuse feed

Source: J. Vehlow, et al, IEA Bioenergy Task 36: Management of Residues from Energy Recovery by Thermal Waste-to-Energy Systems and Quality Standards, 2012

As discussed above in this paper Hampton/NASA Steam Plant which is the site chosen for this study operates 2 boilers each with a refuse feed capacity of 120 tons per day. The breakup of various fractions of residue generated from the total refuse feed rate of 240 tpd from the two boilers is worked out as given in the table below.

Table 6 Fractions of MSW combustion residue: Hampton Steam Plant

Constituent of bottom residue	% of refuse feed	Fraction (tpd), of 240 tpd feed
1. Furnace bottom ash (BA) including grate siftings	27.0%	64.80 tons
2. Scrubber ash and Fabric Filter ash: Fly ash (FA)	3.3%	7.92 tons
Sub-total of combined ash (BA + FA = CA)		72.7 tons
3. Waste water	2.0%	4.80 tons
4. Scrap metal (post combustion separation)	1.4%	3.36 tons
Total	33.7%	80.88 tpd

It is thus calculated that about 72 tons of combined ash (CA) is the amount of total ash that is generated each day by operating two boilers each with 120 tpd refuse feed capacity, and that is the total ash that needs to be treated for solidification/stabilization of toxic elements so that these are immobilized and their leaching within the regulatory limits when the ash is disposed of in the landfill.

1.13 PROBLEM STATEMENT

Advancements during the last two decades in the state-of-the-art modern MSWI technologies and air pollution control (APC) measures have considerably shifted the constituents of concern (toxic elements) from air emissions from these MSWIs to their combustion residues. These residues when either reused as building or road construction materials or disposed of in landfills have the potential to leach toxic pollutants in soil and water.

Table 4 gives the TCLP Standards for toxicity limits of heavy metals in MSW residue ashes.

The APC system modification at the Hampton/NASA Steam plant during November 2005 changed the kinetics of residue ash, especially the fly ash collected from the combustion flue gases, and the combined residue ash including the furnace BA when tested by TCLP Method 1311 was found to have leachability of heavy metals, mainly Cadmium and Lead beyond the EPA regulatory limits.

Leachability of heavy metals especially Cd showed in excess of regulatory threshold when tested as per TCLP method after APC modifications were completed. Table 7 gives some results when Cd in residue ash first tested over the regulatory limits after APC system at Hampton/NASA Steam Plant was upgraded in November, 2005. The concentrations of Cd were found beyond the regulatory threshold.

Table 7 Initial gaps in leachability results and EPA limits

Sample #	Date	Results (mg/L) Cd	Pb	EPA Threshold	
				Cd:	1.0 mg/L
				Pb:	5.0 mg/L
HSP-0206-6A	2/3/2006	1.17	0.221		
HSP-0206-8A	2/4/2006	1.55	0.293		
HSP-0206-13A	2/13/2006	1.38	0.114		
HSP-0406-C1	4/8/206	0.929	0.822		
HSP-0406-C2	4/11/206	1.55	22.2		
HSP-0406-C2A	4/11/206	1.95	10.4		
HSP-0406-C3	4/13/206	1.35	7.11		
HSP-0406-C4	4/17/206	1.92	14.2		
HSP-0406-C4A	4/17/206	1.51	12.5		
HSP-0406-C5A	4/19/206	1.64	9.02		

Source: Hampton Steam Plant data

To overcome the gap between the EPA's leachability limits for heavy metals and the values obtained in the facility's residue ash it became necessary to apply some chemical treatment for stabilization of heavy metals to make it non-hazardous before disposal to sanitary landfill. This was achieved by first using a proprietary chemical and later with dolomitic lime.

The facility further considered following options in this regard:

i) Construct a storage silo large enough to store long-term supplies of dolomite lime transported in bulk trucks to avoid paying heavily for supply in super sacks.

ii) Make process/chemical use changes upstream of fly ash generation, for example to increase spraying of high calcium hydrated lime (which is stored in a silo and mixed with water to make slurry) or to spray a mix of high calcium hydrated lime and dolomite lime in the flue gases to ascertain if it will change the reaction kinetics to the extent that may help eliminate use of dolomite lime in the fly ash collection system downstream of the flue gas path.

iii) Find an alternative to dolomite lime in form of a liquid chemical injection that would use an existing process water injection as part of fly ash conditioning. A small liquid storage tank and pump will be needed for this system in case it is determined to treat the ashes.

iv) Trials with sodium sulfide liquid chemical injection as part of proposal in (iii) above were undertaken and the results obtained are discussed.

1.14 PURPOSE OF THE STUDY

The study outlines and scrutinizes the effectiveness of various fly ash chemical treatment methods currently available to stabilize and immobilize heavy metals in the combined ash that is generated through combustion of MSW in waste-to-energy plants. It applies the results to find a more cost-effective method of treatment of combustion ash beyond those that have been used so far at the Hampton/NASA Steam Plant waste-to-energy facility that has been selected for this study.

The purpose of the study is to establish a treatment method for fly ash to control the concentrations Cd and Pb in the combined ash so that when tested for leachability the concentrations of these metals remain within the EPA regulatory limit of 1 mg/L for Cd and 5 mg/L for Pb so that waste is classified as non-hazardous and safe for disposal in sanitary landfills. As a further goal of the study is to optimize the quantitative and qualitative injection of identified chemical treatment and process controls in the fly ash downstream system in accordance with the variations in the mass flux rate of generation of residue wastes due to the upstream process variations in the operational status of either one or both of the boilers.

1.15 STUDY METHOD

Data for heavy metals concentrations from analytical testing of residue ash Waste-to-Energy Hampton/NASA Steam Plant during past several years are studied. The goal of the research is to develop cost-effective solutions to cover the gap between the leachability concentrations of toxic elements observed in residues from thermal conversion processes of MSW and other solid fuels for energy recovery and the leachability toxicity limits as per EPA’s regulatory threshold. The study explores the best management practices for use and disposal of such wastes. Experimental data are generated by developing and employing process controls and alternative treatment methods and compared with EPA regulatory limits for leaching of heavy metals.

1.16 RESEARCH PLAN AND EXPERIMENTAL DESIGN METHODS

A detailed research plan was worked out and design methods were adopted to represent field conditions while conducting experimental research.

1.16.1 RESEARCH PLAN

The integrating dimensions of the project are based on multidisciplinary design optimization using experimental methodologies decomposed in following steps:

i) Defining clearly the domain of the research project
ii) Identifying set of prior studies that met the *priori* criteria regarding the phenomenon in question
iii) Synthesizing prior research and conducting valid, defensible literature reviews meeting a strong scientific rigor as applied in the data analyses
iv) Developing a randomized experimental design meeting internal validity criteria
v) Conducting experiments at Hampton Steam Plant and estimating causal effects of treatments in random studies
vi) Carrying out initial Exploratory Data Analysis (EDA) for analyzing data from experiments in order to meet the following procedural steps:
    - Detection of mistakes
    - Checking of assumptions
    - Preliminary selection of appropriate models
    - Determining relationships among the explanatory variables, and
    - Assessing the direction and rough size of relationships between explanatory and outcome variables.

vii) Analyzing results by applying parametric inferential statistics and regression techniques

viii) Assessing repeatability of results that satisfy decision criteria and meeting the dimensions of their reproducibility for the entire population at the selected confidence interval of 90%, one-tailed

ix) Integration, validation, and qualification of results

x) Reporting project results and limitations

The study has adopted a quantitative experimental design approach with identified independent and dependent variables for different types of controls and treatment methods to study their cause and effect. It incorporates measures as enumerated above and as appropriate in conduct of this research.

The results from successive use of different treatment methods as listed below and adopted sequentially at various intervals are discussed in this report:

1. Treatment method with a proprietary technology

2. Switch over to cost-effective dolomitic lime fines

3. Use of Dolomitic Hydrated Lime to replace high calcium hydrated lime for flue gas scrubbing

4. Use of increase concentration of High Calcium Hydrated lime with parametric changes in Flue Gas scrubbing conditions

5. Eliminate use of dolomite taking advantage of alkalinity of boiler process water used for conditioning of fly ash

6. Injecting sodium sulfide Na_2S 39% aqueous solution in fly ash conditioning system

1.16.2 EXPERIMENTAL DESIGN APPROACH

The applied research requires the collection and interpretation of data and is based on the systems engineering V-process: the problem of finding the well-performing solution for the treatment of incineration residues has been worked out within the environmental, technological, and economic constraints by breaking up the problem into more manageable sub-problems and then systematically synthesizing the various solutions.

The suggested solution is then examined by verification and validation through qualified test methods and by performing a scientifically determined number of tests to prove its efficacy.

The process development has thus followed the applied systems engineering V-process as depicted below- defining and breaking up the problem on the left and then integrating and qualifying the solution on the right of the V-process (Buede, D. M. 1999, 10).

Where, CI mentioned in the text boxes stands for Configuration Integration.

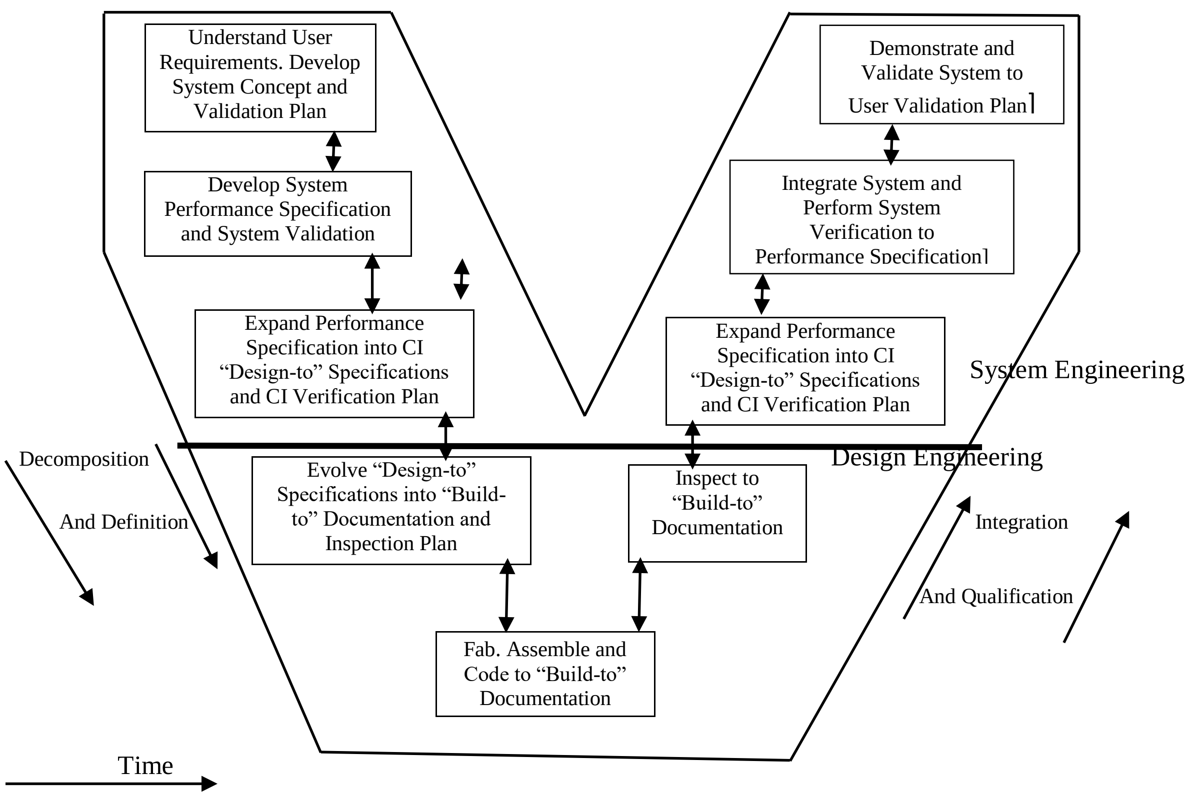


Figure 10 Systems Engineering "Vee", Engineering Design of Systems, Dennis M. Buede, 1999

1.16.3 EXPERIMENTAL DESIGN METHODS

The goal of the experimental design method (Figure 12) was to make correct and objective inference about the process adopted to control the leachability of toxic heavy metals in municipal solid waste incineration residues within regulatory threshold based on information collected from the experiment.

The results of the experiment were then planned to be used to characterize the system and verify if the outcome or solution can be reproduced for use in similar systems and it is capable of being used at any scale of operations.

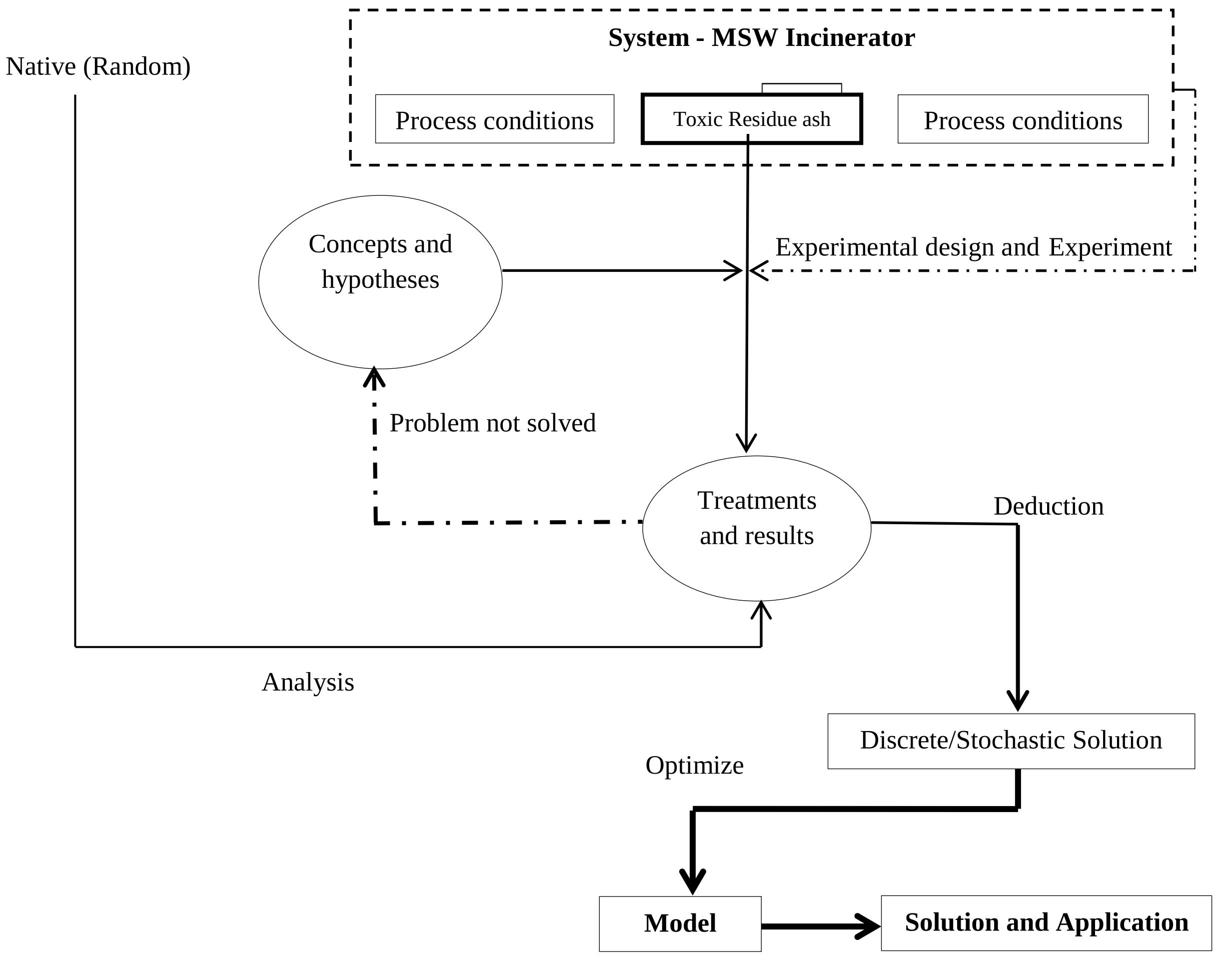


Figure 11 Experimental design methods

Following three basic principles were adopted in designing the experiments:

1. <u>Replication</u>

   It was aimed that the results of the experiment can be applied in similar incineration processes by reducing the effects of minor deviations (noises) in original variables.

2. Randomization

   It was meant to balance out any internal/external influence from the “ill-behaving” variables towards the target solution.

3. Using blocks (process variations)

   This was used to cover various categories of process changes and to ensure that the target solution would be effective in usual applicable process conditions

Keeping the above fundamental principles in mind the experimental design process was carried out in the following steps:

1. Problem conceptualization

   Recognition and statement of the problem

2. Choice of factors

   Treatment as primary control and blocks (process running conditions) as secondary control

3. Selection of response variables

   Variables that might affect the results of the experiments were selected

4. Choice of Experimental Design

   Randomized Complete Block (RCB) design was chosen as this design approach is very flexible for use in any number of treatments and any number of blocks.

5. Performing Experiments and Collecting Samples

   EPA guidelines for sampling procedures according to Method 1311 were used

6. Analysis, conclusions and recommendations

   Samples were sent for analysis to a certified chemical laboratory under an established chain of custody procedure, and were analyzed as EPA Method 1311.

   Results of the concentrations of toxic elements obtained as per TCLP tests were statistically analyzed, concluded as findings of the research, and used for recommendations.

Following calculation steps are used in the Randomized Complete Block (RCB) design:

$$y_{ij} = \mu + \tau_i + \beta_j + \varepsilon_{ij} \quad (i = 1, \ldots, \text{treatments};\ j = 1, \ldots., \text{blocks})$$

Where,

y_{ij} = Response on (i, j)th observations

μ = Overall mean

τ_i = ith **treatment** effect

β_j = jth **block** effect

ε_{ij} = Random error due to (i, j) th Obs. Where $\varepsilon \sim NID(0,\sigma^2)$

F-test based Test of Hypothesis (T.H.) at given level of confidence

a) Test of **treatment** effects

H_o: $\tau_1 = \tau_2 = K = \tau_t = 0$

H: At least one $\tau_i \neq 0$

t.s.	F_0=MS(Treatment)/MSE
t. s.	Test statistics
MS	Mean of Squares
MSE	Mean of Square Errors

b) Test of **block** effects

Ho: $\beta_1 = \beta_2 = K = \beta_b = 0$

H: At least one $\beta_i \neq 0$

t.s. F_0=MS(Block)/MSE

These calculation steps are used later under Chapter 6 Discussions and Statistical Analysis.

CHAPTER 2: RESIDUE ASH TESTING PROCEDURES

2.1 DESCRIPTION OF RESIDUE ASH TESTING PROCEDURES

During the course of developing MSW residue ash test procedures to determine the Toxicity of leachate when disposed of in landfills EPA initially used extraction procedure (EP) test that was modified as Modified Waste Extraction Procedure (MWEP) or water batch test using distilled or ionized water for extraction.

EPA then designed Toxic Characteristics Leaching Procedure (TCLP) test to simulate wastes sitting inside the landfills for a number of years to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphase wastes in landfills. TCLP test procedure methods are detailed in municipal solid waste manual SW-846 Method 1311.

EPA also developed a Synthetic Precipitation Leaching Procedure (SPLP) test. Details of this test procedure methods are provided in municipal solid waste manual SW-846 Method 1312. SPLP was designed to simulate waste material sitting in-situ, i.e. in or on top of the ground surface. Results from SPLP tests are utilized to develop site-specific soil remediation criteria that will be protective of groundwater from excessive contamination from leachate. The primary difference between SPLP and TCLP is the use of different extraction fluids which are dictated by what each test is designed to simulate.

Another test method used is sequential or multiple extraction procedure (MEP) with details of the procedure covered in SW-846 Method 1320.

2.2 TCLP TEST BY EPA METHOD 1311

US EPA has chosen TCLP Method 1311 for testing concentrations of heavy metals. The TCLP procedure uses statistical population Upper Confidence Level 90% (UCL90) one-sided limits (Sample Analysis Guidance Document SW-846). The details of the method are given in Appendix A.

The test uses acetic acid solution to "force" leaching and maintain a prescribed pH to rapidly extract the metals from ash extracts while simulating worst case scenarios of ash disposal. These procedures are designed to provide data artificially in the absence of actual field leachate data to simulate ash leachate characteristics. The TCLP procedure consists of single batch 18-hour simulation at pH = 4.93 for ash pH < 5 (called TCLP Fluid 1) or pH = 2.88 for ash pH > 5 (TCLP Fluid 2). MWC residue ash generally has a pH > 10. The extractions are run under conditions of low (acidic) pH to mimic conditions typically found in landfills containing decomposing organic matter.

Data obtained from TCLP test are used to determine whether a solid waste (residue ash) exhibits the hazardous waste characteristics of toxicity. Solids that fail the TCLP are considered to be hazardous waste under RCRA and cannot be disposed of in landfills. In such case the residue ash is either required to be treated to stabilize or immobilize the heavy metals from leaching or otherwise the waste is to be discarded in separate hazardous waste disposal sites. Solid wastes subjected to TCLP are considered to exhibit Toxic Characteristic (TC) if the waste sample leaches a TC constituent at a level equal to or exceeding the regulatory limit set forth in 40 CFR 261.24 , as per TCLP Standards given in Table 4.

2.3 STATISTICAL METHOD FOR ANALYSIS OF TCLP TEST RESULTS

Following data evaluation approach is adopted in accordance with EPA SW-846 *Test Methods for Evaluating Solid Wastes*:

1. Determine the mean concentration ($\bar{x}$) of the 8-hour composite samples.
2. Determine the standard deviation (s) of the data employed to calculate the mean (i.e., the individual composite extract results)
3. Determine the upper limit at a 90% level of confidence (one-tailed) for the mean of each analyte.
4. If the 90% level of confidence (one-tailed) is less than the applicable Regulatory Threshold (RT) as listed in the Table 7 above, then the waste (ash) passes the TC.
5. Results from the multiple events for the same waste can be combined (pooled) into one data set, and a new confidence interval calculated if the sampling and laboratory analysis were the same for all sampling and analysis events.

6. Use Student's t-test method to compare population means if the underlying population has a normal distribution, otherwise use the Wilcoxon rank Sum Test (also known as the Mann-Whitney U Test) to test whether the populations are identical but not normal.
7. Reasons for "outliers", if any, should be determined, which may include:
   - Contaminated sample equipment
   - Laboratory contamination of the sample
   - Errors in transcription of the data values

   Once a specific reason is documented, the result should be excluded from any further statistical analysis.

2.4 SAMPLING PROCEDURE

Sample collection and preparation for TCLP tests is carried out in the following manner.

In order to ensure that the analytical data used for the TC determination are of known and desired quality, all activities associated with sampling and analysis are conducted under strict Quality Assurance, Quality Control, Chain of Custody procedures. Approved methods for sampling and analysis operations are followed in fulfilment of all regulatory requirements to maintain accuracy, precision, and prevention of bias. This ensured reliability of the data.

Samples are collected either from transport trucks, residue ash conveyor, or from ash pile at intervals of 8 hours, during different operating shifts until a 24-hour composite ash sample was completed. A procedure for random sample grabs under supervision of a knowledgeable shift Operating Engineer is enforced with another person designated as Quality Leader. The composite ash sample is separated into aggregates, unburnts (paper, cardboard, etc.), and unburnables (metals) and weighed separately. Proportionate quantities of the three components are then weighed to make 20 lb. laboratory sample. It is properly labeled, sealed, and stored until sent to a designated and approved laboratory for testing under a Chain of Custody command procedure. An identical 20 lb. sample is prepared to be kept as Archive sample in case the original sample was determined faulty or tempered and had to be rejected. For initial ash characterization, two samples are collected each day for a minimum of one week's operation of the MSW boilers to yield a total of 14 composite samples.

The standardized sampling procedure used at the Hampton/NASA facility is given in Appendix B.

CHAPTER 3: PRIOR RESEARCH STUDIES

Research studies have indicated use of some of the following ways to achieve the stated objective of controlling leaching of toxic heavy metals from MSW combustion residues.

1. Solidification
2. Evaporation and vitrification
3. Stabilization with water-soluble phosphate
4. Treatment of fly ash with NaOH solutions
5. Treatment with EDTA solutions
6. Immobilization with thiourea
7. Heavy metal stabilization with sodium sulfide

3.1 SOLIDIFICATION

The terms solidification and stabilization can be differentiated by saying that in general while solidification can be called as the conversion of a liquid material into a non-liquid material stabilization generally refers to a chemical reaction introduced for the purpose of making the hazardous constituents in the waste less leachable which are discussed later. Solidification methods reduce the surface area but may or may not necessarily decrease leachability of hazardous substances for which the ash treatment process aims for.

These treatments are among the most widely used processes used for waste incineration residues, mainly the combined APC residue ash (Conner, 1990; Gilliam and Wiles, 1996). The main purpose of solidification/stabilization is to reduce leachability by producing a material with modified physical, mechanical and chemical properties, like specific surface area, durability etc. so that the leachability of contaminants are controlled within the regulatory limits.

Some mechanical separation also plays important role in modifying the physical characteristics of the residue stream. Magnetic and eddy-current separations are used as electromechanical separation processes to reduce its ferrous and non-ferrous metal content primarily from bottom ash. According to the IAWG (1997) and Wiles (1996), the ferrous metal content of MSWI bottom ash ranges from 7 to 15% by weight, while nonferrous metals account for approximately 1–2% by weight. These would greatly be reduced for Refuse Derived Fuel (RDF) technologies which employ sorting and separation strategies prior to the combustion process. Metal separation from bottom ash may be performed with a view to either metal scrap recovery or to improvement of bottom ash properties for its utilization. Among the chemical separation treatments, simply washing with water is one of the easiest process for removing highly water-soluble constituents from waste incineration residues but it enormously adds up to the volume of waste to be handled and may sometimes not be a preferred method.

Bottom ash is commonly quenched after dropping off the combustion chamber. A high Liquid/Solid ratio and sufficient residence time in the quenching trench may stimulate a reasonably good thermodynamic equilibrium for somewhat effective heavy metal dissolution process. Bottom ash after quenching may still have some residual contents of soluble components. Additional processes of chemical mobilization or aging (IAWG, 1997; Lahl, 1992) may be able to complete the control of heavy metals from leaching beyond desired limits. Salt compounds in the APC residue ash may account for substantial portion of the total ash and are the cause for the negative properties, like high leachability, high water absorption and corrosiveness of such residues. It has been reported that particularly for dry and semi-dry APC residues the high pH of the ash coupled with the large concentrations of highly-soluble heavy metal chlorides are accountable for the partial extraction of such metals as lead, zinc and cadmium during TCLP testing and residue ash needs additional treatment prior to final disposal. Such treatment would include either chemical stabilization or solidification with hydraulic binders.

The most common hydraulic binders include cement, lime and/or pozzolanic materials. However, weak stabilization efficiencies typically have been recorded for soluble salts. Furthermore, due to their strong amphoteric behavior, treatment of zinc and lead with cement- and lime-based processes may be problematic. Chemical stabilization processes have been proposed which basically involve chemical precipitation of heavy metal-incorporating insoluble compounds and/or heavy metal substitution/adsorption into various mineral species. The principal forms of chemical agents used include sulfides (IAWG, 1997; Katsuura et al., 1996), soluble phosphates (Derie, 1996; Eighmy et al., 1997; Hjelmar et al., 1999a, b; Nzihou and

Sharrock, 2002), ferrous iron sulfate (Lundtorp et al., 1999) and carbonates (Hjelmar et al., 1999a, b). Treatments with hydraulic or chemical binders generally yield good leaching properties at relatively low costs.

Leachate composition is the result of reaction between the various mineral phases in the waste and the leaching fluid. The leachability of strongly soluble species (e.g., alkali salts) is almost pH-independent, whereas for a number of contaminants a clear pH-dependence can be observed. The influence of pH on the leaching of contaminants is strongly related to the nature of the particular contaminant under concern as well as the mineral phase(s) in which this is bound. Three main typical leaching behaviors for solubility-controlled leaching have been identified: cation-forming species and non-amphoteric metal ions (e.g. Cd), amphoteric metals (including Al, Pb, Zn), and oxyanion-forming elements (e.g. As, Cr, Mo, V, B, Sb). The concentration of cation-forming species and non-amphoteric metal ions displays fairly constant high values at pH 10.

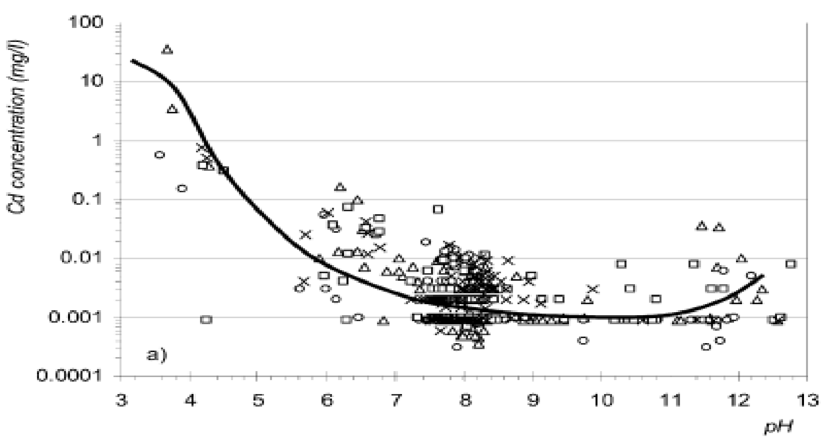


Figure 13 pH dependency of cation-forming species and non-amphoteric metal ions (Cd)

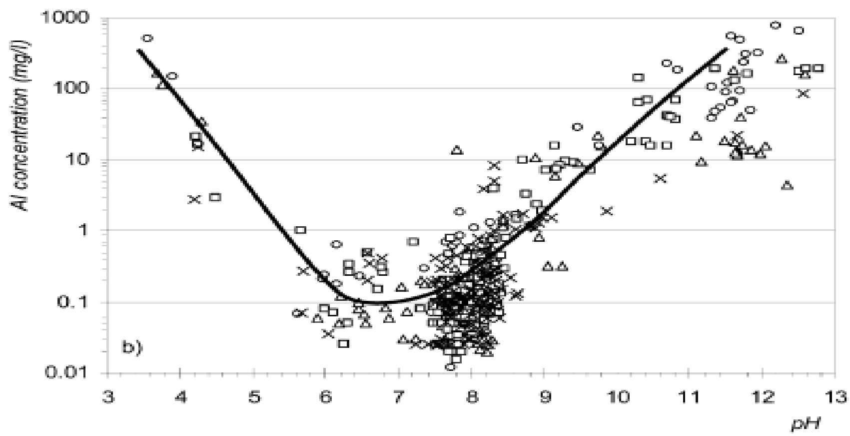


Figure 14 pH dependency of amphoteric metals (including Al, Pb, Zn)

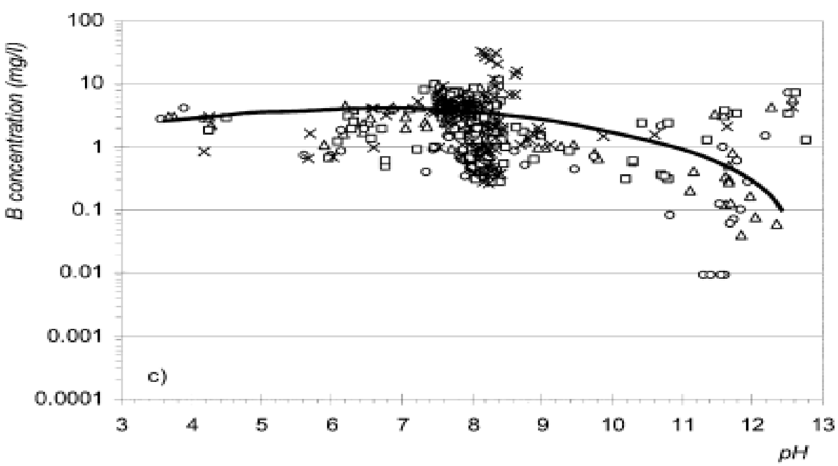


Figure 15 pH dependency of oxyanion-forming elements (e.g. As, Cr, Mo, V, B, Sb)

Source: Figures13, 14, 15 Management of municipal solid waste incineration residues,

T. Sabbas, et al.

Other references in these figures are explained below.

Cd (a), Al and Pb (b) and B (c) concentration in eluates and leachate samples of fresh and aged ash (Δ=solidified MSWI residues; O = MSWI bottom ash; □ = MSWI bottom ash + other ashes; X MSWI residues (mixed)) (Sabbas et al., 2001b).

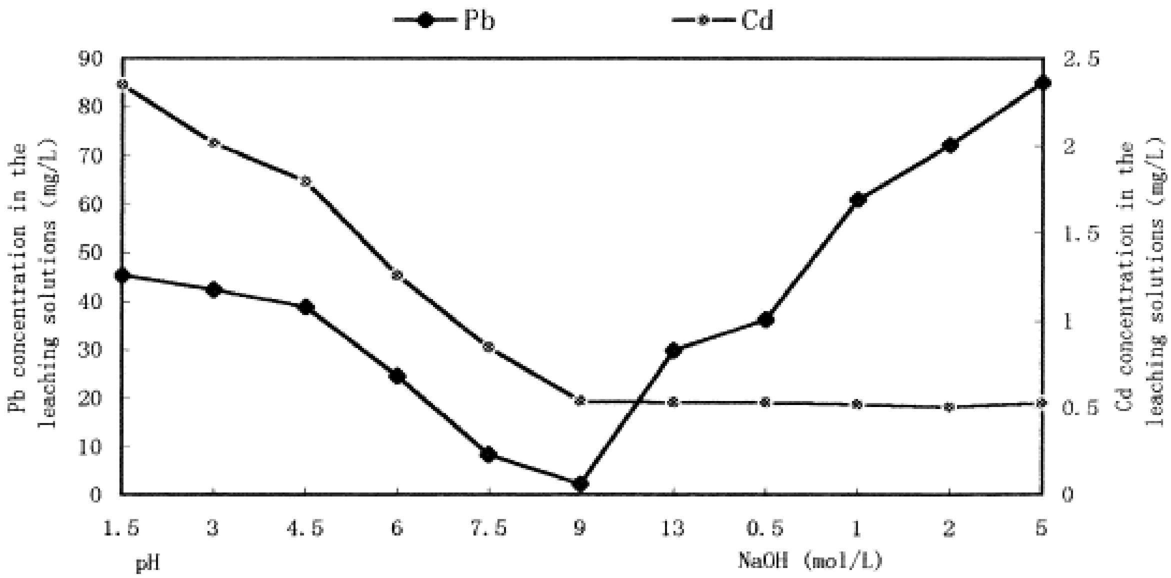


Figure 15 Dependence of the leaching of lead and cadmium from the fly ash on the pH and NaOH concentrations

Source: Journal of Hazardous Materials, Volume 95, Issues 1–2, 2002, 47–63

Solidification process comprises of following three principally different techniques that use cement or asphalt as solidification agent.

3.1.1 SOLIDIFICATION OF UNWASHED FLY ASH

Solidification with cement and asphalt are one the traditional methods used for controlling the leachability of Pb and Cd from MSW residue ashes. The major disadvantage of these methods is volume increase of the resulting ash and cement or asphalt mixture besides the added cost of mixing materials used. The resulting mixture has high chlorine and heavy metal contents and therefore a large amount of high quality cement with good hydraulic properties is required. This method has low stabilization efficiency and the resulting residue may deteriorate during long term storage in a landfill. Because of the large amount of solidification agent needed the overall volume of the solidified product increases causing increase in the cost of disposal.

The results in the following table show that mixtures only at high Ph levels close to 9 show control of leachability of Pb and Cd in the treated mixture.

Table 8 Effect of pH values on the leachability of heavy metals from the fly ash

Metals	**pH = 1.5**	**pH = 3.0**	**pH = 4.5**	**pH = 6.0**	**pH = 7.5**	pH = 9.0
Zn	94.45	88.56	75.43	57.23	28.64	18.65
Cu	2.2416	1.9567	1.3954	0.71171	0.50362	0.17363
Pb	45.37	42.36	38.75	24.56	8.327	**2.345**
Ni	0.95461	0.81150	0.60310	0.3448	0.23151	0.10321
Cd	2.3459	2.0147	1.7956	1.260	0.84530	**0.54281**
Cr	0.22431	0.21242	0.15463	0.13683	0.06254	0.024235

All data in mg/l in the leaching solutions

Source: Youcai Z, Lijie S, Guojian L, *Chemical stabilization of MSW incinerator fly ashes*, Journal of Hazardous Materials, 2001

Besides above observations it is also found that different qualities of cement and asphalt will have different solidification effects as shown by the results in following table.

Table 9 Leachability of the solidified products using different quality of cement and asphalt

	Sample no.				
	1	2	3	4	5
	3:1 (1200:400)[a]	2:1 (1000:500)[a]	1:1 (800:800)[a]	1:2 (500:1000)[a]	1:3 (400:1200)[a]
No. 325 cement					
Zn	12.937	3.3359	2.4326	2.4780	1.5321
Cu	0.67589	0.38451	0.22357	0.24510	0.17645
Pb	4.8976	1.8462	1.0024	1.0243	0.86542
Cd	0.10234	0.031274	0.020135	0.021347	0.021084
Ni	0.28025	0.31279	0.62590	0.72395	0.69637
Cr	0.28579	0.20965	0.19435	0.17463	0.17652
No. 425 cement					
Zn	15.024	4.2924	2.8618	2.5493	1.7405
Cu	0.70040	0.43212	0.25989	0.21370	0.18839

Pb	5.5777	1.9180	1.0596	1.0286	0.81516
Cd	0.10560	0.032977	0.019462	0.022526	0.021084
Ni	026025	0.14633	0.18070	0.38694	0.42217
Cr	0.37570	0.20271	0.18290	0.21820	0.23739
Asphalt					
Pb	4.2377	1.2180	0.87822	0.45861	0.31516
Cd	0.014867	0.012342	0.0086957	0.0078541	0.0061711

All data in mg/l in the leaching solutions

[a] Ratio of fly ash to the cement or asphalt (g : g)

Source: Youcai Z, Lijie S, Guojian L, *Chemical stabilization of MSW incinerator fly ashes*, Journal of Hazardous Materials, 2001

3.1.2 SOLIDIFICATION AFTER BASIC WASHING

Using a base chemical for washing transforms soluble heavy metals chlorides into heavy metals hydroxides. These hydroxides precipitate and after filtration and solidification with low quantities of cement they result in a residue with low chlorine contents but with high heavy metals. These heavy metals will be continuously but slowly released to environment.

3.1.3 SOLIDIFICATION AFTER ACID WASHING

Washing the residue ash with acid solution results is actually a hydrometallurgical process and it will dissolve most of the heavy metals. No post-solidification treatment with cement or asphalt may be needed.

3.2 EVAPORATION AND VITRIFICATION

Removal of heavy metals in fly ash by evaporation at high temperatures has also been practiced. This requires high energy consumption as well as high investments in equipment costs. For these reasons this method is not cost-effective for small and medium size municipal sloid waste incinerators.

3.3 STABILIZATION WITH WATER-SOLUBLE PHOSPHATE

The process uses addition of water soluble phosphate to fly ash and bottom ash residues of municipal solid wastes in order to insolubilize lead and cadmium to an extent as to make the residue in total compliance with EPA regulations. It is claimed that the addition of water-soluble phosphate in residue ashes works for a broad variation in alkalinity of such residues. The water soluble phosphate is either in the form of phosphoric acid, polyphophoric acid, hypophosphoric acid, metaphosphoric acid or their salts.

The amount of water soluble phosphoric acid to be sprayed is recommended to be about 1 to 8 percent by weight of the acid based on the total ash mixture.

The research is presented in US Patent Number: 4,737,356, date of the patent is April 12, 1988 and it is titled as "Immobilization of lead and cadmium in solid residues from the combustion of refuse using lime and phosphate." The inventors Mark J. O'Hara and Mario R. Surgi assigned their research to Wheelabrator Environmental Systems.

Some of the results of this experimental study are placed below:

Table 10 Flue Gas Scrubber Product to Fly Ash ratio

Effect of 4.25% H_3PO_4 in Modified EP Toxicity Test						
FGSP: Fly Ash	4:1	4:1	1:1	1:1	3:7	3:7
% H_3PO_4	0	4.25	0	4.25	0	4.25
EP Toxicity Test						
Initial pH	12.62	12.24	-	7.40	12.46	5.43
Final pH	12.38	10.21	5.38	5.05	4.99	5.11
Extract mg/L						
Pb	5.6	0.1	11.8	0.23	8.46	0.1
Cd	0.014	0.01	1.27	0.45	1.33	0.29

Source: Mark J. O'Hara M. J., Mario R. Surgi M. R.
Immobilization of lead and cadmium in solid residues from the combustion of refuse using lime and phosphate

The phosphoric acid treatment is shown working well for all 3 tests with 4.25 % H3PO$_4$ treatment with Flue Gas Scrubber Products (FGSP) and fly ash (collected from flue gases in Electrostatic Precipitators or Fabric Filter bags) ratios as 4:1, 1:1, and 3:7.

Table 11 Effect of 4.25% H_3PO_4 with BA: FA and FGSP: FA ratios

Bottom Ash: Fly Ash	7:1	7:1	7:1	7:1	9:7	9:7	4:1	4:1
FGSP: Fly Ash	4:1	4:1	3:7	3:7	2:1	2:1	1:1	1:1
% H_3PO_4	-	4.25	-	4.25	-	4.25	-	4.25
EP Toxicity Test								
Initial pH	12.63	12.60	-	7.07	12.60	12.67	12.60	12.68
Final pH	12.43	12.60	5.06	5.18	12.43	10.19	12.60	11.00
Extract mg/L								
Pb	17.0	1.2	12.0	0.31	13.5	0.062	14.0	0.063
Cd	0.090	0.01	2.82	0.70	0.01	0.01	0.01	0.01

Source: Mark J. O'Hara M. J., Mario R. Surgi M. R., Immobilization of lead and cadmium in solid residues from the combustion of refuse using lime and phosphate

The above table includes effectiveness of 4.25 % H3PO$_4$ treatment of residue ash samples with different BA and FA ratios.

3.4 TREATMENT OF FLY ASH WITH NaOH SOLUTIONS

Treating fly ash with sodium hydroxide solutions show that while extraction of lead increases significantly on increasing the pH value or the concentration of NaOH. On the other hand the extraction of Cd either does not change or may increase on increasing the concentration of NaOH as the test results in the following table show.

This chemical is therefore not found suitable for extraction of heavy metals from the fly ash.

Table 12 Leaching of fly ash using NaOH solution [a, b]

	N_aOH concentration (mol/l)				
	0.1	0.5	1	2	5
Pb					
Concentration in the leaching solution (mg/l)	29.83	36.21	60.98	72.18	85.02
Pb leached (%)	19.94	24.20	40.76	48.25	56.83
Content in the leaching residues (mg/kg)	1196	1122	868	763	628
Cd					
Concentration in the leaching solution (mg/l)	0.53290	0.53316	0.52143	0.50499	0.52917
Cd leached (%)	20.90	20.91	20.45	19.80	20.75
Content in the leaching residues (mg/kg)	20.40	20.15	20.27	20.45	20.19

[a] Weight of the fly ash = 10 g.

[b] Volume of N_aOH solution = 100 ml.

Source: Youcai Z, Lijie S, Guojian L, Chemical stabilization of MSW incinerator fly ashes, Journal of Hazardous Materials, 2001

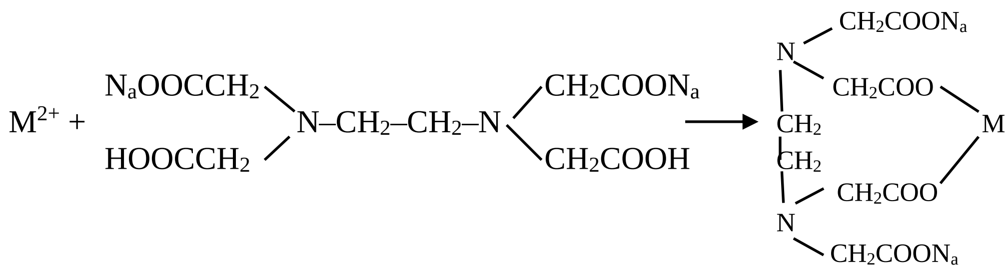
Sodium hydroxide dissolves zinc and lead in the ashes and reduces concentration of leachability of these two metals. The possibility of recovery of dissolved metals is one of the advantages of use of this chemical treatment in residue ashes besides this being a very low cost chemical.

The main disadvantage of use of sodium hydroxide is its inability to reduce the leachability concentration of some metals specially cadmium below the regulatory limits.

3.5 TREATMENT WITH EDTA SOLUTIONS

A complex agent Ethylenediamientetraacetate (EDTA) dissolves the soluble salts in the fly ash and is found useful in removing heavy metals from MSW combustion products and thus reduces the leachability of the toxic elements.

The reactions proceed as shown below:



A list of test results using 5 samples given in the table below indicates that over 70 % of Pb as well as Cd are leached using EDTA solutions in strengths of 0.1 M or above. The leachability of toxic metals in fly ash can thus be reduced below the regulatory levels.

Table 13 Effect of treatment of fly ash with EDTA solutions

	Sample no.				
	1	2	3	4	5
	0.01[a]	0.02[a]	0.05[a]	0.1[a]	0.2[a]
Pb					
Concentration in the leaching solution (mg/l)	27.91	35.74	90.63	108.6	118.2
Pb leached (%)	18.64	23.89	60.58	72.59	79.01
Content in the leaching residues (mg/kg)	1226	1137	568	434	314
Cd					
Concentration in the leaching solution (mg/l)	1.2875	1.3950	1.8020	1.8673	1.9128
Cd leached (%)	50.49	54.70	70.67	73.23	75.01
Content in the leaching residues (mg/kg)	12.75	11.47	7.61	6.630	6.375

[a] EDTA (mol/l)

Source: Youcai Z, Lijie S, Guojian L, Chemical stabilization of MSW incinerator fly ashes, Journal of Hazardous Materials, 2001

There is seen an appreciable increase in leaching of Pb (60.58 to 72.59%) and Cd (70.6% to 73.23%) if the EDTA concentrations is increased from 0.05 to 0.1 mol./l. This concentration range of EDTA solution is therefore recommended for stabilization and control of Pb and Cd leachability in MSW reside ashes.

The mechanism of EDTA working involves dissolution of most of the heavy metals to below their leachability toxicity without adding much to the volume of treated ashes.

3.6 IMMOBILIZATION WITH THIOUREA

As some sample results show in the table below the leachability of the stabilized metal compounds is below the standard limits even at low concentrations of thiourea, i.e. 0.46 to 0.76% of the fly ash weight, as in samples 1 and 2. The quantities of thiourea needed for stabilization of fly ashes will thus be very low.

Thiourea acts as organic precipitant to form insoluble compounds of heavy metals from the fly ash.

Table 14 Fly ash chemical stabilization by use of thiourea

	Sample no.					
	1	2	3	4	5	6
Thiourea added (g)	0.0460	0.0760	0.1649	0.3928	0.7950	1.5345
Thiourea (mol)	0.00060	0.00100	0.00217	0.00516	0.01044	0.02016
Thiourea/flyash (wt %)	0.46	0.76	1.65	3.93	7.95	15.34
C = [Z_n^{2+} + Pb^{2+} + ….] (mol)	1.0301×10^{-4}					
Thiourea/C (molar ratio)	5.8	9.7	21	50	101	196
Concentration in the leaching solution (mg/l)						
Pb	3.572	1.256	0.9798	0.5589	0.0918	0.08782
Cd	0.11220	0.10220	0.084152	0.067321	0.039271	0.025245

Source: Youcai Z, Lijie S, Guojian L, Chemical stabilization of MSW incinerator fly ashes, Journal of Hazardous Materials, 2001

3.7 HEAVY METAL STABILIZATION WITH SODIUM SULFIDE

The concept of stabilization for heavy metals takes root from the fact that metallic sulfides naturally occur in nature and soluble compounds of heavy metals in combustion ashes can be effectively stabilized by converting them into insoluble sulfides.

The leachability of lead and cadmium of fly ash products stabilized by sulfides is shown in table below. The leachability of Pb and Cd is controlled below the leachability toxicity standards at sodium sulfide concentrations between 0.18% and 0.5% of the fly ash weight and is further reduced at higher dosages of sodium sulfide nonahydrate ($Na_2S.9H_2O$), or more simply called sodium sulfide hydrate. It is commercially available as Na_2S 39%.

Table 15 Stabilization of heavy metals Pb and Cd in MSW fly ash

	Sample no.					
	1	2	3	4	5	6
Na_2 S.9H_2O added (g)	0.1795	0.5	1	2	4	6
S^{2+} (mol)	0.00075	0.00208	0.00416	0.00833	0.01665	0.02498
Sodium sulfide/flyash (wt %)	1.8	5	10	20	40	60
C = [Z_n^{2+} + Pb^{2+} + ….] (mol)	1.0301 x 10^{-4}					
S^{2+}/C (molar ratio)	7.3	20	40	81	161	243
Concentration in the leaching solution (mg/l)						
Pb	7.265	2.737	1.265	0.73712	0.12579	0.10112
Cd	0.12342	0.10659	0.095372	0.089752	0.053296	0.044881

Source: Youcai Z, Lijie S, Guojian L, *Chemical stabilization of MSW incinerator fly ashes*, Journal of Hazardous Materials, 2001

CHAPTER 4: LEACHABILITY GAP IN HAMPTON RESIDUE ASH

The combustion residue generated at Hampton plant after air pollution control retrofit displayed leachability of toxic substances beyond the regulatory limit and was subjected to remediation and treatment before it could be transported and disposed in landfill.

4.1 LEACHABILITY OF HEAVY METALS IN EXCESS OF REGULATORY THRESHOLD

Leachability of heavy metals especially Cd showed in excess of regulatory threshold when tested as per TCLP method after APC modifications were completed as per EPA emission guidelines.

Some results obtained from TCLP tests during early 2006 after the APC system at Hampton/NASA Steam Plant was upgraded in November 2005 showed Cd and Pb in residue ash were over the regulatory limits. These results are given in Table 7.

Failure to meet the heavy metals leaching and toxicity regulatory limits in residue ashes resulting from the combustion of municipal solid wastes while operating the facility with the modified air pollution control (APC) equipment forced the facility to stop disposing its residue ashes to the designated sanitary landfill located at Big Bethel, Hampton.

The management hired a hazardous material remediation agency to treat and certify that all the accumulated residue ashes at facility's premises have been converted into non-hazardous and residue ashes no more exhibit any toxicity. These were then disposed of to the landfill after informing State regulators.

The management engaged an agency to design, test and provide a solution to regularly treat the facility's combustion residue ashes so that the facility could be put back to normal operations after establishing satisfactory treatment procedures. The facility's Solid Waste permit from the State regulators requires that permittee completes and demonstrates a 14-day testing and characterization of the residue ash to meet the toxicity requirements.

CHAPTER 5: EXPERIMENTAL TESTS AND RESULTS

The results from successive use of different treatment methods as listed below and adopted sequentially at various intervals are discussed in this report:

5. 1. Treatment method with a proprietary technology

5. 2. Switch over to cost-effective dolomitic lime fines

5. 3. Use of dolomitic hydrated lime to replace high calcium hydrated lime for flue gas scrubbing

5.4. Use of increased concentration of high calcium hydrated lime with parametric changes in flue gas scrubbing conditions

5.5. Eliminate use of dolomite taking advantage of alkalinity of boiler process water used for conditioning of fly ash

5.6. Injecting sodium sulfide Na_2S 39% aqueous solution in FA conditioning system

The different treatment methods attempted are discussed in below.

5.1 TREATMENT METHOD WITH PROPRIETARY TECHNOLOGY

The initial trials included 4% concentration by weight of proprietary chemical to the weight of fly ash to be treated while injection rates ranging between 2% and 3% were used during 14-day characterization tests.

The 14-day residue ash characterization results for 7 metals are produced below. Cadmium leached from residue ash at 32.5% of the regulatory threshold of 1mg/L and all other heavy metals were below 1% of their respective threshold limits. The 8th heavy metal mercury was undetectable.

Table 16 Hampton Residue Ash Characterization: Sept. 2007

METAL	AVERAGE (mg/L)	UCL	Regulatory Threshold (RT)	%RT
Arsenic	0.03000	0.04081	5	0.8%
Barium	0.08229	0.10418	100	0.1%
Cadmium	0.27769	0.32460	1	32.5%
Chromium	0.00307	0.00405	1	0.4%
Lead	0.02564	0.03551	5	0.7%
Selenium	0.00714	0.00780	1	0.8%
Silver	0.00129	0.00158	5	0.0%

Source: Hampton Steam Plant data

UCL: Upper Confidence Limit

RT: Regulatory Threshold

For all of the 14 samples tested there were no results that exceeded the applicable regulatory threshold limits.

5.2 SWITCH OVER TO COST-EFFECTIVE DOLOMITIC LIME FINES

The facility conducted research and experimental studies with use of openly available dolomite lime (57.3% Calcium Oxide and 39.7% Magnesium Oxide) in fine particles for treating its combustion fly ash. It initially conducted some in-house tests with use of dolomite fines by 2% to 3% weight ratio of total fly ash to be treated, i.e. 2 tons per day for both boilers operating. After a series of trials were found successfully controlling the leachability of Cd and Pb within the regulatory threshold, the facility continued with conducting a full 14-day continuous testing and characterization of the combined residue ash as required by EPA and the State Solid Waste permit.

The results of the 14-day tests are given in the table below. The cumulative results indicated that during TCLP tests Cd leached at 93.6% of the leachability limit while Pb leached out at 32.2 % of the limit.

The Dolomitic Lime Product Information and updated results of heavy metal controls achieved with dolomitic lime treatment are also included in the Appendix B.

Raw data and details of tests carried out by dolomite ash treatment method are given in Appendix D.

Table 17 Residue ash test results with dolomite, Dec. 2008

METAL		AVERAGE mg/L	UCL mg/L	RT mg/L	RT %
Arsenic	As	0.00271	0.00376	5	0.1%
Barium	Ba	0.30621	0.45668	100	0.5%
Cadmium	Cd	0.76786	0.93618	1	93.6%
Chromium	Cr	0.01086	0.02057	1	2.1%
Lead	Pb	1.06321	1.60970	5	32.2%
Mercury	Hg	0.000507	0.001806	0.2	0.9%
Selenium	Se	0.00521	0.00756	1	0.8%
Silver	Ag	0.00064	0.00091	5	0.0%

14 Sample Points (includes 4th Quarter Ash Test on 12/16/2008), Hampton Steam Plant data
UCL: Upper Confidence Level
RT: Regulatory Threshold

Some of the TCLP results/data points for Cd control did not fall below the regulatory leachability limits, the cumulative results model was robust, generalizable and defensible even in the face of some outliers lying beyond the averagely drawn trend line. All TCLP test results for Pb had been below its threshold of 5 mg/L.

Routine quarterly testing of residue ash was continued hereafter on a regular basis and cumulative results of all heavy metals were computed based on one-tailed 90% confidence interval as per Student's T analysis method. With results of the each quarterly test added to compute cumulative values of the leachability controls, the percentage of Cd and Pb leached has continued to decline. The up to date cumulative values of percentage of metals leaching as tested according to TCLP method from a total 28 samples tested since 2009 is given in following table.

Table 18 Summary of results with dolomite use, 12/2015

Table includes residue ash tests results ending 12/2015					
METAL		AVERAGE mg/L	UCL mg/L	RT mg/L	%RT
Arsenic	As	0.0114	0.0164	5	0.3%
Barium	Ba	0.7529	0.8384	100	0.8%
Cadmium	Cd	0.2716	0.3406	1	34.1%
Chromium	Cr	0.0404	0.0655	5	1.3%
Lead	Pb	0.6021	0.9027	5	18.1%
Mercury	Hg	0.0031	0.0037	0.2	1.9%
Selenium	Se	0.0054	0.0060	1	0.6%
Silver	Ag	0.0010	0.0012	5	0.0%

28 Sample points for all 8 metals

Source: Hampton Steam Plant data

5.3 USE OF DOLOMITIC HYDRATED LIME TO REPLACE HIGH CALCIUM HYDRATED LIME FOR FLUE GAS SCRUBBING

At one stage facility had also attempted using hydrated lime with certain percentage of magnesium compound besides calcium oxides for spraying in flue gas scrubber in order to add dolomitic feature in the lime. Two types of dolomitic hydrated limes were considered:

a. Dolomitic Hydrate Type N: $Ca(OH)_2$ 66.7%, MgO 31.8%
b. Dolomitic Hydrate Type S: $Ca(OH)_2$ 61.1%, MgO 37.1%

When using the normal Type N dolomitic quicklime and mixing it with water at atmospheric pressure only the calcium oxide portion of the product will get hydrated as the hydration reaction breaks the quick lime down into fine particles of hydrated lime as per reaction below:

$$CaO\text{-}MgO + H_2O \rightarrow Ca(OH)_2\text{-}MgO$$

These products have high neutralizing values are used for a wide variety of industrial applications like acid neutralization and treatment of hazardous wastes.

In case of dolomitic super hydrate Type S hydration is done at high pressure as magnesium oxide requires high pressure levels or long slaking periods for complete hydration. The reaction takes place as follows:

$$CaO\text{-}MgO + 2H_2O \rightarrow Ca(OH)_2\text{-}Mg(OH)_2$$

6 trial tests were carried out by replacing high calcium hydrate for flue gas scrubbing by dolomitic hydrate to fulfill the dual purpose of:

i) Acid scrubbing of flue gases to control SO_2 emissions (as was otherwise done by use of high calcium hydrate, which was now replaced by dolomitic lime)

ii) Use of magnesium component in the dolomitic lime in scrubber to treat and stabilize resulting fly ash collected downstream of the flue gas treatment process.

Detailed information on these products is provided in Appendix C.

It was noticed that sulfur dioxide emissions were mostly controlled within the required limits though not to the extent as was normally done by use of high calcium (96%) hydrated lime and the leachability of heavy metals (Pb and Cd) in the fly ashes were only partially controlled. Out of the 6 tests conducted 4 did not control the leachability of Pb and Cd to within regulatory threshold. In order to overcome this, the facility attempted to increase the dolomitic lime injection rate in scrubber but the lime slurry injection system was not found supporting extra flows. The experiment was therefore suspended until the facility could upgrade the pumps and re-pipe the slurry discharge to enhance its capacity. Dolomitic Hydrate S (Super hydrate) use was not exercised. Summary results of the 6 tests are given in the table below.

Table 19 Summary results of treatment by dolomite hydrated lime, 10/2009

METAL		AVERAGE mg/L	UCL mg/L	RT mg/L	%RT
Arsenic	As	0.01350	0.02157	5	0.4%
Barium	Ba	0.48550	0.57541	100	0.6%
Cadmium	Cd	0.98587	1.22243	1	122.2%
Chromium	Cr	0.06375	0.12123	5	12.1%
Lead	Pb	6.25650	9.21424	5	184.3%
Mercury	Hg	N/A	N/A	0.2	N/A
Selenium	Se	0.00500	0.005000	1	0.5%
Silver	Ag	0.00125	0.00166	5	0.0%

6 Sample Points for Cd and Pb, 4 Sample Points for other metals (Hg was not tested)

Source: Hampton Steam Plant data

5.4 USE OF INCREASED CONCENTRATION OF HIGH CALCIUM HYDRATED LIME WITH PARAMETRIC CHANGES IN FLUE GAS SCRUBBING CONDITIONS

Another option tried was to inject increased amounts of high calcium (96%) hydrated lime slurry in the flue gas scrubber to find out if added lime that remains unreacted in the scrubber would react with fly ash downstream and thus would be helpful in stabilizing the heavy metals in the combined ash to reduce their leachability as tested with TCLP procedure. Details of results obtained during these tests were mixed and are included in the Appendix.

A brief description of experimental trials carried out for 3 to 4 months during 2013 is given here and a summary of results is provided in the table below.

The amount of lime injected into flue gas scrubber was increased in two ways:

a. Lime flow rates of lime slurry pumps were gradually increased form 56 lb per hour (pph) to 90-95 pph during some tests, while it was kept low at 20 pph in 2 tests
b. The concentration of lime slurry was raised from 1.03 to 1.06/1.08

An operational control change was also made during some of the later tests by gradually raising the Fabric Filter (FF) inlet temperature from 325^0 F to 400^0 F.

7 trial tests were conducted with above settings. Results of these tests indicated following set of results:

1. 2 tests marginally controlled Cd within a tab above the limit, and controlled Pb within limits, while the FF inlet temp was low at 325^0 F
2. 2 tests controlled Cd at 126% and 128% of limit, both however controlled Pb in limits, again while the FF inlet temp was lower than 400^0 F
3. 3 later tests were found to effectively control leaching of Cd and Pb within regulatory limits when the FF inlet temp was kept raised to 400^0 F

Results of 3 other tests conducted with lower concentrations of lime slurry and lower slurry flow rates are not included in these results as they did not control Cd well while Pb was controllable within limit.

It can be summarized from the above results that higher concentrations of high calcium hydrated lime slurry alone may be able to control leachability of both Cd and Pb 50% of the time even at lower FF inlet temperatures and even more effectively at higher FF inlet temperatures of 400^0 F and above.

It has also helped reduce cooling water requirement in scrubber to a very large extent thus effecting substantial savings in facility’s water bill.

Table 20 Summary results of treatment by high calcium hydrated lime, 9/2013

Table includes residue ash tests results from 1/2013

UCL: Upper Confidence Limit
RT: Regulatory Threshold

METAL		AVERAGE mg/L	UCL mg/L	RT mg/L	%RT	Remarks	Lime Flows/SO2 control	
						Test #	Unit #1 (Units)	U #2
						CH1	30 (ppm)	40
							Av. Lime:56pph	Lost Flow
Arsenic	As	0.0117	0.0160	5	0.3%	CH2	65 pph SG 1.08	65
Barium	Ba	0.9307	1.1157	100	1.1%	CH3	85 pph SG 1.08	85 pph
Cadmium	Cd	0.8492	1.0735	1	107.4%	CH4	85 pph SG 1.08	85 pph
Chromium	Cr	0.0830	0.1395	5	2.8%	CH5	20 pph SG 1.06	20 pph
Lead	Pb	1.7333	2.6984	5	54.0%	CH6	20 pph SG 1.06	20 pph
Mercury	Hg	0.0034	0.0046	0.2	2.3%	CH7	90 pph (avg) 1.05	95 pph
Selenium	Se	0.0056	0.0064	1	0.6%			
Silver	Ag	0.0046	0.0085	5	0.2%			

7 Sample points for all 8 metals

Summary Results show that the Residue Ash does not exhibit Toxic Characteristics

Sample Point CY 13	Quarterly Sample	Sample Date	Laboratory Test results for all 8 metals: As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Extr. Fluid	Initial/End Pt pH	Since
1	HSP 0113-CH1	1/31/13	0.005	0.522	1.05	0.001	0.02	0.005	0.009	0.001	2	12.00 / 6.31	July '13
2	HSP 0213-CH2	2/6/13	0.019	1.33	1.28	0.16	2.36	0.005	0.005	0.02	2	12.08 / 5.68	Both blrs
3	HSP 0213-CH3	2/8/13	0.005	0.606	1.26	0.001	0.081	0.005	0.005	0.001	2	12.10 / 6.32	FF inlet
4	HSP 0213-CH4/4A	2/14/13	0.010	1.400	1.065	0.037	1.522	0.005	0.005	0.003	2	12.08 / 5.85	Temp.
5	HSP-0713-CH5	7/12/13	0.024	0.854	0.430	0.265	4.640	0.002	0.005	0.001	2	10.74 / 5.02	Continued
6	HSP-0713-CH6	7/16/13	0.014	0.899	0.406	0.112	3.060	0.002	0.005	0.005	2	11.63 / 5.47	at 400°F
7	HSP-0913-CH7/7A	9/6/13	0.005	0.904	0.453	0.005	0.450	0.000	0.005	0.001	2	11.89 / 5.72	

NOTE:
Results of Sample Points 4 and 7 are average values of results of Sample Nos. 4/4A and 7/7A, respectively
For Sample Point 7, the value of Pb concentration is from Sample No. 7A

Source: Hampton Steam Plant data

In place of current use of high calcium hydrated lime slurry in the countercurrent spray tower, a newer product the *magnesium-enhanced lime process* (MEL) can be more effectively as it is a variation of the lime process in that it uses a special type of lime: magnesium-enhanced lime (typically 5% – 8% magnesium oxide) or dolomitic lime (typically 20% magnesium oxide). The MEL process may be designed to utilize the alkalinity of fly ash in addition to the alkalinity of a sorbent. Lime used in the MEL contains magnesium in addition to its calcium component. Because of the greater solubility of magnesium salts compared to calcium sorbents, the scrubbing liquor is significantly more alkaline. Therefore, MEL is able to achieve high SO_2 removal efficiencies in significantly smaller absorber towers than the limestone scrubbers. Additionally, MEL allows for a significant decrease of liquid/gas (L/G) ratio, compared to high calcium hydrated lime for a given SO_2 removal target. This chemical has not been tried at the study site but is recommended as an alternative to the in-line dolomitic lime injection downstream.

5.5 ELIMINATE USE OF DOLOMITE TAKING ADVANTAGE OF ALKALINITY OF BOILER PROCESS WATER USED FOR CONDITIONING OF FLY ASH

Over the years the facility has changed the source of water used for conditioning the fly ash in the screw conveyor that moves the fly ash onto the vibrating pan at a point where the fly ash mixes with the bottom ash being carried form the furnace bottom. The initial source of water mixed for fly ash conditioning in the conveying screw was the city water at ambient temperature. The water was able to condition the fly ash to avoid it being air-borne, but it converted the ash into cement like slurry and ultimately had very detrimental effect on the life of the conditioning screw. Because of frequent failures of conditioning screw in trying to move cementitious ash, the facility has started recycling and utilizing conditioning water from the boiler process blowdown system which is at higher temperature and is no longer resulting in cementing of the fly ash, besides effecting huge savings in water consumption.

The innovative use of hot boiler bow down process water for fly ash conditioning is also providing a source of additional alkalinity to the residue ash and it can be safely assumed that it is helping in maintaining a better pH balance in the residue ashes which in turn is leading to better stabilization of heavy metals.

A set of 5 tests were performed giving consideration to the above aspect of mixing of boiler process water in fly ash for its conditioning. During these tests the system operational variant of setting up the temperature at which the flue gases exit the SDA and then are passed on to the fabric filters for fly ash collection was further changed up from 400^0 F to 430^0 F. The lime slurry flows to the scrubber were however kept as normal and low, and reagent specific gravity was also lowered to 1.03.

The results of the 5 tests carried out with above settings are tabulated below.

The concept of utility of boiler blow down process water in fly ash conditioning coupled with changes in flue gas scrubber operational settings did not seem to be controlling the leachability of either Cd or Pb in any uniform way.

Table 21 Summary results of treatment by high calcium hydrated lime, 11/2015

Sample No.	Sample Date	As	Ba	Cd < 1 mg/L	Cr	Pb < 5 mg/L	Hg	Se	Ag
HSP-815-C1	8/19/15			1.260		9.012			
HSP-915-C2	9/12/15			1.450		3.940			
HSP-915-C3	9/12/15			0.969		8.050			
HSP-915-C4	10/29/15			1.490		25.500			
HSP-915-C5	11/12/15	0.005	0.483	1.020	0.001	0.0127	0.000	0.009	0.001

These tests were conducted at low normal lime slurry flows and low reagent specific gravity

Source: Hampton Steam Plant data

5.6 INJECTING SODIUM SULFIDE Na_2S 39% AQUEOUS SOLUTION IN FLY ASH CONDITIONING SYSTEM

The practice of using dolomitic fines had been continued while the facility carried out its attempts to find other options as well. The base price of dolomitic lime is affordable, but the current packing and transportation costs in 2 ton super sacks costs the facility about the same as the cost of chemical itself. The management of the facility weighed-in following options to overcome it:

a. Construct a storage silo large enough to store long-term supplies of dolomite lime transported in bulk trucks to avoid paying heavily for supply in super sacks.
b. Make process/chemical use changes upstream of fly ash generation, for example to increase spraying of high calcium hydrated lime (which is stored in a silo and mixed with water to make slurry) or to spray a mix of high calcium hydrated lime and dolomite lime in the flue gases to ascertain if it will change the reaction kinetics to the extent that may help eliminate use of dolomite lime in the fly ash collection system downstream of the flue gas path.

c. Find an alternative to dolomite lime in form of a liquid chemical injection that would use an existing process water injection as part of fly ash conditioning. A small liquid storage tank and pump would be needed for this system in case it is determined to treat the ashes.

Initial trials with sodium sulfide liquid (Na_2S 39%) chemical injection as part of proposal in item c. above was undertaken. Results and validity of the results of trials were evaluated to find out if they meet the stabilization criteria of heavy metals.

The results of leachability of Cd and Pb of a test carried out on Feb 3, 2016 are given in the table below.

Table 22 Leachability of Cd and Pb, Sodium sulfide test on Feb 3, 2016

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 2/3/2016 TIME: 1220
GRAB COLLECTION
DATE: 2/3/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - TS
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-01547 16:29

REED & ASSOCIATES

SAMPLE ID: HSP-0216-SS1
SAMPLE NO 16-01547

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.005	5	< 0.005	mg/L	PEJ	02/09/16	1359
Barium	D005	6010C	0.005	100	0.730	mg/L	PEJ	02/09/16	1359
Cadmium	D006	6010C	0.0005	1	0.444	mg/L	PEJ	02/09/16	1359
Chromium	D007	6010C	0.001	5	0.012	mg/L	PEJ	02/09/16	1359
Lead	D008	6010C	0.005	5	0.214	mg/L	PEJ	02/09/16	1359
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	02/08/16	1542
Selenium	D010	6010C	0.005	1	< 0.005	mg/L	PEJ	02/09/16	1359
Silver	D011	6010C	0.001	5	< 0.001	mg/L	PEJ	02/09/16	1359

Source: Laboratory results for Hampton Steam Plant residue Sample ID: HSP-0216-SS1

Total 5 such trial tests were conducted during Feb 3 and March 3, 2016. The results indicated that the leachability of both Cd and Pb has been found below the regulatory limits. The MSW residue ash was treated with an estimated injection rate of 15 gallons per day. Results of these tests are further analyzed in Chapter 8.

CHAPTER 6: DICUSSIONS AND ANALYSIS OF RESULTS OBTAINED DURING USE OF PROPERIETARY COMPOUND AND DOLOMITE

The study used the three principles of experimental design at all stages, starting from ensuring the replication of sample data by resorting to sound engineering controls. Thus it avoided the errors, biases and noises in sampling data. All necessary quality controls were exercised in gathering, preparing, securing, and transporting the samples following well-written and strictly followed procedures and under an established chain of custody command. The sample data were completely randomized by assigning treatments and factoring for all applicable running conditions of the combustion units so that the results of the sample can be elevated to the system level.

With several set of experimental data available for analysis a matrix of causal effects of various Treatment methods is created adding different running conditions of the 2 boiler units as blocks to generate a Randomized Complete Block (RCB) design.

A statistical analysis carried out with the results of first 4 treatment methods that are broadened up to 6 treatment options T1 through T6 and 4 running conditions RC1 through RC4 were used as blocks. The last 2 treatment methods have not been included this analysis as these were either not concluded due to under capacity of the reagent slurry pumping system to the flue gas scrubber or a 6^{th} treatment method number 13.6 was still under way while writing this report and did not have substantial number of test results to be included.

A total of 102 results tested for Cd and Pb at an approved laboratory have been included in this statistical analysis. Mass flux changes during boilers running conditions variability is used in this analysis. Shapiro-Wilk tests for normality at a higher 95 % confidence level and comparisons of scatter graphs did not reveal normality of data as probability values of both Cd and Pb were < 0.001. This would be mainly due to the fact that some of the treatment methods are observed controlling the target limit very differently between various tests and trials.

Table 23 ANOVA: Description of Treatment methods and Running Conditions

Treatment	Description
T1	Properietary 1
T2	Properietary 2
T3	Properietraty 3
T4	Properietary 4
T5	Dol. Lime 2.5%
T6	Dol. Lime 2%

Notes:	
Test Duration	Test duration is homogeneous (24 hours) for all the treatments and Running Conditions (RC)
RC1	Both boilers in continuous running condition
RC2	One boiler in continuous running condition
RC3	1 boiler is running continuously for 24 hours + 1 boiler is starting up
RC4	1 boiler is running continuously for 24 hours + 1 boiler is shutting down
Conc	Concentration is listed in mg/L

Table 24 ANOVA data entries

Treatment	Description
T1	Proprietary 1
T2	Proprietary 2
T3	Proprietary 3
T4	Properitary 4
T5	Dol. Lime 2.5%
T6	Dol. Lime 2%

Notes:	
Test Duration	Test duration is homogeneous (24 hours) for all the treatments and Running Conditions (RC)
RC1	Both boilers are used in continuous running condition
RC2	One boiler used in continuous running condition
RC3	1 boiler is running continuously for 24 hours + 1 boiler is starting up
RC4	1 boiler is running continuously for 24 hours + 1 boiler is shutting down

Cd Control	RC1	RC2	RC3	RC4
T1	1.2, .73			
T2	1.3, 2.2, .59			
T3	.896, .451, .296, .659, .47, .736, .422, .618, .696, .775		.67, .761, .553, 1.19	.805, .905, .776
T4	.96, .776, .296, .451, .47, .659		.422, .736	.696, .676, .805
T5	.242, .224, .215, .204, .663, .127, .28		.178, .315, .35	.347, .272, .164, .306
T6	.242, .178, .593, .0719, .186, .215, .35, .549, .0016, .38, .663, .272, .074, .324, .0005, .280, .306, .821, .0159, .8364, .315, .596, .911, .0316, .461, .970, .213, .5117		.347, .448, 1, .081, .2498, .164, .425, .055, .991, .467, .224, .634	.204, .428, .047, .005, .0005, .127, 1.04, .997, .2714, .5185, .724, .3675, .0094, .1551, .4983

Pb Control	RC1	RC2	RC3	RC4
T1	.02, 14			
T2	.16, 7.1, .04			
T3	.0406, .012, .12, .012, .104, .073, .017, .24, .077, .174		.116, .092, .213, 1.36	.018, .808, 1.06
T4	.406, .012, .120, .012, .104, .116		.096, .213, 1.360	.073, .017, .240
T5	.029, .020, .025, .017, .060, .107, .022		0.013, .005, .005	.005, .021, .008, .022
T6	.029, .02, .025, .017, .06, .005, .021, .008, .022, .235, .085, .0719, .186, .071, .0016, .38, .069, .032, .0005, .348, .0159, .8364, 1.08, .0316, .461, .392, .213, .5117		.107, .016, .022, .007, .013, .027, .122, .081, .2498, .006, .991, .467	.005, .029, .005, 1.79, .012, .005, .0005, 1.46, .2714, .5186, .280, .3675, .0094, .1551, .4983

Source: Table of 102 data sets for Treatments and Running Conditions for ANOVA analysis

As a choice of factors, six treatment methods (T1, T2, T3, T4, T5, T6) under four different boiler running conditions (RC1, RC2, RC3, RC4) are used concurrently for control of concentrations of both the above two heavy metals and results are tested according to the following Test of Hypotheses for each of these two heavy metals.

Control of Cd leachability < 1.0 mg/L and control of Pb leachability < 5.0 mg/L (both tested concurrently under TCLP procedure and with EPA Method 1311) using 6 treatments and 4 running conditions of the two boilers in use at Hampton/NASA Plant.

All samples were collected over an extended number of hours as per an approved and established procedure from the residue ash generated over the previous 24-hour period.

The total number of samples used in the study was spread over several years while different treatment methods were either experimented, or were being proven, or were otherwise used for regular mandated quarterly testing of residue ash.

Following is the total number of samples used for the two constituents:

A. Cadmium 102 samples

B. Lead 102 samples

Samples collected were used for analyzing the concentrations of both toxic pollutants simultaneously.

As a plan for selection of responsible variable, Treatments T1 through T6 were chosen as primary independent variable, while running conditions of the set of two boilers were considered as secondary independent variable affecting the outcomes.

Following choices for experimental designs were used.

(A) Cadmium

F-test based T.H. at 95 % confidence ($\alpha = 0.05$):

Hypothesis #1: (Test of treatment effects: T1 through T6)

H_o: $\tau_1 = \tau_2 = \tau_3 = \tau_4 = \tau_5 = \tau_6 = 1$ ppm

H_a: At least one of τ_1 through $\tau_6 < 1$ ppm

Hypothesis #2: (Test of block effects: RC1 through RC4)

H_o: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 1$ ppm

H_a: At least one of β_1 through $\beta_4 < 1$ ppm

(B) Lead
F-test based T.H. at 95 % confidence ($\alpha = 0.05$):

Hypothesis #1: (Test of treatment effects: T1 through T6)

H_o: $\tau_1 = \tau_2 = \tau_3 = \tau_4 = \tau_5 = \tau_6 = 5$ ppm

H_a: At least one of τ_1 through $\tau_6 < 5$ ppm

Hypothesis #2: (Test of block effects: B1 through B4)

H_o: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 5$ ppm

H_a: At least one of β_1 through $\beta_4 < 5$ ppm

The source of sample data was the fly ash generated at the Waste-to-Energy Hampton/NASA Steam Plant from the combustion process of one or both the operating boilers. It was treated with varying concentrations of different chemicals and representative ash samples were prepared for analysis of heavy metal constituents. The samples were randomly grabbed either from the ash pile, one half of front loader bucket from each truck being loaded for ash disposal, or directly from the ash dumping conveyor at set hourly intervals if the trucks were being loaded directly with ash for disposal to landfills. The total ash grab was then quartered, a single quarter was selected by random coin toss, and that would then be separated into three components: aggregate, paper/cardboard etc. (unburnts), and metals (unburnables). Each component was weighed separately and proportionate weight of each of the three components was calculated and weighed to make a composite 20 lb. sample, all under expert supervision or by a trained quality leader. Two such 20 lb. samples were prepared, one to be tested and the other kept as archive sample in case the original sample got damaged/pilfered or judged unusable, both 20 lb. samples were sealed with forensic tape, signed, and authenticated by the quality leader.

The samples were prepared as described above, kept under control of responsible official, and were then sent to an approved laboratory (or, alternatively were collected by the lab's representative) all under an approved and established chain of custody procedure to ensure safety and security of the collected samples. The sample preparation methodology and analysis is based on EPA guidelines laid out in Solid Wastes Procedure and method SWP-846.

Regression modelling and validation of data distribution was carried out by drawing the curves.

The respective regression curves of the two target pollutants Cd and Pb resembled following shapes:

A. Cd Power model
B. Pb Exponential model

The concentration data of these two pollutants were transferred to power and exponential terms, respectively and the resulting regression curves are shown below.

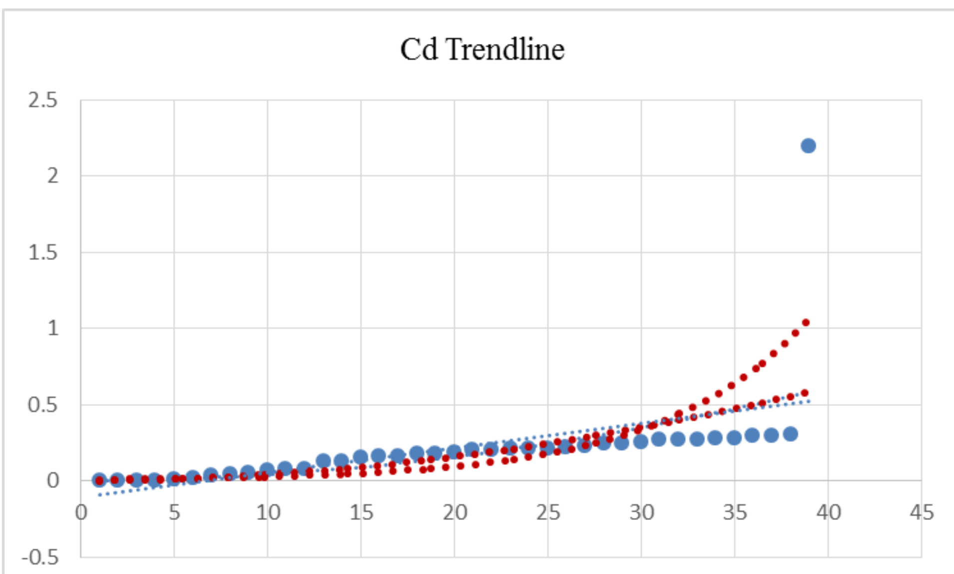


Figure 16 Power and exponential curves for Cd for 102 samples studied

Source: 102 data points for Cd from Hampton test results

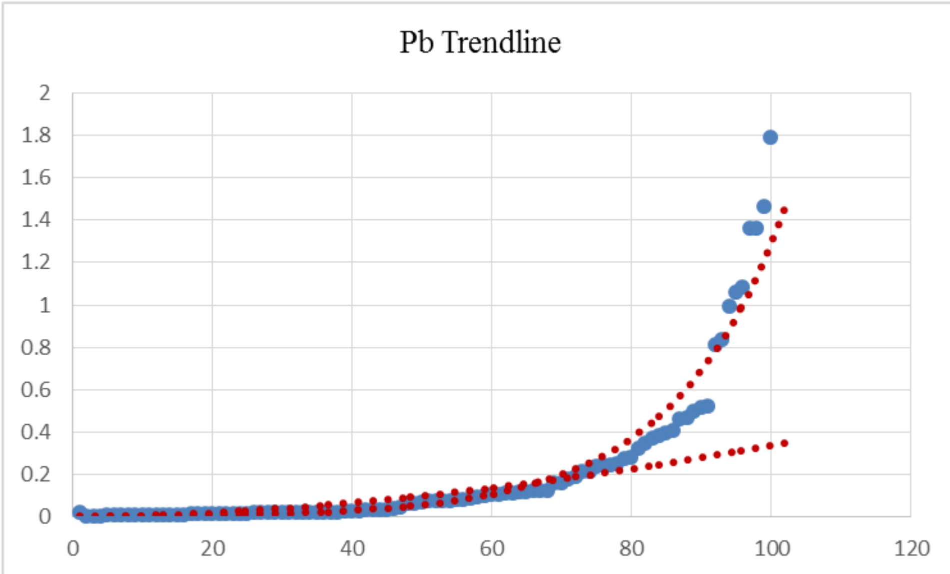


Figure 17 Power ad exponential curves for Pb for 102 ash samples studied

Source: 102 data points for Pb from Hampton Steam Plant test results

Re-runs showed no normality of the data distribution for any of the two pollutants. Besides above models, histograms for both Cd and Pb were drawn as below.

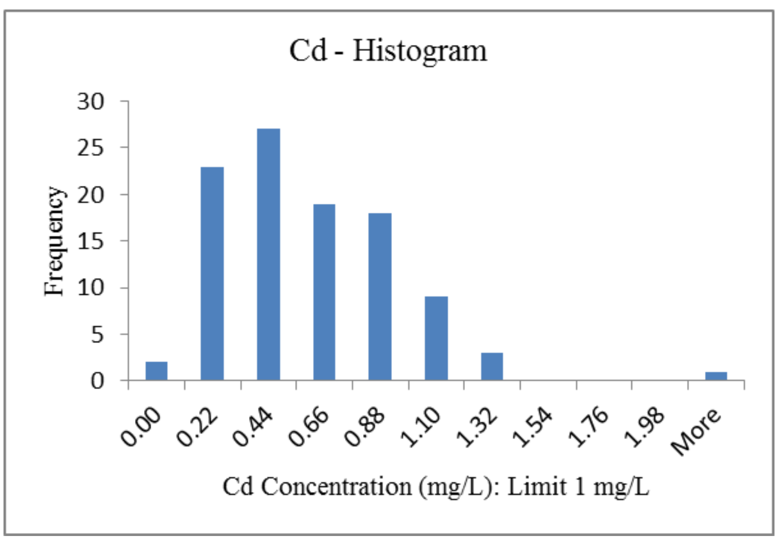


Figure 18 Histogram of concentrations of Cd for 102 ash samples studied

Source: 102 data points for Cd from Hampton Steam Plant test results

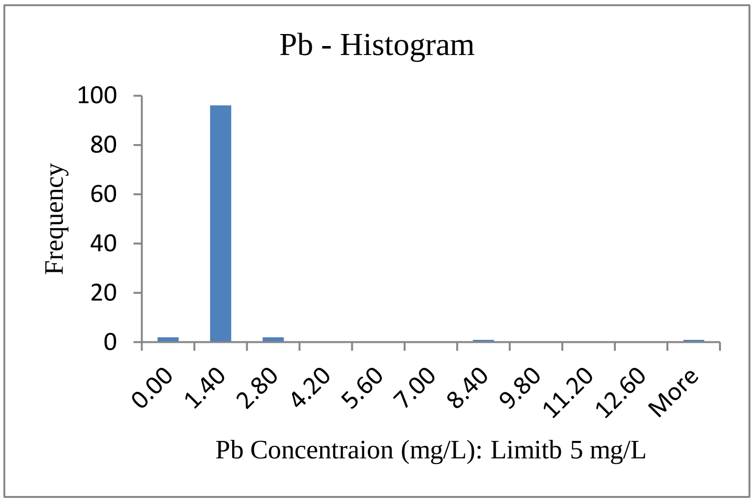


Figure 19 Histogram of concentrations of Pb for 102 ash samples studied

Source: 102 data points for Pb from Hampton Steam Plant test results

Since the number of samples for both Cd and Pb were fairly large, 102 in each case, the sampling distribution of the sample mean is considered approximately normally distributed according to Central Limit Theorem (CLT). This was further verified using Analysis of Variance (ANOVA) procedure.

No data have been considered for filtering in this analysis. There are some concentrations above normal and high outcomes are judged as part of the exploratory testing to find out appropriate treatment for controlling the concentrations of pollutants leached out. These results have therefore been also included in the analysis of variance (ANOVA) study.

The results of the Sample Data, SAS Estimates and ANOVA Output are included in Appendix D of this study.

Following assumptions were made while conducting this study:

1. The municipal solid waste (MSW) used for combustion process is considered mostly of uniform characteristics throughout the year. It is delivered to the boilers in as-received condition

2. The two combustion units (boilers) are identical and operate with similar mass flux rates of fuel inputs and residue ash output.
3. The treatment chemicals used during their respective test duration were qualitatively and qualitatively uniform during the entire period.
4. The samples came from a normally distributed system

The experimental design in the study uses more than two treatments that are the factor of interest has more than two levels (in fact the study is using 6 treatments). The blocks used are significant variables in the sense that while only one boiler is running in steady state, the total mass flux of the combined residues sharply varies quantitatively as well as qualitatively with variations occurring every time the second boiler is shutting down with sharply lowering gradient in flue gas temperature and quantities. Opposite to this, if one boiler is running in steady state but the second boiler is starting up, the total mass flux of the combined residue is experiencing a sharp up-gradient for several hours in flue gas temperatures and quantities.

The study follows the procedure that meets the standards for randomized complete block design by running a complete replicate of the treatment in each block because the actual assignments of each of the 6 treatments are done randomly in each block.

The SAS System ANOVA Procedure table showed the following F- and p-values for the combined ash (CA) treatments and blocks for Cd and Pb, respectively:

	F-value	p-value	Analysis/Result
A. <u>Cd</u>			
CA Treatment	12.69	<0.001	Reject null hypothesis
CA Bulk	2.11	0.1040	Fail to reject null hypothesis

For control of Cd concentrations at 95% level of confidence, the p-value for chemical treatments < 0.05, there is significant evidence that one or more of the treatments are immobilizing and controlling the leachability concentration of Cd. But since the p-value for boilers running conditions is > 0.05, the study fails to reject the null hypothesis and therefore concludes that the boilers running conditions do not have any significant influence on the stabilization and control of Cd leachability concentration.

	F-value	p-value	Analysis/Result
B. <u>Pb</u>			
CA Treatment	14.01	<0.001	Reject null hypothesis
CA Bulk	0.93	0.4292	Fail to reject null hypothesis

For control of Pb concentrations at 95% level of confidence, the p-value for chemical treatments < 0.05, there is significant evidence that one or more of the treatments are immobilizing and controlling the leachability concentration of Pb. However, since the p-value for boilers running conditions is > 0.05, the study fails to reject the null hypothesis and therefore concludes that the boilers running conditions do not have any significant influence on the stabilization and control of Pb leachability concentration.

Detailed discussions on the next study of use of aqueous sodium sulfide for treatment of Hampton facility's residue ash are included in Chapter 8.

CHAPTER 7: COAL COMBUSTION RESIDUES

U.S. coal-fired power plants generate approximately 100 million tons of coal ash annually, and 75% of this is in form of fly ash. Coal combustion residues (CCRs) result from the combustion of coal in steam generating and electric power plants. The residues include coal fly ash and bottom ash and also waste from flue gas desulfurization (FGD) in the electricity generating units (EGUs). Steam electric power plants use variety of fuels including nuclear and fossil fuels such as coal, oil, and natural gas and discharge large quantities of wastewaters. They carry both toxic and bioaccumulative pollutants including arsenic, mercury, selenium, chromium, and cadmium accounting for about 30% of all toxic pollutants that are discharged into surface waters and are governed by Clean Water Act (CWA). This study includes wastewater discharges from coal power plants only.

Recently new processes like coal gasification and clean coal technologies have been introduced for generating electric power from coal and new pollution control measures, like new technologies for flue gas desulfurization (FGD) and flue gas mercury control (FGMC) have been implemented. These have changed the nature of coal power plant waste streams. As a result the toxic pollutants in the coal power plant wastewater discharges are a concern for public health and environment. Toxic metals like mercury, arsenic, lead, and selenium accumulate in fish and contaminate drinking water. The effects of these pollutants can cause cancer, cardiovascular diseases, neurological disorders, and kidney and liver damage.

7.1 REGULATIONS GOVERNING COAL COMBUSTION RESIDUES

Regulations requiring safe disposal of coal combustion residues (CCRs) are relatively recent. EPA finalized the national regulations for safe disposal of CCRs from coal power plants on April 17, 2015. The rules include the technical requirements for CCR landfills and surface impoundments under Resource Conservation and Recovery Act (RCRA) Subtitle D that regulates solid wastes. The rules were the results of extensive study on the effects of coal ash on the environment and public. During the study, EPA also found that the use of wet FGD systems to control sulfur dioxide (SO_2) emissions has increased significantly since the last revision of the effluent guidelines in 1982. It was also estimated that its use will continue to increase after the steam electric power generating units are taking steps to address federal and state air pollution control requirements. FGD wastewaters were generally found to contain significant levels of metals and other pollutants. While advanced treatment technologies are available to treat the FGD wastewater, however most plants were still using surface impoundments designed primarily to remove suspended solids from FGD wastewater. It has also been determined that technologies are available for handling the fly ash and bottom ash generated at a plant without using any water or at least eliminating the discharge of any ash transport water. The waters used to convert fly ash and bottom ash into slurry form to transport these wastes are generated in large quantities from wet systems at coal-fired power plants and contain significant concentrations of metals, including arsenic and mercury.

The Disposal of Coal Combustion Residuals from Electric Utilities final rule (the “Coal Ash Rule,” or the “Rule”), signed December 19, 2014, sets first-ever minimum federal standards for the disposal of coal ash under the Resource Conservation and Recovery Act (RCRA). Through this rulemaking, EPA has elected to classify coal ash as a non-hazardous solid waste subject to regulation under subtitle D of RCRA. This means that the federal government cannot enforce the rule, and cannot mandate that states adopt and enforce the federal standards. EPA “strongly encourages states to revise their Solid Waste Management Plans to implement the standards.” Because the Rule is not enforceable by EPA, and state enforcement is uncertain, a primary enforcement mechanism for the Rule is citizen suits under RCRA. Other standards, such as those found in the Clean Water Act, still apply to coal ash.

One of the major provisions of the Rule is that it calls for the closure of surface impoundments and landfills that fail to meet engineering and structural standards, and regular inspections of the structural safety of surface impoundments. New surface impoundments and landfills will also be restricted to locations not deemed “sensitive,” such as wetlands and earthquake zones. The rules also call for use of fugitive dust controls to reduce windblown coal ash dust, and liner barriers for new units and proper closure of surface impoundments and landfills that will no longer receive CCRs. The final rule means that states must now revise their Solid Waste Management Plans (SWMPs) and submit these revisions to the EPA for approval. “A revised and approved SWMP will signal EPA’s opinion that the state SWMP meets the federal criteria,” the EPA said.

The rule applies to all active landfills and ponds, but it does not apply to following:

a. The placement of coal ash in coal mines

b. Coal ash landfills that ceased receiving coal ash prior to the effective date of the Rule

c. Coal ash units at facilities that have ceased producing electricity prior to the effective date of the Rule

d. Practices that meet the definition of "beneficial use" of coal ash (< 12,400 tons of fill) or any type of past beneficial uses

e. The disposal of coal ash from non-utility boilers burning coal (e.g., paper plants, industrial boilers generating electricity for their own use, university power plants, etc.)

The current rule covering disposal of coal combustion residues has a number of deficiencies:

1. Treats coal ash as a nonhazardous solid waste rather than a hazardous waste, thus regulating coal ash under subtitle D rather than subtitle C
2. Relies on states voluntarily adopting standards and citizen suits for enforceability
3. Continues to allow coal ash to be stored in unlined ponds. Unlike the proposed rule, the final Rule does not call for the lining or closure of all coal ash ponds within 5 years
4. Only requires assessment work to be done by a "qualified professional engineer," not an independent engineer
5. There are no groundwater protection standards for: aluminum, boron, chloride, copper, iron, manganese, pH, sulfate, sulfide, and TDS, so high levels of these pollutants will not trigger corrective action
6. All inactive landfills are not regulated
7. Inactive ponds at inactive power plants are not regulated
8. Closure deadlines provide for multi-year extensions
9. Inactive coal ash ponds closed in the next 3 years will require no post-closure care requirements such as groundwater monitoring and corrective action

10. No specific standards for particulates in the air at coal ash plants
11. Structural fill that is less than 12,400 tons does not require an affirmative demonstration in order to be considered beneficial use.

7.2 PHYSICAL CHARCTERISTICS OF COAL ASH

Coal combustion residues have been studied in detail on the following aspects:

- The process of formation of coal ash
- Coal ash characteristics
- The way the coal ash weathers in the environment

Typically coal ash also has the same components like the various steams generated from combustion of MSW – fly ash from ESP or Fabric filters, flue gas desulfurization (FGD) ash form flue gas cleaning, and bottom ash or boiler slag.

Fly ash from coal combustion is formed when molten minerals such as clay, quartz, and feldspar, solidify in the moving air stream, giving approximately 60% of the fly ash particles a spherical shape. Coal fly ash is a pozzolanic material (as used for concrete production) and has been classified into two classes, F and C, based on the chemical composition of the fly ash.

According to ASTM C 618, the chemical requirements to classify any fly ash are shown in the following table.

Properties of fly Ash Class	Class F	Class C
1. Silicon dioxide (SiO_2) plus aluminum oxide (Al_2O_3) plus iron oxide (Fe_2O_3), min, %	70.0	50.0
2. Sulfur trioxide (SO_3), max, %	5.0	5.0
3. Moisture Content, max, %	3.0	3.0
4. Loss on ignition, max, %	6.0	6.0

Class F fly ash is produced from burning anthracite and bituminous coals. This fly ash has siliceous or siliceous and aluminous material, which itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form cementitious compounds.

Class C fly ash is produced normally from lignite and sub-bituminous coals and usually contains significant amount of Calcium Hydroxide (CaOH) or lime. This class of fly ash, in addition to having pozzolanic properties, also has some cementitious properties (ASTM C 618-99). Color is one of the important physical properties of fly ash in terms of estimating the lime content qualitatively. It is suggested that lighter color indicate the presence of high calcium oxide and darker colors suggest high organic content.

The primary factors that influence the mineralogy of a coal fly ash are:

1. Chemical composition of the coal

2. Coal combustion process including coal pulverization, combustion, flue gas clean up, and fly ash collection operations

3. Additives used, including oil additives for flame stabilization and corrosion control additives.

The minerals present in the coal dictates the elemental composition of the fly ash. But the mineralogy and crystallinity of the ash is dictated by the boiler design and operation. The pozzolanic reactions are as follows:

$$Ca(OH)_2 \Rightarrow Ca{+}{+} + 2[OH]-$$

$$Ca{+}{+} + 2[OH]- + \underset{\text{(Silica)}}{SiO_2} \Rightarrow \underset{\text{(Gel)}}{C\text{-}S\text{-}H}$$

$$Ca{+}{+} + 2[OH]- + \underset{\text{(Alumina)}}{Al_2O_3} \Rightarrow \underset{\text{(Gel)}}{C\text{-}A\text{-}H}$$

Hydration of tri-calcium aluminate in the ash provides one of the primary cementitious products in many ashes.

Fly ash particles also contain crystalline compounds that pass through the combustion zone or are formed at high temperatures. Some elements that become volatile at high temperatures, like arsenic and selenium, later condense at the surface of the fly ash particles as the ash cools. The particles are spherical in shape and are either solid or are with vesicles, as shown in the following figure.

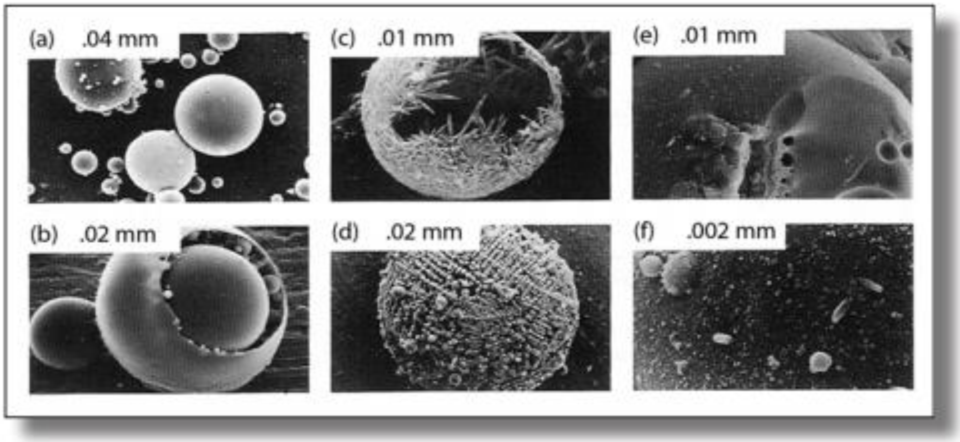


Figure 20 Scanning electron micrographs of fly ash.
EPRI, Coal Ash Characteristics, Management, and Environmental Issues

The 6 different characteristics of fly ash particles shown in the figure are described below.

(a) Typical spherical morphology of glassy particles.

(b) A large hollow sphere formed when entrapped gas expanded during thermal decomposition of calcium carbonate ($CaCO_3$).

(c) A particle etched with hydrofluoric acid to remove surface glass and reveal a shell of interlocking mullite crystals.

(d) A typical magnetic spinel mineral (magnetite) separated from ash after removal of encapsulating glass.

(e) A fractured ash particle containing numerous vesicles. (f) The accumulation of tiny granules of inorganic oxides, crystals, and coalesced ash on the surface of a larger particle.

In majority of the coal power plants, approximately 80% of the units, removal of sulfur form flue gases are based on lime or limestone wet scrubbing. The remaining utilize either sodium-based or lime slurry (spray) dry scrubbing or use various sorbent injection technologies of one form or another. In the United States, coal-fired utility boilers have been adopting newer and best available control technologies for emission control since they are a major source of SO_2 emissions. In the wet scrubbers the alkaline sorbent reacts with the SO_2 gas and is collected in a liquid form as calcium sulfite or calcium sulfate slurry. The calcium sulfite or sulfate is allowed to settle out as most of the water is recycled. Stabilized calcium sulfite FGD scrubber material has been used as an embankment and road base material.

The volatile elements (e.g., As, B, Cl, F, S, Se) are found concentrated in the fly ash or FGD sludge.

Bottom ash that falls to the bottom of the furnace is made up of heavier particles and is mainly composed of amorphous and glassy aluminous silicate from the melted mineral phases in coal. Boiler slag is collected in plants that operate at very high temperatures and where the molten particles are cooled and quenched in water. Coal fly ash and bottom ash show similarity in composition and variability of the nonvolatile inorganic elements (e.g., Al, Ca, Fe, and Si). Total concentrations of several elements (e.g., As, B, Pb, Zn) vary with the coal type used in the burning process. Bottom ash accounts for 25% of all coal combustion residues in USA.

7.3 CHEMICAL COMPOSITION OF COAL ASH

About 90% of mineral components of coal fly ash are the oxides of silicon, aluminum, iron, and calcium, minor constituents such as magnesium, potassium, sodium, titanium, and sulfur account for about 8% while trace constituents such as arsenic, cadmium, lead, mercury, and selenium, together make up less than 1% of the total composition. Typical range of major and trace constituent concentrations in fly ash, bottom ash, rock, and soil for comparison are shown in Table below.

Table 25 Range in bulk composition of fly ash, bottom ash, rock, and soil (mg/Kg)

Component	Fly Ash	Bottom Ash	Rock	Soil
Aluminum	70,000 – 140,000	59,000 – 130,000	9,800 – 96,000	15,000 – 100,000
Calcium	7,400 – 150,000	5,700 – 150,000	6,000 – 83,000	1,500 – 62,000
Iron	34,000 – 130,000	40,000 – 160,000	8,800 – 95,000	7,000 – 50,000
Silicon	160,000–270,000	160,000–280,000	57,000–380,000	230,000–390,000
Magnesium	3,900 – 23,000	3,400 – 17,000	700 – 56,000	1,000 – 15,000
Potassium	6,200 – 21,000	4,600 – 18,000	4,000 – 45,000	4,500 – 25,000

Sodium	1,700 – 17,000	1,600 – 11,000	900 – 34,000	1,000 – 20,000
Sulfur	1,900 – 34,000	BDL – 15,000	200 – 42,000	840 – 1,500
Titanium	4,300 – 9,000	4,100 – 7,200	200 – 5,400	1,000 – 5,000
Antimony	BDL – 16	All BDL	0.08 – 1.8	BDL – 1.3
Arsenic	22 – 260	2.6 – 21	0.50 – 14	2.0 – 12
Barium	380 – 5100	380 – 3600	67 – 1,400	200 – 1,000
Beryllium	2.2 - 26	0.21 – 14	0.10 – 4.4	BDL – 2.0
Boron	120 – 1000	BDL – 335	0.2 – 220	BDL – 70
Cadmium	BDL – 3.7	All BDL	0.5 – 3.6	BDL – 0.5
Chromium	27 – 300	51 – 1100	1.9 – 310	15 – 100
Copper	62 – 220	39 – 120	10 – 120	5.0 – 50
Lead	21 – 230	8.1 – 53	3.8 – 44	BDL – 30
Manganese	91 – 700	85 – 890	175 – 1400	100 – 1,000
Mercury	0.01 – 0.51	BDL – 0.07	0.1 – 2.0	0.02 – 0.19
Molybdenum	9.0 – 60	3.8 – 27	1.0 – 16	All BDL
Nickel	47 – 230	39 – 440	2.0 – 220	5 – 30
Selenium	1.8 – 18	BDL – 4.2	0.60 – 4.9	BDL – 0.75
Strontium	270 – 3100	270 – 2000	61 – 890	20 – 500
Thallium	BDL – 45	All BDL	0.1 – 1.8	0.20 – 0.70
Uranium	BDL – 19	BDL – 16	0.84 – 43	1.2 – 3.9
Vanadium	BDL – 360	BDL – 250	19 – 330	20 – 150
Zinc	63 – 680	16 – 370	25 – 140	22 – 99

BDL Below Detection Limit

Adopted from: EPRI, Coal Ash: Characteristics, Management and Environmental Issues

7.4 LEACHING OF TOXIC ELEMNETS FROM COAL ASH

In a recent incident the coal ash spill at the Tennessee Valley Authority's (TVA) Kingston coal-burning power plant caused a big alarm due to environmental risks involved. The incident became a major subject of investigation of potential environmental and health impacts.

Three major environmental risks were found during this investigation:

1. Release of high levels of fine particle size (<10µm) toxic and radioactive elements.

   Toxic elements As 75 mg/Kg

	Hg	150 μg/Kg
Radioactive elements	$^{226}Ra + ^{228}Ra$	8pCi/g

2. Contamination of surface waters – only in trace levels in Emory and Clinch rivers, due to dilution in the downstream
3. Accumulation of As-rich and Hg-rich coal ash in river sediments

Coal fly ashes are complex particles of a variable composition. The composition of coal fly ash is mainly dependent on the combustion process, the source of coal and the precipitation technique. Toxic constituents in these particles are metals, polycyclic aromatic hydrocarbons and silica. The potential for leaching of these metals not only depends on the total metals content but also influenced by the crystallinity of the fly ash, as this would dictate whether the metals are incorporated within the gaseous phase or within crystalline compounds. The metals in the gaseous phase are expected to leach at much lower rate than that from the crystalline phase. Since the degree of crystallinity is a function of boiler design and remains relatively constant for a given source, leachable materials remain relatively constant for a given ash source. A number of state regulatory agencies have issued source approval for specific generating facilities after the consistency of these materials had been demonstrated. For stabilized soil, the leachability of metals not only depends on the property of the fly ash but also the soil that is used; for example some of these metals leached from the fly ash may to be adsorbed on the clay minerals of the soil.

Experiments conducted on the leaching of metals from the coal combustion ash have revealed that land disposal of coal ash can have potential impact on the ecosystem with increasing acidity of precipitation. It was observed that the toxicity and metal concentrations of the leachates were highest when ash was leached with HCl at pH 4, while the toxicity and concentrations of ash leached with acetic acid (CH_3COOH) were significantly lower compared with ash leached with HCl. The toxicity of the aqueous leachates and concentrations of metals-arsenic, cadmium, chromium, copper, iron, lead, nickel, silver, and zinc, were measured using Microtox and atomic absorption spectrometry, respectively. The table below gives the results of these tests as compared to the EPA fresh water acute criteria.

Table 26 Fresh water acute criteria and metals concentrations (μg/L) in coal ash

Metal	EPA fresh water acute	HCl	CH_3COOH
As	340	12.3	8.7
Cd	1.8	26	2
Cr	16	13.7	3
Cu	-	277.3	74.3
Fe	-	518.7	82.3
Pb	65	30	3
Ni	470	29	13
Zn	120	381	214

Source: EPA fresh water acute criteria

It is noticed that with HCl at pH 4 concentrations of Cd, Cu, and Zn were higher than the EPA fresh water criteria, while only Cu and Zn were higher when CH_3COOH was used. Low soil pH aides the increase in leachability of metals and the metal availability in soils is altered by change in pH due to addition of coal combustion residues. Increased pH was found to generally reduce the availability of Cd, Cu, Ni, Pb, Zn, and other metals.

7.5 UTILIZATION AND DISPOSAL OF COAL ASH

About 45% of coal ash produced in power plants is utilized in many construction and geotechnical purposes. Physical and chemical characteristics of coal ash make it suitable for such useful applications with the primary use of fly ash being as an ingredient in concrete. Bottom ash and coarser boiler slag are utilized as road base materials and for structural fills. Coal ash which is not put to any beneficial use is disposed of and stored in impoundments.

These impoundments or landfills may be located onsite of a power plant or may be sometimes located somewhere outside. These disposal sites are regulated according to the applicable siting requirements, engineering controls, like liners, leachate collection system, run-on and run-off controls etc. The fly ash in these landfills settles to the bottom. In some cases treatment chemical may be added to improve settling, to control pH, or to remove dissolved constituents. The settles ash solids may be then either left in place or may be dredged out to be put to some beneficial uses as mentioned above.

Coal as disposal sites are so far mostly managed by the State regulations where they are situated. Their design, siting, engineering controls in respect of quality and setup of liners, leachate collection system, gradients, run on and runoff controls have not been up to the federal standards, so has been their groundwater monitoring and corrective action requirements in case of statistically significant increase noticed in ground water pollutants. It has been only lately that regulatory and engineering controls for new or expanded units permitted between 1994 and 2004 had tightened according to a study by US EPA and US Department of Energy (DOE) published in 2006.

The potential environmental impacts of coal ash spills depend on the characteristics of the disposal site, characteristics of the coal ash and FGD wastes, control method and the degree of control employed. In general, the major potential impacts are ground and surface water contamination and the "degradation" of large quantities of land. Because of continued use of coal as primary fossil fuel for power generation, the possibility of significant environmental impacts, both regionally and nationally, exist. Both Federal and privately-funded programs are developing additional data and information on disposal of FGD sludges and coal ash.

CHAPTER 8: MOVING AHEAD WITH INJECTING SODIUM SULFIDE Na_2S 39% AQUEOUS SOLUTION IN FLY ASH CONDITIONING SYSTEM

As mentioned in Chapter 5 item 5.6 above the use of 15 gallons per day aqueous sodium sulfide injection worked satisfactorily well in stabilizing the MSW residue ashes, it was decided to continue with carrying out further experiments with use of this chemical as part of this project.

A general molecular equation for reaction of aqueous sodium sulfide with trace metal, for example with a chloride compound of Cd, is given below:

$CdCl_2 + 2Na_2S_{(aq.)} \rightarrow CdS + 2NaCl_{(aq.)}$

A temporary set up consisting of a 55-gallon drum of aqueous sodium sulfide specially arranged for this purpose and a positive displacement variable speed chemical injection pump with a discharge capacity of 1 gal./hr mounted at the top of the drum was used. Four more tests were conducted using the same temporary set up and their results were added up to develop a table of summary results for one-tailed 90% confidence interval by Student's t-statistical method.

The results of leachability tests for Cd and Pb carried out during Feb.–March 2016 and a summary of these results from treatment of FGD and Fly ash residues with varying injection rates of 10 - 15 gallons per day aqueous sodium sulfide calculated as per students t-distribution is given in the table below.

Table 27 Results and Summary of 5 aqueous sodium sulfide treatment tests

Hampton/NASA Steam Plant

Summary of Test Results with injection of aqueous Sodium Sulfide 39% solution into the process water line to fly ash conditioning screw (March 2016)

			UCL: Upper Confidence Limit			July '13
			RT: Regulatory Threshold			Both blrs
						FF inlet
METAL		AVERAGE mg/L	UCL mg/L	RT mg/L	%RT	Temp. at
Arsenic	As	0.0320	0.0501	5	1.0%	**400°F**
Barium	Ba	0.7626	0.9266	100	0.9%	Continued
Cadmium	Cd	0.2328	0.3358	1	33.6%	
Chromium	Cr	0.0100	0.0142	5	0.3%	CY 15-16
Lead	Pb	0.2050	0.3233	5	6.5%	Both FF
Mercury	Hg	0.0002	0.0002	0.2	0.1%	Inlet Temp.
Selenium	Se	0.0324	0.0501	1	5.0%	**430°F**
Silver	Ag	0.0064	0.0100	5	0.2%	Ca. Hyd.
	5	Sample points for Cadmium and Lead				S.G. <1.03
	5	Sample points for all 8 metals				

Summary Results show that the Residue Ash does not exhibit Toxic Characteristics

Sample Point	Quarterly Sampl	Sample Date	As	Ba	Cd < 1	Cr	Pb < 5	Hg	Se	Ag	Extr. Fluid	Initial/End Pt pH
			Laboratory Test results for all 8 metals									
1	HSP 0216-SS1	2/3/16	0.005	0.730	0.444	0.012	0.214	0.0000	0.005	0.001	2	11.37 / 5.63
2	HSP 0216-SS2	2/11/16	0.050	0.440	0.079	0.010	0.050	0.0002	0.050	0.010	1	10.35 / 6.68
3	HSP 0216-SS3	2/19/16	0.050	0.869	0.220	0.017	0.440	0.0002	0.050	0.010	2	9.97 / 5.65
4	HSP 0216-SS4	2/23/16	0.050	1.050	0.141	0.010	0.263	0.0002	0.050	0.010	2	11.24 / 5.64
5	HSP-0316-SS5	3/3/16	0.005	0.724	0.280	0.001	0.058	0.0002	0.007	0.001	1	11.66 / 8.38

Source: Hampton Steam Plant data

The results of the study showed that leachability of all 8 heavy metals was controlled much within the EPA regulatory limit of each. The two generally hard to control heavy metals, e.g. Cd and Pb were controlled at 33.6% and 6.5% leachability limits, respectively.

The leachability control range of Cd (33.6%) and Pb (6.5%) compares very well with what had been achieved by use of dolomitic fine lime that had resulted in control of Cd at 34.1% and that of Pb at 18.1% of leachability limits from the results of 28 sample tests as shown in Table 18 above.

The resulting ash also meets the criteria for corrosivity (pH < 12.5) as well as for ignitability and reactivity. The liquid sulfide mixes with scrubber and APC system FA in very small w/w percentage (<0.1%) of ash to be treated and in a confined atmosphere of FA conditioning screw smoothly and without friction to be ignitable. It is released in so small quantities that it does not present any danger to human health and environment.

The liquid chemical has now been in use at the facility for long period of time and has not shown any of the above hazardous waste conditions.

After the use of aqueous sodium sulfide was proved successful in stabilization and treatment of MSW reside ash at Hampton/NASA Steam Plant a permanent set up with two TACMINA make PW series Solenoid-driven Diaphragm Metering pumps connected to the suction of a 165 gallon capacity container was established in April of 2016 at the facility. One pump was to be operated at a time with the other as standby.

The above results of the 5 tests conducted with treating the facility's residue ash with 15 gallons per day of aqueous sodium sulfide injection were conveyed to the State environmental regulatory authority informing facility's decision to henceforth convert to use of aqueous sodium sulfide for its residue ash treatment.

The regular use of aqueous sodium sulfide treatment was started on 5/11/2016.

A 1/2" stainless steel discharge pipe was laid out from the pump to fly ash conditioning screw outside. Warm boiler process water was mixed on the side of the chemical discharge line at the fly ash conditioning screw. The chemical and warm boiler process water mix and condition the fly ashes and make it into a slurry which is then conveyed by a rotating screw on to a vibrating conveyor which carries furnace bottom ashes by means an incline conveyor. The treated fly ashes and the bottom ashes following it are conveyed to an ash storage area as combined ash. Each aqueous sodium sulfide injection pump had a full load discharge capacity of over 150 gallon per day at the fly ash conditioning screw as set according to the stroke length and the frequency of the strokes per minute, up to a maximum of 300 strokes/min. A partial stroke frequency setting of 10 - 30 strokes/min gave the desired variation of 8 g/day - 40 g/day chemical discharge at the fly ash conditioning screw.

8.1 RESIDUE ASH CHARACTERIZATION TESTS AND ANALYSIS

In order to establish a general applicability of sodium sulfide treatment chemical several rounds of residue ash testing were planned that will replicate its effectiveness in all the running scenarios of boiler operating processes. These included, but not limited to, following:

1. Flue gas cleaning condition changes:
   These affect the SDA residues characteristics.
   a. Reagent specific gravity range: 1.01 - 1.03

b. SDA outlet (F. F. inlet) temperature range: 375^0 F - 430^0 F

2. Particulate (Fly Ash) collection system variables in Fabric Filters:
   a. All 3 modules in service
   b. Only 2 modules in service
3. Boiler running conditions:
   a. <u>One boiler shutdown</u>: Any time it is determined to shutdown a boiler, start collecting residue ash sample on hourly basis as soon as possible and complete 8-hour sample collection that will be kept for processing later and lab testing.
   b. <u>Boiler Startup</u>: At any time a boiler is starting up, start collecting ash sample as soon as possible after lighting fires, and complete 8-hr ash collection as above.
   c. <u>Both boilers shutting down</u>: At any time it is determined to shutdown both boilers for any reason, start collecting samples as soon as possible and complete as many hourly samples as ash is available and seen dropping from shaker pan.
   d. <u>Both boilers starting up at intervals</u>: Collect 8-hour sample soon after startup of the first boiler.

4. Sodium sulfide injection rate:
   a. At current injection rate: 15 g/day
   b. Range of Injection rate to be tested: 8 g/day – 40 g/day

5. Any other process variation and decided as warranted:
   a. Boiler steaming rate
   b. Boiler experiencing upset conditions

A 14-sample residue ash re-characterization schedule was planned with above multivariate conditions.

Samples were collected during various operating conditions of the boilers and at varying chemical injection rates. A total of 15 tests (one additional test over 14 initially planned) were conducted during the period 6/2/2016 through 6/29/2016.

The cumulative results of leachability of 8 heavy metals regulated by EPA obtained from these tests and analyzed using Student's t-distribution with 90% C.I. one-tailed are tabulated below.

Table 28 Summary of 15 aqueous sodium sulfide treatment tests

Summary of Test Results with injection of aqueous Sodium Sulfide 39% solution

Mixed with boiler process water injection to fly ash conditioning screw (June 2016)

UCL: Upper Confidence Limit

RT: Regulatory Threshold

METAL		AVERAGE mg/L	UCL mg/L	RT mg/L	%RT
Arsenic	As	0.0200	0.0277	5	0.6%
Barium	Ba	0.5568	0.6224	100	0.6%
Cadmium	Cd	0.2767	0.3710	1	37.1%
Chromium	Cr	0.0358	0.0575	5	1.1%
Lead	Pb	0.3951	0.6753	5	13.5%
Mercury	Hg	0.0036	0.0080	0.2	4.0%
Selenium	Se	0.0822	0.1055	1	10.5%
Silver	Ag	0.0100	0.0100	5	0.2%
	15	Sample points for Cadmium and Lead			
	15	Sample points for all 8 metals			
Summary Results show that Residue Ash does not exhibit Toxic Characteristics					

Source: Hampton Steam Plant data

The results of the individual tests are also included in the table below.

The results of the study involving 15 samples drawn at varying boiler operating conditions showed that leachability of all 8 heavy metals was controlled much within the EPA regulatory limit of each. The two generally hard to control heavy metals, e.g. Cd and Pb were controlled at 37.1 % and 13.5% leachability limits, respectively.

The leachability control range of Cd (37.1%) and Pb (13.5%) compares very well with what had been achieved by use of dolomitic fine lime that had resulted in control of Cd at 34.1%

and that of Pb at 18.1% of leachability limits from the results of 28 sample tests as shown in Table 18 above.

The results in both instances were analyzed by Students t-analysis at one-tailed 90 % confidence interval.

Table 29 Results of 15 aqueous sodium sulfide treatment tests

Sample	Sample No.	Sample Date	Laboratory Test results for all 8 metals									Initial pH /
			As	Ba	Cd < 1	Cr	Pb < 5	Hg	Se	Ag	Extr. Fluid	End Pt pH
1	HNSP-0616-SST1-	6/2/2016	0.005	0.250	0.028	0.010	0.050	0.0002	0.050	0.010	1	11.75 / 9.89
2	HNSP-0616-SST2	6/3/2016	0.050	0.463	0.110	0.010	0.050	0.0002	0.221	0.010	1	11.22 / 7.45
3	HNSP-0616-SST3	6/6/2016	0.050	0.557	0.136	0.010	0.065	0.0002	0.203	0.010	1	11.45 / 7.07
4	HNSP-0616-SST4	6/7/2016	0.050	0.473	0.067	0.010	0.050	0.0002	0.209	0.010	1	11.29 / 8.05
5	HNSP-0616-SST5	6/8/2016	0.005	0.478	0.368	0.010	0.152	0.0002	0.050	0.010	2	11.62 / 5.83
6	HNSP-0616-SST6	6/9/2016	0.005	0.602	0.137	0.010	0.050	0.0002	0.050	0.010	1	10.97 / 7.35
7	HNSP-0616-SST7	6/10/2016	0.005	0.364	0.005	0.010	0.050	0.0002	0.050	0.010	1	11.18 / 8.01
8	HNSP-0616-SST8	6/13/2016	0.005	0.250	0.065	0.010	0.050	0.0500	0.050	0.010	1	11.08 / 7.30
9	HNSP-0616-SST9	6/14/2016	0.005	0.704	0.373	0.173	1.350	0.0006	0.050	0.010	2	11.96 / 5.44
10	HNSP-0616-SST10	6/21/2016	0.005	0.810	0.460	0.202	3.040	0.0004	0.050	0.010	2	11.56 / 5.52
11	HNSP-0616-SST11	6/22/2016	0.050	0.580	0.636	0.010	0.214	0.0002	0.050	0.010	2	11.43 / 5.36
12	HNSP-0616-SST12	6/28/2016	0.005	0.535	1.010	0.020	0.241	0.0002	0.050	0.010	2	11.13 / 5.54
13	HNSP-0616-SST13	6/24/2016	0.005	0.827	0.335	0.032	0.403	0.0002	0.050	0.010	2	10.76 / 5.46
14	HNSP-0616-SST14	6/28/2016	0.005	0.845	0.253	0.010	0.112	0.0002	0.050	0.010	1	11.75 / 7.39
15	HNSP-0616-SST15	6/29/2016	0.050	0.614	0.167	0.010	0.050	0.0002	0.050	0.010	2	11.80 / 5.54

Source: Hampton Steam Plant data

All numerical values are leachability in mg/L as tested by EPA Method 1311

A pump setting of 15 strokes per minute adopted for three tests at serial number 2 to 4 above gave a nominal injection rate of 12.5 g/day at the discharge point of chemical at fly ash conditioning screw.

The results indicated a sustained control of both Cd and Pb within the permit limits, except that they include one outlier for leachability of Cd for the sample HNSP-0616-SST12 drawn on 6/28/2016 when the leaching of this trace metal was observed as 1.010 mg/L which is 1% over the EPA limit for this metal.

The results also include an uncharacteristic high result of Pb leaching at 3.040 mg/L as tested for sample HNSP-0616-SST10 drawn on 6/21/2016. Although it was well within the EPA leachability limit for this metal, but this trace metal was not quite often observed leaching at this high ppm value from the dozens of samples tested.

The consumption rate of aqueous sodium sulfide was estimated as below:

Injection rate at 15 strokes per minute:	12.5 g/day
Sp. Density of aqueous sodium sulfide:	1.12 – 1.13
Estimated chemical consumption rate:	120 lb/ day

Estimated percentage of chemical use for treatment of fly ash:

Fly ash generated from combustion of 240 tons/day MSW = 12 tons/day

Estimated % of chemical use for trace metal stabilization = 120 lb/24,000 lb ash

= <u>0.5% by weight of fly ash</u>

Total ash generated from combustion of 240 tpd of MSW = 80 tons/day

Estimated % of chemical use for treatment of total ash = 120 lb/160,000 lb ash per day

= <u>0.075% by weight of total ash</u>

These results again indicate the pH of the treated residue during all tests was below 12 and also proved non-hazardous in respect of ignitability and reactivity.

A regression analysis of these two metals without taking into account these outliers has also been carried out and is shown in the respective charts drawn below.

The linear and exponential regression models of these results are drawn below.

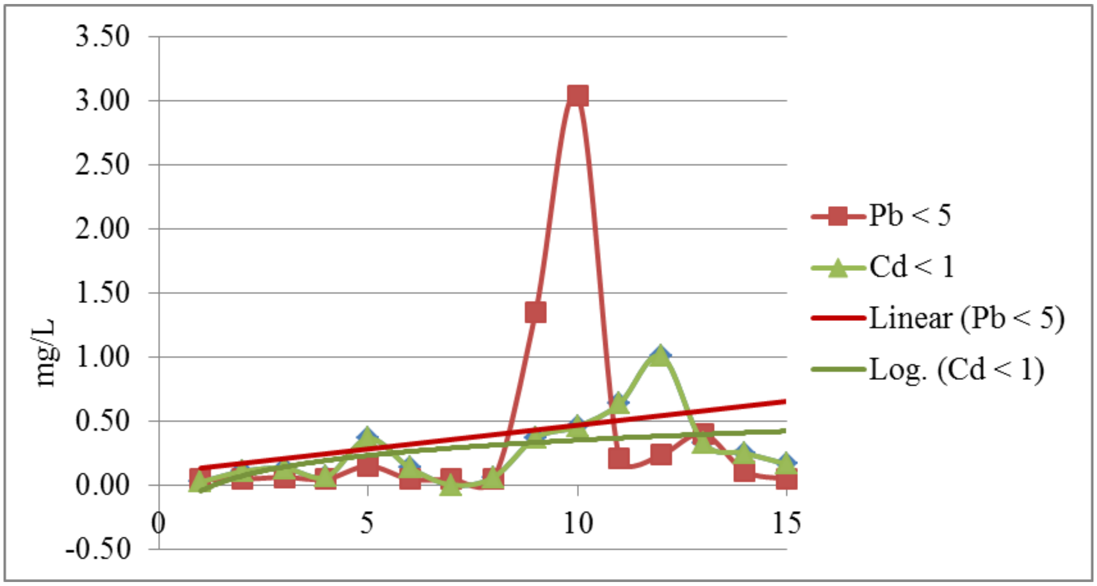


Figure 21 Logarithmic regression models for 15 values of Cd and Pb, drawn together

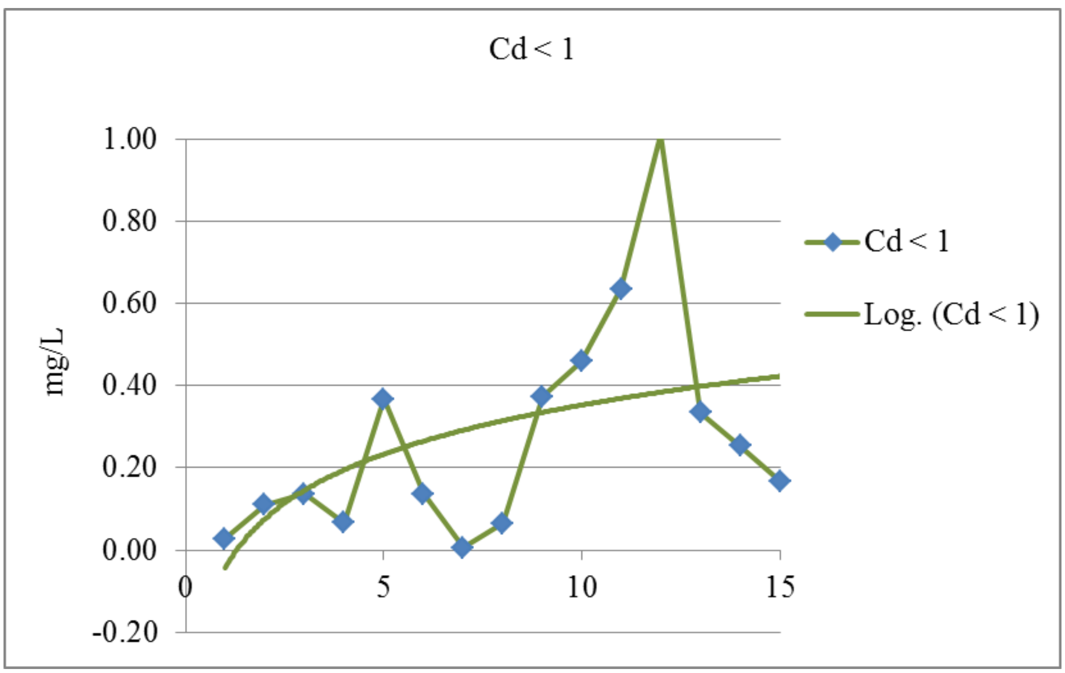


Figure 22 Logarithmic regression model for all 15 values of Cd only

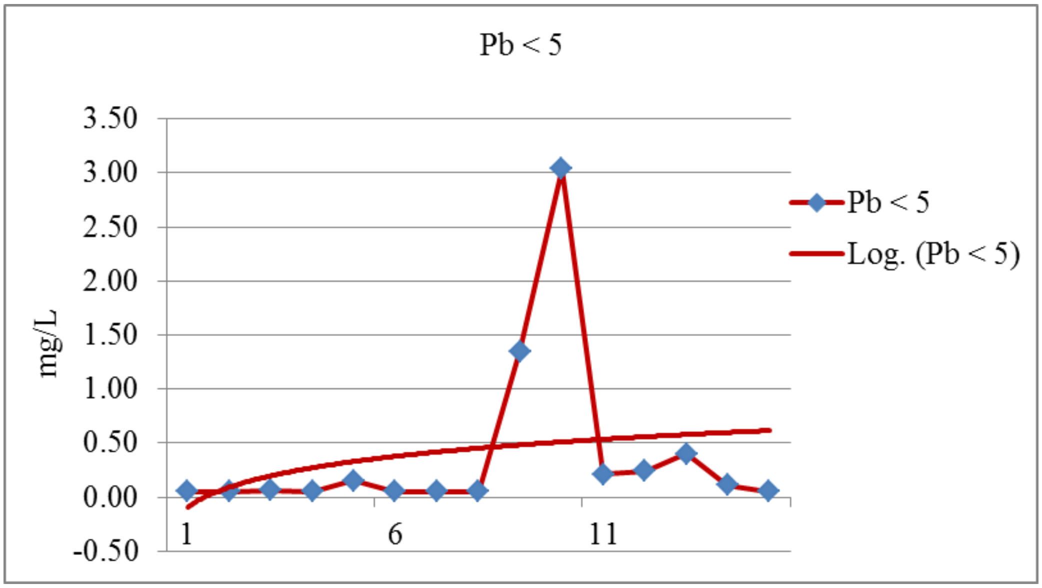


Figure 23 Logarithmic regression model for all 15 values of Pb only

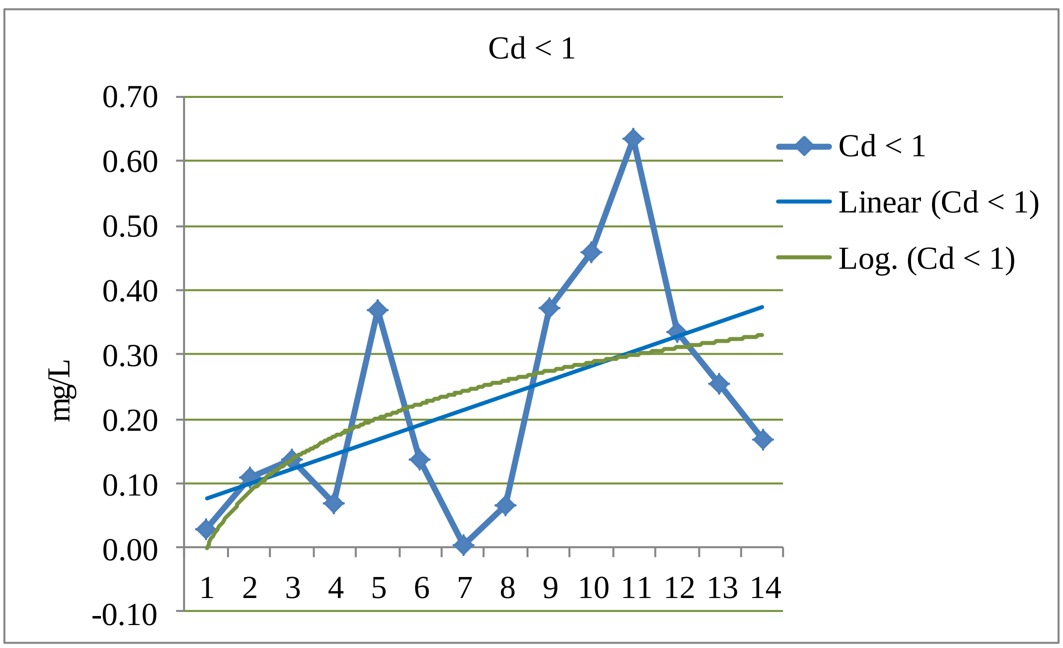


Figure 24 Linear and Logarithmic regression models for 14 values of Cd excluding outlier

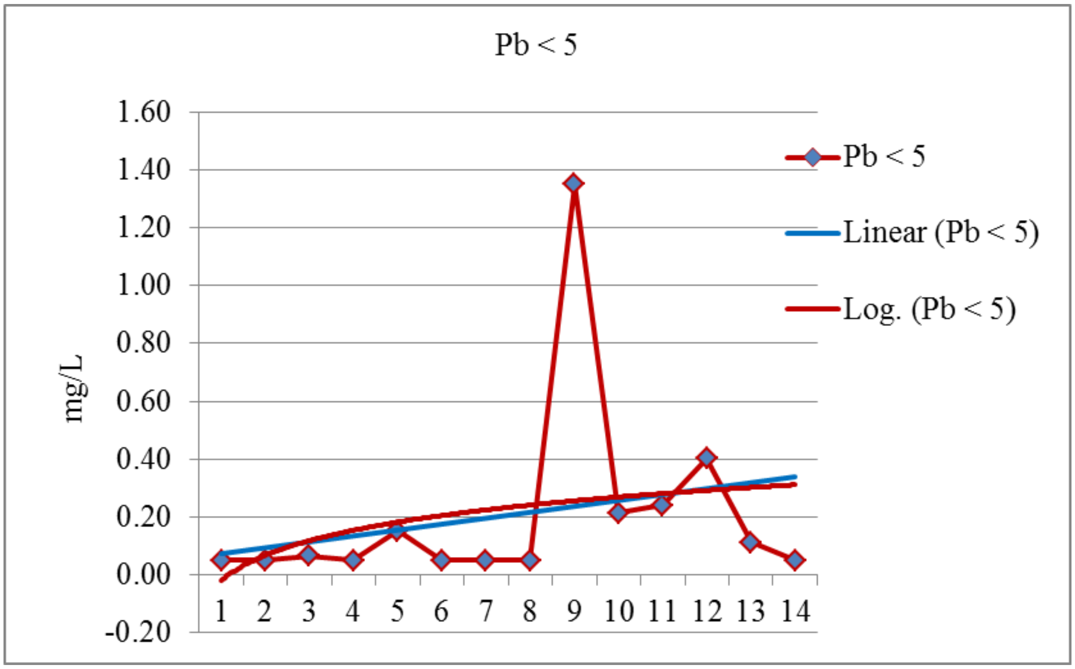


Figure 25 Linear and Logarithmic regression models for 14 values of Pb excluding outlier

Raw data and details of test results are included in Appendix E.

8.2 SETTING UP PERMANENT CHEMICAL INJECTION SYSTEM

Initially a small metering pump was mounted over a 55 gallon plastic drum containing the sodium sulfide aqueous solution as shipped by the vendor as shown below as a temporary experimental set up to start with trial treatment.

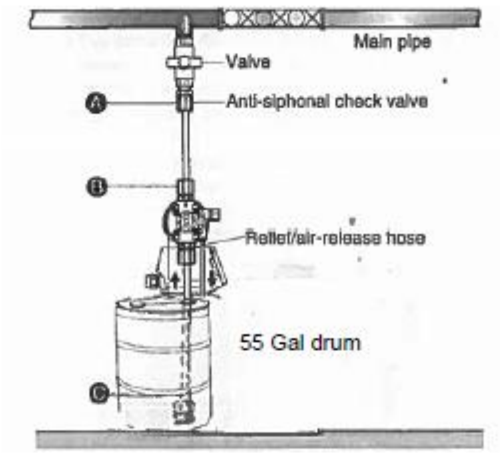


Figure 26 Temporary set up for liquid treatment chemical trials
Source: Hampton Steam Plant

A Check valve, B Discharge-side joint, C Foot valve

Five trial tests were conducted with this temporary set up. The treatment of FGD and Fly ash residues with varying injection rates of 10 - 15 g/day aqueous sodium sulfide solution proved positive in immobilizing the heavy metals in the combined residue ash when tested with TCLP method in all the five treatment trials runs.

After the trials with temporary chemical injection arrangement were successfully completed it was replaced with a permanent set up with TACMINA make PW series Solenoid-driven Diaphragm Metering pump connected to the suction of a 165 gallon capacity polyethylene tank in April of 2016.

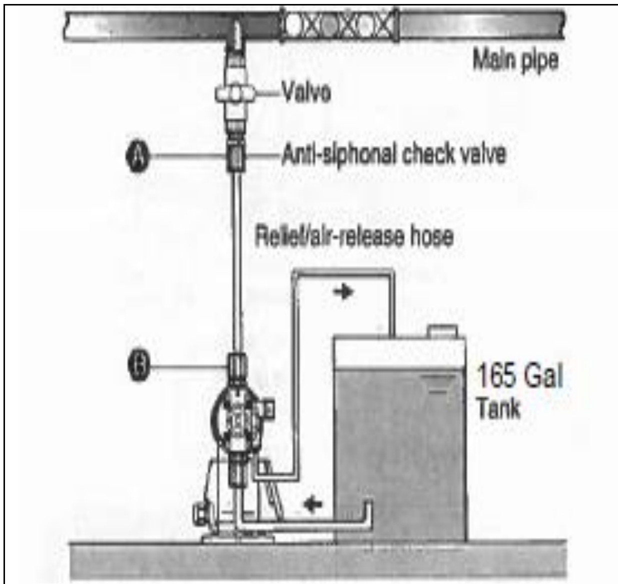


Figure 27 Diagram showing permanent chemical injection arrangement

Figure 28 Chemical System Installation at Hampton Plant

Figure 29 Technician checking the installation of chemical injection to fly ash

Figure 30 A parallel boiler hot process water injection is sent to fly ash

The maximum discharge capacity of the PW-30 R model used was 30 ml/min when set at 300 strokes/min and stroke length set at 100%. The range of setting varies from 0.1 - 300 strokes/min (max). The pump discharges obtained is a pulse type flow.

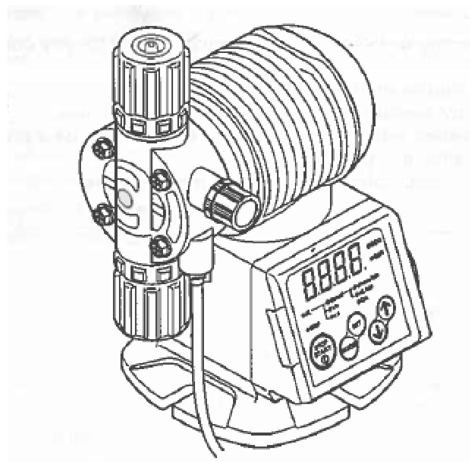


Figure 31   A PW series Standard pulsing type diaphragm metering pump

The injection rate was to be controlled using one of the following three available options:

1. Setting the discharge capacity by manual operation
2. Setting the discharge capacity by setting the stoke length
3. Controlling operation using signal input

A PWM series Analog-input type pump was chosen (option 2) and chemical flow was set by adjusting the strokes per minute rate keeping the stroke length at 100%. The numerical value of the stroke/min display can be done using the Up ↑ and Down ↓ arrows.

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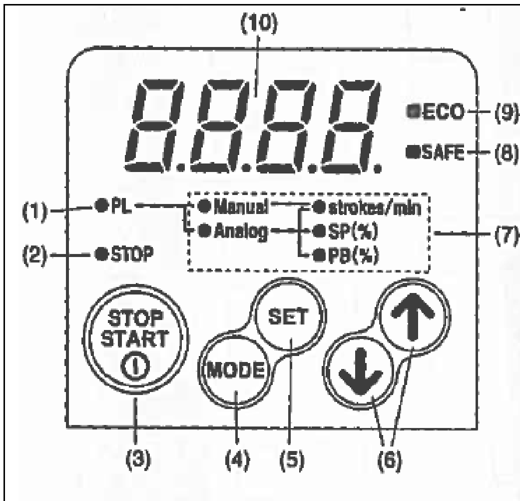
The product flow was first manually measured using a graduated measuring cylinder and setting the pulsing rate to random strokes per minute, e.g. 15, 20, or 25 while timing the pump's operation for a set number of minutes, say 5 minutes. The pumps discharge was thus calculated in ml/min, which could then be converted to gal/day rate. An average chemical flow rate in range of 10 to 15 g/day was targeted based on the experimental data that provided the successful immobilization of heavy metals in the facility's residue ash during full scale testing with both boilers operating at their full rated capacity.

A 15 strokes/min setting provided on an average a chemical flow rate of 33 ml/min which equals to 12.5 g/day when both boilers are in service. Several sets of measurements were done to verify the chemical flow rate per day.

It was also worked out that in case of only boiler in service a chemical discharge rate of 10gal/min was needed to satisfactorily immobilize the heavy metals in the residue ash resulting from the operation of a single boiler. This flow was achieved at the pump pulsing rate of 12 strokes/min, as against the setting of 15 strokes/min to obtain an injection rate of 12.5 g/day.

The control panel of the PWM series analog-input type pump used is show below.



PWM series pump operation

No.	Name	Function
(1)	PL Lamp	This lights while power is supplied
		During operation it blinks at timing of operation
(2)	STOP Lamp	This lights while the pump is shutdown
(3)	STOP/STAR	This is used to start or stop operation
(4)	MODE Key	This used to switch the operation mode
(5)	SEY Key	This is used to enter what has been set
		It is used to transfer from the mode display screen to the setting screens
(6)	↑↓ KEY	These are used to change the setting values
(7)	Mode display	The lamp alongside the now operating or now set mode lights
(8)	SAFE mode display	This lights when the SAFE mode setting is ON
(9)	ECO LAMP	This lights during operation that involves minimal power consumption. *This lights regardless of the ECO mode setting
(10)	DISPLAY	The setting values are displayed here.

Figure 32 PWM series analog-input pump

Two of such PWM series analog-input pumps were installed. One pump was to be operated at a time with the other was kept as standby.

The permanent sodium sulfide injection system as shown below was installed, tested and completed on 6/17/2016. Initially the chemical discharge from the pump was injected into the boiler process water line that carried the mixture of boiler water and sodium sulfide up to the discharge point at the conditioning screw.

Figure 33   Conducting pump trial settings

Figure 34   Measuring flows

The 15 characterization tests conducted during June 2016 simulated to a considerable extent the actual steam plant operating conditions and some of the tests included the periods when either one or both the boilers were shut down or were starting up.

Other test conditions varied during the 15 characterization tests included:

1. Fabric Filter inlet temperature
2. Fabric Filter modules in service: either all 3 or a pair of 1-2, 2-3, or 1-3
3. Reagent specific gravity: 1.0 to 1.2
4. SO_2 control parameters: 40 ppm to 60 ppm
5. Boilers' output rates were kept constant and steady steaming was ensured during the testing period. However, daily normal on-line cleaning operations of soot blowing made the boilers swing for short durations and thus simulated the normal boiler running conditions to a considerable extent.
6. Boiler upsets that included shutting down and starting up of one or both the boilers during the test period was managed to be included to simulate actual operating scenarios.

The following table includes the variations in operating conditions during that were managed during the 15 tests conducted between 6/1/2016 through 6/29/2016. The results of these 15 tests are shown in Table 30 below.

Table 30 Boilers' operating condition variations during 15 tests

Sl. No.	Test ID	Test Date	Fabric Filter Inlet Temp. ^{0}F	F.F. Modules in service	SO_2 control set point (ppm)	Reagent specific gravity	Sodium Sulfide injection rate (gal/d)	Boilers running/system status
1	HNSP-0616-SST1-A	6/2/016	375	All 3	50	1.02	12.5	Fly ash system maint.
2	HNSP-0616-SST 2	6/3/2016	400	All 3	40	1.02	12.5	Normal
3	HNSP-0616-SST 3	6/6/2016	430	1, 3	60	1.01	12.5	Normal
4	HNSP-0616-SST 4	6/7/2016	400	1,2	60	1.01	13.5	Normal
5	HNSP-0616-SST 5	6/8/2016	430	2,3	60	1.01	16.0	Normal
6	HNSP-0616-SST 6	6/9/2016	430	All 3	50	1.00	18.0	Normal
7	HNSP-0616-SST 7	6/10/2016	430	1,3	60	1.01	20.0	Normal
8	HNSP-0616-SST 8	6/13/2016	400	2,3	60	1.00	14.0	Normal
9	HNSP-0616-SST 9	6/14/2016	430	All 3	60	1.01	14.0	Normal
10	HNSP-0616-SST 10	6/21/2016	430	All 3	60	1.01	13.0	Both boilers in startup condition
11	HNSP-0616-SST 11-A	6/22/2016	430	All 3	60	1.01	10.0	Both boilers shutdown and startup quick
12	HNSP-0616-SST 12	6/28/2016	430	All 3	60	1.01	10.0	Both boilers in startup condition
13	HNSP-0616-SST 13	6/24/2016	430	All 3	60	1.01	10.0	Both boilers in startup condition
14	HNSP-0616-SST 14	6/28/2016	430	All 3	60	1.01	10.0	Normal
15	HNSP-0616-SST 15-A	6/29/2016	430	All 3	60	1.01	10.0	Normal

Later as an additional precaution and to ensure safe discharge of the measured chemical directly into the fly ash at conditioning screw, a separate dedicated stainless steel pipe line was run from the pumps directly to the fly ash conditioning screw.

Figure 35 Direct chemical injection in fly ash Figure 36 Loading of dolomite eliminated

After a separate dedicated chemical injection line was laid to directly discharge sodium sulfide chemical into the fly ash conditioning screw, 6 additional confirmatory tests beyond the 15 conducted and shown above were conducted during the month of July/August, 2016 keeping the boilers running at set process conditions without changing any control parameters.

The results of 6 confirmatory tests are reproduced below.

Table 31 Results of 6 confirmatory tests conducted during August 2016

Point	Sample No.	Sample Date	Laboratory Test results of all 8 heavy metals(mg/L)							
			As	Ba	Cd<1	Cr	Pb<5	Hg	Se	Aq
16	HNSP-0716-SST16	7/28/2016	0.050	0.550	0.420	0.010	0.095	0.0002	0.050	0.010
17	HNSP-0816-SST17	8/5/2016	0.050	0.429	0.906	0.010	0.245	0.000	0.0500	0.010
18	HNSP-0816-SST18	8/9/206	0.050	0.562	0.017	0.010	0.050	0.0002	0.050	0.010
19	HNSP-0816SST19A	8/17/2016	0.050	0.380	0.042	0.010	0.109	0.0002	0.050	0.010
20	HNSP-0816-SST20	8/25/2016	0.050	0.553	0.315	0.010	0.102	0.0002	0.202	0.010
21	HNSP-0816-SST21	8/28/2016	0.050	0.309	0.044	0.010	0.050	0.0002	0.050	0.010

The analysis of these final results with the boilers steady state running conditions and with an ensured supply of sodium sulfide treatment chemical through a direct discharge pipe line up to the fly ash conditioning screw indicate a firm and constantly reliable response of the chosen chemical to successfully immobilize the heavy metals in the MSW residue.

The table below shows the cumulative results of a total of 21 characterization tests and an improvement in control of leaching of Cd and Pb which is further dropped to 27.3% and 9.7% respectively of their regulatory limits against 37.1% and 13.6% leaching obtained after conducting 15 tests as shown in table 28 above.

These additional tests thus established a very safe and reliable control of leaching of heavy metals in MSW residue ash by the sodium sulfide treatment method even at very low injection rates.

Table 32 Cumulative results of 21 tests with sodium sulfide treatment: 8/2016

Hampton/NASA Steam Plant

Summary of Test Results with injection of aqueous Sodium Sulfide 39% solution

Mixed with boiler process water injection to fly ash conditioning screw (August 2016)

UCL: Upper Confidence Limit

RT: Regulatory Threshold

METAL		AVERAGE mg/L	UCL mg/L	RT mg/L	%RT
Arsenic	As	0.0143	0.0202	5	0.4%
Barium	Ba	0.3977	0.4852	100	0.5%
Cadmium	Cd	0.1976	0.2730	1	27.3%
Chromium	Cr	0.0256	0.0414	5	0.8%
Lead	Pb	0.2822	0.4842	5	9.7%
Mercury	Hg	0.0025	0.0057	0.2	2.8%
Selenium	Se	0.0587	0.0783	1	7.8%
Silver	Ag	0.0071	0.0085	5	0.2%

21 Sample points for Cadmium and Lead

21 Sample points for all 8 metals

Summary Results show that Residue Ash does not exhibit Toxic Characteristics

Source: Hampton Steam Plant data

The results of TCLP test results of two other MSW waste-to-energy plants, one from Covanta Fairfax, Virginia and the other Wheelabrator, Portsmouth, Virginia are included in Appendix F for comparison purposes.

8.3 COST SAVINGS, RELIABILITY AND EASE OF OPERATION

Use of aqueous sodium sulfide (at injection rate of 12.5 g/day) has resulted in following cost savings by switching over from dolomite treatment in cost of chemical and labor etc.:

A. Costs for chemicals + shipping and labor:

	Material costs/mo.	Labor/mo.	Total Costs/year
1. Dolomite	\$16,039.80	\$607.00	\$199,761.60
2. Sodium Sulfide	\$ 4,535.18	Nil	\$54,422.20
Savings in cost of chemicals and labor:			\$145,339.20/yr

B. Savings in maintenance costs (Est., $400/mo.)	$4,800/yr
Est. Total annual savings:	$150,139.20

Earlier research had resulted in replacing a proprietary chemical that was used since March 2005 to use of dolomite lime during November of 2008. The savings from changeover of chemicals at that time was estimated as $380,854/yr calculated at FY 09 rates. That had resulted in total savings of approximately $2.86 million during the 7 ½ years it had been kept replaced with dolomite.

Further research to find even a better and cheaper substitute for dolomite, during which 4 or 5 alternative chemicals and operating process adjustments were made, tried and tested for long enough periods of time before they had to be given up for lack of sustained good results, has now resulted in an easily injectable and environmentally safer substitute at much lower associated costs for stabilization of our combustion residues before their disposal to landfill. It has lesser chances of spills and lower footprint compared to use of dolomite.

The cumulative savings from these two changeovers in use of chemicals total over $530,000 per year.

CHAPTER 9: CONCLUSION

This study has determined the characteristics of residue ash from municipal solid waste mass burn waste-to-energy plants. The studies conducted by researching various experimental characterization and stabilization technologies for stabilization and rendering the residue ash non-hazardous for disposal to landfill and those observed and analyzed through the applied research designs at the Hampton facility have resulted in the following conclusions:

(1) The toxic heavy metals in the fly ash generated in the municipal solid waste combustion process are effectively stabilized by using any one of treatment chemicals: a proprietary chemical, dolomite, and sodium sulfide. Use of dolomitic lime had resulted in saving the Hampton facility $380,850 per year (at 2009 rates) since 2009.

(2) The boilers running conditions do not have any significant influence on the stabilization and control of leachability concentration below EPA limit of 1 ppm for Cd and limit of 5 ppm for Pb, as their probability values as obtained by statistical analysis was <0.05.

(3) Stabilization by use of sodium sulfide aqueous solution offers advantage over treatment of fly ash by dolomite in that it eliminates the manpower requirement to individually upload bags of dolomite which are currently being obtained from suppliers in 1 ton super sacks due to fact that no storage silo has been built so far to entertain bulk supplies. Changing over to liquid sodium sulfide treatment therefore results in savings in manpower deployment by the facility as well as result in operational ease of pumping a liquid solution to fly ash.

(4) Another effective treatment of fly ash is using complex agents such as Ethylene Diamine Tetra-acetic Acid disodium salt (EDTA). The cost comparison between dolomite and EDTA and also between sodium sulfide aqueous solution and EDAT has not been examined, but it is given that complex agents like EDTA are bound to cost much more than either of the other two treatment chemicals and will go against the very goal of this study, that is to find a cost-effective solution for fly ash treatment at the Hampton facility.

(5) The concentrations of heavy metals especially Cd and Pb in the fly ash collected in scrubber hopper after flue gas scrubbing and those precipitated in fabric filters bags have increased after modification of APC equipment to meet EPA's new emission guidelines. Very low concentrations of these two pollutants are found emitting through the stack flue gases as has been found out from the results of Hampton facility's annual stack emission tests during last 8 or 9 years.

(6) Toxic heavy metals Cd and Pb bind themselves less with the finer particles in fly ash as compared to binding with courser ash particles of the bottom ash. The immobilization of Cd and Pb in finer fly ash particles therefore requires additional stabilization products.

(7) The heavy metal studies in municipal waste combustion ash indicate that their behavior is pH dependent. It has been found that the final pH of ash suspension during TCPL testing affects the behavior of retention or release of Cd and Pb and is dependent upon the initial pH of the solution, the alkalinity, and the buffer capacity of the ash.

The strong acidic fluid used during TCLP testing weighing twenty times the weight of ash sample and then tumbled for eighteen hours to simulate the long term landfill disposal conditions has either pH of 4.93 (Fluid 1) or a pH of 2.88 (Fluid 2). As the pH is based on logarithmic scale, Fluid 2 is more than 100 times acidic than Fluid 1 and is called for the residues that contain significant caustic buffers. Determination of which TCLP fluid to use for a non-homogeneous waste like MWC residue ash is very critical toxicity leachate testing.

(8) Over the course of finding a cost-effective treatment for stabilization of residue ash the Hampton facility has affected substantial savings in water usage, energy consumption, and cost-of-lime usage by switching over to dolomite fines and it can expect further cost savings are expected by using sodium sulfide aqueous solution treatment by carrying out flue gas scrubbing at elevated temperatures of up to 430^0 F to continue with savings in water usage.

(9) The MWC residue ash form mass burn facility at Hampton is very heterogeneous and can be used as soil cover material in landfill as the metals and overs from the residue ash are separated during post-combustion process. The facility's residue ash is not suitable for

disposal or utilization for road pavement or as a mixing agent with construction material. Residues from Refuse Derived Fuel (RDF) plants however may be found advantageous for such usage after a combination of chemical treatment or stabilization with traditional cement or asphalt solidification as suggested in some studies.

(10) The results of this study can be replicated in other mass burn facilities after testing and validation as they would apply for large mass burn facility-specific residues as the current study was carried out for a very small Class II (less than 250 tons per day) facility at Hampton.

CHAPTER 10: RECOMMENDATIONS

The following recommendations for further work on this topic are made:

(1) It may be possible to reduce the current injection rate of 12 gal./day of sodium sulfide aqueous solution for treatment of residue ash by further experimentation. The amount of chemical injection may need to be tweaked in to obtain repeatability and good control of heavy metal leachability. For example, in case the facility is running at reduced boiler loads resulting in reduction in tonnage of residue ash generated, or in the case of one boiler being shut down for repairs, the chemical injection rate can be modulated or reduced to match with the reduced ash loads.

(2) In case for some reason, although very unlikely, use dolomite is chosen as an alternative to sodium sulfide injection for residue ash treatment some reduction in current injection rate of 2% by weight of fly ash may be achievable with acceptable results.

(3) In place of current use of high calcium hydrated lime slurry in the countercurrent spray tower, either a Magnesium-Enhanced Lime (MEL) with an estimated concentration of 5-8 percent magnesium oxide, or dolomitic lime which is normally 20 percent magnesium oxide, may be used with better results, both for acid absorption in flue gases and as a pH binder in fly ash collected from air pollution control (APC) equipment as it is able to achieve high SO_2 removal efficiencies in significantly smaller absorber towers. This product is also recommended for further studies as an alternative to the in-line dolomitic lime injection treatment of combustion fly ash.

(4) In the beginning the solid waste incineration residues were used in construction material and soil conditioner, and now with increased awareness of their hazardous nature and more environmental concerns, these are being treated with more care and then properly disposed of in landfills. Experiments are being conducted and processes are being developed in order to extract precious resources like iron, aluminum, copper, zinc and other metals from these residues. Research in this area should be encouraged so that waste incineration is used both for utilizing its energy potential as well as for recycling metals.

(5) It has been generally agreed that the proportion of mass transfer partitioning of metals in flue gases and those in bottom and APC ashes is not affected by variations in waste input and operating conditions. With rapid advances being used to improve the energy efficiency during MSW combustion in recent years, it is difficult to gather enough information that can throw light on the exact physical and chemical processes taking place in modern state-of-the art municipal solid waste incinerators. Further research on this will improve our knowledge on the effects of varying operating conditions on partitioning of metal in different waste streams and will be useful both for their effective control as well as for their future reuse.

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APPENDICES

APPENDIX A

TCLP METHOD 1311

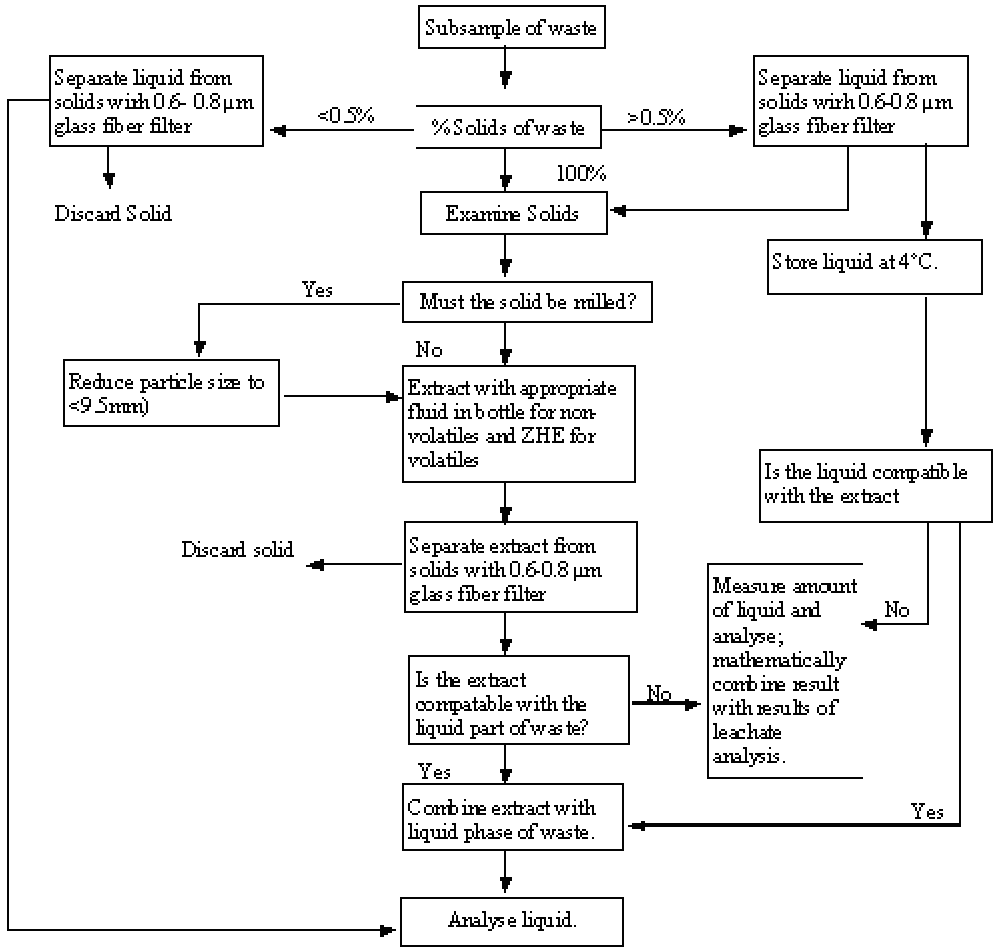
TOXICITY CHARACTERISTIC LEACHING PROCEDURE

EPA has published Toxic Procedure Leaching Procedure (TCLP) Guidance Foe the Sampling and Analysis of Municipal Waste Combustion Ash for the Toxicity Characteristic (TC).

EPA Publication Number 530-R-95-036 of July 1995 provides the purpose, sampling approach and analysis method. The MSW combustion residue is tumbled with twenty times its weight of a strong acid for eighteen hours to simulate long term disposal in a landfill. The extraction fluid used normally is anhydrous acetic or nitric acid with either a pH of 4.93 (called Fluid 1) or a pH of 2.88 (called Fluid 2), depending on the initial pH of the extracted residue.

Highly acidic Fluid 2 is used for wastes containing high levels of caustic buffers.

The following flow diagram provides the steps used in TCLP analysis.


Subsample of waste
% Solids of waste
<0.5%
>0.5%
100%
Separate liquid from solids wirh 0.6- 0.8 µm glass fiber filter
Discard Solid
Separate liquid from solids wirh 0.6-0.8 µm glass fiber filter
Examine Solids
Store liquid at 4°C.
Must the solid be milled?
Yes
No
Reduce particle size to <9.5mm)
Extract with appropriate fluid in bottle for non-volatiles and ZHE for volatiles
Is the liquid compatible with the extract
Discard solid
Separate extract from solids with 0.6-0.8 µm glass fiber filter
Measure amount of liquid and analyse; mathematically combine result with results of leachate analysis.
No
Is the extract compatable with the liquid part of waste?
No
Yes
Combine extract with liquid phase of waste.
Yes
Analyse liquid.

APPENDIX B

STANDARD PROCEDURE FOR COLLECTION OF RESIDUE ASH SAMPLES

SOLID WASTE MANUAL # SW 297

HAMPTON/NASA STEAM MPLANT

Residue Ash Testing Protocol

Residue ash generated at the Facility has consistently shown not to be toxic when tested by the Toxic Characteristic Leaching Procedure. Testing protocol includes full characterization and re-characterization four times annually with a single eight hour composite tested for the eight TCLP metals. Quarterly samples will be tested for the eight metals listed in Table 3.2 of the Virginia Hazardous Waste Management Regulations. Testing is done on the combined residue ash only. Results will be evaluated statistically using the Student's T normal distribution. Results will be reported to DEQ Tidewater Waste Office, within ninety (90) days of sampling with the following information.

1) Date and place of sampling and analysis
2) The names of individuals doing the sampling and analysis
3) Copy of the completed "Chain of Custody" form
4) Sampling and analytic methods used
5) Results of the analysis
6) Statistical analysis of results and historical data
7) Certification signed by the Steam Plant Manager

Residue Ash Characterization

The waste must demonstrate non-hazardous characteristics to be disposed of as solid waste in accordance with Subtitle D standards. The initial testing will be fourteen samples done over at least a seven (7) day period. Each day samples will be gathered and prepared by the procedures of Method HSP-3A. The test results will be evaluated using a Student's T distribution at a 90% confidence interval, one tailed. Student's T distribution is for samples that are small compared to the amount of material being tested, and is specifically designated in the TC Rule.

If the upper bound of the confidence interval is above the regulatory threshold for any substance listed in the Hazardous Waste Management Regulations 40CFR 261.24, Table 1, then the waste fails the toxicity characteristic. Two of the initial fourteen samples will be tested for all species found in the Hazardous Waste Management Regulations40CFR 261.24, Table 1. The others will be tested for metals only: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.

Method HSP-3A: Residue Ash Composite Sample

The purpose of this method is to obtain a residue ash sample that is truly representative of the mass of waste disposed during that twenty-four hour period. All residue ash samples will be obtained by quartering and weighing, and then will be reduced in sized to two inches or smaller. A twenty pound three component mass proportioned sample will be prepared for analysis. The sample will be delivered under chain of custody to the analytical laboratory. At the laboratory the sample components will be reduced to three eights of an inch or less. The sub-sample components will then be recombined into a one kilogram mass proportion sample. A Toxic Characteristic Leaching Procedure (TCLP) will then be done on the sample in accordance with SW-846 Method 1311 procedures.

Sampling Equipment:

2 1 and 5 gallon plastic buckets with covers and 1 quart zip lock bags.

4 Heavy duty foxtail dust brushes, brooms, and shovels.

2 Wheelbarrows with 2" grid screen box

6 ½ cubic yard bins for weighing

1 Platform scale {+/-1 lb.}

* Gloves, dust masks, disposable coveralls, plastic bags

* Hammers, shears, and saws

Gathering the Sample:

A sample will be gathered over a six hour period while residue ash is being loaded that was generated over the previous twenty-four hours. Each random grab sample will be one half front load bucket of residue taken from each truck being loaded, set into a sample pile, and then covered. The grab will be flattered then quartered. A single quarter will be selected by random coin toss, and that would then be mixed, flattened and quartered. One quarter will be selected for the sample processing. A second quarter would be used for a second distinct sample if needed, but only a single quality sample is needed. As an alternate samples can be grabbed as per Method HSP-5A.

Initial Sample Preparation:

Quality assurance procedures will be followed to ensure a true mass proportioned sample is prepared for testing.

1) Separate all materials by passing through a two inch screen. Large residue components will be segregated into metal and combustibles. All aggregate will be swept off the late pieces back into the aggregate sample.
2) Weigh all sample components in plastic bins with the platform scale. Measure weight to the half-pound and record on a residue sample record sheet.
3) Calculate the mass proportion of the residue ash sample in percent aggregate, percent metal and percent unburns.

4) Take some of the unburns and metal and reduce its size to two inch or less for the sample. Reduce to two inch or less by the following methods.

   a) Five pound hammer from a height of twelve inches.

   b) Scissors for unburned paper or plastic.

   c) Shears for sheet metal and bimetallic cans.

   d) Saws for scrap metal (Collect all shavings and add to the aggregate).

5) Document the weight and description of any material removed from sample.

6) Prepare two 20 pounds composite samples as follows:

   a) Calculate pounds required for a mass proportioned sample by multiplying the component proportion decimal by twenty pounds.

   b) Mix, quarter, and then weigh with the scale to get a representative mass proportioned sample of residue ash aggregate.

   c) Put the residue ash aggregate into a clean five gallon container.

   d) Weigh to get representative sub-samples of the metal and unburns.

   e) Put the metal and the unburns sub-samples in a zip lock bag.

   f) Put both sub-sample containers in the five gallon bucket, cover, and seal with forensic tape.

7) Alternative "aggregate only" samples can be directed for samples. Discard all oversized metal and unburns. Mix, quarter and weigh out two twenty pound samples. One will be analyzed and the other archived.

8) Document data and calculations. Initiate chain of custody form and secure the sample. One or two samples will be prepared and analyzed; one quality sample will be prepared and archived.

Analysis:

Analysis will be done in accordance with the procedures prescribed in EPA SW-846, Method 1311, and the Toxic Characteristic Leaching Procedure. Analysis may be done for eight metals, or for all species found in Table 3.2 of the Virginia Hazardous Waste Management Regulations. Results will be evaluated by the methods of EPA SW-846 and applicable Virginia regulations. Archived samples will be used to repeat and quality check. Results will be evaluated statistically in accordance with the methods outlined in Tables 9.1 and 9.2 of EPA SW-846, Test Methods for Evaluating Solid Waste.

Quality Assurance Plan:

One team member will be designated as the Quality Leader. All container weights, scale operation, sample weight data, and quarter selection will be performed by the Quality Leader. The Steam Plant Engineer will monitor sampling and provide on-site verification of data and calculations. Quality points are specific tasks during the sampling that small errors can cause large procedure bias (see Table IV). These tasks must be given extensive effort, oversight, and review. Specific problems with any quality point should be documented by the Quality Leader. The sampling team will review and discuss quality points prior to testing.

TABLE IV: Residue Ash Sampling Quality Points	
QUALITY POINT	QUALITY CONTROL
Grab Samples	The Quality Leader shall not look at the residue before signaling to grab from that front loader bucket. Buckets to be grabbed will be determined by random number.
Weighing	Each container must have an accurate known empty weight. Place sample bin square and center to the scale platform. Double check all calculations for net weight. Ensure scale platform remains clean. Quality Weights should be taken after sample preparation to detect any errors.
Precision Weighing	Daily checks with calibrated weights shall be performed and documented. When using the precision balance round and document weights to the half milligram. Document empty weights of beakers and filter media. Operate the equipment as per the manufacturer's instructions.
Screening	Pay special attention during screening to prevent any loss of material or intentional segregation.
Size Reduction to < 2 inch	First attempt reducing with blows of the hammer. Unburnt paper can be cut with scissors. Sheet metal can be sheared and hammered. Dry cell batteries should be hammered then sawed. All saw shavings must be recovered and added to the aggregate. Reduction must be done in a clean area. All sample material must be collected and weighed.
Size Reduction to 3/8 inch	Size reduction may be done with the methods described above, or a laboratory hammer mill or similar device may be used.
Calculations	Double check calculations. Utilize spreadsheets as practical. All calculations shall be documented for further review.
Wet Trench	Wet trench floaters or other conditions can cause residue ash sample errors. Maintain trench water pH between 8 and 9.
Sample Security	The custodian must at all times maintain control over the sample by locking, securing cover, sealing with forensic tape or by other measures to ensure the sample integrity.

Quality assurance can be maintained only if the integrity of the sample is protected. The residue ash sample Chain of Custody must be documented. At all times the custodian must have the sample secured and under complete control. At any time if the custodian cannot assure the custody and integrity of the sample, it will be invalidated and discarded.

Contract laboratories must be a Virginia certified lab and have a full quality assurance program in accordance with guidelines in SW-846 and ASTM Standards. Analysis methods, data, calculations, and results must have quality assurance review and certification.

Periodically an archived sample will be submitted to the laboratory or to a third party laboratory for quality comparisons. Archived samples will be retained until all results are received and analyzed. However, archived samples will not be analyzed for any species unless the holding times listed in Table V can be met.

TABLE V: SAMPLE MAXIMUM HOLDING TIME (days)				
	From: Field Collection To: TCLP Extraction	From: TCLP Extraction To: Prep Extraction	From: Prep Extraction To: Analysis	Total Elapsed Time
Volatiles	14	NA	14	28
Semi-Volatiles	14	7	40	61
Mercury	28	NA	28	56
Metals	180	NA	180	360

Corrective Action

In the event a single quarterly test result was not characteristic of the results of previous testing the quality control sample would be analyzed. The numerical average of the two samples would be considered the sample test results.

The Steam Plant Manager, or his designee, may prescribe corrective action to ensure the sample is representative of the residue mass being disposed. Any corrective action must be completely documented and reported. Corrective Action may include, but is not limited to the following:

1) Repeating the residue sampling.
2) Testing the archived sample to get an average test result.
3) Invalidate any or all samples due to uncertainties caused by facility operating problems, the testing procedure, or a broken chain of custody.

APPENDIX C

HAMPTON STEAM PLANT AUTHORIZATION LETTER FOR USE OF FACILITY DATA FOR THIS STUDY

Sandeep Kumar, Ph.D.
Assistant Professor
Department of Civil & Environmental Engineering
Kaufman Hall, Room 137C, Old Dominion University
Norfolk, VA 23529-0241

27 May 2016

Dr. Kumar,

I understand that Anil Mehrotra, the Plant Engineer here at the Hampton/NASA Steam Plant, is pursuing his Doctorate in Engineering. Your e-mail of 11 May reports that his topic revolves around 'INERTIZATION, UTILIZATION, AND SAFE DISPOSAL OF INCINERATION RESIDUES' and you asked whether he could use the data he collected from the Steam Plant in his dissertation. The Steam Plant commissioned him, and your team, to discover a suitable alternative to the second residue ash treatment of dolomitic lime in Project #200198-010. Further, the Steam Plant assisted with his studies via an education assistance subsidy. With that in mind, and considering we are a public entity seeking a solution to save public funds, I think it is wholly proper for him to use the data he so diligently collected to aid his academic advancement and maximize that investment.

Please let me know if your office requires any further documentation and thank you for your work so far.

Sincerely,

John MacDonald
Plant Manager
Hampton/NASA Steam Plant

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

APPENDIX D

RAW DATA: DOLOMITE TREATMENT METHOD

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Hampton/NASA Steam Plant

Summary of Quarterly Test Results since 2009

Table includes residue ash tests results ending 12/2016

UCL: Upper Confidence Limit
RT: Regulatory Threshold

METAL		AVERAGE mg/L	UCL mg/L	RT mg/L	%RT
Arsenic	As	0.0165	0.0218	5	0.4%
Barium	Ba	0.0136	0.0313	100	0.0%
Cadmium	Cd	0.3310	0.3850	1	38.5%
Chromium	Cr	0.0544	0.0804	5	1.6%
Lead	Pb	0.5419	0.8065	5	16.1%
Mercury	Hg	0.0028	0.0033	0.2	1.7%
Selenium	Se	0.0113	0.0148	1	1.5%
Silver	Ag	0.0022	0.0029	5	0.1%
	32	Sample points for all 8 metals			

Summary Results show that the Residue Ash does not exhibit Toxic Characteristics

Results of 32 Residue Sample Tests with dolomite lime treatment

1/2009 – 12/2016

Sample Pt	Quarterly Sample	Sample Date	Laboratory Test results for all 8 metals							
CY 09 Qrtly			As	Ba	Cd	Cr	Pb	Hg	Se	Ag
1	HSP 0209-Q1A	02/27/09	0.005	0.542	0.072	0.001	0.0050	0.005	0.007	0.003
2	HSP 0409-Q2	04/07/09	0.005	1.08	0.002	0.001	0.0050	0.005	0.008	0.001
3	*HSP 0809-Q3*	*08/21/09*	0.005	1.08	0.324	0.006	0.1640	0.005	0.005	0.001
4	HSP 1109-Q4	11/10/09	0.005	0.786	0.016	0.001	0.0080	0.005	0.005	0.001
CY 10 Qrtly										
5	HSP 0110-Q1	01/15/10	0.005	0.638	0.032	0.001	0.0050	0.005	0.005	0.001
6	HSP 0510-Q2	05/13/10	0.005	0.537	0.213	0.001	0.0050	0.005	0.009	0.001
7	HSP 0910-Q3	09/10/10	0.005	0.475	0.081	0.001	0.0080	0.005	0.005	0.001
8	*HSP 1210-Q4/4A*	*12/28/10*	0.005	0.825	0.991	0.001	2.6200	0.005	0.012	0.001
CY 11 Qrtly										
9	HSP 0211-Q1A	02/18/11	0.005	0.56	0.005	0.001	0.0050	0.005	0.005	0.001
10	HSP 0511-Q2	05/13/11	0.005	0.797	0.271	0.001	0.0120	0.005	0.005	0.001
11	*HSP 0711-Q3*	*07/21/11*	0.1	0.991	0.368	0.177	2.0500	0.005	0.005	0.001
12	HSP 1111-Q4	11/29/11	0.005	0.565	0.155	0.001	0.0080	0.005	0.006	0.001
CY 12 Qrtly										
13	HSP 0312-Q1	03/08/12	0.005	0.819	0.186	0.001	0.0130	0.005	0.005	0.001
14	HSP 0512-Q2	5/11/2012	0.005	0.810	0.380	0.001	0.0430	0.005	0.005	0.001
15	HSP 0712-Q3	7/26/2012	0.0050	0.8790	0.0005	0.0010	0.0050	0.0050	0.0050	0.0010
16	*HSP 1112-Q4*	*11/30/2012*	0.0110	1.7100	0.8364	0.0940	1.6300	0.0050	0.0050	0.0010
CY 13 Qrtly										
17	HSP 0213-Q1	2/22/2013	0.0050	0.8020	0.4610	0.0080	0.0850	0.0050	0.0050	0.0010
18	HSP 0513-Q2	5/21/2013	0.0510	1.3000	0.5117	0.4290	4.2900	0.0002	0.0050	0.0010
19	HSP 0813-Q3	8/21/2013	0.0050	0.8860	0.2498	0.0010	0.0850	0.0002	0.0050	0.0010
20	HSP 1013-Q4	12/3/2013	0.0160	1.1200	0.4670	0.1030	2.2100	0.0005	0.0005	0.0010
CY 14 Qrtly										
21	HSP 0314-Q1	3/13/2014	0.0060	0.6940	0.0005	0.0030	0.0160	0.0002	0.0050	0.0010
22	HSP 0614-Q2	6/5/2014	0.0050	0.7700	0.5185	0.0010	0.0210	0.0004	0.0070	0.0010
23	HSP 0814-Q3	8/20/2014	0.0050	0.7630	0.0094	0.0010	0.0050	0.0002	0.0100	0.0010
24	HSP 1114-Q4	11/20/2014	0.0050	0.5100	0.4983	0.0010	0.0050	0.0002	0.0050	0.0010
CY 15 Qrtly										
25	HSP 0215-Q1	2/12/2015	0.0350	0.4910	0.7616	0.2940	3.5500	0.0002	0.0060	0.0020
26	HSP 0615-Q2	6/16/2015	0.0050	0.6500	0.1947	0.0010	0.0050	0.0002	0.0060	0.0010
27	HSP 0915-Q3	9/24/2015	0.0050	0.6690	1.0200	0.0190	0.4770	0.0002	0.0050	0.0010
28	HSP 1215-Q4	12/9/2015	0.0050	0.4340	0.0505	0.0010	0.0050	0.0002	0.0050	0.0010
CY 16 Qrtly										
29	HSP 0316-Q1	3/10/2016	0.0500	0.5360	0.8600	0.2460	2.3800	0.0006	0.0500	0.0100
30	HSP 0516-Q2	5/17/2016	0.0500	0.5760	0.2090	0.0100	0.0500	0.0002	0.0500	0.0100
31	HSP 0816-Q3	8/17/2016	0.0500	0.3800	0.0420	0.0100	0.1090	0.0002	0.0500	0.0100
32	HSP 1116-Q4	12/7/2016	0.0500	0.5940	0.8070	0.3220	3.3200	0.0000	0.0500	0.0100

APPENDIX E

RAW DATA: SODIUM SULFIDE TREATMENT METHOD

June 2016 – August 2016

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0616–SST1

Sample Collection: Wed June 1, 2016
QA Sample Preparation: Thu June 2, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 09:00 AM on Wed. June 1, 2016 & will continue until 0400 PM Wed. June 1, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Wed. June 1:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting: 09:00 AM — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending: 16:00 PM — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

*

Test Day Control Parameters			
Reagent Specific Gravity	1.02	SO_2 Control	50 ppm
Fabric Filter Inlet Temp.	375°F	FF Modules on	All 3
Boilers steam rate	33 pph	Sodium Sulfide rate	125 g/day
Boilers running condition		Any important change	

Remarks: MAINT MADE REPAIRS TO INCLINE CONVEYOR
0923-1035 MAINT REPAIRED 4 Flights AND 2 ATTACHMENT

Thu. June 2

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample. Follow QA and Chain of Custody procedures.

Thank you,

Anil Mehrotra
Plant Engineer

* make these changes on 5/31 (Tue) morning

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/15/2016 TIME: 1215
GRAB COLLECTION
DATE: 6/2/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - TL
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-10591 14:19

3755 12.5 gpt
All 3 wells

SAMPLE ID: HSP-0616-SST1A
SAMPLE NO 16-10591

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/17/16	1105
Barium	D005	6010C	0.250	100	< 0.250	mg/L	PEJ	06/17/16	1105
Cadmium	D006	6010C	0.005	1	0.028	mg/L	PEJ	06/17/16	1105
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	06/17/16	1105
Lead	D008	6010C	0.050	5	< 0.050	mg/L	PEJ	06/17/16	1105
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/17/16	1158
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/17/16	1105
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/17/16	1105

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

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The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.75
Extraction Fluid used: #1
Final (end point) pH of Extraction Fluid: 9.89

Authorized By: Elaine Claiborne
Elaine Claiborne, Laboratory Director
Date: 17-Jun-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

ANALYSIS SAMPLE
CHAIN OF CUSTODY

375°F
5 std

SAMPLE NUMBER: HSP-0616-SST 1A

MATERIAL: RESIDUE ASH

SAMPLE PREPARED BY: Leonard

METHOD: HSP-3A

16-10591

CUSTODIAN	FROM		TO	
Bill Leonard	2 June 16	0700	2 June 16	0930
	6/2/16	0930	15 June 16	1150
June Green	6/15/16	1150	6/15/16	~~1250~~ (A) 1215

061516

Q. A. Weight: 22.5 lb.

(A) Test: TCLP- All metals

Reviewed By: Accepted

Date: 6/17/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records Page 1

SAMPLE # HSP-0616-SST1 | Sample Date: 6/2/16 | Method Used: HSP 3A

Sample Certified Valid: 6/17/16 Anil Melwani, MS, PE

GRAB	1	2	3	4	5	6	7	8
Time	0907	1003	1106	1207	1300	1406	1507	1603
Initials	YDD	YDD	RB	RB	YDB	YDD	RB	RB
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
1.	~~44 ½~~ MB	15.	40 ½	**Unburnt Combustibles**
2.	21 ½	16.	41 ½	1. 44 ½
3.	27	17.	35	2. 36 ½
4.	28	18.	38 ½	3. 46 ½
5.	25 ½	19.	35	4. 49 ½
6.	~~21~~ 31	20.	28 ½	5. 17 ½
7.	41 ½	21.		6. 62 ½
8.	47	22.		**Unburnable (Metal)**
9.	52 ½	23.		1. 17 ½
10.	56 ½	24.		2.
11.	57 ½	25.		3.
12.	46 ½	26.		4.
13.	49 ½	27.		5.
14.	39 ½	28.		6.

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0616-SST 1

Wet Trench pH: 8.9 | Boilers Operating: 1, 2 | Weather: Cloudy/Misty

Chemical Treatment/ Injection Rate: 12.5 gals a day

Comments:

Reagent Spec Grav. 1.02
Fabric Filter inlet 375
Boiler stm rate 33 pph
SO_2 cont. 50 ppm
FF modules on all 3

Team (s): A-B Teams

Quality Leader: Name Jack Dye Designation: AO

Team Leader: Name Martin Benfield Designation: OE

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	14.5	73.3		Total: 22.5 Lbs.
Unburnt	5.0	25		With bucket and lid.
Unburnable	0.5	1.7		

Verification by Quality Leader or Team Leader

Sign: Benfield

Date: 6/2/16

Hampton/NASA Steam Plant

Residue Ash Sample Treated with 12.5 gal/day Sod. Sulfide

Method HSP 3A

Sample # HSP- 0616-SST1 (Both boilers in service)

Date: June 2, 2016 (FF inlet Temp. 375° F, SO_2 Control 50 ppm)

Aggregate	**752.5**
Unburnt	**257.0**
Metals	**17.5**
Total	**1027.0**

Mass Proportion in %

Aggregate	73.3%
Unburnt	25.0%
Metals	1.7%
	100.0%

Mass Proportion in lbs. for 20 lb. sample

	Enter Rounded Up Values in lb.	Calculated Proportion
Aggregate	**14.5**	14.65 lbs.
Unburnt	**5.0**	5.00 lbs.
Metals	**0.5**	0.34 lbs.
Total	**20.0**	20.00 lbs.

Aggregate	Unburnt	Metals
21.5	44.5	17.5
27.0	36.5	
28.0	46.5	
25.5	49.5	
41.0	17.5	
41.5	62.5	
47.0		
52.5		
56.5		
57.5		
46.5		
49.5		
39.5		
40.5		
41.5		
35.0		
38.5		
35.0		
28.5		

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST2

Sample Collection: Thu. June 2, 2016
QA Sample Preparation: Fri. June 3, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Thu. June 2, 2016 & will continue until 19:00 hrs Thu. June 2, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Thu. June 2:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Pre-set on Wed. June 1 at 5:00 PM)			
Reagent Specific Gravity	1.02	SO_2 Control	40 ppm
Fabric Filter Inlet Temp.	400°F	FF Modules on	All 3
Boilers steam rate	33 pph	Sodium Sulfide rate	12.5 ~~? g/day~~
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Adju
13.59/
5:00
6/1

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash 3. Ash conveyor issues 4. Others

Fri. June 3

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample. Follow QA and Chain of Custody procedures.

Thank you,
6/1/16

Anil Mehrotra
Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/7/2016 TIME: 1500
GRAB COLLECTION
DATE: 6/3/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - AC
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-10085 17:05

400°F
12.5 gpd
All 3 wps

SAMPLE ID: HSP-0616-SST2
SAMPLE NO 16-10085

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/10/16	1607
Barium	D005	6010C	0.250	100	0.467	mg/L	PEJ	06/10/16	1334
Cadmium	D006	6010C	0.005	1	0.110	mg/L	PEJ	06/10/16	1334
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	06/10/16	1334
Lead	D008	6010C	0.050	5	< 0.050	mg/L	PEJ	06/10/16	1334
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/10/16	1412
Selenium	D010	6010C	0.050	1	0.221	mg/L	PEJ	06/10/16	1607
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/10/16	1334

ANALYSIS SAMPLE CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0611-SST2

MATERIAL: RESIDUE ASH

SAMPLE PREPARED BY: Donald Woodards

METHOD: HSP-3A

16-10085

CUSTODIAN	FROM		TO	
Donald A. Woodards	3 June 16	0700	3 June 16	0940
Bill Leonard	3 June 16	0940	6/7/16	1430 hr
Austin Mayfield	→		6-7-16	1430
Austin Mayfield			6-7-16	1500
[illegible]			6-7-16	1600

Q. A. Weight: 22.5 lbs

Test: TCLP - All Metals

Reviewed By: [illegible] Anil ordwaste MS PE

Date: 6/3/2016

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-SS72 | Sample Date: 6/8/16 | Method Used: HSP-3A

Sample Certified Valid: 6/17/16 Plant Engineer

GRAB	1	2	3	4	5	6	7	8
Time	1200	1304	1405	1510	1600	1700	1802	1905
Initials	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
1.	40 lbs	15.	31.5 lbs	**Unburnt Combustibles**
2.	46 lbs	16.	29 lbs	1. 45 lbs
3.	47 lbs	17.	45.5 lbs	2. 35 lbs
4.	45 lbs	18.	42.5 lbs	3. 36 lbs
5.	53.5 lbs	19.	40.5 lbs	4. 34 lbs
6.	42.5 lbs	20.	38.5 lbs	5. 39 lbs
7.	36.5 lbs	21.		6. 39.5 lbs
8.	39 lbs	22.		**Unburnable (Metal)**
9.	41.5 lbs	23.		1. 10.5 lbs
10.	31.5 lbs	24.		2. 12.5 lbs
11.	40.5 lbs	25.		3.
12.	38 lbs	26.		4.
13.	31 lbs	27.		5.
14.	37.5 lbs	28.		6.

34.5 lb
29.5 lb

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0616-SST2

Wet Trench pH: 8.8 | Boilers Operating: Both | Weather: Cloudy & clear

Chemical Treatment/ Injection Rate: Sodium Sulfide Injection @ 12.5 gals per day

Comments:

Team (s): D Woodard, Jackie Dye, R. Luke, A. Smith, R. Darrah, J. Drips

Quality Leader: Name Jackie Dye Designation: Ash Handler

Team Leader: Name Donald Woodard Designation: OP. Eng.

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	797	71.6	14.5	Total: 22.5 Lbs.
Unburnt	292.5	23.6	5.0	With bucket and lid.
Unburnable	23	2.1	.5	

Verification by Quality Leader or Team Leader

Sign: [signature]

Date: 3 June 16

SAMPLE # HSP-0616-SST2 , DATE 6/3/2016

1) a) aggregate 797
b) unburnts 292.5
c) metals 23
d) total 1112.50

2) a) aggregate $\frac{a}{d} \times 100\%$ = 71.6
b) unburnts $\frac{b}{d} \times 100\%$ = 26.3
c) metals $\frac{c}{d} \times 100\%$ = 2.1
d) total = 100 %

to second decimal point

3) a) aggregate 14.2
b) unburnts 5.26
c) metals .42
d) total = 20 lbs

round up/down to 1/2 lb.

4) a) aggregate = 14.5
b) unburnts = 5.0
c) metals = 0.5
d) total = 20 lb.

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST3

Sample Collection: Fri. June 3, 2016
QA Sample Preparation: Mon. June 6, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Fri. June 3, 2016 & will continue until 19:00 hrs Fri. June 3, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Fri. June 3:
AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Pre-set on Thu. June 2 at 8:00 PM)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	2 mods. 1, 3
Boilers steam rate	33 pph	Sodium Sulfide rate	12.5 g/day ✓ OK
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others

Mon. June 6
07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample. Follow QA and Chain of Custody procedures.

Thank you,

6/2/16

Anil Mehrotra
Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/7/2016 TIME: 1500
GRAB COLLECTION
DATE: 6/6/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - AC
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-10084 17:05

430°F
12.5 gpd
Med. 1, 3

SAMPLE ID: HSP-0616-SST3
SAMPLE NO 16-10084

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/10/16	1602
Barium	D005	6010C	0.250	100	0.557	mg/L	PEJ	06/10/16	1330
Cadmium	D006	6010C	0.005	1	0.136	mg/L	PEJ	06/10/16	1330
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	06/10/16	1330
Lead	D008	6010C	0.050	5	0.065	mg/L	PEJ	06/10/16	1330
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/10/16	1410
Selenium	D010	6010C	0.050	1	0.203	mg/L	PEJ	06/10/16	1602
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/10/16	1330

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

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The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.45
Extraction Fluid used: #1
Final (end point) pH of Extraction Fluid: 7.07

Authorized By: Elaine Claiborne
Elaine Claiborne, Laboratory Director
Date: 10-Jun-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ◆ Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

Jun 10 2016 5:08PM JAMES R. REED & ASSOC. 17578731498 p.6

ANALYSIS SAMPLE
CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0616-SST3

MATERIAL: residue ash

SAMPLE PREPARED BY: Tony Taylor

METHOD: HSP-3A

16-10084

CUSTODIAN	FROM		TO	
	DATE	TIME	DATE	TIME
Tony Taylor	6/6/16	0700	6/6/16	1010 Am
Bill Leonard	6/6/16	1010	6/7/16	14:30pm
Austin May	→		6-7-16	1430
Austin May			6-7-16	1500
[illegible]			6-7-16	1500

Bill Leonard

Q. A. Weight: 22.5

Test: TCLP All metals

Reviewed By: Anil Mehrotra MS, PE

Date: 6/17/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-SST3

Sample Date: 6/6/2016
Method Used: HSP-3A

Sample Certified Valid: [signature] 6/17/16 [signature] MS, PE

GRAB	1	2	3	4	5	6	7	8
Time	1505	1600	1701	1806	1915	2020	2120	2220
Initials	[illegible]	RWJ	RWJ	RWJ	MB	MB	MB	MB
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"			
				Unburnt Combustibles			
1.	53.0	15.	44.0	1.	33.5	7.	41.0
2.	64.0	16.	41.0	2.	36.0	8.	
3.	63.5	17.	45.0	3.	29.5	9.	
4.	70.5	18.	43.5	4.	50.0	10.	
5.	69.0	19.	39.0	5.	43.0	11.	
6.	66.5	20.	37.5	6.	49.5	12.	
7.	67.5	21.	46.5	Unburnable (Metal)			
8.	61.0	22.	44.0	1.	24.5		
9.	57.0	23.	42.5	2.	11.5		
10.	65.5	24.	38.5	3.			
11.	59.5	25.		4.			
12.	67.5	26.		5.			
13.	40.0	27.		6.			
14.	49.0	28.					

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0616-SST3

Wet Trench pH: 9.0 | Boilers Operating: 1+2 | Weather: Clear

Chemical Treatment/ Injection Rate: Sodium Sulfide : ~~3.5~~ 12.5 gal /day

Comments: Test day control Parameters ; Reagent specific gravity - 1.01, F.F. inlet temp. - 430°F, boiler steam rate - 33Kpph, boiler running condition - Normal, SO^2 control - 60ppm, FF Modules on - 1 & 3, Sodium sulfide rate - 3.5 gal per day.

Team (s): D-Team

Quality Leader: Name Tony Taylor Designation: HHSP (OE)

Team Leader: Name ________ Designation: ________

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	1277	80.0	16	Total: 22.5 Lbs.
Unburnt	282.5	18.0	3.5	With bucket and lid.
Unburnable	36.0	2.25	0.5	

Verification by Quality Leader or Team Leader

Sign: Tony Taylor

Date: 6/6/16

sample # HSP-0616-SST3
date # 6/6/2016

1) a) aggregate 1277
b) unburnt 282.5
c) metal 36
d) total 1595.5

2) a) aggregate a/d x100 % = 80.0%
b) unburnt b/d x100 % = 17.7 %
c) metal c/d x100 % = 2.25%
d) total 100 %

3) a) aggregate 16 lb.
b) unburnt 3.5 lb
c) metal .5
d) total 20 lb.

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST4

Sample Collection: Mon. June 6, 2016
QA Sample Preparation: Tue. June 7, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Mon. June 6, 2016 & will continue until 19:00 hrs Tue. June 7, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Mon. June 6:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	400°F	FF Modules on	Mod 1, 2
Boilers steam rate	33 pph	Sodium Sulfide rate	13·5 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others

Tue. June 7

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample. Follow QA and Chain of Custody procedures.

Thank you,
6/6

Anil Mehrotra
Plant Engineer

Jun 10 2016 5:07PM JAMES R. REED & ASSOC. 17578731498 p.1

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/7/2016 TIME: 1500
GRAB COLLECTION
DATE: 6/7/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - AC
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-10083 17:05

400°F
13.5 9Pd
Med 1, 2

SAMPLE ID: HSP-0616-SST4
SAMPLE NO 16-10083

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/10/16	1558
Barium	D005	6010C	0.250	100	0.473	mg/L	PEJ	06/10/16	1325
Cadmium	D006	6010C	0.005	1	0.067	mg/L	PEJ	06/10/16	1325
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	06/10/16	1325
Lead	D008	6010C	0.050	5	< 0.050	mg/L	PEJ	06/10/16	1325
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/10/16	1407
Selenium	D010	6010C	0.050	1	0.209	mg/L	PEJ	06/10/16	1558
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/10/16	1325

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.29
Extraction Fluid used: # 1
Final (end point) pH of Extraction Fluid: 8.05

Authorized By: Elaine Claiborne
Elaine Claiborne, Laboratory Director
Date: 10-Jun-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

Jun 10 2016 5:07PM JAMES R. REED & ASSOC. 17578731498 p.3

ANALYSIS SAMPLE
CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0616-55T4

MATERIAL: Residue Ash

SAMPLE PREPARED BY: JACK D DYE

METHOD: HSP-3A

16-10083

CUSTODIAN	FROM		TO	
Jack D. Dye	0730	7 JUN 16	0910	7 JUN 16
Bill Leonard	0910	7 June 16	6/7/16	14:30 pm
[illegible]	→	→	6-7-16	1430
[illegible]			6-7-16	1500
[illegible]			6-7-16	1500

Q. A. Weight: 22.5

Test: TCLP- All Metals

Reviewed By: [signature] Anil Melwani MS, PE

Date: 6/17/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-5574 | Sample Date: 7 JUN 16 | Method Used: HSP - 3A

Sample Certified Valid: 6/17/16

GRAB	1	2	3	4	5	6	7	8
Time	1207	1305	1405	1515	1610	1702	1747	1851
Initials	[illegible]	PWJ	[illegible]	PWJ	PWJ	[illegible]	PWJ	PWJ
GRAB	9	10	11	12	13	14	15	16
Time								
Initials								
GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
1.	49	15.		**Unburnt Combustibles**
2.	50	16.		1. 56½
3.	50.5	17.		2. 35.5
4.	41	18.		3.
5.	38	19.		4.
6.	43	20.		5.
7.	34	21.		6.
8.	35.5	22.		**Unburnable (Metal)**
9.	50.5	23.		1. 12 LBS
10.	44	24.		2.
11.	45	25.		3.
12.	37	26.		4.
13.	41	27.		5.
14.	18.5	28.		6.

8.5 pH

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0616-SST4

Wet Trench pH: 8.5 | Boilers Operating: 1+2 | Weather: WET/RAINY/CLOUDY

Chemical Treatment/ Injection Rate: 13.5 g/day

Comments:

REAGENT SPEC. GRAV. - 1.01
FABRIC FILTER INLET TEMP. - 400°F
BOILERS STEAM RATE - 33K pph
SO_2 CONTROL - 60 ppm
FF MODULES - #1&2
SODIUM SULFIDE RATE - 3.5 gallon/per/day

Team (s): B

Quality Leader: Name JACK D DYE Designation: ______

Team Leader: Name Bill Leonard Designation: ______

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	577	84.7	17.0	Total: 22.5 Lbs.
Unburnt	92	13.5	2.5	With bucket and lid.
Unburnable	12	1.7	0.5	

Verification by Quality Leader or Team Leader

Sign: Bill Leonard

Date: 6/7/16

Calculation Sheet

20 Lb. Ash Sample

Sample # HSP-0616-SST4

Date : 6/7/16

1

Sub Total (Lbs)

a. Aggregate	577.0
b. Unburnt	92.0
c. Metal	12.0
d. TOTAL	681

2

Mass Proportion (%)

A. Aggregate ($\frac{a}{d} \times 100\%$)	84.7
B. Unburnt ($\frac{b}{d} \times 100\%$)	13.5
C. Metal ($\frac{c}{d} \times 100\%$)	1.7
D. TOTAL	100%

3

Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20Lb)	16.94
Unburnt (B × 20 Lb)	2.7
Metal (C × 20Lb)	.34
Total	20 Lb

4

Rounded up/down (Lbs)
(To 1/2 Lb)

Aggregate	17.0	Lb.
Unburnt	2.5	Lb
Metal	.5	Lb
Total	20.0 Lb	

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST5

Sample Collection: Tue. June 7, 2016
QA Sample Preparation: Wed. June 8, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Tue. June 7, 2016 & will continue until 19:00 hrs Wed. June 8, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Tue. June 7:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting: 12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending: 19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours. Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	Mod 2, 3
Boilers steam rate	33 pph	Sodium Sulfide rate	16.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash 3. Ash conveyor issues 4. Others

Wed. June 8

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample. Follow QA and Chain of Custody procedures.

Thank you,

Anil Mehrotra
Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/10/2016 TIME: 1350
GRAB COLLECTION
DATE: 6/8/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - DB
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-10338 14:19

430°F
16 gpd
Mod 2, 3

SAMPLE ID: HSP-0616-SST5
SAMPLE NO 16-10338

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/16/16	1435
Barium	D005	6010C	0.250	100	0.478	mg/L	PEJ	06/16/16	1435
Cadmium	D006	6010C	0.005	1	0.368	mg/L	PEJ	06/16/16	1435
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	06/16/16	1435
Lead	D008	6010C	0.050	5	0.152	mg/L	PEJ	06/16/16	1435
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/17/16	1125
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/16/16	1435
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/16/16	1435

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

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The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.62
Extraction Fluid used: #2
Final (end point) pH of Extraction Fluid: 5.83

Authorized By: Elaine Claiborne
Elaine Claiborne, Laboratory Director
Date: 17-Jun-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

8JUN16

ANALYSIS SAMPLE
CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0616-SST5

MATERIAL: Residue Ash

SAMPLE PREPARED BY: Martin Benfield

METHOD: HSP-3A

16-10338

CUSTODIAN	FROM		TO	
Martin Benfield	0700	8JUN16	0840	8JUN16
	0840	6/8/16	0950	6/10/16
	0950	6-10-16	1350	6-10-16
	6/10/16	@1350		

Q. A. Weight: 22.5 LB

Test: TCLP All Metals

Reviewed By: Anil Malhotra MS, PE

Date: 6/17/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-SS75 — Sample Date: 6-8-16 — Method Used: HSP-3A

Sample Certified Valid: [illegible] 6/17/16 Arnel McWorster

GRAB	1	2	3	4	5	6	7	8
	7 JUN 16							
Time	1211	1304	1402	1502	1602	1703	1905	1900
Initials	JAD	TT/JAD	TT/JAD	K	K	K	K	[illegible]
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
				Unburnt Combustibles
1.	34 ½	15.	35	1. 47 ½
2.	47	16.	35	2. 29.5
3.	43	17.	32 ½	3. 33
4.	37 ½	18.		4. 34 ½
5.	34 ½	19.		5.
6.	34 ½	20.		6.
7.	35	21.		**Unburnable (Metal)**
8.	29 ½	22.		1. 17 ½
9.	30 ½	23.		2.
10.	43	24.		3.
11.	35	25.		4.
12.	40 ½	26.		5.
13.	40	27.		6.
14.	34	28.		

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0606-SST5

Wet Trench pH: 8.7 | Boilers Operating: #1, #2 | Weather: Sunny, clear

Chemical Treatment/ Injection Rate: Sodium Sulfide @ 16.0 gal/day

Comments: Reagent Spec. Grav. 1.01
FF Inlet Temp 430°F
Steam Rate 33 pph
FF modules on 2, 3
SO2 control 60

Team (s): A Team

Quality Leader: Name Jack Dye Designation: AO

Team Leader: Name Martin Benfield Designation: OE

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	621	79.31	16.0	Total: 22.5 Lbs.
Unburnt	144.5	18.45	3.5	With bucket and lid.
Unburnable	17.5	2.23	.5	

Verification by Quality Leader or Team Leader

Sign: Martin Benfield

Date: 6/8/16

Calculation Sheet

20 Lb. Ash Sample

8.7 pH
#2 Trench
Both Blrs

Sample # HSP-D616-SST5

Date : 6/8/16

(1)

Sub Total (Lbs)

a. Aggregate	621
b. Unburnt	144.5
c. Metal	17.5
d. TOTAL	783

(2)

Mass Proportion (%)

A. Aggregate ($\frac{a}{d} \times 100\%$)	79.31
B. Unburnt ($\frac{b}{d} \times 100\%$)	18.45
C. Metal ($\frac{c}{d} \times 100\%$)	2.23
D. TOTAL	100%

(3)

Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20Lb)	15.86
Unburnt (B × 20Lb)	3.69
Metal (C × 20Lb)	.44
Total	20 Lb

(4)

Rounded Up/down (Lbs)
(To 1/2 Lb)

Aggregate	16.0 Lb.
Unburnt	3.5 Lb
Metal	.5 Lb
Total	20.0 Lb

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST6

Sample Collection: Wed. June 8, 2016
QA Sample Preparation: Thu. June 9, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Wed. June 8, 2016 & will continue until 19:00 hrs ~~Thu.~~ Wed June ~~9~~8, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Wed. June 8**:**

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Set these values after 7:00 pm on 6/7)			
Reagent Specific Gravity	1.00	SO_2 Control	50 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 pph	Sodium Sulfide rate	180 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others

Thu. June 9

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample. Follow QA and Chain of Custody procedures.

Thank you,
6/7/16

Anil Mehrotra
Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/10/2016 TIME: 1350
GRAB COLLECTION
DATE: 6/9/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - DB
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-10339 14:19

REED & ASSOCIATES

430°F
18 gpd
All 3 mol

SAMPLE ID: HSP-0616-SST6
SAMPLE NO 16-10339

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/16/16	1407
Barium	D005	6010C	0.250	100	0.602	mg/L	PEJ	06/16/16	1407
Cadmium	D006	6010C	0.005	1	0.137	mg/L	PEJ	06/16/16	1407
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	06/16/16	1407
Lead	D008	6010C	0.050	5	< 0.050	mg/L	PEJ	06/16/16	1407
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/17/16	1110
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/16/16	1407
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/16/16	1407

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

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The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 10.97
Extraction Fluid used: #1
Final (end point) pH of Extraction Fluid: 7.35

Authorized By: Elaine Claiborne
Elaine Claiborne, Laboratory Director
Date: 17-Jun-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

ANALYSIS SAMPLE
CHAIN OF CUSTODY

9 JUN 16

SAMPLE NUMBER: HSP-0616-5576

MATERIAL: Residue Ash

SAMPLE PREPARED BY: JACK D. DYE

METHOD: HSP-3A

16-10339

CUSTODIAN	FROM		TO	
Jack D. Dye	0700	9 JUN 16	1005	9 JUN 16
Bill Lovard	1005	9 June 16	0950	6/10
[illegible]	0950	6-10-16	1350	6-10-16
[illegible]	6-10-16	@1350		

Q. A. Weight: 22.5 LBS

Test: TCLP, All Metals

Reviewed By: Neil Melvin

Date: 6/17/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-SST6 | Sample Date: 9 JUN 16 | Method Used: HSP-3A

Sample Certified Valid: 6/17/16 Au... MS, PE

GRAB	1 8/4/16	2	3	4	5	6	7	8
Time	1204	1312	1406	1507	1606	1707	1806	1911
Initials	TT/JDD	JDD	JDD/JK	JDD/JK	JK	JK	JK	RD
GRAB	9	10	11	12	13	14	15	16
Time								
Initials								
GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"	
				Unburnt Combustibles	
1.	35	15.	34.5		
2.	36	16.	24.5	1. 35.5	7. 26
3.	33.5	17.	32	2. 39	8. 36.5
4.	37.5	18.	29.5	3. 36	9. 33.5
5.	38	19.	35.5	4. 50.5	10. 34.5
6.	41	20.	28.5	5. 27	11.
7.	44.5	21.	33.5	6. 37.5	12.
8.	46.5	22.	37	Unburnable (Metal)	
9.	49.5	23.	32.5	1. 11.5	
10.	53	24.	28	2. 15	
11.	49.5	25.	22.5	3.	
12.	54.5	26.		4.	
13.	55	27.		5.	
14.	45	28.		6.	

- Page 2

Residue ash Sample Data Records
(Please Sign and Date below)

Sample # HSP-0616-SST6

Wet Trench pH: 9.1 | Boilers Operating: 1+2 | Weather: Clear

Chemical Treatment/ Injection Rate: 18.0 Gallon/day

Comments:

Team (s): B

Quality Leader: Name JACK D DYE Designation: AD

Team Leader: Name PHIL GAMBLE Designation: OE

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	956	71.45	14.5	Total: 22.5 Lbs.
Unburnt	356	26.58	5	With bucket and lid.
Unburnable	26.5	1.97	.5	

Verification by Quality Leader or Team Leader

Sign:

Date: 6/9/16

Calculation Sheet

20 Lb. Ash Sample

Sample # HSP-0616-SST B

Date : 6/9/16

(1)

Sub Total (Lbs)

a.	Aggregate	956.5
b.	Unburnt	356.0
c.	Metal	26.5
d.	TOTAL	1339.0

(2)

Mass Proportion (%)

A. Aggregate ($\frac{a}{d} \times 100\%$)	71.43
B. Unburnt ($\frac{b}{d} \times 100\%$)	26.58
C. Metal ($\frac{c}{d} \times 100\%$)	1.97
D. TOTAL	100%

(3)

Calculate 20 Lb Proportion (Lb)

(upto 2 decimal point)

Aggregate (A × 20 Lb)	14.28
Unburnt (B × 20 Lb)	5.31
Metal (C × 20 Lb)	0.39
Total	20 Lb

(4)

Rounded up/down (Lbs)

(To 1/2 Lb)

Aggregat	14.5	Lb.
Unburnt	5.0	Lb
Metal	0.5	Lb
Total	20.0 Lb	

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST7

Sample Collection: Thu. June 9, 2016
QA Sample Preparation: Fri. June 10, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Thu. June 9, 2016 & will continue until 19:00 hrs Thu. June 9, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Thu. June 9:
AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Set these values after 7:00 pm on 6/8)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	Mod 1, 3
Boilers steam rate	33 pph	Sodium Sulfide rate	10.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others:

Fri. June 10
07:30–10:00 AM Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample. Follow QA and Chain of Custody procedures.

Thank you,
6/8
Anil Mehrotra
Plant Engineer

8.9 PH

AFTER LAST SAMPLE COLLECTED PLACE AL FF MODULES IN SERVICE BL

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/10/2016 TIME: 1350
GRAB COLLECTION
DATE: 6/10/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - DB
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-10340 14:19

430'F
204pd
Mod 1, 3

SAMPLE ID: HSP-0616-SST7
SAMPLE NO 16-10340

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/16/16	1429
Barium	D005	6010C	0.250	100	0.364	mg/L	PEJ	06/16/16	1429
Cadmium	D006	6010C	0.005	1	< 0.005	mg/L	PEJ	06/16/16	1429
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	06/16/16	1429
Lead	D008	6010C	0.050	5	< 0.050	mg/L	PEJ	06/16/16	1429
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/17/16	1113
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/16/16	1429
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/16/16	1429

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.18
Extraction Fluid used: #1
Final (end point) pH of Extraction Fluid: 8.01

Authorized By: Elaine Claiborne
Elaine Claiborne, Laboratory Director
Date: 17-Jun-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

10 JUN 16

ANALYSIS SAMPLE
CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0616-SST7

MATERIAL: Residue Ash

SAMPLE PREPARED BY: Jack Dye

METHOD: HSP-3A

16-10340

CUSTODIAN	FROM		TO	
Martin Benfield	0700	6/10/16	0840	6/10/16
[illegible]	0840	6/10/16	0950	6/10/16
Donna Boyd	0950	6-10-16	1350	6-10-16

Q. A. Weight: 22½ lbs

Test: TCLP All Metals

Reviewed By: [illegible] 6/20/16 [illegible]

Date: 6/10/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-SST7	Sample Date: 6/9/16 Method Used: HSP-3A

Sample Certified Valid: [illegible] 6/20/16 [illegible] PE

GRAB	1	2	3	4	5	6	7	8
	9 JUN 16							
Time	1225	1305	1402	1507	1612	1710	1811	1906
Initials	7DD	7DD	7DD	7DD	TT	[illegible]	TT	[illegible]
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
1.	38.5	15.	34 ½	**Unburnt Combustibles**
2.	37	16.	29	1. 43
3.	45 ½	17.	31	2. 29 ½
4.	39	18.	32	3. 32 ½
5.	37 ½	19.	30	4. 24
6.	36 ½	20.	32	5. 21
7.	39	21.	23	6. 12
8.	46 ½	22.		**Unburnable (Metal)**
9.	38 ½	23.		1. 23
10.	35 ½	24.		2.
11.	36 ½	25.		3.
12.	33	26.		4.
13.	31 ½	27.		5.
14.	38	28.		6.

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # 4SP-0616-SST7

Wet Trench pH: 8.9 | Boilers Operating: 1, 2 | Weather: Clear, Sunny

Chemical Treatment/ Injection Rate: 20 gal/Day Sodium Sulfide

Comments: Reagent Spec Gravity 1.01
FF inlet temp. 430°F
Boilers Steam Rate 33 pph
SO2 control 60 ppm
FF modules on 1, 3

Team (s): A and B

Quality Leader: Name Jack Dye Designation: AO

Team Leader: Name Martin Benfield Designation: OE

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	744	80.1	16	Total: 22 ½ Lbs.
Unburnt	162	17.4	3.5	With bucket and lid.
Unburnable	23	2.5	0.5	

929

Verification by Quality Leader or Team Leader

Sign: Martin W. Benfield

Date: 6/10/16

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST8

Sample Collection: Fri. June 10, 2016
QA Sample Preparation: Mon. June 13, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Fri. June 10, 2016 & will continue until 19:00 hrs Fri. June 10, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Fri. June 10:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting: 12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending: 19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours. Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Set these values after 7:00 pm on 6/9)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	400°F	FF Modules on	Mod 2, 3
Boilers steam rate	33 pph	Sodium Sulfide rate	14.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_____

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash 3. Ash conveyor issues 4. Others

Mon. June 13

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample. Follow QA and Chain of Custody procedures.

Thank you,

Anil Mehrotra
Plant Engineer

When last sample collected resume operation with all modules in the fabric filters
BL

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/15/2016 TIME: 1215
GRAB COLLECTION
DATE: 6/13/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - TL
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-10592 14:19

REED & ASSOCIATES

400°F
14 gpd
MP 2,3

SAMPLE ID: HSP-0616-SST8
SAMPLE NO 16-10592

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/17/16	1110
Barium	D005	6010C	0.250	100	< 0.250	mg/L	PEJ	06/17/16	1110
Cadmium	D006	6010C	0.005	1	0.065	mg/L	PEJ	06/17/16	1110
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	06/17/16	1110
Lead	D008	6010C	0.050	5	< 0.050	mg/L	PEJ	06/17/16	1110
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/17/16	1148
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/17/16	1110
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/17/16	1110

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

NELAP ACCREDITED TNI LABORATORY

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

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The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.08
Extraction Fluid used: #1
Final (end point) pH of Extraction Fluid: 7.30

Authorized By: Elaine Claiborne

Elaine Claiborne, Laboratory Director

Date: 17-Jun-16

ANALYSIS SAMPLE
CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0616-SST8

MATERIAL: Residue Ash

SAMPLE PREPARED BY: Donald Woodard

METHOD: HSP-3A

16-10592

CUSTODIAN	FROM		TO	
Donald Woodard	13 June 16	0700	13 June 16	0950
[illegible]	6/13/16	0950	15 June 16	1150
Tina Greer	6/15/16	1150	6/15/16	1215

Q. A. Weight: 22.5 lbs

(A) Test: TCLP - All Metals

Reviewed By: [illegible] Melvin MS, PE

Date: 6/29/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-SS8

Sample Date: 10 Jun 16
Method Used: HSP-3A

Sample Certified Valid: 6/30/16 McWorter MS, PE

GRAB	1 10 JUN 16	2	3	4	5	6	7	8
Time	1202	1304	1402	1504	1609	1707	1815	1910
Initials	TDD	TDD	TDD	TDD	JK	JK	TT	DD
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
1.	70.5 lbs	15.		**Unburnt Combustibles**
2.	43.5 lbs	16.		1. 33 lbs
3.	46 lbs	17.		2. 32 lbs
4.	48 lbs	18.		3.
5.	49.5 lbs	19.		4.
6.	54 lbs	20.		5.
7.	47.5 lbs	21.		6.
8.	58 lbs	22.		**Unburnable (Metal)**
9.	55 lbs	23.		1. 21 lbs
10.	42.5 lbs	24.		2.
11.	41.5 lbs	25.		3.
12.	44.5 lbs	26.		4.
13.	35 lbs	27.		5.
14.	27.5 lbs	28.		6.

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0616-SST8

Wet Trench pH: 9.1	Boilers Operating: 1+2	Weather: Clear

Chemical Treatment/ Injection Rate: Sodium Sulfide Inj. 0 gpd

Comments:

Team (s): A. Smith, R Darrah

Quality Leader: Name Jackie Dye Designation: Ash Handler

Team Leader: Name Donald Woodard Designation: OP Eng

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	663	88.5	17.5 lbs	Total: 22.5 Lbs.
Unburnt	65	8.7	2.0 lbs	With bucket and lid.
Unburnable	21	2.8	.5 lbs	

Verification by Quality Leader or Team Leader

Sign: [signature]

Date: 6/16/16

Calculation Sheet

20 Lb. Ash Sample

Sample # HSP-0616-SST8

Date : 6/13/16

① Sub Total (Lbs)

a.	Aggregate	663
b.	Unburnt	65
c.	Metal	21
d.	TOTAL	749

② Mass Proportion (%)

A. Aggregate ($\frac{a}{d} \times 100\%$)	88.51
B. Unburnt ($\frac{b}{d} \times 100\%$)	8.67
C. Metal ($\frac{c}{d} \times 100\%$)	2.8
D. TOTAL	100%

③ Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20 Lb)	17.70
Unburnt (B × 20 Lb)	1.73
Metal (C × 20 Lb)	.56
Total	20 Lb

④ Rounded Up/down (Lbs)
(To 1/2 Lb)

Aggregate	17.5	Lb.
Unburnt	2.0	Lb
Metal	.5	Lb
Total	20.0 Lb	

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST9

Sample Collection: Mon. June 13, 2016
QA Sample Preparation: Tue. June 14, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Mon. June 13, 2016 & will continue until 19:00 hrs Mon. June 13, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Mon. June 13:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (After last sample collection on 6/10)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 pph	Sodium Sulfide rate	14.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues   2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues   4. Others

Tue. June 14

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra
Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/15/2016 TIME: 1215
GRAB COLLECTION
DATE: 6/14/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - TL
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-10593 14:19

REED & ASSOCIATES

430PF
14 9td
AL 3

SAMPLE ID: HSP-0616-SST9
SAMPLE NO 16-10593

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/17/16	1202
Barium	D005	6010C	0.250	100	0.704 M	mg/L	PEJ	06/17/16	1202
Cadmium	D006	6010C	0.005	1	0.373 M	mg/L	PEJ	06/17/16	1202
Chromium	D007	6010C	0.010	5	0.173	mg/L	PEJ	06/17/16	1202
Lead	D008	6010C	0.050	5	1.35 M	mg/L	PEJ	06/17/16	1202
Mercury	D009	7470A	0.0002	0.2	0.0006	mg/L	TLG	06/17/16	1223
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/17/16	1202
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/17/16	1202

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.96
Extraction Fluid used: #2
Final (end point) pH of Extraction Fluid: 5.44
M Matrix spike % recovery outside acceptance range.

Authorized By: Elaine Claiborne

Elaine Claiborne, Laboratory Director

Date: 17-Jun-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

ANALYSIS SAMPLE
CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0616-5579

MATERIAL: Ash residue

SAMPLE PREPARED BY: C-D

METHOD: HSP- 3A

16-10593

CUSTODIAN	FROM		TO	
[illegible]	6/14/16	0730	6/14/16	0853
[illegible]	6/14/16	0853	15 June 16	1150
Tina Greer	6/15/16	1150	6/15/16	1215

Q. A. Weight: 22.5

(A)

Test: TCLP- All metals

Reviewed By: [illegible] Anil Malhotra NSPE

Date: 6/20/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-SST9	Sample Date: 6/14/16 Method Used: HSP-3A

Sample Certified Valid: 6/20/16 [illegible] MS PE Plant Engineer

GRAB	1 13 JUN 16	2	3	4	5	6	7	8
Time	1219	1308	1405	1509	1605	1723	1814	1914
Initials	TAD	TAD	TAD	TAD	RD	RD	RD	TT
GRAB	9	10	11	12	13	14	15	16
Time								
Initials								
GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
				Unburnt Combustibles
1.	32.5	15.		1. 17
2.	39	16.		2. 48.5
3.	41.5	17.		3.
4.	52.5	18.		4.
5.	59	19.		5.
6.	60	20.		6.
7.	57	21.		**Unburnable (Metal)**
8.	62	22.		1. 21.5
9.	50.5	23.		2.
10.	52.5	24.		3.
11.	40	25.		4.
12.	48	26.		5.
13.		27.		6.
14.		28.		

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0616-SST9

Wet Trench pH: 8.4 | Boilers Operating: 1-2 | Weather: Sunny

Chemical Treatment/ Injection Rate: 14.0 gal/day

Comments:

Reagent Specific Gravity 1.01, SO^2 Control 60 ppm
Fabric Filter Inlet Temp 400°F F.F. Modules Mod 2,3
Boilers steam rate 33 pph Sodium Sulfide rate 4.0 g/day
Boilers running condition Normal

Team (s): C-D

Quality Leader: Name Taylor Designation: Ash Pad

Team Leader: Name Krajcir Designation: Ash Pad

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	594.5	87.23	17.5	Total: 22.5 Lbs.
Unburnt	65.5	9.61	2.0	With bucket and lid.
Unburnable	21.5	3.15	.5	

Verification by Quality Leader or Team Leader

Sign: [signature]

Date: 6/14/16

Calculation Sheet

20 Lb. Ash Sample

Sample # HSP-0616-SST9

Date : 6-14-2016

(1)

Sub Total (Lbs)

a. Aggregate 594.5

b. Unburnt 65.5

c. Metal 21.5

d. TOTAL 681.5

(2)

Mass Proportion (%)

A. Aggregate ($\frac{a}{d} \times 100\%$) 87.23

B. Unburnt ($\frac{b}{d} \times 100\%$) 9.61

C. Metal ($\frac{c}{d} \times 100\%$) 3.15

D. TOTAL 100%

(3)

Calculate 20 Lb Proportion (Lb)

(upto 2 decimal point)

Aggregate (A x 20Lb) 17.44

Unburnt (B x 20 Lb) 1.92

Metal (C x 20Lb) .63

Total 20 Lb

(4)

Rounded up/down (Lbs)

(To 1/2 Lb)

Aggregat 17.5 Lb.

Unburnt 2.0 Lb

Metal .5 Lb

Total 20.0 Lb

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0616–SST10

Sample Collection: Mon. June 20, 2016
QA Sample Preparation: Tue. June 21, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Mon. June 20, 2016 & will continue until 19:00 hrs Mon. June 20, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Mon. June 20:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (After permanent Sod. Sulfide system setup on 6/17)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 pph	Sodium Sulfide rate	13.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others

2.12
5.25 ml/
9-11
5t201

Tue. June 21

07:30–10:00 AM Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra
Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/22/2016 TIME: 1125
GRAB COLLECTION
DATE: 6/21/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: CLIENT
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-11204 17:51

SAMPLE ID: HNSP-0616-SST10
SAMPLE NO 16-11204

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/30/16	1609
Barium	D005	6010C	0.250	100	0.810 M	mg/L	PEJ	06/30/16	1609
Cadmium	D006	6010C	0.005	1	0.460 [illegible]	mg/L	PEJ	06/30/16	1609
Chromium	D007	6010C	0.010	5	0.202	mg/L	PEJ	06/30/16	1609
Lead	D008	6010C	0.050	5	3.04 [illegible]	mg/L	PEJ	06/30/16	1609
Mercury	D009	7470A	0.0002	0.2	0.0004	mg/L	TLG	06/30/16	1642
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/30/16	1609
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/30/16	1609

James R. Reed & Associates
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(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.56

Extraction Fluid used: 2

Final (end point) pH of Extraction Fluid: 5.52

M1 Matrix spike % recovery is outside acceptance range.

Authorized By: Elaine Claiborne

Elaine Claiborne, Laboratory Director

Date: 30-Jun-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

Jun 30 2016 5:53PM JAMES R. REED & ASSOC. 17578731498 p.6

ANALYSIS SAMPLE CHAIN OF CUSTODY

21 JUN 16

SAMPLE NUMBER: HNSP-N.U.-SST10

MATERIAL: Residue Ash

SAMPLE PREPARED BY: John Krajcir

METHOD: HSP-3A

16-11204 A

CUSTODIAN	FROM		TO	
John Krajcir	0710	6/21/16	0840	6/21/16
[illegible]	0840	6/21/16	1105	6/22/16
Austin Mang	1105	6-22-16	~~1105~~	~~6/22/16~~
Austin Mang	1125	6-22-16	[illegible]	6/22/16 @ 1125

Q. A. Weight: 22.5 lb

Test: ~~6/21/16~~ TCLP All Metals

Reviewed By: [illegible] Neil Nelustra

Date: 7/1/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE #	HSP-0616-SST 10	Sample Date:	6/20/16
		Method Used:	HSP-3A

Sample Certified Valid: ____________________

GRAB	1	2	3	4	5	6	7	8
	20 JUN 16							
Time	1205	1304	1407	1503	1605	1715	1810	1910
Initials	TDD	TDD	TDD	TDD	PWD	PWH	PWD	MWB
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"	
				Unburnt Combustibles	
1.	44.5	15.		1.	44.0
2.	45.5	16.		2.	12.5
3.	43	17.		3.	
4.	40.5	18.		4.	
5.	44.5	19.		5.	
6.	43	20.		6.	
7.	40	21.			**Unburnable (Metal)**
8.	44.5	22.			
9.	39.0	23.		1.	11.0
10.	41.0	24.		2.	
11.	26.0	25.		3.	
12.		26.		4.	
13.		27.		5.	
14.		28.		6.	

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0616-SST10

Wet Trench pH: 8.9	Boilers Operating: 1, 2 Startup	Weather: Sunny + Clear

Chemical Treatment/ Injection Rate: 13.0 gal/day

Comments: #2 BLR was down & startup at 1400
Reagent Specific Gravity 1.01 / SO2 Control 60ppm
F.F Inlet Temp 430°F / FF Modules on All 3
Boiler STm Rate 33pph / Sodium sulfide rate ~~3.0~~ 2.0 g/day
Boiler running condition N Any important change
#2 BLR was down + back on line

Team (s): D-Team

Quality Leader: Name Taylor Krajcir Designation: Ash Pad

Team Leader: Name Dye Designation: Ash Pad

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	451.5	86.9	17.5	Total: 22.5 Lbs.
Unburnt	56.6	10.8	2.0	With bucket and lid.
Unburnable	11.0	2.1	.5	

Verification by Quality Leader or Team Leader

Sign: John Kje

Date: June 21/2016

Calculation Sheet

20 Lb. Ash Sample

Sample # HNSP-0616-SST10

Date : 6/21/2016

(1) Sub Total (Lbs)

a. Aggregate	451.5
b. Unburnt	56.5
c. Metal	11.0
d. TOTAL	519.0

(2) Mass Proportion (%)

A. Aggregate $(\frac{a}{d} \times 100\%)$	86.9
B. Unburnt $(\frac{b}{d} \times 100\%)$	10.8
C. Metal $(\frac{c}{d} \times 100\%)$	2.11
D. TOTAL	100%

(3) Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20 Lb)	17.38
Unburnt (B × 20 Lb)	2.16
Metal (C × 20 Lb)	.422
Total	20 Lb

(4) Rounded Up/down (Lbs)
(To 1/2 Lb)

Aggregate	17.5 Lb.
Unburnt	2.0 Lb
Metal	.5 Lb
Total	20.0 Lb

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0616–SST11

Sample Collection: Tue. June 21, 2016
QA Sample Preparation: Wed. June 22, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon Tue. June 21, 2016 & will continue until 19:00 hrs Tue. June 21, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to the following schedule and Quality Assurance procedures:

Tue. June 21:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (After last sample is collected on 6/20)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 pph	Sodium Sulfide rate	10.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others

Wed. June 22

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra
Plant Engineer

Jun 30 2016 5:52PM JAMES R. REED & ASSOC. 17578731498 p.1

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/22/2016 TIME: 1125
GRAB COLLECTION
DATE: 6/22/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: CLIENT
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-11203 17:51

SAMPLE ID: HNSP-0616-SST11
SAMPLE NO 16-11203

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/30/16	1604
Barium	D005	6010C	0.250	100	0.431 M	mg/L	PEJ	06/30/16	1604
Cadmium	D006	6010C	0.005	1	0.732 [redacted]	mg/L	PEJ	06/30/16	1604
Chromium	D007	6010C	0.010	5	0.112	mg/L	PEJ	06/30/16	1604
Lead	D008	6010C	0.050	5	9.68 [redacted]	mg/L	PEJ	06/30/16	1604
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/30/16	1639
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/30/16	1604
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/30/16	1604

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ◆ Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.43

Extraction Fluid used#2

Final (end point) pH of Extraction Fluid: 5.36

(M) Matrix spike % recovery is outside acceptance range.

Authorized By: Elaine Claiborne

Elaine Claiborne, Laboratory Director

Date: 30-Jun-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

ANALYSIS SAMPLE CHAIN OF CUSTODY

22 JUN 16

SAMPLE NUMBER: HNSP-0616-65711

MATERIAL: Residue Ash

SAMPLE PREPARED BY: J. Krajcir

METHOD: HSP-3A

16-11203

CUSTODIAN	FROM		TO	
[illegible]	0700	22 JUN 16	0850	22 JUN 16
[illegible]	0850	6/22/16	1105	6/22/16
[illegible]	1105	6-22-16		
[illegible]	1125	6-22-16	[illegible]	6/22/16 @ 1125

Q.A. Weight: 22.5 lbs

Test: TCLP Metals

Reviewed By: Anil Malhotra MS, PE

Date: 7/1/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HNSP-0616-SST4 | Sample Date: 6/22/16 | Method Used: HSP-3A

Sample Certified Valid: 7/1/16 Anil Melwattia, MS, PE Plant Engineer

GRAB	1	2	3	4	5	6	7	8
Time	1615	1705	1810	1930	2020	2125	2215	2320
Initials	PWD	PWD	PWD	MB	MB	MB	MB	MB
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
1.	33	15.		**Unburnt Combustibles**
2.	35	16.		1. 43.5
3.	37	17.		2. 35.5
4.	34	18.		3.
5.	32.5	19.		4.
6.	40	20.		5.
7.	37.5	21.		6.
8.	39	22.		**Unburnable (Metal)**
9.	37.5	23.		1. 24.5
10.	42	24.		2.
11.	46.5	25.		3.
12.	41	26.		4.
13.	28	27.		5.
14.	29.5	28.		6.

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HUSP-0616-SST 11

Wet Trench pH: 8.6	Boilers Operating: 1+2	Weather: Clear

Chemical Treatment/ Injection Rate: Sodium Sulfide Injection 10 gpd
All other parameters normal.

Comments: Both boilers shutting down due to power outage, then #2 Boiler starting up during ash sample collection on 6/21/16
#1 Blr starting up during last 4 grabs of sample on 6/21/16

Team (s): J. Kratzer, J. Jones, D. Snopp, W. Zelobski

Quality Leader: Name John Kratzer Designation: SPO II

Team Leader: Name Jackie Dye Designation: Ash Handler

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	512.5	83.19	16.5	Total: 22.5 Lbs.
Unburnt	79	12.82	2.5	With bucket and lid.
Unburnable	24.5	3.97	1.0	

Verification by Quality Leader or Team Leader

Sign: [signature]

Date: 6/21/16

Calculation Sheet

20 Lb. Ash Sample

Sample # HNSP-0616-SST 11

Date : 6/22/2016

① Sub Total (Lbs)

a.	Aggregate	512.5
b.	Unburnt	79
c.	Metal	24.5
d.	TOTAL	616

② Mass Proportion (%)

A. Aggregate ($\frac{a}{d} \times 100\%$)	83.19
B. Unburnt ($\frac{b}{d} \times 100\%$)	12.82
C. Metal ($\frac{c}{d} \times 100\%$)	3.97
D. TOTAL	100%

③ Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20 Lb)	16.63
Unburnt (B × 20 Lb)	2.56
Metal (C × 20 Lb)	.79
Total	20 Lb

④ Rounded Up/down (Lbs)
(To 1/2 Lb)

Aggregate	16.5	Lb.
Unburnt	2.5	Lb
Metal	1.0	Lb
Total	20.0 Lb	

Hampton/NASA Steam Plant
Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST12

Sample Collection: Wed. June 22, 2016
QA Sample Preparation: Tue. June 28, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start after boiler start-up on Wed. June 22, 2016 & will continue until completing 8 grabs on Wed. June 22, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Wed. June 22**:**

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
After boiler Start-up — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
After completing 8 grabs: — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours.
Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (After last sample is collected on 6/21)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	10.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others

Tue. June 28
07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra
Plant Engineer

REPORT OF ANALYSIS

CLIENT:	Hampton/NASA Steam Plant	SAMPLE RECEIPT	
ATTN:	Anil Mehrotra, Plant Engineer	DATE: 6/29/2016	TIME: 1055
ADDRESS:	50 Wythe Creek Road	GRAB COLLECTION	
CITY:	Hampton, VA 23666	DATE: 6/28/2016	TIME: 0700
PHONE:	(757) 865-1914	COLLECTED BY:	CLIENT
FAX:	e: amehrotra@hampton.gov	PICK UP BY:	REED - TL
		NUMBER OF CONTAINERS:	1
SPECIAL NOTES:		GOOD CONDITION	☑ Good ☐ Other (See C-O-C)
		REPORT NO:	16-11557 11:28

SAMPLE ID: HSP-0616-SST12
SAMPLE NO 16-11557

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/30/16	1711
Barium	D005	6010C	0.250	100	0.535	mg/L	PEJ	06/30/16	1711
Cadmium	D006	6010C	0.005	1	1.01	mg/L	PEJ	06/30/16	1711
Chromium	D007	6010C	0.010	5	0.020	mg/L	PEJ	06/30/16	1711
Lead	D008	6010C	0.050	5	0.241	mg/L	PEJ	06/30/16	1711
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/30/16	1648
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/30/16	1711
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/30/16	1711

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VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

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The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.13
Extraction Fluid used: #2
Final (end point) pH of Extraction Fluid: 5.54

Authorized By: Elaine Claiborne

Elaine Claiborne, Laboratory Director

Date: 01-Jul-16

James R. Reed & Associates
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(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

ANALYSIS SAMPLE
CHAIN OF CUSTODY

28 JUN 16

SAMPLE NUMBER: HSP-0616-SST12

MATERIAL: RESIDUE ASH

SAMPLE PREPARED BY: JACK D. DYE

METHOD: HSP-3A

16-11557A

CUSTODIAN	FROM		TO	
[signature]	0700	28 JUN 16	0930	28 JUN 16
[signature]	0930	6/28/16	1030	~~6/28/16~~
Tina Greer	062916	1030	1055	6/29/16 062916

Q. A. Weight: 22.5 LBS

Test: TCLP - all metals

Reviewed By: [signature] Amit Mehrotra MS, PE

Date: 7/1/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant Residue ash Sample Data Records								- Page 1
SAMPLE # HSP-0616-SST12				Sample Date: 6/28/16 (sample prep, delayed/postponed) Method Used: HSP-3A				
Sample Certified Valid: [illegible] 7/1/16 Arid Melenta MSPE								
GRAB	22 Jun 16	2	3	4	5	6	7	8
Time	1800	1935	2030	2140	2315	2430	0030	0215
Initials	PWD	MB	MB	MB	MB	MB	MB	MB
GRAB	9	10	11	12	13	14	15	16
Time								
Initials								
GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

Date of collection 6/22/16

WEIGHT TALLY SHEET (+ or - ½ Lb)					
Aggregate		Aggregate		Other Materials Over 2"	
1.	36.5	15.		Unburnt Combustibles	
2.	39.5	16.		1.	46.
3.	37	17.		2.	45
4.	42	18.		3.	8
5.	46.5	19.		4.	
6.	51.5	20.		5.	
7.	51	21.		6.	
8.	36.5	22.		Unburnable (Metal)	
9.	15	23.		1.	8.5
10.		24.		2.	
11.		25.		3.	
12.		26.		4.	
13.		27.		5.	
14.		28.		6.	

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # (HSP-3A) HSP-0616-SST12

Wet Trench pH: 9.0 | Boilers Operating: 1,2 startup | Weather: Humid, MUGGY, light RAIN

Chemical Treatment/ Injection Rate: Sodium sulfide 12 gallons/day

Comments: MUGGY, HUMID, LIGHT RAIN AT END of TEST
BOTH BOILERS WERE IN START-UP
CONDITION AT THE TIME ASH SAMPLES
WERE COLLECTED.

Team (s): TEAM D, ASH TEAM

Quality Leader: Name JACK DYE Designation:

Team Leader: Name Designation:

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	355.5	76.8%	15.5 lb	Total: 22.5 Lbs.
Unburnt	99.0	21.4%	4.0 lb	With bucket and lid.
Unburnable	8.5	1.8%	0.5 lb	

Verification by Quality Leader or Team Leader

Sign: Jack D. Dye

Date: 28 JUN 16

Date of collection 6/22

Hampton/NASA Steam Plant
Residue Ash Sample Treated with 10gal/day Sod. Sulfide

Method HSP 3A

Sample # HSP- 0616-SST12 (Both boilers in service)
Date: June 28, 2016 (FF inlet Temp. 430 F)

		Aggregate	Unburnt	Metals
Aggregate	**355.5**	36.5	46.0	8.5
Unburnt	**99.0**	39.5	45.0	
Metals	**8.5**	37.0	8.0	
Total	**463.0**	42.0		
Mass Proportion in %		46.5		
Aggregate	76.8%	51.5		
Unburnt	21.4%	51.0		
Metals	1.8%	36.5		
	100.0%	15.0		

Mass Proportion in lbs. for 20 lb. sample

	Rounded Up in lbs.	Calculated Proportion
Aggregate	**15.5**	15.36 lbs.
Unburnt	**4.0**	4.28 lbs.
Metals	**0.5**	0.37 lbs.
Total	**20.0**	20.00 lbs.

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0616–SST13

Sample Collection: Thu. June 23, 2016

QA Sample Preparation: Fri. June 24, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to be done during boiler shutdown and start-up on Thu. June 23, 2016 & will continue until completing 8 grabs on Thu. June 23, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Thu. June 23**:**

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

During Boiler Shutdown/Start-up — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending: After completing 8 grabs: — Continue 1-minute residue ash grab every hour as per above procedure for 8-hours. Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (After last sample is collected on 6/22)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	10.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash 3. Ash conveyor issues 4. Others

Fri. June 24

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra

Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/24/2016 TIME: 1420
GRAB COLLECTION
DATE: 6/24/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - AC
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-11448 17:51

SAMPLE ID: HSP-0616-SST13
SAMPLE NO 16-11448

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/30/16	1706
Barium	D005	6010C	0.250	100	0.827	mg/L	PEJ	06/30/16	1706
Cadmium	D006	6010C	0.005	1	0.335	mg/L	PEJ	06/30/16	1706
Chromium	D007	6010C	0.010	5	0.032	mg/L	PEJ	06/30/16	1706
Lead	D008	6010C	0.050	5	0.403	mg/L	PEJ	06/30/16	1706
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/30/16	1645
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/30/16	1706
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/30/16	1706

James R. Reed & Associates
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VELAP# 460013
EPA# VA00015

Jun 30 2016 5:55PM JAMES R. REED & ASSOC. 17578731498 p.9

ANALYSIS SAMPLE CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0616-SST13

MATERIAL: Residue ASH

SAMPLE PREPARED BY: [signature]

METHOD: HSP-3A

16.11448

CUSTODIAN	FROM		TO	
[signature]	0700	24 JAN 16	0945	24 Jun 16
[signature]	6/24	0945	6/24/16	2:03 pm
[signature]	6-24	1403	6-24-16	1420
[signature]	6-24	1420		

Q. A. Weight: 22.5 LBS

Test: TCLP - All Metals

Reviewed By: [signature] Malhotra MS PE

Date: 7/1/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-SST13 | Sample Date: 6/24/16 | Method Used: HSP 3A

7/1/16 And Melinda

Sample Certified Valid: Burn Down / Half Hour Grab

GRAB	1	2	3	4	5	6	7	8
	23 June	Burn	Down			Bring	Up	
Time	0858	0927	1000	1031	2305	0010	0104	0200
Initials	TDD	TDD	TDD	TDD	RB	RB	RB	RB

Date of collection 6/23/16

GRAB	9	10	11	12	13	14	15	16
Time								
Initials								

GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
1.	40.5	15.		**Unburnt Combustibles**
2.	41.5	16.		1. 13.5
3.	44	17.		2. 35
4.	53	18.		3.
5.	46.5	19.		4.
6.	47	20.		5.
7.	42.5	21.		6.
8.	33.5	22.		**Unburnable (Metal)**
9.		23.		1. 10
10.		24.		2.
11.		25.		3.
12.		26.		4.
13.		27.		5.
14.		28.		6.

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0616-SST13

Wet Trench pH: 8.3 | Boilers Operating: 1&2 shutdown 2 startup by #1 | Weather: Rainy / thunder

Chemical Treatment/ Injection Rate: ____

Comments: Rainy, THUNDER POWER FAILURE
after FIRST GRAB VERY Little RESIDUE CAME OUT
1/2 hr GRAB FOR BURN DOWN
1000 GRAB VERY/VERY LITTLE. WATER also for 1031 GRAB
SWITCHED FROM TRENCH 2 to TRENCH 1. DRUGGED TRENCH 2
SODIUM SULFIDE RATE 10 # G/DAY

Team (s): ____

Quality Leader: Name JACK DYE Designation: AQ

Team Leader: Name ____ Designation: ____

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	348.5	85.62	17	Total: 22.5 Lbs.
Unburnt	48.5	11.91	2.5	With bucket and lid.
Unburnable	10	2.45	.5	

Verification by Quality Leader or Team Leader

407.0

Sign: Jack D. Dye

Date: 24 JUN 16

Calculation Sheet

20 Lb. Ash Sample

Sample # HSP-0616-SJT 13

Date : 6/24/2016

(1) Sub Total (Lbs)

a.	Aggregate	348.5
b.	Unburnt	48.5
c.	Metal	10.0
d.	TOTAL	407.0

(2) Mass Proportion (%)

A.	Aggregate ($\frac{a}{d} \times 100\%$)	85.62
B.	Unburnt ($\frac{b}{d} \times 100\%$)	11.91
C.	Metal ($\frac{c}{d} \times 100\%$)	2.45
D.	TOTAL	100%

(3) Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20 Lb)	17.12
Unburnt (B × 20 Lb)	2.38
Metal (C × 20 Lb)	.49
Total	20 Lb

(4) Rounded Up/down (Lbs)
(TO 1/2 Lb)

Aggregate	17.0 Lb.
Unburnt	2.5 Lb
Metal	.5 Lb
Total	20.0 Lb

Hampton/NASA Steam Plant
Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0616–SST14

Sample Collection: Mon. June 27, 2016
QA Sample Preparation: Tue. June 28, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon on Mon. June 27, 2016 & will continue until 7:00 pm on Mon. June 27, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Mon. June 27:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs: — Continue 1-minute residue ash grab every hour as per above Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (After last sample is collected on 6/23)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	12.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others

Tue. June 28

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra
Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 6/29/2016 TIME: 1055
GRAB COLLECTION
DATE: 6/28/2016 TIME: 0900
COLLECTED BY: CLIENT
PICK UP BY: REED - TL
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-11558 11:28

SAMPLE ID: HSP-0616-SST14
SAMPLE NO 16-11558

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	06/30/16	1651
Barium	D005	6010C	0.250	100	0.845	mg/L	PEJ	06/30/16	1651
Cadmium	D006	6010C	0.005	1	0.253	mg/L	PEJ	06/30/16	1651
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	06/30/16	1651
Lead	D008	6010C	0.050	5	0.112	mg/L	PEJ	06/30/16	1651
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	06/30/16	1724
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	06/30/16	1651
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	06/30/16	1651

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.75
Extraction Fluid used: #1
Final (end point) pH of Extraction Fluid: 7.39

Authorized By: Elaine Claiborne

Elaine Claiborne, Laboratory Director

Date: 01-Jul-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

ANALYSIS SAMPLE CHAIN OF CUSTODY

28 June 16

SAMPLE NUMBER: HSP-0616-SST14

MATERIAL: RESIDUE BS17

SAMPLE PREPARED BY: [signature]

METHOD: HSP-3A

16-11558A

CUSTODIAN	FROM		TO	
[signature]	0900	28 Jun 16	1030	28 Jun 16
[signature]	1030	6/28/16	1030	6/29/16
[signature]	1030	062916	1055	062916

Q. A. Weight: 22.5 lB

Test: TCLP: All Metals

Reviewed By: [signature] MS, PE

Date: 7/1/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Sample Collected 6/27/16

Hampton/NASA Steam Plant Residue ash Sample Data Records								Page 1
SAMPLE # HSP-0616-SST14				Sample Date: 6/28/16 Method Used: HSP-3A				
Sample Certified Valid: 7/1/16 [illegible] / Melvin [illegible] MS, PE								
GRAB	1 27 Jun 16	2	3	4	5	6	7	8
Time	1203	1305	1403	1509	1600	1705	1800	1915
Initials	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	PWD	PWD	MB
GRAB	9	10	11	12	13	14	15	16
Time								
Initials								
GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)					
Aggregate		Aggregate		Other Materials Over 2"	
1.	41	15.	43	Unburnt Combustibles	
2.	43	16.		1.	56.5
3.	41.5	17.		2.	52.5
4.	39.5	18.		3.	42.5
5.	40.5	19.		4.	31
6.	39.5	20.		5.	
7.	44.5	21.		6.	
8.	47	22.		Unburnable (Metal)	
9.	44	23.		1.	13.5
10.	43	24.		2.	
11.	40.5	25.		3.	
12.	47	26.		4.	
13.	44	27.		5.	
14.	~~[illegible]~~ 44	28.		6.	

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0616-SST14

Wet Trench pH: 8.7 | Boilers Operating: 1 & 2 | Weather: Cloudy, Light Rain

Chemical Treatment/ Injection Rate: Sodium Sulfide injection. 10 gal/day

Comments: ARASED TRENCH AT/ABOUT 0930 ON 27 JUN 16
TESTING DAY RAIN (28 JUN 16) AND THUNDER

Both Boilers Operating
Normal.

Team (s): Team D, ASH TEAM

Quality Leader: Name JACK D. Dye Designation:

Team Leader: Name Designation:

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	647	76.7	15.5	Total: 22.5 Lbs.
Unburnt	182.5	21.6	4	
Unburnable	13.5	1.6	.5	With bucket and lid.

Verification by Quality Leader or Team Leader

Sign: Jack D Dye

Date: 28 JUN 16

Hampton/NASA Steam Plant
Residue Ash Sample Treated with 10 gal/day Sod. Sulfide
Sample collected on June 27, 2016
Method HSP 3A

Sample # HSP- 0616-SST14 (Both boilers in service)
Date: June 28, 2016 (FF inlet Temp. 430 F)

Aggregate	**647.0**
Unburnt	**182.5**
Metals	**13.5**
Total	**843.0**

Aggregate	Unburnt	Metals
41.0	56.5	13.5
43.0	52.5	
41.5	42.5	
39.5	31.0	
40.5		
39.5		
44.5		
47.0		
44.0		
43.0		
40.5		
47.0		
44.0		
49.0		
43.0		

Mass Proportion in %

Aggregate	76.7%
Unburnt	21.6%
Metals	1.6%
	100.0%

Mass Proportion in lbs. for 20 lb. sample

	Rounded Up in lbs.	Calculated Proportion
Aggregate	**15.5**	15.35 lbs.
Unburnt	**4.0**	4.33 lbs.
Metals	**0.5**	0.32 lbs.
Total	**20.0**	20.00 lbs.

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0616–SST15

Sample Collection: Tue. June 28, 2016
QA Sample Preparation: Wed. June 29, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon on Tue. June 28, 2016 & will continue until 7:00 pm on Tue. June 28, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Tue. June 28:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs: — Continue 1-minute residue ash grab every hour as per above Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (After last sample is collected on 6/27)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	10.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others

Wed. June 29

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra
Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 7/5/2016 TIME: 1230
GRAB COLLECTION
DATE: 6/29/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - AC
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-11732 14:42

REED & ASSOCIATES

SAMPLE ID: HSP-0616-SST15-A
SAMPLE NO 16-11732

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	07/08/16	1517
Barium	D005	6010C	0.250	100	0.641	mg/L	PEJ	07/08/16	1517
Cadmium	D006	6010C	0.005	1	0.167	mg/L	PEJ	07/08/16	1517
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	07/08/16	1517
Lead	D008	6010C	0.050	5	< 0.050	mg/L	PEJ	07/08/16	1517
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	07/07/16	1025
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	07/08/16	1517
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	07/08/16	1517

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.66

Extraction Fluid used: 1

Final (end point) pH of Extraction Fluid: 8.52

Authorized By: Elaine Claiborne

Elaine Claiborne, Laboratory Director

Date: 11-Jul-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

ANALYSIS SAMPLE
CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0616-SST15-A

MATERIAL: RESIDUE ASH

SAMPLE PREPARED BY: DONALD WOODARD

METHOD: HSP-3A

16.11732

CUSTODIAN	FROM		TO	
DONALD A WOODARD	6/29/16	0700	6/29/16	0855
[signature]	6/29/16	0855	7/5/16	12:15
[signature]	7-5-16	1215	7-5-16	1230
[signature]	7-5-16	1230		

Q. A. Weight: 22.5 lbs

Test: TCLP ALL METALS

Reviewed By: [signature] Amit Malhotra MS, PE

Date: 7/15/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0616-SST15

Sample Date: 6/28/16
Method Used: HSP-3A

Sample Certified Valid: 7/25/16 Mehrotra, MS, PE

GRAB	28 Jun 16	2	3	4	5	6	7	8
Time	1205	1303	1410	1502	1615	1715	1805	1915
Initials	TAD	TAD	PWG	TAD	PWG	PWG	PWG	MB
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
1.	47.5	15.		**Unburnt Combustibles**
2.	44.5	16.		1. 32
3.	36.5	17.		2. 35
4.	22	18.		3. 30.5
5.	42.5	19.		4. 35
6.	40	20.		5.
7.	38	21.		6.
8.	31.5	22.		**Unburnable (Metal)**
9.	41	23.		1. 7.5
10.	45.5	24.		2.
11.	30.5	25.		3.
12.		26.		4.
13.		27.		5.
14.		28.		6.

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-06-16-SST15

Wet Trench pH: 9.1 | Boilers Operating: 1+2 | Weather: clear

Chemical Treatment/ Injection Rate: Sodium Sulfide Injection 10.5 gpd

Comments:

Team (s): A. Smith, R. Darrah

Quality Leader: Name Jackie Dye Designation: Ash Handler

Team Leader: Name Dennis Woodard Designation: Op Eng

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	419.5	75.6	15	Total: 23.5 Lbs. With bucket and lid.
Unburnt	132.5	23.7	4.5	
Unburnable	7.5	1.3	.5	

Verification by Quality Leader or Team Leader

Sign: [signature]

Date: 6/29/16

Hampton/NASA Steam Plant
Residue Ash Sample Treated with 10 gal/day Sod. Sulfide
Sample collected on June 28, 2016
Method HSP 3A

Sample # HSP- 0616-SST15 (Both boilers in service)
Date: June 29, 2016 (FF inlet Temp. 430 F)

Aggregate	**419.5**
Unburnt	**132.5**
Metals	**7.5**
Total	**559.5**

Aggregate	Unburnt	Metals
47.5	32.0	7.5
44.5	35.0	
36.5	30.5	
22.0	35.0	
42.5		
40.0		
38.0		
31.5		
41.0		
45.5		
30.5		

Mass Proportion in %	
Aggregate	75.0%
Unburnt	23.7%
Metals	1.3%
	100.0%

Mass Proportion in lbs. for 20 lb. sample

	Rounded Up in lbs.	Calculated Proportion	
Aggregate	**15.0**	15.00	lbs.
Unburnt	**4.5**	4.74	lbs.
Metals	**0.5**	0.27	lbs.
Total	**20.0**	20.00	lbs.

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0716–SST16

Sample Collection: Wed. July 27, 2016

QA Sample Preparation: Thu. July 28, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon on Wed. July 27, 2016 & will continue until 7:00 pm on Wed. July 27, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Wed. July 27:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting: 12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending: 19:00 hrs: — Continue 1-minute residue ash grab every hour as per above. Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Set these conditions before collecting samples)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	13.0 g/day
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

17 s/m 13.3

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash 3. Ash conveyor issues 4. Others

Thu. July 28

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra

Plant Engineer

* chemical discharge rate at screw 11.4 gpd

(based on 30 ml/min, measured on 7 2/1

~~Revised~~ Estimated Discharge @ 17 strokes/min ≈ 13.3 gpd (35 ml/min

REPORT OF ANALYSIS

CLIENT:	Hampton/NASA Steam Plant	SAMPLE RECEIPT	
ATTN:	Anil Mehrotra, Plant Engineer	DATE: 7/29/2016 TIME: 1315	
ADDRESS:	50 Wythe Creek Road	GRAB COLLECTION	
CITY:	Hampton, VA 23666	DATE: 7/28/2016 TIME: 0000	
PHONE:	(757) 865-1914	COLLECTED BY:	CLIENT
FAX:	e: amehrotra@hampton.gov	PICK UP BY:	REED - ML
		NUMBER OF CONTAINERS:	1
SPECIAL NOTES:		GOOD CONDITION	☑ Good ☐ Other (See C-O-C)
		REPORT NO:	16-13405 15:29

17 strokes/min

SAMPLE ID: HSP-0716-SST16
SAMPLE NO 16-13405

Estimated 34 ml/min

$\boxed{@\ 17\ \frac{\text{stroke}}{\text{min}} = 13.0\ \text{gpd}}$

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	08/05/16	1224
Barium	D005	6010C	0.250	100	0.550	mg/L	PEJ	08/05/16	1224
Cadmium	D006	6010C	0.005	1	0.420	mg/L	PEJ	08/05/16	1224
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	08/05/16	1224
Lead	D008	6010C	0.050	5	0.095	mg/L	PEJ	08/05/16	1224
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	08/05/16	1159
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	08/05/16	1224
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	08/05/16	1224

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.25
Extraction Fluid used: 2
Final (end point) pH of Extraction Fluid: 5.95

Authorized By: Elaine Claiborne
Elaine Claiborne, Laboratory Director
Date: 05-Aug-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

28 July 16

ANALYSIS SAMPLE CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0716-SST16

MATERIAL: Residue Ash

SAMPLE PREPARED BY: [signature]

METHOD: HSP-3A

CUSTODIAN	FROM		TO	
[signature]	0700	28 July 16	0850	28 July 16
[signature]	0850	28 July 16		
[signature]	9.41	29 July	9.42	7/29/16
[signature]	0943	7.29.16	13.5	7.29.16

Q. A. Weight: 22.5 LBS

JRA 16-13485

Test: TCLP All Metals

Rush Results

Reviewed By: [signature]

Date: 8/5/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0716-SST16 Sample Date: 7-28-16
Method Used: HSP-3A

Sample Certified Valid: Anil Mehrotra, 8/6/16 MS PE

GRAB	1 MIN GRAB 27JUL16	2	3	4	5	6	7	8
Time	1201	1304	1407	1500	1604	1703	1807	1908
Initials	JAD	RB	RB	RB	RB	RB	RB	TI
GRAB	9	10	11	12	13	14	15	16
Time								
Initials								
GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
				Unburnt Combustibles
1.	31	15.	47	1. 22½
2.	38½	16.	44½	2.
3.	43	17.	33	3.
4.	46	18.	20½	4.
5.	37½	19.		5.
6.	37	20.		6.
7.	36½	21.		Unburnable (Metal)
8.	37½	22.		1. 22
9.	46	23.		2.
10.	44	24.		3.
11.	43	25.		4.
12.	45	26.		5.
13.	49½	27.		6.
14.	44	28.		

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0716-SST16

Wet Trench pH: 10.1	Boilers Operating: 1+2	Weather: HOT, MUGGY

Chemical Treatment/ Injection Rate: SoDium SulFiDe

Comments: corrected 13.3 ~~11.4~~ gallons / day

[Pump #1 set at 17 strokes/min.]

Chemical discharge measured at Fly Ash Screen

= 30 ml. / min (CTea

= ~~11.4~~ 13.3 gal / day

Team (s): B

Quality Leader: Name JACK D. DYE Designation: AD

Team Leader: Name PHIL GAMBLE Designation: OE

Mass Proportion Samples

	Lbs.	lb/(%)	20 Lb. Sample	Q.A. Weight
Aggregate	~~7???~~ 73.5	18.84	(94.2%) 19.0	Total: 22.5 Lbs.
Unburnt	22.5 ~~.5?~~	0.58	(2.9%) 0.5	With bucket and lid.
Unburnable	22 ~~.5?~~	0.51	(2.9%) 0.5	

Verification by Quality Leader or Team Leader

Sign: Jack D. Dye

Date: 28 July 16

Hampton/NASA Steam Plant

Residue Ash Sample Treated with ~~11.4~~ 13.1 gal/day Sod. Sulfide

Sample collected on July 27, 2016

Method HSP 3A

Sample # HSP- 0716-SST16 (Both boilers in service)

Date: July 28, 2016 (FF inlet Temp. 430 F)

Aggregate	**723.5**
Unburnt	**22.5**
Metals	**22.0**
Total	**768.0**

Mass Proportion in %

Aggregate	94.2%
Unburnt	2.9%
Metals	2.9%
	100.0%

Mass Proportion in lbs. for 20 lb. sample

	Rounded Up in lbs.	Calculated Proportion
Aggregate	**19.0**	18.84 lbs.
Unburnt	**0.5**	0.59 lbs.
Metals	**0.5**	0.57 lbs.
Total	**20.0**	20.00 lbs.

Aggregate	**Unburnt**	**Metals**
31.0	22.5	22.0
38.5		
43.0		
46.0		
37.5		
37.0		
36.5		
37.5		
46.0		
44.0		
43.0		
45.0		
49.5		
44.0		
47.0		
44.5		
33.0		
20.5		

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0716–SST17

Sample Collection: Thu. Aug 4, 2016

QA Sample Preparation: Fri. Aug 5, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon on Thu. Aug 4, 2016 & will continue until 7:00 pm on Thu. Aug 4, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Thu. Aug 4:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs: — Continue 1-minute residue ash grab every hour as per above. Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Set these conditions before collecting samples)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	15 Strokes/min
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

*
SSI
12:2

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash 3. Ash conveyor issues 4. Others

Fri. Aug 5

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra
Plant Engineer

* Flow Rate measured with new 250 ml. graduated cylinder

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 8/5/2016 TIME: 1315
GRAB COLLECTION
DATE: 8/5/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - BS
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-13911 15:56

REED & ASSOCIATES

15 strokes/min
12.2 gpd

SAMPLE ID: HSP-0816-SST17
SAMPLE NO 16-13911

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	TLG	08/12/16	1445
Barium	D005	6010C	0.250	100	0.429	mg/L	TLG	08/12/16	1445
Cadmium	D006	6010C	0.005	1	0.906 M	mg/L	TLG	08/12/16	1445
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	TLG	08/12/16	1445
Lead	D008	6010C	0.050	5	0.245	mg/L	TLG	08/12/16	1445
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	08/11/16	1208
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	TLG	08/12/16	1445
Silver	D011	6010C	0.010	5	< 0.010	mg/L	TLG	08/12/16	1445

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

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The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.62
Extraction Fluid used: 2
Final (end point) pH of Extraction Fluid: 5.77

M: Matrix spike % recovery outside acceptance range (71%)
possibly due to high background.

Authorized By: Elaine Claiborne
Elaine Claiborne, Laboratory Director
Date: 12-Aug-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 8/5/2016 TIME: 1315
GRAB COLLECTION
DATE: 8/5/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - BS
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-13911 15:56

REED & ASSOCIATES

SAMPLE ID: HSP-0816-SST17
SAMPLE NO 16-13911

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	TLG	08/12/16	1445
Barium	D005	6010C	0.250	100	0.429	mg/L	TLG	08/12/16	1445
Cadmium	D006	6010C	0.005	1	0.906 M	mg/L	TLG	08/12/16	1445
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	TLG	08/12/16	1445
Lead	D008	6010C	0.050	5	0.245	mg/L	TLG	08/12/16	1445
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	08/11/16	1208
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	TLG	08/12/16	1445
Silver	D011	6010C	0.010	5	< 0.010	mg/L	TLG	08/12/16	1445

Date: Aug 5, '16
Sodium Sulfide Treatment Results

Pump Setting: 15 strokes/min
SSI rate: 12 gal. per day

Results: Sat

8/12/16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

NELAP ACCREDITED TNI LABORATORY

ANALYSIS SAMPLE
CHAIN OF CUSTODY

5 AUG 16

SAMPLE NUMBER: HSP-0816-SST17

MATERIAL: Residue ASH

SAMPLE PREPARED BY: [signature]

METHOD: HSP-3A

16-13911

CUSTODIAN	FROM		TO	
[signature]	0700	5 AUG 16	0855	5 Aug 16
[signature]	0855	5th Aug 16	1250	8/5/16
TS [signature]	8/5/16	1250	1315	8/5/16
[signature]	8/5/16	1315		

Q. A. Weight: 22.5

Test: TCLP
All Metals
Rush Results

Reviewed By: [signature]

Date: 8/15/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE #	HSP-0816-SST17	Sample Date:	8/5/16
		Method Used:	HSP 1A
Sample Certified Valid:	8/12/16 Anil Malhotra MS, PE Plant Engineer		

GRAB	1 MIN GRAB 1 4 AUG 16	2	3	4	5	6	7	8
Time	1208	1302	1404	1505	1602	1700	1805	1909
Initials	YDD	YDD	YDD	YDD	DD	DD	DD	TT
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
				Unburnt Combustibles
1.	36 ½	15.	28	
2.	49	16.	28½	1. 21
3.	45 ½	17.	26	2.
4.	48 ½	18.	22	3.
5.	45	19.	24	4.
6.	51 ½	20.		5.
7.	28 ½	21.	Total 705.5	6.
8.	42	22.		**Unburnable (Metal)**
9.	37	23.		1. 14
10.	33 ½	24.		2.
11.	31½	25.		3.
12.	36½	26.		4.
13.	28½	27.		5.
14.	28½	28.		6.

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HNSP- 0816 - SST 17

Wet Trench pH: 9.1	Boilers Operating: #1, #2	Weather: Part Cloudy

Chemical Treatment/ Injection Rate: 15 strokes / min 12 gal / day

Comments: 1500 4 AUG 16 SURGE BIN PLUGGED UP.
TOP PLATCO VALVE STOP FOR SHORT TIME. MAINT WIRED BOTH OPEN

Team (s):

Quality Leader: Name Jack Dye Designation: AO

Team Leader: Name Martin Benfield Designation: OE

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	670.5	95.03	~~19.5~~ 19.0 lbs	Total: 22.5 Lbs.
Unburnt	21.0	2.97	.5 lbs	With bucket and lid.
Unburnable	14.0	1.98	.5 lbs	

Verification by Quality Leader or Team Leader

Sign:

Date: 8/5/16

Calculation Sheet

20 Lb. Ash Sample

Sample # HSP-0816-SST 17

Date : Aug. 5, 2016

(1) Sub Total (Lbs)

a.	Aggregate	670.5
b.	Unburnt	21.0
c.	Metal	14.0
d.	TOTAL	705.5

(2) Mass Proportion (%)

A. Aggregate $\left(\frac{a}{d} \times 100\%\right)$	95.03
B. Unburnt $\left(\frac{b}{d} \times 100\%\right)$	2.97
C. Metal $\left(\frac{c}{d} \times 100\%\right)$	1.98
D. TOTAL	100%

(3) Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20Lb)	19.00
Unburnt (B × 20Lb)	.594
Metal (C × 20Lb)	.396
Total	20 Lb

(4) Rounded Up/down (Lb)
(To 1/2 Lb)

Aggregate	19.0	Lb.
Unburnt	.5	Lb
Metal	.5	Lb
Total	20.0 Lb	

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0816–SST18

Sample Collection: Mon. Aug 8, 2016
QA Sample Preparation: Tue. Aug 9, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon on Mon. Aug 8, 2016 & will continue until 7:00 pm on Mon. Aug 8, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Mon. Aug 8:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs: — Continue 1-minute residue ash grab every hour as per above. Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Set these conditions before collecting samples)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on *	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	12 ~~15~~ Strokes/min (App 12 9.5
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues   2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues   4. Others

Tue. Aug 9

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,
8/5/16
Anil Mehrotra, Plant Engineer

Fri 8/5/16 C-Team D. Woodar

12 strokes/min → 125 ml/

= 25 ml/m

$\boxed{@\ 12\ \frac{\text{strokes}}{\text{min}} = 9.5\ \text{gpd}}$

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 8/9/2016 TIME: 1455
GRAB COLLECTION
DATE: 8/9/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: CLIENT
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)
REPORT NO: 16-14111 15:56

REED & ASSOCIATES

SAMPLE ID: HSP-0816-SST18
SAMPLE NO 16-14111

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst	Date	Time
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	TLG	08/12/16	1452
Barium	D005	6010C	0.250	100	0.562	mg/L	TLG	08/12/16	1452
Cadmium	D006	6010C	0.005	1	0.017	mg/L	TLG	08/12/16	1452
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	TLG	08/12/16	1452
Lead	D008	6010C	0.050	5	< 0.050	mg/L	TLG	08/12/16	1452
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	08/11/16	1218
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	TLG	08/12/16	1452
Silver	D011	6010C	0.010	5	< 0.010	mg/L	TLG	08/12/16	1452

Date: Aug. 9, 2016 Sod. Sulfide Treatment Resi

Pump Setting: 12 strokes/min

SSI Rate: 9.5 gal. per day

Results: Sat

NOTE: Reset Sod. Sulfide pump setting To 12 strokes/min.

8/12/1

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

NELAP ACCREDITED TNI LABORATORY

REPORT OF ANALYSIS

NOTES:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 10.87

Extraction Fluid used: 1

Final (end point) pH of Extraction Fluid: 6.67

Authorized By: Elaine Claiborne

Elaine Claiborne, Laboratory Director

Date: 12-Aug-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0816-SST8

Sample Date: 8/9/16
Method Used: HSP-3A

Sample Certified Valid: 8/12/16 Amit Mehrotra, MS, PE

GRAB	1 8AUG16 1 min GRAB	2 8AUG16 1 min grab	3	4	5	6	7	8
Time	1330	1416	1530	1625	1735	1830	1930	2030
Initials	YDD/PG	PWG/[illegible]	YDD/PG	PWDD	PWDD	PWDD	MWB	MWB
GRAB	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Time								
Initials								
GRAB	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)					
Aggregate		**Aggregate**		**Other Materials Over 2"**	
1.	40	15.	39½	**Unburnt Combustibles**	
2.	38	16.	38	1.	55
3.	39½	17.		2.	48
4.	40½	18.		3.	38
5.	38½	19.		4.	43½
6.	41½	20.		5.	30½
7.	38½	21.		6.	
8.	40	22.		**Unburnable (Metal)**	
9.	38	23.		1.	19
10.	43½	24.		2.	18½
11.	42½	25.		3.	16
12.	39	26.		4.	8½
13.	45	27.		5.	
14.	40	28.		6.	

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0816-SST18

Wet Trench pH: 9.2	Boilers Operating: 1+2	Weather: cloudy rain

Chemical Treatment/ Injection Rate: 12 M/L per minute @ 9.5 gpd (12 strokes/min.
Sodium Sulfide Injection

Comments: MAGNET TURN OFF. METAL MIX WITH ASH.
DID TRENCH MORNING of [illegible] (Dt. 8/8/16)

Team (s): A. Smith, P. Darrah, D Jarrett, J Mercer

Quality Leader: Name Damon Woodard Designation: OP ENL

Team Leader: Name Jaorte D/E Designation: Ash Handler

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	642	69.86	13.97 = 14 lb	Total: 22.5 Lbs.
Unburnt	215	23.39	4.68 = 5 lb	With bucket and lid.
Unburnable	62	6.75	1.35 = 1 lb	

Verification by Quality Leader or Team Leader

Sign: [signature]

Date: 8/9/16

Calculation Sheet

20 Lb. Ash Sample

Sample # HSP-0816-SST18

Date : 8/9/16

① Sub Total (Lbs)

a. Aggregate 642
b. Unburnt 215
c. Metal 62

d. TOTAL 919

② Mass Proportion (%)

A. Aggregate $\left(\frac{a}{d} \times 100\%\right)$ 69.86
B. Unburnt $\left(\frac{b}{d} \times 100\%\right)$ 23.39
C. Metal $\left(\frac{c}{d} \times 100\%\right)$ 6.75

D. TOTAL 100%

③ Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20Lb) 13.97
Unburnt (B × 20Lb) 4.68
Metal (C × 20Lb) 1.35

Total 20 Lb

④ Rounded Up/down (Lbs)
(TO 1/2 Lb)

Aggregate 14 Lb.
Unburnt 5. Lb
Metal 1. Lb

Total 20.0 Lb

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0816–SST19-Q3

Sample Collection: Tue. Aug 16, 2016
QA Sample Preparation: Wed. Aug 17, 2016

(Use this test as Q 3 Test

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon on Tue. Aug 16, 2016 & will continue until 7:00 pm on Tue. Aug 16, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Tue. Aug 16:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs: — Continue 1-minute residue ash grab every hour as per above Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Set these conditions before collecting samples)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	12 Strokes/min
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues 4. Others

Wed. Aug 17

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra, Plant Engineer

Mehrotra, Anil

From:	Paula Jackson <pjackson@jrreed.com>
Sent:	Tuesday, September 20, 2016 10:55 AM
To:	Mehrotra, Anil
Subject:	TCLP re-extraction and comparison analysis

Anil,
You will be receiving two reports that summarize the re-extraction analysis that we recently performed on your TCLP samples.
The following is a more detailed explanation. Please call me if you have any questions.

The re-extraction/analysis from sample received 8/17/16 duplicated the original results . Based on initial chemistries, we were required to use extraction fluid #2. Analysis confirms the sample is hazardous for Pb.
Cadmium was quantitated at 0.803mg/L (which is just under the hazardous limit).

However, the re-extraction/analysis from sample received 8/31/16 did not duplicate. Based on initial chemistries, we were required to use extraction fluid #2. This differs from the previous extraction of fluid #1. It is important to note the final endpoint pH differs dramatically for each extraction 8.29/5.18 respectively. This explains the dramatic difference in the quantitation of metals. Metals will leach readily in an acidic environment. Consequently, the re-extraction/analysis for this sample is hazardous for Pb.

Paula Jackson
Inorganic Department Supervisor
757-873-4703

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SAMPLE RECEIPT
DATE: 8/31/2016 TIME: 1215
GRAB COLLECTION
DATE: 8/17/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - AC
NUMBER OF CONTAINERS: 1
GOOD CONDITION [✓] Good [ ] Other (See C-O-C)

SPECIAL NOTES:

REPORT NO: 16-15518 14:12

Supplement to Report No.:16-15518
Revised Re-analysis (See Notes)

New Test Report
9/20/16

SAMPLE ID: HNSP-0816-SST19-A-Q3
SAMPLE NO 16-15518

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	9/6/2016	1340
Barium	D005	6010C	0.250	100	0.380	mg/L	PEJ	9/6/2016	1340
Cadmium	D006	6010C	0.005	1	0.042	mg/L	PEJ	9/6/2016	1340
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	9/6/2016	1340
Lead	D008	6010C	0.050	5	0.109	mg/L	PEJ	9/6/2016	1340
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	9/6/2016	1545
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	9/6/2016	1340
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	9/6/2016	1340

REPORT OF ANALYSIS

NOTE:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.30 9/7/16
Extraction Fluid used: #1
Final (end point) pH of Extraction Fluid: 8.29

Re-extracted 9/8/2016
Initial pH: 11.24
Extraction Fluid used: #2
Final (end point) pH of Extraction Fluid: 5.18
Sample hazardous for Lead - 5.64 mg/L,
Non Hazardous for Cadmium - 0.675 mg/L

RESPECTFULLY SUBMITTED

Elaine Claiborne

Elaine Claiborne
Laboratory Director
20-Sep-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SAMPLE RECEIPT
DATE: 8/31/2016 TIME: 1215
GRAB COLLECTION
DATE: 8/17/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - AC
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)

SPECIAL NOTES:

REPORT NO: 16-15518 7:40

Initial Test Report - 9/7/16

SAMPLE ID: HNSP-0816-SST19-A-Q3
SAMPLE NO 16-15518

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	9/6/2016	1340
Barium	D005	6010C	0.250	100	0.380	mg/L	PEJ	9/6/2016	1340
Cadmium	D006	6010C	0.005	1	0.042	mg/L	PEJ	9/6/2016	1340
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	9/6/2016	1340
Lead	D008	6010C	0.050	5	0.109	mg/L	PEJ	9/6/2016	1340
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	9/6/2016	1545
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	9/6/2016	1340
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	9/6/2016	1340

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

REPORT OF ANALYSIS

NOTE:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.30

Extraction Fluid used: #1

Final (end point) pH of Extraction Fluid: 8.29

RESPECTFULLY SUBMITTED

Elaine Claiborne

Elaine Claiborne
Laboratory Director
07-Sep-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

ANALYSIS SAMPLE
CHAIN OF CUSTODY

17 AUG 16

SAMPLE NUMBER: HNSP-0816-SST19-A-Q3 MATERIAL: refuse

SAMPLE PREPARED BY: TONY TAYLOR METHOD: HSP-3A

16,15518

CUSTODIAN	FROM		TO	
Tony Taylor	0710	8/17/16	0855	8/17/16
	0855	8/17/16	1150	8/31/16
Austin [illegible]	1150	8-31-16	1215	8-31-16

Q. A. Weight: 22.5 lbs

Test: TCLP All Metals

Reviewed By: 9/8/16 Anil Mehrotra MS, PE

Date:

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SAMPLE RECEIPT
DATE: 8/17/2016 TIME: 1415
GRAB COLLECTION
DATE: 8/17/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - AC
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)

SPECIAL NOTES:

REPORT NO: 16-14702 14:12

Supplement to Report No.:16-14702
Revised Re-analysis (See Notes)

New Test Report
9/20/16

SAMPLE ID: HNSP-0816-SST19-Q3
SAMPLE NO 16-14702

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	8/30/2016	1717
Barium	D005	6010C	0.250	100	0.827	mg/L	PEJ	8/30/2016	1717
Cadmium	D006	6010C	0.005	1	1.04	mg/L	PEJ	8/30/2016	1717
Chromium	D007	6010C	0.010	5	0.114	mg/L	PEJ	8/30/2016	1717
Lead	D008	6010C	0.050	5	10.3	mg/L	PEJ	8/30/2016	1717
Mercury	D009	7470A	0.0002	0.2	0.0021	mg/L	TLG	8/30/2016	1628
Selenium	D010	6010C	0.050	1	0.716	mg/L	PEJ	8/30/2016	1717
Silver	D011	6010C	0.010	5	0.024	mg/L	PEJ	8/30/2016	1717

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 • Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

NELAP ACCREDITED TNI LABORATORY

REPORT OF ANALYSIS

NOTE:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 11.55
Extraction Fluid used: 2
Final (end point) pH of Extraction Fluid: 5.40

Re-extracted 9/8/2016
Initial pH: 11.10
Extraction Fluid used: 2
Final (end point) pH of Extraction Fluid: 5.43
Sample confirmed Hazardous for Lead - 5.64 mg/L,
Non Hazardous for Cadmium - 0.803 mg/L

RESPECTFULLY SUBMITTED

Elaine Claiborne

Elaine Claiborne
Laboratory Director
20-Sep-16

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 8/17/2016 TIME: 1415
GRAB COLLECTION
DATE: 8/17/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - AC
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)

REED & ASSOCIATES

Retest Archive Sample
SST 19A - Q3

SAMPLE ID: HNSP-0816-SST19-Q3
SAMPLE NO 16-14702

Initial Test Report: 8/30/16

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time
Toxic Characteristic Leaching Procedure by SW-846 Method 1311							
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ 8/30/2011717
Barium	D005	6010C	0.250	100	0.827	mg/L	PEJ 8/30/2011717
Cadmium	D006	6010C	0.005	1	1.04	mg/L	PEJ 8/30/2011717
Chromium	D007	6010C	0.010	5	0.114	mg/L	PEJ 8/30/2011717
Lead	D008	6010C	0.050	5	10.3	mg/L	PEJ 8/30/2011717
Mercury	D009	7470A	0.0002	0.2	0.0021	mg/L	TLG 8/30/2011628
Selenium	D010	6010C	0.050	1	0.716	mg/L	PEJ 8/30/2011717
Silver	D011	6010C	0.010	5	0.024	mg/L	PEJ 8/30/2011717

NOTE: *JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Initial pH: 11.55
Extraction Fluid used: 2
Final (end point) pH of Extraction Fluid: 5.40

RESPECTFULLY SUBMITTED

Elaine Claiborne

Elaine Claiborne
Laboratory Director
30-Aug-16

Investigated and contacted test lab James R. Reed. The lab is pulling samples from last 2 batches SST-19 & 29 to retest.

Anil Mehrotra
MS,

ANALYSIS SAMPLE
CHAIN OF CUSTODY

17 AUG 16

SAMPLE NUMBER: HNSP-0816-SST19-Q3 MATERIAL: refuse

SAMPLE PREPARED BY: [signature] METHOD: HSP-3A

16.14702

CUSTODIAN	FROM		TO	
[signature]	0710	8/17/16	0855	8/17/16
[signature]	0855	8/17/16	0945	8/17/16
Austin [signature]	0945	8-17-16	1400	8-17-16
[signature]	1415	8.17.16	1415	8.17.16

Q. A. Weight: 22.5 lbs

Test: TCLP All Metals Rush Results

Retest 9/8/16

Reviewed By: __________

Date: __________

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant Residue ash Sample Data Records								- Page 1
SAMPLE # HSP-0816-SST19-Q3				Sample Date: 8/17/16 Method Used: HSP-3A.				
Sample Certified Valid: Archived				Archived sample was tested at verified original sample results uncharacteristic and hence rejected. 9/7/16 Melnot				
GRAB	1	2	3	4	5	6	7	8
Time	1200	1301	1408	1500	1610	1700	1805	1915
Initials	JDD/PG	JDD/PG	JDD	JDD/PG	PWJ	PWJ	PWJ	MB
GRAB	9	10	11	12	13	14	15	16
Time								
Initials								
GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)					
Aggregate		Aggregate		Other Materials Over 2"	
1.	45.0	15.	7.5	Unburnt Combustibles	
2.	49.0	16.		1.	28.0
3.	48.5	17.		2.	40.0
4.	54.5	18.	total = 687.5	3.	
5.	54.0	19.	88.4 %	4.	
6.	48.0	20.		5.	total = 68
7.	49.0	21.		6.	8.75 %
8.	47.5	22.		Unburnable (Metal)	
9.	46.0	23.		1.	22.0
10.	50.0	24.		2.	
11.	41.0	25.		3.	
12.	42.5	26.		4.	total = 22
13.	56.0	27.		5.	2.82 %
14.	49.0	28.		6.	

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HNSP-0816-SST19Q3

Wet Trench pH: 8.2	Boilers Operating: 1 & 2	Weather: Sunny

Chemical Treatment/ Injection Rate: 12 strokes /min

Comments: Parameter for test: specific gravity 1.01, SO_2 control 60ppm, FF temp 430°F with all 3 modules, Boiler steam rate 33Kpph, Sodium sulfide rate 12 strokes per min

Team (s): C+D

Quality Leader: Name Jack Dye Designation: ______

Team Leader: Name Tony Taylor Designation: ______

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	687.5	88.4	17.5	Total: 22.5 Lbs.
Unburnt	68	8.75	2.0	With bucket and lid.
Unburnable	22	2.82	.5	

TOTAL: 777.5

Verification by Quality Leader or Team Leader

Sign: Tony Taylor

Date: 8/17/16

Hampton/NASA Steam Plant
Procedure for Characterization of Residue Ash treatment with Sodium Sulfide
Sample Number: HNSP–0816–SST20

Sample Collection: Wed. Aug 24, 2016
QA Sample Preparation: Thu. Aug 25, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 12:00 noon on Wed. Aug 24, 2016 & will continue until 7:00 pm on Wed. Aug 24, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Wed. Aug 24:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting:
12:00 noon — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending:
19:00 hrs: — Continue 1-minute residue ash grab every hour as per above. Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Set these conditions before collecting samples)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	12 Strokes/min
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues   2. Upset condition: trench cleaning/ wet trash
3. Ash conveyor issues   4. Others

Thu. Aug 25

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra, Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SPECIAL NOTES:

SAMPLE RECEIPT
DATE: 8/25/2016 TIME: 1025
GRAB COLLECTION
DATE: 8/25/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - BS
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)

REED & ASSOCIATES

SAMPLE ID: HSP-0816-SST20
SAMPLE NO 16-15218

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time	
Toxic Characteristic Leaching Procedure by SW-846 Method 1311								
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	8/30/2011708
Barium	D005	6010C	0.250	100	0.553	mg/L	PEJ	8/30/2011708
Cadmium	D006	6010C	0.005	1	0.315	mg/L	PEJ	8/30/2011708
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	8/30/2011708
Lead	D008	6010C	0.050	5	0.102	mg/L	PEJ	8/30/2011708
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	8/30/2011651
Selenium	D010	6010C	0.050	1	0.202	mg/L	PEJ	8/30/2011708
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	8/30/2011708

NOTE: *JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Initial pH: 11.57
Extraction Fluid used: 1
Final (end point) pH of Extraction Fluid: 7.88

RESPECTFULLY SUBMITTED

Elaine Claiborne

Elaine Claiborne
Laboratory Director
30-Aug-16

ANALYSIS SAMPLE
CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0816-SST20

MATERIAL: Residue Ash + Metal

SAMPLE PREPARED BY: Donald Woodard

METHOD: HSP- 3A

16-15218

CUSTODIAN	FROM		TO	
Donald Woodard	8/25/16	0700	8/25/16	0840
	8/25/16	0840	8/25/16	0958
	8/25/16	0958	8/25/16	1025
	8/25/16	1025		

Q. A. Weight: 22.5 lbs

Test: TCLP - All metals

Reviewed By: ____________

Date: 8/30

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant Residue ash Sample Data Records								- Page 1
SAMPLE # HSP-0816-SST20				Sample Date: 8/25/16 Method Used: HSP-3A				
Sample Certified Valid: 24 aug 16 8/30/16 Anil Mehrotra, MS, PE								
GRAB	1	2	3	4	5	6	7	8
Time	0958	1130	1204	1306	1408	1516	16:05	1700
Initials	TDD	TDD	TDD	TDD/PG	TDD/PG	TDD	DS	DS
GRAB	9	10	11	12	13	14	15	16
Time								
Initials								
GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"	
				Unburnt Combustibles	
1.	41	15.		1.	34.5
2.	54.5	16.		2.	53
3.	51.5	17.		3.	31
4.	44	18.		4.	
5.	49	19.		5.	
6.	52.5	20.		6.	
7.	45.5	21.		Unburnable (Metal)	
8.	38	22.		1.	13.5
9.	20	23.		2.	
10.	43	24.		3.	
11.	43.5	25.		4.	
12.	73	26.		5.	
13.		27.		6.	
14.		28.			

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # HSP-0816-SST20

Wet Trench pH: 8.6	Boilers Operating: 1 & 2 *	Weather: clear & sunny

Chemical Treatment/ Injection Rate: SSI @ 12 STROKES PER MINUTE 9.5 gallons PER DAY

Comments: * CLOSED DOOR ON #1 BLR DUE TO TUBE LEAK AT 0850. #1 BLR CAME OFF LINE AT 1015.

Team (s): D. WOODARD, T. TAYLOR, J. JONES, R. Lito

Quality Leader: Name D. WOODARD Designation: OP ENG

Team Leader: Name JACKIE Dyo Designation: ASH HANDLER

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	555.5	80.8	16	Total: 22.5 Lbs.
Unburnt	118.5	17.24	3.5	With bucket and lid.
Unburnable	13.5	1.96	.5	

Verification by Quality Leader or Team Leader

Sign: [signature]

Date: 8/25/16

Calculation Sheet

20 Lb. Ash Sample

Sample # HSP-0816-SSTZD

Date : 8/25/16

1

Sub Total (Lbs)

a. Aggregate 555.5

b. Unburnt 118.5

c. Metal 13.5

d. TOTAL 687.5

2

Mass Proportion (%)

A. Aggregate ($\frac{a}{d} \times 100\%$) 80.8

B. Unburnt ($\frac{b}{d} \times 100\%$) 17.24

C. Metal ($\frac{c}{d} \times 100\%$) 1.96

D. TOTAL 100%

3

Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20Lb) 16.16

Unburnt (B × 20Lb) 3.45

Metal (C × 20Lb) .39

Total 20 lb

4

Rounded Up/down (Lbs)
(TO 1/2 Lb)

Aggregate 16 Lb.

Unburnt 3.5 Lb

Metal .5 Lb

Total 20.0 Lb

Hampton/NASA Steam Plant

Procedure for Characterization of Residue Ash treatment with Sodium Sulfide

Sample Number: HNSP–0816–SST21

(During start-up of Boiler #1)

Sample Collection: Fri. Aug 26, 2016

QA Sample Preparation: ~~Fri. Sep. 2, 2016~~ Sun. Aug 28, 2016

An 8-hour **residue ash sample collection** with Sodium Sulfide injection is to start at 6:00 pm on Fri. Aug 26, 2016 & will continue until 1:00 am on Sat. Aug 27, 2016. The sample will be gathered, prepared, and sealed for analysis as per Method HSP–3A according to following schedule/QA procedures:

Fri. Aug 26:

AM Team — Ensure all test conditions given in Test Day Control Parameters below are set accordingly. Mention specific existing condition. Move the residue truck out from underneath the shaker pan and bring self-dumping sample collection hopper near shaker pan.

Starting: 6:00 pm — Operating Engineer on watch will randomly signal the residue handling operator to move the hopper underneath the pan and will let the residue ash drop directly in hopper for 1 minute.

Ending: 01:00 am: — Continue 1-minute residue ash grab every hour as per above Self-dumping ash sample hopper will be kept locked by OE on watch during entire ash collection period until ready for sorting.

Test Day Control Parameters (Set these conditions before collecting samples)			
Reagent Specific Gravity	1.01	SO_2 Control	60 ppm
Fabric Filter Inlet Temp.	430°F	FF Modules on	All 3
Boilers steam rate	33 kpph	Sodium Sulfide rate	12 Strokes/min
Boilers running condition	Normal: Y/N *	Any important change	_ _ _ _ _

Remarks: * 1. Mechanical issues 2. Upset condition: trench cleaning/ wet trash 3. Ash conveyor issues 4. Others

Fri. Sept 2:

07:30–10:00 AM — Use Method HSP-3A for ash sorting and preparation of a 20 lb sample for laboratory analysis and another 20 lb archive sample.

Always follow QA/QC and Chain of Custody procedures as per DEQ Permit # 297.

Thank you,

Anil Mehrotra, Plant Engineer

REPORT OF ANALYSIS

CLIENT: Hampton/NASA Steam Plant
ATTN: Anil Mehrotra, Plant Engineer
ADDRESS: 50 Wythe Creek Road
CITY: Hampton, VA 23666
PHONE: (757) 865-1914
FAX: e: amehrotra@hampton.gov

SAMPLE RECEIPT
DATE: 8/29/2016 TIME: 1013
GRAB COLLECTION
DATE: 8/28/2016 TIME: 0000
COLLECTED BY: CLIENT
PICK UP BY: REED - BS
NUMBER OF CONTAINERS: 1
GOOD CONDITION ☑ Good ☐ Other (See C-O-C)

SPECIAL NOTES:

REPORT NO: 16-15353 7:40

SAMPLE ID: HSP-0816-SST21
SAMPLE NO 16-15353

Parameter	EPA HW No.	Method Number	JRA QL	Regulatory Level	Result	Unit	Analyst/Date/Time		
Toxic Characteristic Leaching Procedure by SW-846 Method 1311									
Arsenic	D004	6010C	0.050	5	< 0.050	mg/L	PEJ	9/6/2016	1321
Barium	D005	6010C	0.250	100	0.309	mg/L	PEJ	9/6/2016	1321
Cadmium	D006	6010C	0.005	1	0.044	mg/L	PEJ	9/6/2016	1321
Chromium	D007	6010C	0.010	5	< 0.010	mg/L	PEJ	9/6/2016	1321
Lead	D008	6010C	0.050	5	< 0.050	mg/L	PEJ	9/6/2016	1321
Mercury	D009	7470A	0.0002	0.2	< 0.0002	mg/L	TLG	9/6/2016	1526
Selenium	D010	6010C	0.050	1	< 0.050	mg/L	PEJ	9/6/2016	1321
Silver	D011	6010C	0.010	5	< 0.010	mg/L	PEJ	9/6/2016	1321

REPORT OF ANALYSIS

NOTE:

JRA Quantification Level is the concentration of the lowest calibration standard above zero with a reliable signal.

Reproduction of this report is not permitted, except in full, without written approval from James R Reed & Associates.

The results on this report relate only to the sample(s) provided for analysis.

Results conform to NELAC standards, where applicable, unless otherwise indicated.

Initial pH: 10.99

Extraction Fluid used: #1

Final (end point) pH of Extraction Fluid: 7.42

RESPECTFULLY SUBMITTED

Elaine Claiborne

Elaine Claiborne
Laboratory Director
07-Sep-16

James R. Reed & Associates
770 Pilot House Drive, Newport News, VA 23606
(757) 873-4703 ● Fax: (757) 873-1498

VELAP# 460013
EPA# VA00015

28Aug16

ANALYSIS SAMPLE
CHAIN OF CUSTODY

SAMPLE NUMBER: HSP-0816-SS721

MATERIAL: Residue ASH

SAMPLE PREPARED BY: [signature]

METHOD: HSP-3A

16-15353

CUSTODIAN	FROM		TO	
[signature]	0700	28Aug16	1100	28Aug16
[signature]	1100	28Aug16	1013	29Aug16
[signature]	1013	8/29/16		

Q. A. Weight: 22.5 LBS

Test: TCLP All Metals

Reviewed By: [signature] Harold Melvin MS, PE

Date: 9/9/16

Hampton/NASA Steam Plant
50 Wythe Creek Road, Hampton, Virginia, (757) 865-1914 fax (757) 865-1317

Hampton/NASA Steam Plant
Residue ash Sample Data Records - Page 1

SAMPLE # HSP-0816-SST21 | Sample Date: 26 AUG 16 | Method Used: HSP-3A

Sample Certified Valid: 9/7/16 Paul Melendez MS, PE Plant Engineer

GRAB	26 AUG 16 1 MIN GRAB	2	3	4	5	6	7	8
Time	6:10 pm	1905	2007	2108	2203	2302	0001	0100
Initials	TT							
GRAB	9	10	11	12	13	14	15	16
Time								
Initials								
GRAB	17	18	19	20	21	22	23	24
Time								
Initials								

WEIGHT TALLY SHEET (+ or - ½ Lb)

Aggregate		Aggregate		Other Materials Over 2"
1.	41.5	15.	38	**Unburnt Combustibles**
2.	42	16.		1. 36
3.	48	17.		2. 50.5
4.	43	18.		3.
5.	47	19.		4.
6.	49	20.		5.
7.	49	21.		6.
8.	46	22.		**Unburnable (Metal)**
9.	45	23.		1. 31.5
10.	47	24.		2.
11.	47.5	25.		3.
12.	54	26.		4.
13.	49.5	27.		5.
14.	42	28.		6.

Residue ash Sample Data Records - Page 2
(Please Sign and Date below)

Sample # ______________

Wet Trench pH: 8.6 | Boilers Operating: 1 & 2 Boiler 1 startup | Weather: MUGGY / HUMID

Chemical Treatment/ Injection Rate: ______________

Comments: BRING UP BOILER / LIGHT-OFF #1 /

Team (s): ______________

Quality Leader: Name ______________ Designation: ______________

Team Leader: Name JACK DYE Designation: ______________

Mass Proportion Samples

	Lbs.	%	20 Lb. Sample	Q.A. Weight
Aggregate	689	.9	18	Total: 22.5 Lbs.
Unburnt	87	.1	1.5	With bucket and lid.
Unburnable	32	.04	.5	

Verification by Quality Leader or Team Leader

Sign: Jack D. Dye

Date: 28 Aug 16

Calculation Sheet

20 Lb. Ash Sample

28 Aug 16
Tony Taylor

Sample # HNSP-0816-SS T21

Date : 8/26/16

(1)

Sub Total (Lbs)

a. Aggregate 689

b. Unburnt 87

c. Metal 32

d. TOTAL 807

(2)

Mass Proportion (%)

A. Aggregate ($\frac{a}{d} \times 100\%$) .9 (85

B. Unburnt ($\frac{b}{d} \times 100\%$) .1 (11%

C. Metal ($\frac{c}{d} \times 100\%$) .04 (4

D. TOTAL 100%

(3)

Calculate 20 Lb Proportion (Lb)
(upto 2 decimal point)

Aggregate (A × 20Lb) 18 (17)

Unburnt (B × 20Lb) 2 (2)

Metal (C × 20Lb) .8 (0.8)

Total 20 lb

(4)

Rounded up/down (Lbs
(To 1/2 Lb)

Aggregat 18 Lb (1

Unburnt 1.5 Lb (2

Metal .5 Lb (1

Total 20.0 Lb

APPENDIX F

OTHER MSW PLANTS HEAVY METALS TCLP RESULTS

1. Covanta, Fairfax, Virginia

2. Wheelabrator, Portsmouth, Virginia

COVANTA

Covanta Fairfax, Inc.
A Covanta Company
9898 Furnace Rd
Lorton, VA 22079
Tel 703 690 5860
Fax 703 690 4223

Mass Burn

VA DEPARTMENT OF ENVIRONMENTAL QUALITY
NORTHERN
AUG 21 2013
REGIONAL OFFICE
WOODBRIDGE, VA

August 19, 2013

Mr. Richard Doucette
Land Protection and Revitalization Program Manager
Virginia Department of Environmental Quality
Northern Virginia Regional Office
13901 Crown Court
Woodbridge, VA 22193-1453

Subject: Covanta Fairfax, Inc. Permit-by-Rule #545
1st 2013 Semi-Annual TCLP Ash Sampling and Test Report

Dear Mr. Doucette,

Pursuant to PBR #545, Attachment II, Ash Residue Testing the 1st 2013 Semi-Annual TCLP Ash Sampling and Test Report is hereby submitted to demonstrate compliance:

> *In accordance with 9 VAC 20-80-370.D.8., the facility shall perform a chemical analysis of all residual ash generated in accordance with the facility's permit. Based on a statistical analysis performed using ash testing data from 1994 to 2009, and the quantity of ash generated by the facility, the facility shall perform semi-annual ash sampling and report results within 90 days of sample collection in accordance with 9 VAC 20-80-370.D.8.d.*

The analytical data was evaluated in complete compliance with the procedures set forth and required by SW-846. The statistical evaluation has determined that the waste does not exhibit a hazardous characteristic and that it should be managed as a nonhazardous solid waste.

Please contact me if you have any questions or comments.

Regards,

Scott P. Drew
Facility Manager

Cc: C. Forbes (Fairfax County Solid Waste)
L. Boone (Fairfax County Solid Waste)
D. Shabat (Dvirka and Bartilucci)
J. Herrmann (CFI)

Encls

TABLE 3 LABORATORY RESULTS FOR THE
COVANTA FAIRFAX, INC

3.1 SAMPLE SPECIFIC RESULTS

SAMPLE ID NUMBER	SAMPLE DATE	As (mg/l)	Ba (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Hg (mg/l)	Se (mg/l)	Ag (mg/l)
FFX/CA/TCLP/13.05.28/1A	5/28/2013	< 0.250	< 0.25	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
FFX/CA/TCLP/13.05.29/2A	5/29/2013	< 0.250	< 0.25	< 0.0500	< 0.2500	< 0.2500	0.00043	< 0.050	< 0.2500
FFX/CA/TCLP/13.05.30/2A	5/30/2013	< 0.250	< 0.25	< 0.0500	< 0.2500	< 0.2500	0.00083	< 0.050	< 0.2500
FFX/CA/TCLP/13.05.31/1A	5/31/2013	< 0.250	0.54	< 0.0500	< 0.2500	< 0.2500	0.00100	< 0.050	< 0.2500
FFX/CA/TCLP/13.05.31/2A	5/31/2013	< 0.250	0.57	< 0.0500	< 0.2500	< 0.2500	0.00067	< 0.050	< 0.2500
FFX/CA/TCLP/13.06.03/1A	6/3/2013	< 0.250	0.54	< 0.0500	< 0.2500	< 0.2500	0.00094	< 0.050	< 0.2500
FFX/CA/TCLP/13.06.03/2A	6/3/2013	< 0.250	0.54	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
FFX/CA/TCLP/13.06.04/1A	6/4/2013	< 0.250	0.63	< 0.0500	< 0.2500	< 0.2500	0.00220	< 0.050	< 0.2500
FFX/CA/TCLP/13.06.04/2A	6/4/2013	< 0.250	0.50	< 0.0500	< 0.2500	< 0.2500	0.00095	< 0.050	< 0.2500
FFX/CA/TCLP/13.06.06/1A	6/6/2013	< 0.250	0.52	< 0.0500	< 0.2500	< 0.2500	0.00080	< 0.050	< 0.2500
FFX/CA/TCLP/13.06.06/2A	6/6/2013	< 0.250	< 0.25	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
FFX/CA/TCLP/13.06.07/1A	6/7/2013	< 0.250	0.51	< 0.0500	< 0.2500	< 0.2500	0.00073	< 0.050	< 0.2500
FFX/CA/TCLP/13.06.07/2A	6/7/2013	< 0.250	0.56	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
FFX/CA/TCLP/13.06.11/1A	6/11/2013	< 0.250	0.64	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500

3.2 STATISTICAL RESULTS

	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
NUMBER OF SAMPLES	14	14	14	14	14	14	14	14
DEGREES OF FREEDOM	13	13	13	13	13	13	13	13
SAMPLE MEAN (XBAR)	0.250	0.47	0.050	0.250	0.250	0.00068	0.050	0.250
SAMPLE VARIANCE (S^2)	0.0E+00	0.02	0.000	0.0E+00	0.000	2.9E-07	0.0E+00	0.0E+00
STANDARD DEVIATION (S)	0.0E+00	0.15	0.000	0.00E+00	0.000	5.4E-04	0.0E+00	0.0E+00
STD ERROR (S XBAR)	0.0E+00	0.04	0.000	0.00E+00	0.000	1.4E-04	0.0E+00	0.0E+00
80% CI Upper Limit (actual)	**0.250**	**0.52**	**0.050**	**0.250**	**0.250**	**0.00088**	**0.050**	**0.250**
80% CI Upper Limit (exp. of lognormal)								
MAXIMUM	0.250	0.64	0.050	0.250	0.250	0.00220	0.050	0.250
MINIMUM	0.250	0.25	0.050	0.250	0.250	0.00020	0.050	0.250
3.3 REGULATORY THRESHOLD	5.0	100.0	1.0	5.0	5.0	0.2	1.0	5.0

Table 4

COMPARISON OF SW-846 STATISTICAL RESULTS
ANDREGULATORY THRESHOLDS
FOR METAL ANALYTES

Analyte	90% Upper Confidence Interval per SW-846 (b)	Regulatory Threshold (a)
Metals		
Arsenic	0.250	5.0
Barium	0.520	100.0
Cadmium	0.050	1.0
Chromium	0.250	5.0
Lead	0.250	5.0
Mercury	0.00088	0.2
Selenium	0.050	1.0
Silver	0.250	5.0

(a) 40 CFR Part 261. All units are expressed as milligrams per liter (mg/L).

(b) 90% Upper Confidence Interval as a single-tailed distribution is equivalent to an 80% Upper Confidence Interval as a two-tailed distribution.

COVANTA
ENERGY
for a cleaner world

Covanta Alexandria/Arlington, Inc.
5301 Eisenhower Ave
Alexandria, VA 22304
Tel 703 370 7722
Fax 703 751 2567

Mass Burn

March 23, 2016

Mr. Richard Doucette
Solid Waste Manager
Virginia Department of Environmental Quality
Northern Virginia Regional Office
13901 Crown Court
Woodbridge, VA 22193

Reference: Covanta Alexandria/Arlington, Inc. (CAAI) PBR #551
2016 Semi-Annual TCLP Ash Analysis

Dear Mr. Doucette,

CAAI has enclosed the first semi-annual TCLP Ash Test Report for 2016. The samples were collected from February 16-25, 2016.

Please contact me if you have any questions or comments.

Regards,

Bryan Donnelly

Bryan Donnelly
Facility Manager

BD/KMM

CC:
W. Skrabak (City of Alexandria)
K. Perrin (HDR)*
K. Perszyk (VADEQ)*

*Report sent via email.

COVANTA ENERGY GROUP, INC.
CEMS/TESTING DEPARTMENT

ENVIRONMENTAL TEST REPORT
FOR
COVANTA ALEXANDRIA/ARLINGTON, INC.

CEG REPORT NO.:	4093
REPORT DATE:	March 23, 2016
PREPARED FOR:	Alexandria Resource Recovery Facility
PURPOSE:	Characterization of Ash Residue
SAMPLE PERIOD:	February 16 through February 25, 2016
PREPARED BY:	Covanta Energy Group, Inc. Department 14 - CEM/Emission Testing

TABLE 3 LABORATORY RESULTS FOR THE
COVANTA ALEXANDRIA/ARLINGTON, INC

3.1 SAMPLE SPECIFIC RESULTS

SAMPLE ID NUMBER	As (mg/l)	Ba (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Hg (mg/l)	Se (mg/l)	Ag (mg/l)
Alex/CA/TCLP/16.02.16/1B	< 0.250	0.98	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.17/1A	< 0.250	0.85	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.17/1B	< 0.250	1.20	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.18/1A	< 0.250	0.92	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.18/1B	< 0.250	0.85	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.19/1A	< 0.250	1.10	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.19/1B	< 0.250	0.96	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.22/1A	< 0.250	1.00	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.22/1B	< 0.250	0.89	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.23/1A	< 0.250	1.10	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.23/1B	< 0.250	1.10	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.24/1A	< 0.250	0.82	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.24/1B	< 0.250	0.93	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500
Alex/CA/TCLP/16.02.25/1A	< 0.250	0.88	< 0.0500	< 0.2500	< 0.2500	< 0.00020	< 0.050	< 0.2500

3.2 STATISTICAL RESULTS

	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
NUMBER OF SAMPLES	14	14	14	14	14	14	14	14
DEGREES OF FREEDOM	13	13	13	13	13	13	13	13
SAMPLE MEAN (XBAR)	0.250	0.97	0.050	0.250	0.250	0.00020	0.050	0.250
SAMPLE VARIANCE (S^2)	0.0E+00	0.01	0.000	0.0E+00	0.000	3.2E-39	0.0E+00	0.0E+00
STANDARD DEVIATION (S)	0.0E+00	0.12	0.000	0.00E+00	0.000	5.6E-20	0.0E+00	0.0E+00
STD ERROR (S XBAR)	0.0E+00	0.03	0.000	0.00E+00	0.000	1.5E-20	0.0E+00	0.0E+00
80% CI Upper Limit (actual)	**0.250**	**1.012**	**0.050**	**0.250**	**0.250**	**0.00020**	**0.050**	**0.250**
80% CI Upper Limit (exp. of lognormal)								
MAXIMUM	0.250	1.20	0.050	0.250	0.250	0.00020	0.050	0.250
MINIMUM	0.250	0.82	0.050	0.250	0.250	0.00020	0.050	0.250
3.3 REGULATORY THRESHOLD	5.0	100.0	1.0	5.0	5.0	0.2	1.0	5.0

(a) Less than symbol (<) indicates laboratory result below the detection limit.
The value used in this table is one-half (1/2) of the detection limit provided by the laboratory.

Table 4

COMPARISON OF SW-846 STATISTICAL RESULTS
ANDREGULATORY THRESHOLDS
FOR METAL ANALYTES

Analyte	90% Upper Confidence Interval per SW-846 (b)	Regulatory Threshold (a)
Metals		
Arsenic	0.250	5.0
Barium	1.012	100.0
Cadmium	0.050	1.0
Chromium	0.250	5.0
Lead	0.250	5.0
Mercury	0.0002	0.2
Selenium	0.050	1.0
Silver	0.250	5.0

(a) 40 CFR Part 261. All units are expressed as milligrams per liter (mg/L).

(b) 90% Upper Confidence Interval as a single-tailed distribution is equivalent to an 80% Upper Confidence Interval as a two-tailed distribution.

RDF

Wheelabrator
PORTSMOUTH

HD
RECEIVED – DEQ
APR 10 2015
Tidewater Regional Office

April 9, 2015

Jeff Deibler
Waste Compliance Technical Coordinator
Virginia Department of Environmental Quality
5636 Southern Blvd.
Virginia Beach, VA 23462

Re: Wheelabrator Portsmouth WTE Ash Test Results

Dear Mr. Deibler,

In accordance with 9VAC20-81-340.E.7 please find enclosed a copy of the chemical analyses of residue Completed in February 2015.

If you have any questions about this submittal, you can reach me at 393-3105,

Sincerely,

Jeff Landrum
Environmental Manager

Enclosure

3809 Elm Avenue | Portsmouth, VA 23704 | tel 757.393.3100 | fax 757.393.3178 | www.wtienergy.com

RECEIVED – DEQ
APR 10 2015
Tidewater Regional Office

DOCUMENT CERTIFICATION

Facility Name: Wheelabrator Portsmouth Inc.

Registration No. 61018

Facility Location: Portsmouth, VA

Type of Submittal Attached: 2015 Residue Chemical Analysis Results

Certification: I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering and evaluating the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name of Responsible Official (Print): Rob Johnson

Title: Plant Manager

Signature: [signature] **Date:** 04/09/2015

Wheelabrator P...smouth Inc

INORGANIC ANALYSIS REPORT

Residue Chemical Analsysis Report

2/15/15 - 2/21/15

Report Date : 3/30/2015

SAMPLE ID	SAMPLED BY	DATE	AM/PM	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
				Sampling Event (in mg/L)							
6014	JL / JL	2/15/2015	AM	< 0.2	1.0	< 0.01	< 0.02	3	< 0.0002	< 0.2	< 0.02
6015	JL / JJ	2/15/2015	PM	< 0.2	0.9	< 0.01	< 0.02	14.2	< 0.0002	< 0.2	< 0.02
6016	JL / JL	2/16/2015	AM	< 0.2	0.6	1.1	< 0.02	1.4	0.00031	< 0.2	< 0.02
6020	JL / JJ	2/16/2015	PM	< 0.2	1.0	< 0.01	< 0.02	5.4	< 0.0002	< 0.2	< 0.02
6021	NMT / MK	2/17/2015	AM	< 0.2	1.0	< 0.025	< 0.02	3.4	< 0.0002	< 0.2	< 0.02
6022	MK / MK	2/17/2015	PM	< 0.2	0.9	< 0.01	< 0.02	1	< 0.0002	< 0.2	< 0.02
6023	CC / CC	2/18/2015	AM	< 0.2	0.6	0.2	0.062	3.1	< 0.0002	< 0.2	< 0.02
6024	CC / JJ	2/18/2015	PM	< 0.2	1.1	0.16	0.069	2.9	< 0.0002	< 0.2	< 0.02
6025	DS / MK	2/19/2015	AM	< 0.2	1.5	0.51	0.029	1.2	< 0.0002	< 0.2	< 0.02
6026	MK / MK	2/19/2015	PM	< 0.2	0.9	< 0.01	< 0.02	8.9	< 0.0002	< 0.2	< 0.02
6027	NMT / MK	2/20/2015	AM	< 0.2	1.2	0.28	< 0.02	0.63	< 0.0002	< 0.2	< 0.02
6028	MK / MK	2/20/2015	PM	< 0.2	0.9	< 0.01	< 0.02	< 0.02	< 0.0002	< 0.2	< 0.02
6029	JL / JL	2/21/2015	AM	< 0.2	1.0	< 0.01	< 0.02	1.4	< 0.0002	< 0.2	< 0.02
6030	JL / MK	2/21/2015	PM	< 0.2	1.1	0.38	0.045	1	< 0.0002	< 0.2	< 0.02
NUMBER OF SAMPLES				14	14	14	14	14	14	14	14
AVERAGE				0.200	0.964	0.195	0.029	3.396	0.0002	0.200	0.020
STD DEVIATION				0.00	0.23	0.31	0.02	3.87	0.0000	0.00	0.00
STD ERROR = STD DEV/SQRT(# OF SAMPLES)				0.00	0.06	0.08	0.00	1.03	0.0000	0.00	0.00
T.20 (FROM CHART)				1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35
CI = AVERAGE + T.20(STD ERROR)				0.200	1.048	0.306	0.035	4.793	0.0002	0.200	0.020
Reporting Limit:				5.00	100.00	1.00	5.00	5.00	0.20	1.00	5.00

Leaching Rate 30%   94%

Ash Moisture Test

Date	Result (Pass/Fail)	Comments
2/18/2015	Pass	Test completed as part of the Quarterly Residue Testing, no free liquids present.

RECEIVED – DEQ
APR 10 2015
Tidewater Regional Office

4/9/2015

Wheelabrator
PORTSMOUTH

RDF

April 28, 2016

Jeff Deibler
Waste Compliance Technical Coordinator
Virginia Department of Environmental Quality
5636 Southern Blvd.
Virginia Beach, VA 23462

Re: Wheelabrator Portsmouth WTE Ash Test Results

Dear Mr. Deibler,

In accordance with 9VAC20-81-340.E.7 please find enclosed a copy of the chemical analyses of residue Completed in March 2016.

If you have any questions about this submittal, you can reach me at 393-3105,

Sincerely,

Jeff Landrum
Environmental Manager

Enclosure

RECEIVED – DEQ
APR 28 2016
Tidewater Regional Office

DOCUMENT CERTIFICATION

Facility Name: Wheelabrator Portsmouth Inc.

Registration No. 61018

Facility Location: Portsmouth, VA

Type of Submittal Attached: 2016 Residue Chemical Analysis Results

Certification: I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering and evaluating the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name of Responsible Official (Print): Rob Johnson

Title: Plant Manager

Signature: [signature] **Date:** 04/28/2016

Wheelabrator I .tsmouth Inc

INORGANIC ANALYSIS REPORT

Residue Chemical Analsysis Report

Report Date : 4/12/2016

				Sampling Event (in mg/L)							
SAMPLE ID	SAMPLED BY	DATE	AM/PM	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
6014	JL / NMT	3/13/2016	AM	< 0.5	< 1.0	1	< 0.05	0.099	< 0.0002	< 0.5	< 0.05
6015	NMT / AD	3/13/2016	PM	< 0.5	< 1.0	0.83	0.069	4.3	< 0.0002	< 0.5	0.059
6016	JL / JL	3/14/2016	AM	< 0.5	1.5	0.66	0.06	0.79	< 0.0002	< 0.5	0.061
6020	JL / AD	3/14/2016	PM	< 0.5	1.1	< 0.025	< 0.05	0.05	0.00026	< 0.5	< 0.05
6021	JL / NT	3/15/2016	AM	< 0.5	1.3	0.56	< 0.05	0.27	< 0.0002	< 0.5	0.054
6022	NT / AD	3/15/2016	PM	< 0.5	< 1.0	< 0.025	< 0.05	< 0.05	< 0.0002	< 0.5	< 0.05
6023	NT / NT	3/16/2016	AM	< 0.5	1.1	< 0.025	< 0.05	0.069	< 0.0002	< 0.5	< 0.05
6024	MK / AD	3/16/2016	PM	< 0.5	< 1.0	< 0.025	< 0.05	< 0.05	0.00038	< 0.5	< 0.05
6025	JL / JL	3/17/2016	AM	< 0.5	1.7	0.61	< 0.05	0.47	< 0.0002	< 0.5	0.076
6026	JL / MK	3/17/2016	PM	< 0.5	1.3	0.77	< 0.05	0.49	< 0.0002	< 0.5	0.05
6027	JL / JL	3/18/2016	AM	< 0.5	1.4	1.1	< 0.05	0.17	< 0.0002	< 0.5	< 0.05
6028	JL / MK	3/18/2016	PM	< 0.5	1.1	1.1	< 0.05	0.19	< 0.0002	< 0.5	< 0.05
6029	AD / MK	3/19/2016	AM	< 0.5	< 1.0	< 0.025	< 0.05	< 0.05	0.00027	< 0.5	< 0.05
6030	MK / MK	3/19/2016	PM	< 0.5	1.2	1.1	< 0.05	0.19	< 0.0002	< 0.5	< 0.05
NUMBER OF SAMPLES				14	14	14	14	14	14	14	14
AVERAGE				0.500	1.193	0.561	0.052	0.517	0.0002	0.500	0.054
STD DEVIATION				0.00	0.22	0.45	0.01	1.11	0.0001	0.00	0.01
STD ERROR = STD DEV/SQRT(# OF SAMPLES)				0.00	0.06	0.12	0.00	0.30	0.0000	0.00	0.00
T.20 (FROM CHART)				1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35
CI = AVERAGE + T.20(STD ERROR)				0.500	1.272	0.723	0.054	0.918	0.0002	0.500	0.056
Reporting Limit:				5.00	100.00	1.00	5.00	5.00	0.20	1.00	5.00
						72/		< 20/			

Ash Moisture Test

Date	Result (Pass/Fail)	Comments
3/16/2016	Pass	Test completed as part of the Quarterly Residue Testing, no free liquids present.

Wheelabrator Portsmouth Inc.
A Waste Management Company
3809 Elm Ave
Portsmouth, VA 23704

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4D
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APR 09 2013
Tidewater Regional Office

April 8, 2013

Jeff Deibler
Waste Compliance Technical Coordinator
Virginia Department of Environmental Quality
5636 Southern Blvd.
Virginia Beach, VA 23462

Re: Wheelabrator Portsmouth WTE Ash Test Results PBR500

Dear Mr. Deibler,

In accordance with 9VAC20-81-340.E.7 please find enclosed a copy of the chemical analyses of residue Completed in March 2013.

If you have any questions about this submittal, you can reach me at 393-3105,

Sincerely,

Jeff Landrum
Environmental Manager

Enclosure

WM

DOCUMENT CERTIFICATION

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APR 09 2013
Tidewater Regional Office

Facility Name: Wheelabrator Portsmouth Waste to Energy Facility

Facility Location: Portsmouth, VA

Type of Submittal Attached: March 2013 Residue Chemical Analysis Results

Certification: I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering and evaluating the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name of Responsible Official (Print): Paul Grego

Title: Plant Manager

Signature: Paul Grego **Date:** 04/08/2013

Wheelabrator [illegible]smouth Inc
INORGANIC ANALYSIS REPORT

Residue Chemical Analsysis Report

Report Date : 3/27/2013

				Sampling Event (in mg/L)							
SAMPLE ID	SAMPLED BY	DATE	AM/PM	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
5817	MK / JJ	3/4/2013	AM	< 0.5	< 1	< 0.005	< 0.05	2.2	< 0.0002	< 0.5	< 0.05
5818	JJ / JJ	3/4/2013	PM	< 0.5	< 1	< 0.005	< 0.05	0.21	0.0003	< 0.5	< 0.05
5819	JL / JL	3/5/2013	AM	< 0.5	< 1	< 0.005	< 0.05	6.9	< 0.0002	< 0.5	< 0.05
5820	MK / BM	3/5/2013	PM	< 0.5	< 1	< 0.005	< 0.05	0.38	< 0.0002	< 0.5	< 0.05
5821	MK / NT	3/6/2013	AM	< 0.5	2	< 0.005	< 0.05	0.8	< 0.0002	< 0.5	< 0.0[illegible]
5822	NMT / BM	3/6/2013	PM	< 0.5	< 1	< 0.005	< 0.05	< 0.05	0.00024	< 0.5	< 0.[illegible]
5823	NMT / MK	3/7/2013	AM	< 0.5	< 1	< 0.005	< 0.05	4.3	< 0.0002	< 0.5	< 0.05
5824	MK / MK	3/7/2013	PM	< 0.5	< 1	0.32	< 0.05	0.078	0.00069	< 0.5	< 0.05
5825	NMT / BM	3/8/2013	AM	< 0.5	< 1	0.18	< 0.05	< 0.05	0.0016	< 0.5	< 0.05
5826	BM / BM	3/8/2013	PM	< 0.5	< 1	< 0.005	< 0.05	0.22	< 0.0002	< 0.5	< 0.05
5827	NMT / BM	3/9/2013	AM	< 0.5	1.3	0.29	< 0.05	0.42	0.00069	< 0.5	< 0.05
5828	BM / BM	3/9/2013	PM	< 0.5	< 1	< 0.005	< 0.05	3.7	< 0.0002	< 0.5	< 0.05
5829	NMT / MK	3/10/2013	AM	< 0.5	< 1	< 0.005	< 0.05	< 0.05	< 0.0002	< 0.5	< 0.05
5830	MK / MK	3/10/2013	PM	< 0.5	< 1	0.32	< 0.05	2.3	0.0035	< 0.5	< 0.05
NUMBER OF SAMPLES				14	14	14	14	14	14	14	14
AVERAGE				0.500	1.093	0.083	0.050	1.547	0.0006	0.500	0.050
STD DEVIATION				0.00	0.27	0.13	0.00	2.10	0.0009	0.00	0.00
STD ERROR = STD DEV/SQRT(# OF SAMPLES)				0.00	0.07	0.04	0.00	0.56	0.0002	0.00	0.00
T.20 (FROM CHART)				1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.[illegible]
CI = AVERAGE + T.20(STD ERROR)				0.500	1.191	0.130	0.050	2.306	0.0009	0.500	0.050
Reporting Limit:				5.00	100.00	1.00	5.00	5.00	0.20	1.00	5.00

Ash Moisture Test

Date	Result (Pass/Fail)	Comments
3/7/2013	Pass	Test completed as part of the Quarterly Residue Testing, no free liquids present.

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APR 09 20[illegible]
Tidewater [illegible] Office

3/27/2013

VITA

Anil Mehrotra, M.S., P.E., BCEE

E-mail: amehr002@odu.edu
mehrotraa@tncc.edu

Education: D. Eng. candidate, CEE, Old Dominion Univ., expected completion summer 2017
M.S. Environmental Engineering, Old Dominion Univ., Norfolk
2 Graduate Courses (8 credits), Environmental Management, Harvard University
B.S. Mechanical Engineering, IIT, Roorkee (previously Univ. of Roorkee), India
B.S. (Math, Physics, Chemistry), Agra College, India

Licenses: P.E. License 0402 043969
Board Certified Environmental Engineer (American Academy of Env. Engineers)
Advanced Engineering in Energy Systems Certificate, ODU, fall 2014
CPE, Certified Plant Engineer Certificate, from Association of Facilities Engineers
ASME QRO (Qualified Resource Operator) License, P-1745
Virginia Waste Facility Operators Class I-Class IV License, 460-5002344
Virginia Master Naturalist Certificate, VCE, Virginia Tech, Cohort 4, 2012

Professional Experience: Over 48 yrs. in conventional and alternative energies, combustion technologies, plant operations and maintenance, environmental engineering.

Current Employment: Plant Engineer, Hampton/NASA Steam Plant 2001 to date

Industrial plant systems engineering design, upgrades and management
Environmental audits for effectively maintaining facility's following permits:

1. Title V Air permit,
2. Municipal Solid Waste permit for waste processing, ash treatment & disposal,
3. Wastewater discharge permit

Knowledgeable in the Clean Air Act, National Pollutant Discharge Elimination System (NPDES) regulations, Resource Conservation and Recovery Act (RCRA), Superfund and Amendments and Reauthorization Act (SARA Tier II), Safe Drinking Water Act (SDWA), Spill Prevention, Control, and Countermeasure (SPCC)

Employee training in standards of plant engineering and operations

Manager, Safety & Health for compliance with OSHA regulations and safety audits

Previous Experience: <u>High capacity energy plants (India): Toshiba, GE, Mitsubishi, CE model turbines/boilers</u>

High pressure boilers & turbines designs, operation, maintenance 1968 – 1973
District energy supply, power distribution network designing 1974 - 1979
Heavy machinery dynamics, vibration analysis, performance testing 1980 - 2000

Designing and engineering, project scheduling, start-up, environmental management, budgeting, issuing RFP, vendor selection, awarding and managing

contracts, operation and Maintenance of power generation equipment, leadership and organizational management.
Developing and teaching industrial operating standards & technical training modules

Professional Memberships:

Member, State Advisory Board, VA Air Pollution Control Board	Since 2010
Water Environment Federation, International Coordination Committee	Since 2012
American Society of Safety Engineers	Since 2007
National Safety Council	Since 2007
ASME International	Since 2001

Research Papers and Professional Skills Development:

Doctoral research on immobilization and treatment of municipal solid waste incineration residues, Old Dominion University, June, 2017

Sustainable Use of Fibrous Natural Resources- Treatment Methods for Increased Utilization of Bamboo, August, 2015

Heat and Energy Recovery from Biosolids, M.S. Thesis, Old Dominion University, May, 2015

Adjunct Faculty, Science Engineering and Technology, Thomas Nelson Community College, Hampton, Virginia since fall 2015

Thermal Treatment of Municipal Solid Waste to Produce Biofuels, Independent Study, Old Dominion University, June, 2013

City of Hampton facility representative for ASME and EPA Air Pollution Control Technologies and Regulations, Emission Guidelines and GHG Reporting Tools

District Energy Systems – Improving Efficiency for Producing Electricity, Heating and Cooling Building Complexes, Participant Member, Va. State Advisory Board, Nov. '12

Energy Efficiency Measures as Best Available Control Technology for Green House Gases, Principal Contributor, State Advisory Board Energy Efficiency Group, Nov. 2011.

OSHA General Industry 10-hr and 32-hr Safety and Health training, attended Deportment of Labor and Industries, and Federal Emergency Management courses.

Instructor since November 2011 Waste Management Facility Operator Class I Course Training to City of Hampton employees, and other waste processors in Virginia.

Paper, Pollination Ecology and Insect Foraging, Fundamentals of Ecology, Harvard University Extension School, October 2011

Fine Particle Air Pollution –Respiratory health issues concerning at risk population in Hampton Roads, Southeastern Virginia, Environmental Management, Harvard University Extension School, July 1, 2011.

Author, Waste Management Facility Operators Course Modules, Approved Training provider, Department of Professional and Occupational Regulations, Virginia, July 17, 2011

Climate Change Mitigation and Adaptation in the Commonwealth, Member State Advisory Board on Air Pollution, Va. State Air Pollution Control Board, Dec, 10.

Reducing Compliance Costs through Modernized Reporting, Principal Contributor, State Advisory Board Compliance Cost Group, December, 2010.

Green House Gas Option Rating Priority Summary, State Advisory Board on Air Pollution, Virginia State Air Pollution Control Board, December 2010.

Applied Research, Cost Effective Alternative for MSW residue ash treatment with utilization of dolomitic lime.

Author, Refuge Fired Steam Generating Facility Thermodynamics and Electrical Operator Training Modules, Hampton, Virginia, October 2008.

Paper, Boiler Engineering and Tube Failure Analysis, International Conference on Boiler Tube Failure, Power Management Institute, National Thermal Power Corporation, NOIDA, UP, India, June 24-26, 1998.

Paper, Deformation and Integrity of Structural Components at Elevated Temperatures, Institute of Technology, Banaras Hindu Univ., Varanasi, UP, India, 1998

Paper, Condition Monitoring and Modifications to Control Stray Voltages in 500 MW Turbine-Generator Shafts, Anpara B Thermal Power Station, UPSEB (now U.P. Power Corporation Ltd.), India, Nov. 10, 1995

Study of Advanced Maintenance Technologies of Modern Super Thermal Power Stations, Drakelow Power Plant, Powergen, (now E.ON UK), Central Electricity Generation Board, UK, June 10 – Aug. 28, 1990.

Research paper and site demo on Enhanced Life-Expectancy of Feedwater Booster Pump by Modified Design Sealol-Durametallic Rotary Shaft Seals, Anpara A Thermal Power Station, UPSEB (now U.P. Power Corp. Ltd.), India, Oct.7-10, 1987