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PVT LANDFILL
HUMAN HEALTH RISK ASSESSMENT
OF AES CONDITIONED ASH
LIMITED DEMONSTRATION PROJECT

Submitted To:

PVT Landfill
87-2020 Farrington Hwy
Waianae, Hawaii 96792

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EXECUTIVE SUMMARY

The Hawaii Department of Health (DOH) has requested that a demonstration project and human health risk assessment be performed to evaluate the safety of using AES conditioned coal ash for various soil replacement operational uses at PVT Landfill. According to the DOH the demonstration project and assessment should include all uses for which ash is being considered for beneficial reuse. Beneficial reuses evaluated in this assessment include:

- Daily cover,
- Void space fill,
- Interim daily cover and;
- Liquid adsorption

The demonstration project consisted of ambient air monitoring for respirable dust during actual operational use of AES ash for void space fill and daily cover. Respirable dust concentrations (PM10) were measured by Active Air Monitoring and Real-Time Personal DataRAM (pDR). The respirable particulate data measured in the demonstration project was used in conjunction with chemical analytical data of AES ash samples collected from 2008 to 2009 to estimate chemical concentrations at specific receptor locations at the work site and in the adjacent community. Forty-two (42) composite conditioned ash samples (analyzed for antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, mercury, molybdenum, nickel, selenium, silver, thallium, and zinc) were included in the analysis. The UCL 95 percentile mean concentration was assumed to be representative of future conditioned ash chemical concentrations to be used at PVT for operational uses. Utilization of such a robust historical dataset ensured that inter- and intra-batch variability was not a significant contributor to uncertainty. All respirable dust measured in this study was assumed to be ash-derived.

Potential health risks were estimated for landfill workers directly working with ash who may inhale ash-derived dust and ingest and dermally absorb metals in ash. Potential health risks via the inhalation pathway were also estimated for hypothetical adult and child residents who live approximately 1/4 mile downwind from the demonstration project site. Potential estimated lifetime cancer risks were compared to the USEPA and DOH regulatory level of concern of $1 X 10^{-5}$ for commercial and industrial workers and $1 x 10^{-6}$ for residential receptors. Estimated noncarcinogenic risks are presented as total site Hazard Indices that sum the Hazard Quotients of each Chemical of Potential Concern at the site. A total Hazard Index of 1 was considered to be the regulatory level of concern.

Although not specifically evaluated in the demonstration project and risk assessment, the use of AES conditioned ash for other operational uses such as interim cover and liquid adsorption is qualitatively addressed below and is also considered acceptable practice. The use of AES ash as interim cover was considered for analysis but was deemed *Not Required* because PVT standard operating procedures require that any ash used as soil replacement be covered by a minimum of 6 inches of soil within 1 month of application (i.e., there are no true interim cover scenarios anticipated). Quantitative risk evaluation of AES ash for liquid adsorption was also deemed *Not Required.* The addition of any liquids to coal ash was presumed to increase percent moisture and for all practical purposes reduce dust and airborne particulate generation. Any risk associated with ash further wetted for the purposes of liquid adsorption was assumed to be lower than uses evaluated in the current assessment.

WORKER RESULTS

Two worker scenarios were evaluated. The first scenario assumed a worker is in the immediate vicinity of ash dumping and ash use, 8 hours per day, 250 days a year, for 25 years and contacts ash and inhales chemicals in ash-derived dust. The second worker scenario assumed a worker is in the immediate vicinity of ash use during final daily end cap activities 1 hour per day, 250 days a year, for 25 years. Cumulative carcinogenic and noncarcinogenic risks to both worker scenarios were below regulatory levels of concern. For the 8 hour worker, the total cumulative carcinogenic risk and noncarcinogenic hazard index was 1E-05 and 0.8 respectively. Cumulative carcinogenic risk and noncarcinogenic hazards for the 1 hour daily end cap worker were 1E-05 and 0.3, respectively.

HYPOTHETICAL RESIDENT RESULTS

The residential scenario assumed fugitive dust is generated during ash dumping, ash handling activities and wind erosion. The residential scenario assumed migration of fugitive dust (24 hrs/day) to residential areas located approximately ¼ mile away from the site. Residents were assumed to inhale site-derived dust 24 hrs/day, 350 days/year for 30 years. Carcinogenic and noncarcinogenic risks due to inhalation pathways only were 5E-08 and .01, respectively.

SECTION 1
INTRODUCTION

PVT Landfill has retained AMEC Earth and Environmental (AMEC) to quantify potential human health risks associated with various operational uses of AES conditioned ash at PVT Landfill. This document presents the results of the beneficial ash reuse demonstration project and corresponding human health risk assessment (HHRA). The methodology and approach to this study have been previously described in the Sampling and Analysis Plan (AMEC, 2009) and are discussed herein. Deviations from the sampling plan are noted in this report.

According to the DOH the demonstration project and assessment should include all uses for which ash is being considered for beneficial reuse. Beneficial reuses evaluated in this assessment include:

- Daily cover,
- Void space fill,
- Interim daily cover and;
- Liquid adsorption

The HHRA evaluated the impact to workers at the Site during delivery, movement and handling of coal ash. The risk assessment assumed workers would directly contact coal ash as well as inhale airborne particulates containing heavy metals present in ash generated from movement and use of AES ash. The HHRA also evaluated risks to nearby residents (in a residential scenario). Residents were assumed to be exposed to metals in fugitive dust generated by operational uses of ash.

1.1 Site and Sampling Area Location

The PVT Landfill Site is located at 87-2020 Farrington Highway on the western side of the island of O'ahu, in Nanakuli, Hawai'i (Figure 1). The PVT Landfill Site consists of an irregularly shaped 15.44-acre parcel of land (Latitude/Longitude: 21° 23' 50" N/158° 09' 00"W). The Site is bounded by residential areas at its southern and western borders.

1.2 Approach

This investigation was performed in 2 phases:

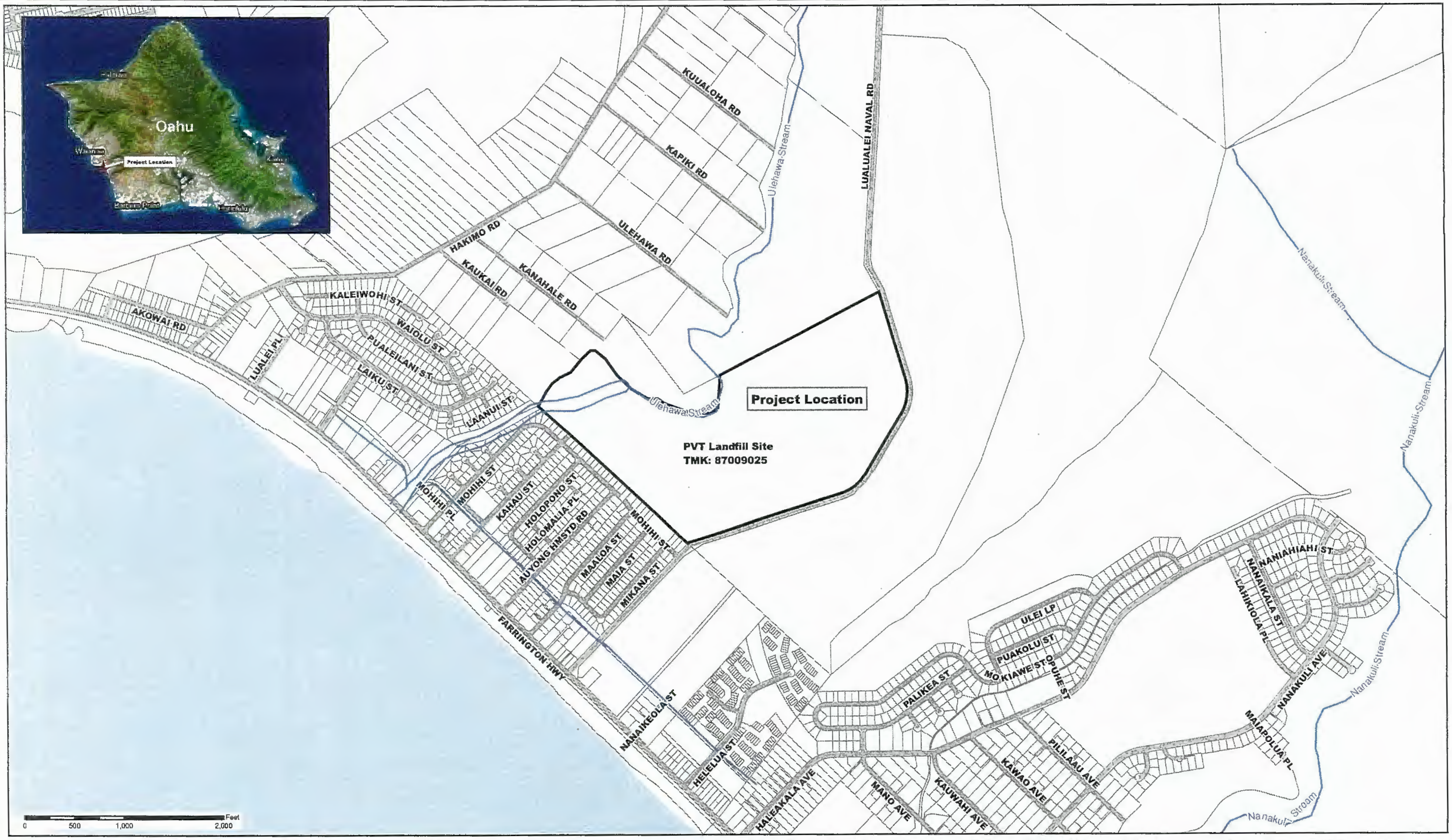
Phase 1: Ambient Air Monitoring (Section 2)

- Respirable dust concentrations (PM10) were measured by Active Air Monitoring and Real-Time Personal Data Rams (PDR)

Phase 2: Human Health Risk Assessment (Section 3)

- Conditioned ash analytical lab data for metals were combined with fugitive dust data measured in Phase 1 to assess the potential for human health risks to workers and nearby residents.

Respirable particulate data was used in conjunction with ash analytical data (provided by PVT Landfill) to estimate COPC concentrations at specific receptor locations at the site and in the adjacent community. Ash analytical data (from AES Hawaii through PVT Landfill) provided historical metals data for AES Coal Ash. Mean historic metals concentrations were assumed to represent future ash concentrations. All dust generated was assumed to be ash-derived.



PVT Landfill: Project Location

Source: Base GIS Data from State of Hawaii, Hawaii GIS Program

amec

W.O.	325190008
DESIGN	LRK
DRAWN	LRK
DATE	06/23/2005

FIGURE 1

PVT LANDFILL
87-2020 FARRINGTON HWY
WAIANAE, HAWAII 96792

SECTION 2
AIR MONITORING

Air monitoring was performed in order to determine the respiratory risk associated with the delivery, movement and handling of ash. AMEC utilized two monitoring methods, active air sampling and real-time air monitoring, to determine the amount of respirable particulates (PM10) generated during operational use of AES ash. Air monitoring for respirable dust was conducted at the landfill on October 26, 2009. Air sampling locations are shown on Figure 2 and in Appendix B, photos. Following is a description of the two air monitoring methods used:

Active Air Sampling

Active air sampling was utilized to collect air particulates during different landfill activities. Five (5) sets of low-flow air pumps were positioned at different areas of the landfill face. The pumps were placed at the following locations: 1) by the ash pile, 2) at the road above the ash pile, 3) high area above the ash pile, 4) east of the ash pile, and 5) during end cap activities. Pumps ran for the duration of ash handling activities during delivery and use of fresh AES coal ash. The pumps were set at an air collection rate appropriate for total dust and PM10 particulates. Air samples were submitted to the laboratory for total dust and PM10 analysis.

Real-Time Air Monitoring

Real-time air monitoring, via Personal DataRAM (pDR), was the second method used to determine if nuisance dust was being generated during specific landfill activities (delivery of ash, movement of ash in between delivery of waste, movement of ash at the end of the day). PM10 data was collected using a pDR with cyclone to determine respirable dust concentrations associated with the above listed specific activities.

Results from both the active and real-time sampling events were evaluated and the maximum concentration from either of the data sets was used in the air dispersion model, SCREEN3. SCREEN3 is a single source Gaussian plume model which provides maximum ground-level concentrations for point, area, flare, and volume sources, as well as concentrations in the cavity zone, and concentrations due to inversion break-up and shoreline fumigation. SCREEN3 is a screening version of the ISC3 model.

As previously mentioned, the active sampling data provides dust concentrations from a specific landfill activity (ash handling activities during delivery and use of fresh AES coal ash). This concentration is collected over an abbreviated period of time and does not represent an 8-hour time weighted average (TWA). The pDR real time data better represents the 8-hour TWA as it was collected over the course of the work day and therefore higher dust generation periods are offset by periods of lower dust generation. A summary of dust data for the active sampling event and pDR readings are presented in Tables 2-1 and 2-2. Again, in an effort to be health protective, this assessment has utilized the highest dust concentrations in evaluating potential risk.

TABLE 2-1

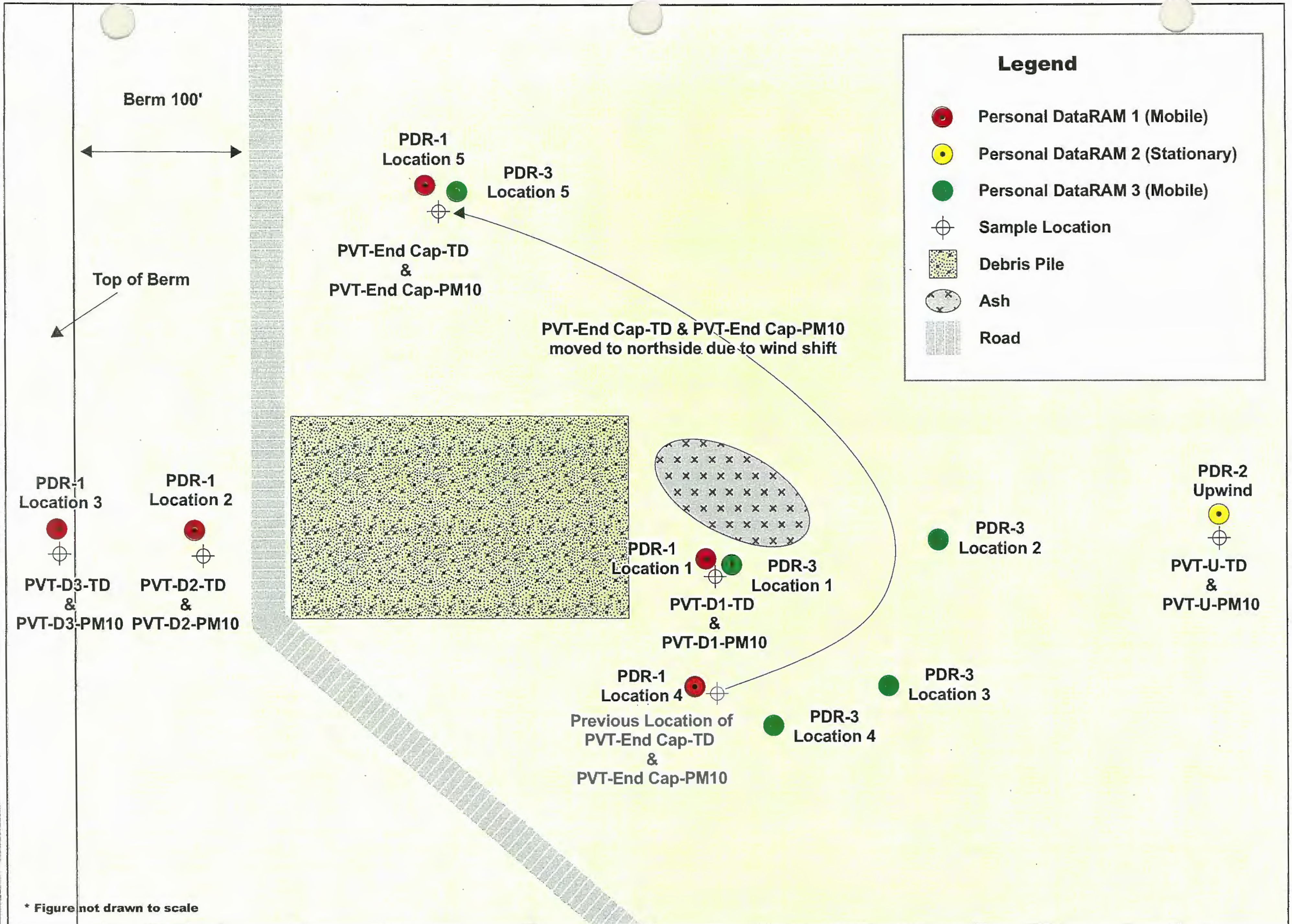
PM10 Active Air Monitoring Results

Sample ID - Location	Concentration (mg/m^3)
PVT-D1 PM10 – Ash Pile	0.3
PVT-D2 PM10 – Road Above Ash Pile	0.59
PVT-D3 PM10 – High Area Above Ash Pile	0.34
PVT-U PM10 – East of Ash Pile	0.05
PVT-End Cap PM10 – Ash Pile	1.1

TABLE 2-2

Personal DataRAM (PDR) PM10 Ambient Air Monitoring Results

Location	Maximum Concentration (mg/m^3)	Average Concentration (mg/m^3)
PDR-1 – Followed Active Samples D1-2-3-End Cap	1.67	0.044
PDR-2 – Upwind Location by PVT-U	2.88	0.055
PDR-3 - Rover	3.584	0.051



PVT Landfill

Sample Locations

FIGURE 2

SECTION 3
HUMAN HEALTH RISK ASSESSMENT

A human health risk assessment was conducted to quantify potential risks to workers at the facility and for adult and children residents who might breathe site-related chemicals associated with ash handling activities. Chemicals of Potential Concern (COPCs) included all metals analyzed by AES. Workers were assumed to directly contact ash and inhale dust generated during operational activities, specifically, during the application of ash as daily cover and void space fill. Residential receptors were evaluated assuming they would inhale fugitive dust only.

As described in Section 2 above, AMEC collected fugitive dust data to determine realistic emission rates for specific operational uses. Emission rates were then used as inputs into SCREEN3 to conservatively estimate maximum ground-level concentrations of respirable dust at the nearest residential receptor point. Respirable particulate data was used in conjunction with ash analytical data (provided by PVT Landfill) to estimate COPC concentrations at specific receptor locations at the site and in the adjacent community. Potential health risks via the inhalation pathway were estimated for adult and child residents who reside approximately 1/4 mile from disposal site. Potential health risks were also estimated for workers at the facility which may inhale ash derived dust and directly contact the ash.

The phases of the risk process are described herein. The protocol adopted is consistent with the approach recommended by the National Research Council (NRC). The NRC, established by the National Academy of Sciences (NAS) to further scientific knowledge and to advise the federal government, has established a four-step paradigm for conducting health-based risk assessments (NAS 1983). This paradigm has been adopted by USEPA as well as many federal and state regulatory agencies. In accordance with the NRC recommendations, this risk assessment is organized into the following four steps:

- Hazard Identification;
- Toxicity Assessment;
- Exposure Assessment; and
- Risk Characterization.

Each of these steps is detailed in the section below.

3.1 Hazard Identification

In this step, compounds assumed to be of concern are selected for inclusion in the quantitative risk assessment. These compounds are designated as COPCs. The selection of COPCs for this investigation is based upon historical information regarding the chemical composition of AES conditioned ash.

Analytical data for metals were provided for ash samples collected bi-monthly at AES for the years 2008 and 2009. A total of forty-two (42) composite conditioned ash samples were included in this risk assessment. Metals analyzed include antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, mercury, molybdenum, nickel, selenium, silver, thallium, and zinc. Valence state of chromium was not available and was assumed present in a 1:6 chromium VI to chromium III ratio. All chemicals listed above were included as COPCs for evaluation in the human health risk assessment.

3.2. Toxicity Assessment

The USEPA states that the purpose of the Toxicity Assessment is to "weigh available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects" (USEPA 1989a)." In essence, the Toxicity Assessment can also be described as a Dose-Response Assessment. A Dose-Response Assessment is used to identify both the types of adverse health effects a COPC may potentially cause, as well as the relationship between the amount of COPCs to which receptors may be exposed (dose) and the likelihood of an adverse health effect (response). The USEPA characterizes adverse health effects as either carcinogenic or noncarcinogenic and dose-response relationships are defined for oral and inhalation routes of exposure. Dermal exposure toxicity criteria are estimated based on oral criteria. The results of the toxicity assessment, when combined with the results of the exposure assessment provide an estimate of potential risk.

The most current USEPA-verified dose-response criteria were used in this assessment. Dose-response information was obtained from the following sources, in order of priority:

U.S. EPA's Integrated Risk Information System (IRIS) (USEPA, 2009a);

U.S. EPA's Provisional Peer Reviewed Toxicity Values (PPRTV) (USEPA, 2009b);

Agency for Toxicity Substances and Disease Registry (ASTDR, 2009)

U.S. EPA's Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997);

In the case of lead, there is no U.S. EPA-verified Reference Dose. However, because lead was only detected at concentrations below Hawaii Department of Health Environmental Action Levels (EALs), and U.S. EPA Regional Screening Levels (RSLs), it was not considered for further quantitative analysis.

Noncarcinogenic dose-response information for both oral and inhalation routes of exposure were used when available. To evaluate inhalation exposure, U.S. EPA has derived reference concentrations (RfCs) for certain compounds. For use in estimating intake, these RfCs (in units of mg/m^3) are converted to reference doses (RfDs) (in units of mg/kg-day) by multiplying by a 20 m^3/day inhalation rate and dividing by the adult body weight of 70 kg (USEPA 1997b). This conversion allows the risk assessment to consider activity-specific inhalation rates described in the exposure assessment.

To evaluate carcinogenic risks from oral exposures, the U.S. EPA has derived cancer slope factors expressed in terms of $(mg/kg\text{-}day)^{-1}$. Carcinogenic dose-response values for inhalation exposures are generally provided as inhalation unit risk (IUR) values expressed in terms of $(\mu g/m^3)^{-1}$. For this assessment, IUR values are converted to an inhalation CSF correcting for body weight, inhalation rates, and units using the following equation:

$$CSF_{inh} = \frac{IUR \times 70kg}{20m^3 / day} \times 1000 \mu g / mg$$

where:

CSF_{inh}	=	inhalation cancer slope factor (mg/kg-day)-1
IUR	=	inhalation unit risk ($\mu g/m^3$)
70 kg	=	body weight

1000 µg/mg	=	conversion factor; and
20 m^3/day	=	inhalation rate.

3.3 Exposure Assessment

In the Exposure Assessment, the magnitude and frequency of a receptors' potential exposure to COPCs is quantified. Exposure factors including length and duration of exposure, inhalation and ingestion rates, body weights, and absorption adjustment factors are designated during this phase of work. Based on the results of above-described tasks, the final phase of the exposure assessment is the derivation of exposure point concentrations and the calculation of average daily doses. The results of the exposure assessment are described in the following subsections.

3.3.1 Identification of Receptors

Potential human receptors for this investigation are adult workers at the facility and adult and children residents who may breathe fugitive dust containing COPCs. Adult and child residents were identified based on characteristics of the site and surrounding area and the specific concerns of the neighboring community.

3.3.2 Identification of Potential Exposure Pathways

Potential exposure pathways are the mechanisms by which the receptors in the study area may be exposed to compounds emitted from the landfill during disposal events. According to U.S. EPA (1989), four elements must be present in order for a potential human exposure pathway to be complete:

- a source and mechanism of compound release to the environment ;
- an environmental transport medium;
- an exposure point, or point of potential contact with the potentially impacted medium; and
- a receptor with a route of exposure at the point of contact.

The pathways examined in this risk assessment include:

- Direct contact for the workers on site;
- Inhalation for the workers to dust onsite; and,
- Inhalation of fugitive dust offsite to neighboring communities.

3.3.3 Identification of Exposure Scenarios

Exposure scenarios describe the frequency and magnitude of exposure to chemicals as they relate to specific receptors and exposure pathways. The exposure scenarios evaluated in this risk assessment include the following:

- Industrial Workers presumed to be exposed to contaminants in ash via direct contact and onsite dust generation during ash handling operations 8 hours/day, 250 days/year for a 25 year period;
- Industrial (daily endcap) workers presumed to be exposed to contaminants in ash via direct contact and onsite dust generation during daily end capping operations 1 hour/day, 250 days/year for a 25 year period;
- Resident Adults presumed to be exposed to contaminants in ash via fugitive dust generation. Ash handling operations are assumed to occur 24 hrs/day for a 24 year period;
- Resident Children presumed to be exposed to contaminants in ash via fugitive dust generation. Ash handling operations are assumed to occur 24 hrs/day for a 6 year period;

The two residential scenarios are summed to create a total 30 year residential scenario including 6 years as a child and 24 years as an adult.

3.3.4 Estimation of Exposure Point Concentrations in Ash

Exposure point concentrations for constituents detected in the ash were estimated using all relevant analytical data provided to AMEC from AES Hawaii. Exposure point concentrations (UCL 95th percentile on the mean) were derived in accordance with USEPA guidance (USEPA, 2002a) using USEPA's ProUCL software (USEPA, 2004c). Results are presented in Appendix E. In calculating exposure point concentrations, a value equal to one-half the limit of detection reported by the laboratory was used as a surrogate concentration for those constituents that were not detected in a particular sample as specified by U.S. EPA (1989a). Table 2-3 presents the EPCs calculated in this assessment.

TABLE 2-3

Exposure Point Concentrations in Ash

Constituent	EPC Concentration in Ash (mg/kg)
METALS	
Antimony	0.719
Arsenic	18.17
Barium	645.2
Beryllium	3.121
Boron	769.7
Cadmium	0.606
Chromium VI (1:6 VI:III Ratio)*	8.232
Copper	35.39
Iron	25350
Lead	21.64
Mercury, Divalent	0.404
Molybdenum	6.741
Nickel	95.72
Selenium	1.931
Silver	0.772
Thallium	0.651
Zinc	596.7

3.3.5 Estimation of Exposure Point Concentrations in Fugitive Dust

In order to estimate the concentration of chemicals transported by fugitive dust to resident locations it was first necessary to estimate the respirable dust concentration at receptor locations. This process required the derivation of two scenario-specific PM10 emission rates (Q). The first emission rate (hereafter called Ash Handling Activities Emission Rate) estimated via the Box Model (Stern 1984) describes the dust generating potential caused by various human activities at the landfill (i.e., dumping, pushing, compacting). The second emission rate is based on the unlimited erosion model (hereafter called the Unlimited Erosion Model Emission Rate) and estimates the PM10 emission rate due to atmospheric dispersion generated from wind erosion of site ash (assuming contaminated ash is left uncovered).

<u>Ash Handling Activities Emission Rate</u>

PM10 emissions would be generated by several landfill ash handling activities. The PM10 emission rate (Q) during these activities was determined using a Box Model (Stern, 1984).

Estimation of the ash handling activities PM10 emission rate could either be based on the maximum PM10 concentration at any monitoring location during active air sampling or on the maximum average PM10 concentration collected from the PDR data sets. The maximum PM10 concentration from any monitoring location (1100 ug/m^3) which occurred during the final end cap activities was significantly higher than the average PDR data (55 ug/m^3) and was conservatively chosen as the PM10 concentration for modeling purposes. Health risks estimated using the average PM10 concentration from the PDR would be significantly lower than estimated in this assessment for inhalation pathways.

The Box Model is presented as below:

$$E_{10} = (L \times Q / (h \times u_{mean})) \times 10^6$$

or

$$Q = (E_{10} \times h \times u_{mean}) / (L \times 10^6)$$

where:

- Q: PM10 emission rate (g/s-m^2)
- E_{10}: PM10 concentration (ug/m^3)
- h: mixing height
- u_{mean}: mean wind speed (m/s), and
- L: landfill length.

The PM10 concentration (E_{10}) was derived from site-specific data obtained during the air monitoring sampling. The maximum onsite PM10 concentration for any of the five monitoring locations was 1100 ug/m^3. This occurred during the end cap activities and was used for emission rate calculations for the fugitive dust emission rates. The emission rate based on this value is 1.4E-04 g/s-m^2. Calculations are presented below.

$$Q = (E_{10} \times h \times u_{mean}) / (L \times 10^6)$$

Parameters		Value	Reference
Q:	PM10 emission rate (g/s-m^2)		calculated
E10:	PM10 concentrations (ug/m^3)	1100	
h:	mixing height	2	
umean:	mean wind speed (m/s)	2.8	site-specific
L:	landfill length	45	site-specific

Q = 1.4E-0 4

Unlimited Erosion Model Emission Rate

The second emission rate was derived using the unlimited erosion factor. The unlimited erosion factor equation is used to determine the emission rate due to atmospheric dispersion generated from wind erosion of soil (assumes ash erosion is equivalent and left uncovered). Site-specific PM10 data are not required. The equation used to estimate the emission rate assuming wind dispersion of uncovered ash is provided below.

$$Q = 0.036 \times (1 - V) \times (u_{mean} / u_{t)}^3 \times F(y) \times (1/3600)$$

where:

- Q: PM10 emission factor (g/s-m^2)
- V: fraction of surface vegetative cover, V = 0 (assumption)
- u_{mean}: mean annual wind speed (m/s), u_{mean} = 2.8 m/s (site-specific data)
- ut: threshold value of wind speed at 7m (m/s)
- y: y = 0.886 u_t / u_{mean} (dimensionless ratio), and
- F(y): function of y (USEPA 1985).

For this equation, the fraction of surface vegetative cover was assumed to be zero. As mentioned above, the site-specific wind speed is 2.8 m/s (6.2 mph). Parameters for u_t and F(y) were obtained from USEPA (2004a) and are equal to 11.32 and 0.194 m/s, respectively. Using these variables and the above equation, the emission factor for PM10 (PM10 emission rate, or Q) was calculated as 2.9E-08 g/s-m^2. Calculations are presented below.

$$Q = 0.036 \times (1 - V) \times (u_{mean} / u_{t)}^3 \times F(y) \times (1/3600)$$

Parameters		Value	Reference
Q:	PM10 emission factor (g/s-m^2)		calculated
V:	fraction of surface vegetative cover	0	
umean:	mean annual wind speed (m/s)	2.8	site-specific
F(y):	function of y [0.886 ut / umean (dimensionless ratio)]	0.194	default (USEPA 2004a)
ut:	threshold value of wind speed at 7 m (m/s)	11.32	default (USEPA 2004a)

Q = 2.9E-08

SCREEN3 PM10 Concentrations

The SCREEN3 air dispersion model (Version 96043) (USEPA 1995) was used to predict off-site ambient PM10 concentrations for various scenarios based on the calculated emission rates for both ash handling operations and wind erosion of the landfill surface. SCREEN3 determines 1-hour maximum chemical concentrations under worst-case wind conditions. It assumes that fugitive dust blows in the direction of the receptor continuously, 100% of the time. The model does not allow for an adjustment to be made to the percentage of time wind blows in the direction of the residents over a longer averaging time. To account for this, U.S. EPA states that annual average PM10 concentrations should be calculated by multiplying the 1-hour maximum concentration by a factor of 0.08 (USEPA 1992). However, this assessment utilized a Hawaii-specific value of 0.2 (Personal Communication with Dr. Barbara Brooks, HEER Office). 0.2 is a health protective adjustment factor which considers Hawaii-specific wind and meteorological conditions.

The source areas at the ash disposal area of the landfill site were modeled as ground-level sources of 45 x 45 square meters (0.5 acre). 0.5 acres is the USEPA Region 9 default source size as well as the approximate area of ash handling at PVT Landfill. The receptors were deployed using the SCREEN3 receptor distance array ranging from 402 meters (1/4 mile) out to 8,047 meters with a receptor height of 1 .8 m. It was assumed that the entire area was an emission source.

SCREEN3 calculations were based on the following assumptions:

Parameter	Value
Source type	area
Source release height	0.1 m
Length of larger side for area	45 m
Length of smaller side of area	45 m
Receptor height above ground	1.8 m
Urban or Rural Area	Rural
Meteorology	
Stability class	1 – Unstable/Turbulent
Anemometer height wind	2.8 m/s

As noted above, air dispersion modeling was conducted for both dust generated in ash handling activities and due to wind erosion, in order to conservatively estimate the amount of wind blown dust to nearby residential areas.

1. SCREEN3 air dispersion modeling results for ash handling activities resulted in a maximum respirable dust concentration of 4.669 ug/m^3 at a distance of 1/4 mile away for dust generating activities. After applying the 0.2 adjustment factor, the annual average respirable dust concentration is 0.934 ug/m^3 at a distance of 1/4 mile away for dust generating activities. This annual average is significantly lower than the National Ambient Air Quality Standards (NAAQS) PM10 annual limit of 50 ug/m^3.
2. SCREEN3 air dispersion modeling results for the wind erosion data set result in a maximum respirable dust concentration of 0.00099 ug/m^3 at a distance of 1/4 mile away for dust generating activities. After applying the 0.2 adjustment factor, the annual average respirable dust concentration is 0.0002 ug/m^3 at a distance of 1/4 mile away from the demonstration project site. This annual average is significantly lower than the National Ambient Air Quality Standards (NAAQS) PM10 annual limit of 50 ug/m^3.

The SCREEN3 air dispersion model calculations are presented in Appendix F. Table 2-4 lists the measured $_{PM10}$ concentration at the site and SCREEN3 results at 1/4 mile.

TABLE 2-4

PM10 Respirable Dust Concentrations

	Measured Concentration (ug/m^3)	Estimated Concentration at 1/4 mile* (ug/m^3)
Ash Handling Activities		
PVT- End CapPM10	1100	0.934
Unlimited Erosion Model		
	NA	*0.00099*

Estimation of COPC Concentrations in Dust at Offsite Locations

Estimated dust concentrations, both via ash handling activities as well as the unlimited erosion model, as determined by the SCREEN3 were multiplied by the exposure point concentration of the COPCs in the ash (Table 2-3) to estimate the concentration of COPCs in the fugitive dust which migrates to neighborhoods approximately ¼ mile offsite to the potential residential receptors.

Estimation of COPC Concentrations in Dust at Onsite Locations

Measured PM10 concentrations, the maximum measured during the course of the day and during end cap activities, were multiplied by the exposure point concentration of the COPCs in ash (Table 2-3) to estimate the concentration of COPCs in the dust for inhalation pathway to the workers onsite. Maximum PM10 concentration measured during the course of the day was 590 ug/m^3. Maximum PM10 concentration measured during end cap activities was 1100 ug/m^3, which was also conservatively used in the SCREEN3 analysis for modeling dust migration off site.

3.3.6 Exposure Dose Calculations

This section describes the equations and assumptions used to evaluate a receptor's potential exposure to compounds. The equation used to calculate Chronic Average Daily Dose (CADD) estimates a receptor's potential daily intake from exposure to compounds with potential noncarcinogenic effects. According to USEPA (1989), the exposure dose is calculated by averaging over the period of time for which the receptor is assumed to be exposed. The CADD for each compound via each route of exposure is compared to the noncarcinogenic reference dose for that compound in order to estimate the potential noncarcinogenic hazard index due to exposure to that compound via that route of exposure.

For compounds with potential carcinogenic effects, the equation for Lifetime Average Daily Dose (LADD) is employed to estimate potential exposures. In accordance with USEPA (1989), the LADD is calculated by averaging the assumed exposure over the receptor's entire lifetime (assumed to be 70 years). The LADD for each compound via each route of exposure is combined with the cancer slope factor for that compound in order to estimate the potential carcinogenic risk due to exposure to that compound via that route of exposure.

The equations for estimating a receptor's average daily dose (both lifetime and chronic) are presented in the following subsections. The exposure parameters used in each potential exposure pathway are also discussed in the following subsections.

Estimation of Potential Exposure via Inhalation

Calculations of potential risk resulting from the inhalation of the respirable fraction of particulates in air (i.e., particles < 10 pm in diameter) are presented in Appendix G. The equation used to calculate the CADD and LADD due to inhalation exposure is as follows:

$$A = \frac{B \times C \times D \times E \times F \times G \times H}{I \times J}$$

where:

A = Average Daily Dose following Inhalation (mg/kg-day)
B = Compound Concentration in Ash(mg/kg)
C = Concentration of Respirable Particulates in Air (mg/m^3)
D = Inhalation Rate (m^3/hr)
E = Exposure Time (hr/day)
F = Exposure Frequency (days/year)
G = Exposure duration (years)
H = Inhalation Absorption Adjustment Factor (unitless)
I = Body Weight (kg)
J = Averaging Time (days)

Estimation of Potential Exposure via Direct Contact

Ash Ingestion

$$A = \frac{B \times C \times D \times E \times F \times G \times H}{I \times J}$$

where:

A = Average Daily Dose Due to Ash Ingestion (mg/kg-day)

B = Constituent Concentration in Ash (mg/kg)

C = Unit Conversion Factor (1×10^{-6} kg/mg)

D = Ingestion Rate (mg/day)

E = Exposure Frequency (days/year)

F = Exposure Duration (years)

G = Oral-Soil Absorption Adjustment Factor (unitless)

H = Area Use Factor (unitless)

I = Body Weight (kg)

J = Averaging Time (days)

Dermal Contact with Ash

$$A = \frac{B \times C \times D \times E \times F \times G \times H \times I}{J \times K}$$

where:

A = Average Daily Dose Due to Dermal Contact (mg/kg-day)

B = Constituent Concentration in Ash (mg/kg)

C = Unit Conversion Factor (1×10^{-6} kg/mg)

D = Skin Adherence Factor (mg/cm^2)

E = Skin Surface Area Exposed (cm^2/day)

F = Exposure Frequency (days/year)

G = Exposure Duration (years)

H = Dermal-Soil Absorption Adjustment Factor (unitless)

I = Area Use Factor (unitless)

J = Body Weight (kg)

K = Averaging Time (days)

Each of the parameters in these equations is described below.

<u>Chemical Concentration in Ash</u>

The data used in this risk assessment are provided in Appendix D. EPCs were calculated using the 95% UCL of the analytical data (Table 2-3).

<u>Concentration of Respirable Particulates in Air</u>

Respirable particulate concentrations in air at offsite locations for the residential scenarios were calculated in the SCREEN3 analysis. Respirable particulate concentrations in air onsite for the worker scenarios were the measured PM10 concentrations. It was assumed that 100% of the respirable particles are ash-derived.

<u>Inhalation Rate</u>

Inhalation of particulate matter is a function of the ambient concentration of particulate matter, inhalation rate, relative bioavailability, and human body weight.

It is assumed that the average inhalation rate is age and activity dependent. The average daily inhalation rate for children was assumed to be 10 m^3/day. The average daily inhalation rate for adults was assumed to be 20 m^3/day.

Exposure Time and Frequency

Assuming that dust is generated only during ash handling activities, offsite residents would be exposed to contaminants only for the duration of these operations. However, for this assessment it was assumed that ash handling operations are occurring 24 hrs/day for the entire exposure duration period. Accordingly, offsite adult and children residents were also assumed to be continuously exposed to fugitive dust generated from the site 24 hours/day, 350 days/year. Workers were assumed to be on site for an 8 hours/day, 250 days/year. End cap workers were assumed to be exposed for only 1 hour/day, 250 days/year.

Exposure Duration

As previously described, the risk assessment assumes that potential offsite residential receptors are exposed for a 30 year period. This 30 year duration is split between 6 years as a child and 24 years as an adult. The worker receptor assumes a 25 year employment tenure.

Absorption Adjustment Factors

Absorption is assumed to be 100% via the inhalation route of exposure for all COPCs. The oral and dermal absorption adjustment factors were taken from the Hawaii Department of Health EALs, U.S. EPA RSLs, or derived by AMEC. In cases where no absorption factor was found, a default of 1 was used.

Body Weight

The body weights assumed in this risk assessment are 15 kg for the child and 70 kg for the adult receptors (USEPA 2001c).

Averaging Time

The average daily dose of COPCs used to calculate noncarcinogenic risks must be averaged over the duration which the receptor is assumed to be exposed (USEPA 1989). Therefore, in the CADD calculations, the averaging time is equal to the exposure duration (above).

The average daily dose used to determine potential carcinogenic effects, however, must be averaged over the entire lifetime (70 years), regardless of the length of time which the receptor is assumed to be exposed (USEPA 1989).

TABLE 2-5

Exposure Assumptions

Receptor	Parameter (units)	Value
Adult Resident	Exposure Duration (hr/d)	24
	Exposure Frequency (d/y)	350
	Exposure Period (y)	24
	Body Weight (kg)	70
	Averaging Period - Lifetime (d)	25550
	Averaging Period - Chronic Noncancer (d)	8760
	Inhalation Rate	0.833 m^3/hr
	Respirable particulate concentration in air (mg/m^3)	9.34E-04 mg/m^3
	Fraction from Site (unitless)	1
Child Resident	Exposure Duration (hr/d)	24
	Exposure Frequency (d/y)	365
	Exposure Period (y)	6
	Body Weight (kg)	15
	Averaging Period - Lifetime (d)	25550
	Averaging Period - Noncancer (d)	2190
	Inhalation Rate	0.417 m^3/hr
	Respirable particulate concentration in air (mg/m3)	9.34E-04 mg/m^3
	Fraction from Site (unitless)	1
Worker	Exposure Duration (hr/d)	8
	Exposure Frequency (d/y)	250
	Exposure Period (y)	25
	Body Weight (kg)	70
	Averaging Period - Lifetime (d)	25550
	Averaging Period - Noncancer (d)	9125
	Inhalation Rate	0.833 m^3/hr
	Ingestion Rate	100 mg/day
	Skin Surface Area	3300 cm^2
	Adherence Factor	0.29 mg/cm^2/event
	Respirable particulate concentration in air (mg/m3)	5.90E-01 mg/m^3
	Fraction from Site (unitless)	1

End Cap Worker	Exposure Duration (hr/d)	1
	Exposure Frequency (d/y)	250
	Exposure Period (y)	25
	Body Weight (kg)	70
	Averaging Period - Lifetime (d)	25550
	Averaging Period - Noncancer (d)	9125
	Inhalation Rate	0.833 m^3/hr
	Ingestion Rate	100 mg/day
	Skin Surface Area	3300 cm^2
	Adherence Factor	0.29 mg/cm^2/event
	Respirable particulate concentration in air (mg/m3)	1.10E+00 mg/m^3
	Fraction from Site (unitless)	1

3.4 Risk Characterization

The Risk Characterization combines the results of the Exposure Assessment with the results of the Toxicity Assessment to derive quantitative estimates of the potential for adverse health effects to occur as a result of potential exposure to AES coal ash. The potential for both noncarcinogenic and carcinogenic effects are estimated for each receptor for each potential exposure pathway identified in the Exposure Assessment. The risks from each exposure pathway are summed to obtain an estimate of total risk for each receptor.

The risk characterization is the step in the risk assessment process that combines the results of the exposure assessment and the toxicity assessment for each compound of concern in order to estimate the potential for carcinogenic and noncarcinogenic human health effects from chronic exposure to that compound. This section summarizes the results of the risk characterization for each receptor evaluated in the risk assessment.

3.4.1 Noncarcinogenic Risk Characterization

The potential for exposures to COPCs to result in adverse noncarcinogenic health effects is estimated for each receptor by comparing the Chronic Average Daily Dose (CADD) for each compound with the Reference Dose for that compound. The resulting ratio, which is unitless, is known as the Hazard Quotient (HQ) for that compound. The HQ is calculated using the following formula:

$$A = \frac{B}{C}$$

where:

A = Hazard Quotient (unitless);
B = Chronic Average Daily Dose (mg/kg-day); and
C = Reference Dose (mg/kg-day).

When the Hazard Quotient for a given compound does not exceed 1, the Reference Dose has not been exceeded, and no adverse noncarcinogenic health effects are expected to occur as a result of exposure to that compound via that route. The HQs for each compound are summed to yield the Hazard Index (HI) for that pathway. An HI is calculated for each receptor for each pathway by which the receptor is assumed to be exposed. A Total Hazard Index for a chemical is then calculated for each receptor by summing the pathway-specific HIs. A Total HI for a chemical that does not exceed 1 for a given receptor indicates that no adverse noncarcinogenic health effects are expected to occur as a result of that receptor's potential exposure to a chemical in the environmental media. The HIs calculated for this assessment are presented in Table 2-7. All HIs were lower than the U.S. EPA and HDOH criterion goal of 1.

TABLE 2-7

Noncarcinogenic Risk

RECEPTOR	HAZARD QUOTIENT
Worker, 8-hour inhalation exposure	6E-01
Worker, 1-hour end cap inhalation exposure	1E-01
Worker, dermal and ingestion exposure	2E-01
Adult Resident, inhalation exposure	4E-03
Child Resident, inhalation exposure	9E-03

3.4.2 Carcinogenic Risk Characterization

The purpose of carcinogenic risk characterization is to estimate the likelihood, over and above the background cancer rate, that a receptor will develop cancer in his or her lifetime as a result of facility-related exposures to COPCs in various environmental media. This likelihood is a function of the dose of a compound and the Cancer Slope Factor (CSF) for that compound. The relationship between the Excess Lifetime Cancer Risk (ELCR) and the estimated Lifetime Average Daily Dose (LADD) of a compound may be expressed by the exponential equation:

$$A = 1 - e^{-BC}$$

where:

A = Excess Lifetime Cancer Risk (unitless);
B = Cancer Slope Factor (1/(mg/kg-day)); and
C = Lifetime Average Daily Dose (mg/kg-day).

When the product of the CSF and the LADD is much greater than 1, the ELCR approaches 1 (i.e., 100% probability). When the product is less than 0.01 (10^{-2}), the equation can be closely approximated by the linear equation:

$$A = B \times C$$

where:

A = Excess Lifetime Cancer Risk (unitless);
B = Cancer Slope Factor (1/(mg/kg-day)); and
C = Lifetime Average Daily Dose (mg/kg-day).

The product of the CSF and the LADD is unitless, and provides an estimate of the potential carcinogenic risk associated with a receptor's exposure to that compound via that pathway. ELCRs are calculated for each potentially carcinogenic compound. For each receptor, the ELCRs for each pathway by which the receptor is assumed to be exposed are calculated by summing the potential risks derived for each compound. A Total Excess Lifetime Cancer Risk is then calculated by summing the pathway-specific ELCRs. The ELCRs calculated for this assessment are presented in Table 2-8. All risks to the offsite residential receptors were substantially lower than the USEPA and HDOH point of departure value of 1 E-06. Risks to the two worker scenarios exceeded the point of departure value of 1E-06, but were below the USEPA and DOH regulatory level of concern of 1E-05 for commercial and industrial workers.

TABLE 2-8

Carcinogenic Risk

RECEPTOR	CANCER RISK
Worker, 8-hour inhalation exposure	5E-06
Worker, 1-hour end cap inhalation exposure	1E-06
Worker, dermal and ingestion exposure	5E-06
Adult Resident, inhalation exposure	3E-08
Child Resident, inhalation exposure	2E-08

TABLE 2-9

Final Risk Results

Human Health Risk Assessment

RECEPTOR	Hazard Index	Cancer Risk
End Cap Worker Total (End Cap Inhalation + Direct Contact)	**3E-01**	**6E-06**
Worker Total (Worker Inhalation + Direct Contact)	**8E-01**	**1E-05**
Residential Total (Child Inhalation + Adult Inhalation)	**1E-02**	**5E-08**

SECTION 4
UNCERTAINTY ANALYSIS

The risk assessment for the beneficial reuse of AES coal ash at PVT Landfill contains many assumptions that lead to significant uncertainty. The assumptions that introduce the greatest amount of uncertainty in this risk assessment are discussed in this section. They are discussed in general terms, because for most of the assumptions there is not enough information to assign a numerical value that can be factored into the calculation of risk.

Within any of the four steps of the risk assessment process, assumptions must be made due to a lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less support. Every assumption introduces some degree of uncertainty into the risk assessment process. Conservative assumptions are made throughout the risk assessment to ensure that the health of local residents is protected. Therefore, when all of the assumptions are combined, it is much more likely that actual risks, if any, are overestimated rather than underestimated.

4.1 Hazard Identification

During the Hazard Identification step, compounds are selected for inclusion in the quantitative risk assessment. For this assessment all 17 metals analyzed for in AES coal ash were selected as COPCs. As such the level of uncertainty in selecting COPCs is also assumed low. Accordingly, little uncertainty is introduced by the Hazard Identification step.

4.2 Toxicity Assessment

Dose-response values are usually based on limited toxicological data. For this reason, a margin of safety is built into estimates of both carcinogenic and noncarcinogenic risk, and actual risks are lower than those estimated. The two major areas of uncertainty introduced in the dose-response assessment are: (1) animal to human extrapolation; and (2) high to low dose extrapolation.

Human dose-response values are often extrapolated, or estimated, using the results of animal studies. Extrapolation from animals to humans introduces a great deal of uncertainty in the risk assessment because in most instances, it is not known how differently a human may react to the chemical compared to the animal species used to test the compound. The procedures used to extrapolate from animals to humans involve conservative assumptions and incorporate several uncertainty factors that overestimate the adverse effects associated with a specific dose. As a result, overestimation of the potential for adverse effects to humans is more likely than underestimation.

Predicting potential health effects from the facility emissions requires the use of models to extrapolate the observed health effects from the high doses used in laboratory studies to the anticipated human health effects from low doses experienced in the environment. The models contain conservative assumptions to account for the large degree of uncertainty associated with this extrapolation (especially for potential carcinogens) and therefore, tend to be more likely to overestimate than underestimate the risks.

This risk assessment also took a very conservative approach regarding the bioaccessible fraction of COPCs available to be absorbed by the body. These relative absorption factors (RAFs) estimate the amount a chemical that is absorbed by the body through different routes of exposure. Hawaii Department of Health EAL Table and U.S. EPA RSL Table have recommended dermal and gastro-intestinal absorption fractions for different compounds. This risk assessment utilized these fractions for the direct contact oral and dermal pathways. For the inhalation pathway the most conservative default value of 1 was assumed for these fractions meaning the entire concentration of chemicals would be available for absorption by the body. More realistic bioaccessible fractions for this pathway could be derived and would most likely reduce the portrayed risk in this assessment.

4.3 Exposure Assessment

During the exposure assessment, exposure point concentrations are estimated, and exposure doses are calculated. Exposure point concentrations are the estimated concentrations of compounds to which humans may be exposed. Because ambient air chemical concentrations do not exist at the remote receptor locations at levels which would most likely exceed analytical detection limits, and direct measurement of would be confounded by non-relevant sources, exposure point concentrations were estimated using models containing numerous assumptions, such as the amount of compound released from the site, the dispersion of the compound in air and its fate and transport in the environment, and the location of people potentially exposed to released compounds. Once the concentrations in an environmental medium such as air have been predicted, the calculation of human exposure and dose involves making additional assumptions. The major sources of uncertainty associated with these assumptions are discussed below.

4.3.1 Estimation of Particulate Emission Factors

Offsite concentrations of COPCs for this risk assessment were either derived from a single ambient air-monitoring event. Maximum dust monitored during this event was used to model fugitive dust concentration to offsite receptors. This assumption is extremely health-protective because it most certainly would overestimate the amount of dust that could result from ash handling operations to occur on site. For example, the particulate emission factor was derived from the PM10 concentration from the location with the maximum particulate reading. Had the average at all monitoring locations been used, PM10 concentrations would have been significantly lower. Similarly, the PM10 concentration was also monitored using real time personal data rams (PDR). The average PM10 concentration over the course of the day from the PDR was significantly lower than the measured PM10 concentration from the air pumps. To be health protective, the cassette data from the active air sampling was carried forward in the human health risk assessment. Use of the PDR data would significantly lower the quantified human health risks.

4.3.2 Estimation of Airborne Dust Concentrations Offsite

There is some uncertainty in the estimation of airbome dust concentrations, because the risk assessment does not separately consider dust concentrations on days when winds are high. This uncertainty is minimal, however, as described below. The current risk assessment utilizes an EPA screening air dispersion model that assumes winds are blowing towards residential receptors 24 hours a day, 365 days a year at 2.8 m/s for either a 1-year or 30-year period. The USEPA states that a 0.08 times multiplication factor should be used to convert the 1-hr maximum average to an annual average. This was not done in this evaluation. Instead, an adjustment factor of 0.2 was applied to estimate the annual average (personal communication with Dr. Barbara Brooks, HEER

Office). Had a more realistic air dispersion model been used, the ambient dust concentrations at remote receptor locations would have been lower.

4.3.3 Estimation of Exposure Dose

Exposure point concentrations are estimated values of what is a Reasonable Maximum Exposure across the entire site. Given that these are estimates, a significant amount of uncertainty can be introduced into the assessment. A 95% UCL was used as the exposure point concentration in AES coal ash. Implementation of the 95% UCL estimates that the value calculated is greater than or equal to the true mean 95% of the time when calculated for a random data set. This assumption therefore introduces significant uncertainty as it relates to the true risk and almost certainly overestimates both site concentrations and risk. Additional uncertainty is also introduced by assuming non-detect laboratory results as present at ½ the sample reporting limit. In reality this may over or under estimate the actual concentration of the contaminant in the sample. As analytical methods have a limit to their accuracy at very low concentrations, this introduces uncertainty in the assessment.

Once the concentrations of the potentially released compounds in air have been predicted through modeling, the extent of human exposure must be estimated. This requires making assumptions about the frequency and duration of human exposure.

Uncertainty may be associated with some of the assumptions used to estimate how often exposure occurs. Such assumptions include location, accessibility, and use of an area. With this in mind, the receptor, or person who may potentially be exposed, and the location of exposure were defined for this risk assessment. The locations where certain activities were assumed to take place have been purposely selected because chemical concentrations and frequency of exposure are expected to be high (i.e., use of the maximally affected areas). In this assessment, residential receptors were assumed to live in the neighboring communities for 30 years and be present 24 hours per day, 350 days per year. The workers were assumed to be present at the site 8 hours per day, 250 days per year, and have a employment tenure of 25 years. However, actual frequencies and durations of exposure are likely to be much lower than assumed, because residents are not likely to stay in one place and may, for instance, work far away or move to another location. Furthermore the remaining lifetime of the landfill will probably not approach the estimated duration of lifetime, residence, or employment. In these cases, the person's potential exposure would be reduced, and the health risks discussed in this assessment would be overestimated.

4.4 Risk Characterization

The risk of adverse human health effects depends on estimated levels of exposure and dose-response relationships. Once exposure to and risk from each of the selected compounds is calculated, the total risk posed by disposal operations is determined by combining the health risk contributed by each compound. For virtually all combinations of compounds present in chemicals evaluated in this assessment, there is little or no evidence of interaction. However, in order not to understate the risk, it is assumed that the effects of different compounds may be added together.

SECTION 5
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APPENDIX A

Ambient Air Monitoring Field Notes

PVT Dust Monitoring

1050- Up wind location cassettes (PVT-U-PM10, PVT-U-TD) and dataRam set up and activated to run until EOD.
1110- Sampling cassettes PVT-D1-PM10 and PVT- D1-TD set up about 20-25 feet SE from ash pile and activated near beginning of ash dump.
1115- Rover (Amec dataRam) activated about 35 feet SE of ash pile.
1135- Ash Dump. Wind strong to east.
1145- D1 off.
1150- Moved Rover 20' east and 10' north.
1158- D2 (PVT-D2-PM10 and PVT- D2-TD) set up and awaiting ash dump.
1203- Dozer piling ash pile.
1208- Dozer pau.
****- dataRam at D2 had pump turned off after D1 sampling.
1230- dataRam at D2 pump turned on.
1245- Moved Rover ~25' south (wind direction a steady SE). Checked on upwind pumps-OK.
****- Debris trucks deliver and dump debris all day. Water truck waters various areas of road and debris pile all day.
1312- ash truck onsite. Samplers at D2 turned on.
1315- ash dump. Could not get attention of spotter. Other vehicles onsite continue to work while ash is dumped. Wind still towards SE.
1325- D2 samplers off.
1330- D3 (PVT-D2-PM10 and PVT- D2-TD) samplers set up. Solid SE winds.
1349- Moved Rover 20' south.
1350- ash truck onsite.
1351- pumps at D3 on.
1405- pumps off. dataRam left on. Debris trucks continue to dump and the water truck continues to make its rounds.
1428- ash truck dumps.
1431- debris pile capping begins.
1435- Debris pile capping samplers (PVT-End Cap-PM10 and PVT- End Cap-TD) turned on.
1542- Moved samplers to north side due to steady north wind.
1545- Upwind samplers uprighted.
1547- Rover to north side
1555- capping is pau. Samplers off. MB de-mobs and offsite.

On October 26, 2009, Amec performed air monitoring and sampling for Total Dust and Respirable Dust (PM10) at the PVT Land Company Landfill, Nanakuli, Hawaii. Inalab Laboratory of Honolulu provided Amec with pre-weighed 37mm PVC cassettes installed with 0.8um MCE filters. Sampling consisted of two (2) pre-weighed cassettes, each attached by tubing to a personal pump. One of the two cassettes was fitted into a Gilian Cyclone cassette holder that separates respirable dust from particulate matter of 10 microns or more and the other cassette drew unfiltered air to collect total dust. Both samples were collected at a rate of 1.7 L/min. Monitoring of respirable dust consisted of a personal pump attached to a Thermo Electro Corporation personal DataRam 1200 (pDR 1200) with cyclone attachment. Air was pumped through the pDR 1200 at the rate of 1.2L/min. per manufacturer's instructions for PM10 monitoring. Sampling and monitoring coincided with 3 ash deliveries and the capping of the debris pile at EOD. Samples and air monitoring data were collected at five (5) pre-determined locations:

1. Upwind of the ash pile, approximately 500' E side. (Samples PVT-U-TD, PVT-U-PM10)
2. Adjacent to the ash pile, SE side. (Samples PVT-D1-TD, PVT-D1-PM10)
3. Approximately 20' above the debris pile, W side. (Samples PVT-D2-TD, PVT-D2-PM10)
4. Approximately 100' above the debris pile on upper soil plateau, W side. (Samples PVT-D3-TD, PVT-D3-PM10)
5. Adjacent to the ash pile during EOD capping of the debris pile, SE and N side. (Samples PVT-End Cap-TD, PVT-End Cap-PM10)

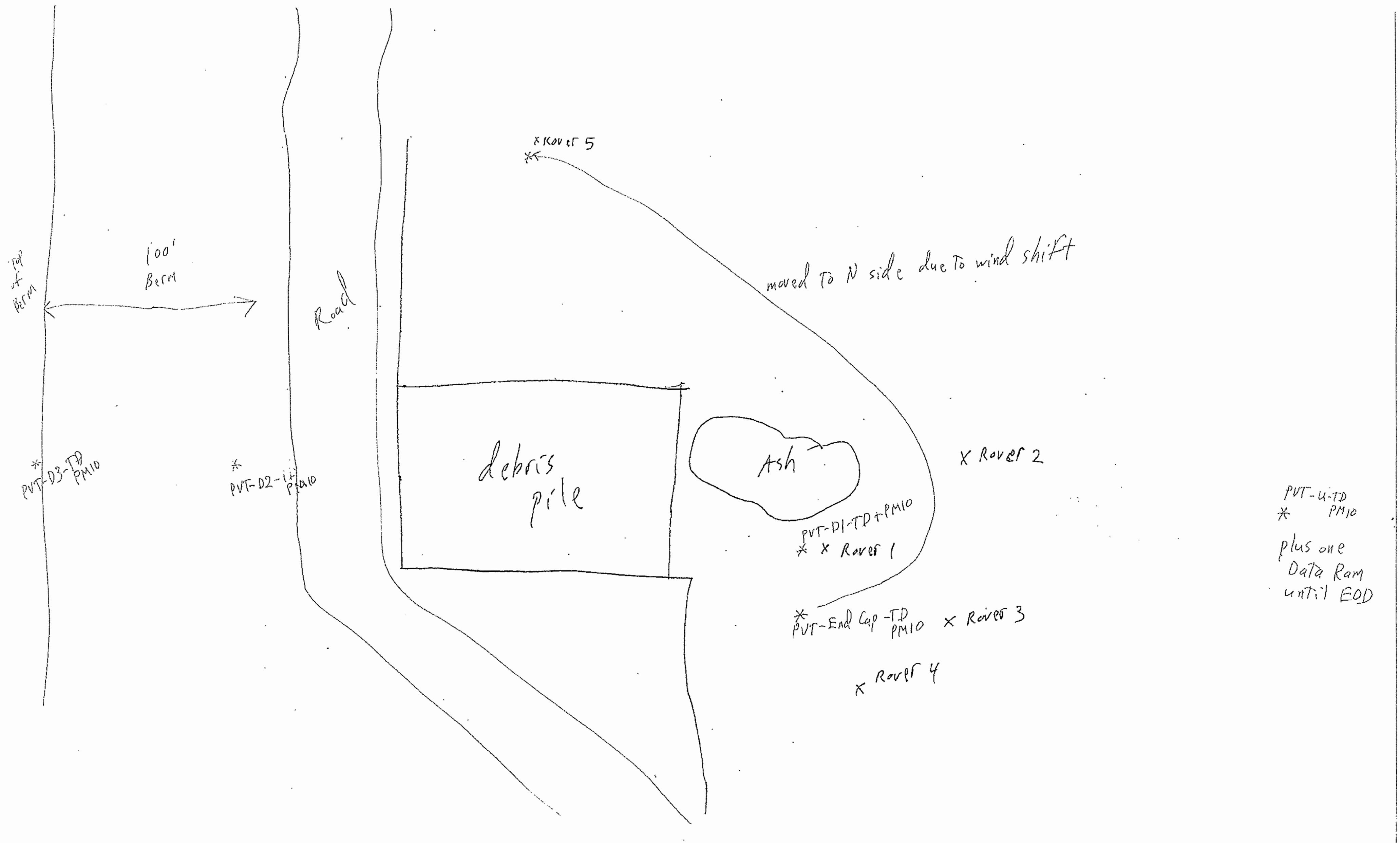
In addition to the 5 pre-determined locations, a pDR 1200 monitor measured the concentration of respirable dust from various downwind locations onsite.

Sample collection times are as follows:

1. Upwind: 1050-1555
2. D1: 1110-1145
3. D2: 1158-1208
4. D3: 1351-1405
5. End Cap: 1435-1555

The End Cap sample was collected from two locations according to the wind direction.

The pictures are provided and show sampling locations


Top of Berm
100' Berm
Road
* PVT-D3-TD PM10
* PVT-D2-TD PM10
debris pile
Ash
x Rover 5
moved to N side due to wind shift
x Rover 2
PVT-D1-TD+PM10
* x Rover 1
* PVT-End Cap-TD PM10
x Rover 3
x Rover 4
PVT-U-TD
* PM10
plus one Data Ram until EOD

APPENDIX B

Ambient Air Monitoring Photographs


10.26.2009


10.26.2009


10 26 2009

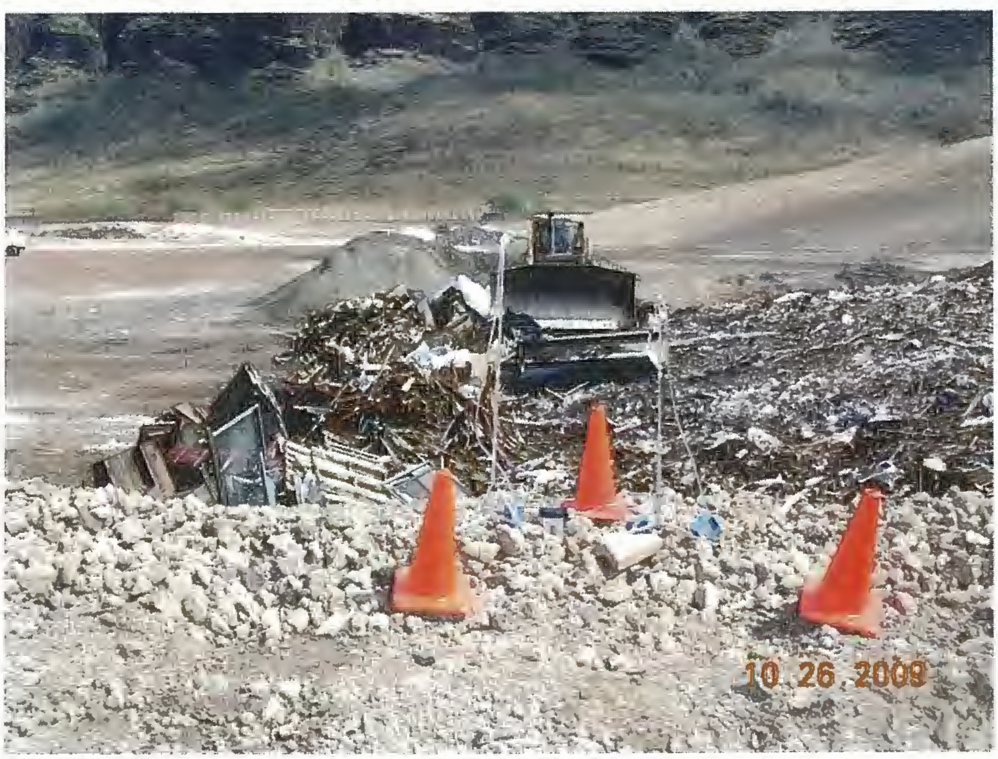

10 26 2009


10.26.2009


10 26 2009


10 26 2009


10 26 2009


10 26 2009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C&D YARD
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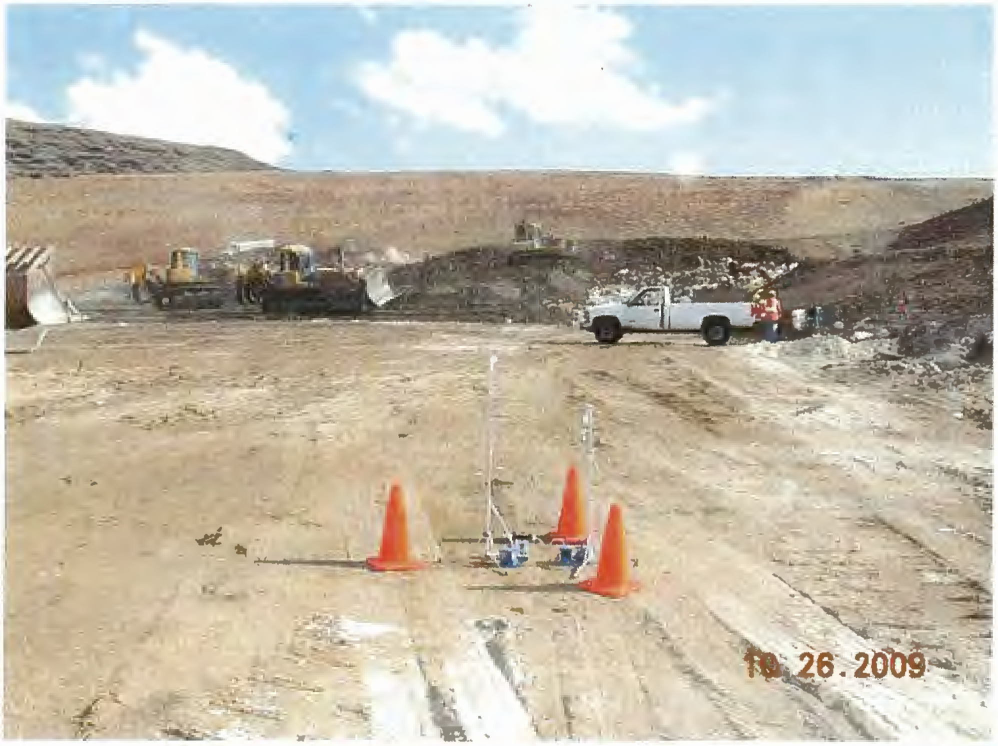
10.26.2009


10.26.2009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APPENDIX C

Ambient Air Monitoring Analytical Results

INALAB, Inc.

LABORATORY DIVISION
ANALYTICAL REPORT

30 October 2009

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Honolulu HI 96819

Phone Number (808) 545-2462
Facsimile: (808) 528-5379

Analytical Results

INALAB JOB NO: 20092608
CLIENT REFERENCE: PVT Landfill - 947/000002.0002 (10/26/09) - Total Dust

******* **Air-Total Nuisance Dust** *******

NIOSH **Method:** 0500(mod)

INALAB NO	Your Sample Description	Sample Type	Results	Units	Date Submitted	Date Analyzed
20091027021	01. PVT-D1 PM10: ASH PILE (Pre-weighed Cassette)	UNK	0.3	mg/m3	10/27/09	10/29/09
REMARKS:						
20091027022	02. PVT-D1 TD: ASH PILE (Pre-weighed Cassette)	UNK	0.76	mg/m3	10/27/09	10/29/09
REMARKS:						
20091027023	03. PVT-D2 PM10: ROAD ABOVE ASH PILE (Pre-weighed Cassette)	UNK	0.59	mg/m3	10/27/09	10/29/09
REMARKS:						
20091027024	04. PVT-D2 TD: ROAD ABOVE ASH PILE (Pre-weighed Cassette)	UNK	0.82	mg/m3	10/27/09	10/29/09
REMARKS:						
20091027025	05. PVT-D3 PM10: High Area Above ASH PILE (Pre-weighed Cassette)	UNK	0.34	mg/m3	10/27/09	10/29/09
REMARKS:						
20091027026	06. PVT-D3 TD: High Area Above ASH PILE (Pre-weighed Cassette)	UNK	0.92	mg/m3	10/27/09	10/29/09
REMARKS:						
20091027027	07. PVT-U- PM10: EAST of ASH PILE (Pre-weighed Cassette)	UNK	0.05	mg/m3	10/27/09	10/29/09
REMARKS:						
20091027028	08. PVT-U-TD: EAST of ASH PILE (Pre-weighed Cassette)	UNK	0.62	mg/m3	10/27/09	10/29/09
REMARKS:						

INALAB, Inc. is an AIHA IHLAP ACCREDITED LABORATORY (Accreditation No. 101812) with scope of accreditation including metals, solvents, fiber counts and bulk asbestos. INALAB, Inc. is a participant in the Compressed Air Proficiency Test (CAPT) program.

Mr. Russell Okoji
AMEC Earth & Environmental
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Analytical Results

INALAB JOB NO: 20092608
CLIENT REFERENCE: PVT Landfill - 947/000002.0002 (10/26/09) - Total Dust

******* Air-Total Nuisance Dust *******

NIOSH **Method:** 0500(mod)

INALAB NO	Your Sample Description	Sample Type	Results	Units	Date Submitted	Date Analyzed
20091027029	09. PVT-End Cap - PM10: ASH PILE (Pre-weighed Cassette)	UNK	1.1	mg/m3	10/27/09	10/29/09
REMARKS:						
20091027030	10. PVT-End Cap - TD: ASH PILE (Pre-weighed Cassette)	UNK	4.6	mg/m3	10/27/09	10/29/09
REMARKS:						
20091027256	Blank 1	UNK	< 0.01	mg/filter	10/27/09	10/29/09
REMARKS:						
20091027257	Blank 2	UNK	< 0.01	mg/filter	10/27/09	10/29/09
REMARKS:						

BATCH QC/QA

Analyte Recovery (%): 100 **Precision (% RPD):** N/A **System Blank** Acceptable

All analysts participate in interlaboratory quality control testing to continueously document profiency. *The sample(s) analysis(ses) subject of this analytical report was (were) conducted in general accordance with the procedures associated with the"analytical method" referenced above. Modifications to this methodology may have been made based upon the analyst's professional judgment and / or sample matrix effects encountered. 1. The analysis of sample relates only to the sample analyzed, and may or may not be representative of the original source of the material submitted for our analysis. 2. UNK refers to the sample submitted for this evaluation/ analysis. 3. DUP means a duplicate analysis of the Unk sample. 4. REP refers to a second preparation of the Unk sample. 5. Tr means TRACE, i.e., the analyte of interest was, to a reasonable degree of scientific certainty present, but was BELOW the quantifiable limits of this determination (stated). 6. ">" means greater than the numerical value listed. 7. "<" means less than the numerical value listed. 8. ND = NOT DETECTED which means the analyte, if present below our stated detection limit/ level. 9. RPD = Relative Percent Deviation [unk-dup]/ave(unk,dup)*100. 10. This report is not to be duplicated except in full without the expressed written permission of INALAB, Inc. 11. This report should not be construed as an endorsement for a product or a service by the AIHA or any affiliated organizations. 12. Sample and associated sampling/ collection data is reported as provided by client. 13. For air samples, results are calculated based on the reported air volumes. 14. Analytical methods marked with an "#" are not within our AIHA Scope of Accreditation. 15. Results have not been corrected for blank determinations unless noted in remarks.

DID INALAB FORENSIC DIVISION COLLECT THESE SAMPLES? **No**

Approved Signatory
Laboratory Manager

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30 October 2009

INALAB, Inc.

Experts in Environmental, Forensic, Occupational and Laboratory Services

OFFICIAL LABORATORY CHAIN OF CUSTODY

Analysis Company Name: **INALAB, Inc.**
Street Address: 3615 Harding Avenue, Suite 308
City/State/Zip: Honolulu, HI 96816
Telephone No: (808) 735-0422 FAX: (808) 735-0047

Please Do Not Write in Shaded Areas. Thank you :-)

INALAB JOB #: 2009 INALAB CLIENT I.D.#:

"TAT" (Turn-Around-Time)
[x] 3-5 Work DAYS (standard)
[ ] 2 Work DAYS
[ ] Priority (1 Work DAY)
[ ] Rush (< 1 Work Day)
[ ] Immediate: 4 Hours

Date: 10-27-09
Inalab's CLIENT/Co. Name: Amec E+E
Telephone Number: 808 783-6840
Project Name / Job #: PVT Landfill 9471000020002
Delivered By (print name): mark Bigelow

INALAB Sample NUMBER(s) This Column For INALAB Use Only	Your Sample No./I.D.	Client's Sampling Location	Client's Sample DESCRIPTION	Date / Time Collected	SAMPLE MATRIX	Client: Please State Your Required ANALYSIS	AIR VOLUME
	PVT-D1 PM10	Ash Pile	pre-weighed	10/26/09, 1110-1145	Dust	PM 10	59.5 L./min
	PVT-D1 TD	"	cassette	"		Niosh Total dust 0500	"
	PVT-D2 PM10	Road above ash pile		1158-1208		PM10	17 L./min
	PVT-D2 TD	"		"		Niosh Total dust 0500	"
	PVT-D3 PM10	High area above ash pile		1351-1405		PM10	23.8 L./min
	PVT-D3 TD	"		"		Niosh Total Dust 0500	"
	PVT-U-PM10	East of Ash Pile		1050-1555		PM10	518.5 L./min
	PVT-U-TD	"		"		Niosh Total Dust 0500	"
	PVT-End Cap-PM10	Ash Pile		1435-1555		PM 10	34 L./min
	PVT-End Cap-TD	"		"		Niosh Total dust 0500	"

Relinquished By: (Signature)	Date / Time	Received By: (Signature)	Date / Time
x [signature]	10/27/09 / 1105	x [signature]	10/27/09 / 11:05 am
x	/	x	/
x	/	x	/

Send Report To: E-MAIL Address OR [ ] Number
[ ] rachel.okoji@amec.com

SAMPLE NO(s): TO

SPECIAL NOTATION: TAT Note: If sample(s) are received after 9:00 A.M., that day will not count as a TAT day. Thank you for your support

Please include 2 pre-weighed cassettes ~~and~~ for Blank analysis.

Received Via: PICK-UP____ DROP BOX____ FEDEX____ USPS____ UPS____ Office D/O ✓

Copy of "COC" ____YES ____NO

pDR-1000 S/N: 06082
User ID: 6114
Tag Number: 01
Number of logged points: 577
Start time and date: 18:08:09 07-Mar
Elapsed time: 04:48:30
Logging period (sec): 30
Calibration Factor (%): 100
Max Display Concentration: 1.670 mg/m³
Time at maximum: 18:44:10 Mar 07
Max STEL Concentration: 0.138 mg/m³
Time at max STEL: 18:46:09 Mar 07
Overall Avg Conc: 0.044 mg/m³
Logged Data:

D1-2-3-End Cap

Point	Date	Time	Avg.(mg/m³)
1	07 Mar	18:08:39	0.027
2	07 Mar	18:09:09	0.022
3	07 Mar	18:09:39	0.021
4	07 Mar	18:10:09	0.038
5	07 Mar	18:10:39	0.034
6	07 Mar	18:11:09	0.029
7	07 Mar	18:11:39	0.025
8	07 Mar	18:12:09	0.022
9	07 Mar	18:12:39	0.022
10	07 Mar	18:13:09	0.023
11	07 Mar	18:13:39	0.019
12	07 Mar	18:14:09	0.020
13	07 Mar	18:14:39	0.023
14	07 Mar	18:15:09	0.030
15	07 Mar	18:15:39	0.027
16	07 Mar	18:16:09	0.023
17	07 Mar	18:16:39	0.024
18	07 Mar	18:17:09	0.030
19	07 Mar	18:17:39	0.023
20	07 Mar	18:18:09	0.061
21	07 Mar	18:18:39	0.041
22	07 Mar	18:19:09	0.026
23	07 Mar	18:19:39	0.037
24	07 Mar	18:20:09	0.134
25	07 Mar	18:20:39	0.052
26	07 Mar	18:21:09	0.038
27	07 Mar	18:21:39	0.056
28	07 Mar	18:22:09	0.049
29	07 Mar	18:22:39	0.054
30	07 Mar	18:23:09	0.044
31	07 Mar	18:23:39	0.052
32	07 Mar	18:24:09	0.055
33	07 Mar	18:24:39	0.042
34	07 Mar	18:25:09	0.065
35	07 Mar	18:25:39	0.112
36	07 Mar	18:26:09	0.095
37	07 Mar	18:26:39	0.142
38	07 Mar	18:27:09	0.116
39	07 Mar	18:27:39	0.145
40	07 Mar	18:28:09	0.168
41	07 Mar	18:28:39	0.121
42	07 Mar	18:29:09	0.030
43	07 Mar	18:29:39	0.022
44	07 Mar	18:30:09	0.023
45	07 Mar	18:30:39	0.063
46	07 Mar	18:31:09	0.050
47	07 Mar	18:31:39	0.023
48	07 Mar	18:32:09	0.029
49	07 Mar	18:32:39	0.043
50	07 Mar	18:33:09	0.023
51	07 Mar	18:33:39	0.026
52	07 Mar	18:34:09	0.075
53	07 Mar	18:34:39	0.062
54	07 Mar	18:35:09	0.028
55	07 Mar	18:35:39	0.094
56	07 Mar	18:36:09	0.133
57	07 Mar	18:36:39	0.059

58,	07 Mar,	18:37:09,	0.173
59,	07 Mar,	18:37:39,	0.080
60,	07 Mar,	18:38:09,	0.047
61,	07 Mar,	18:38:39,	0.152
62,	07 Mar,	18:39:09,	0.196
63,	07 Mar,	18:39:39,	0.079
64,	07 Mar,	18:40:09,	0.159
65,	07 Mar,	18:40:39,	0.307
66,	07 Mar,	18:41:09,	0.294
67,	07 Mar,	18:41:39,	0.250
68,	07 Mar,	18:42:09,	0.098
69,	07 Mar,	18:42:39,	0.026
70,	07 Mar,	18:43:09,	0.023
71,	07 Mar,	18:43:39,	0.122
72,	07 Mar,	18:44:09,	0.816
73,	07 Mar,	18:44:39,	0.191
74,	07 Mar,	18:45:09,	0.073
75,	07 Mar,	18:45:39,	0.126
76,	07 Mar,	18:46:09,	0.330
77,	07 Mar,	18:46:39,	0.025
78,	07 Mar,	18:47:09,	0.024
79,	07 Mar,	18:47:39,	0.030
80,	07 Mar,	18:48:09,	0.011
81,	07 Mar,	18:48:39,	0.014
82,	07 Mar,	18:49:09,	0.009
83,	07 Mar,	18:49:39,	0.035
84,	07 Mar,	18:50:09,	0.011
85,	07 Mar,	18:50:39,	0.010
86,	07 Mar,	18:51:09,	0.017
87,	07 Mar,	18:51:39,	0.012
88,	07 Mar,	18:52:09,	0.016
89,	07 Mar,	18:52:39,	0.015
90,	07 Mar,	18:53:09,	0.011
91,	07 Mar,	18:53:39,	0.012
92,	07 Mar,	18:54:09,	0.010
93,	07 Mar,	18:54:39,	0.015
94,	07 Mar,	18:55:09,	0.013
95,	07 Mar,	18:55:39,	0.024
96,	07 Mar,	18:56:09,	0.076
97,	07 Mar,	18:56:39,	0.053
98,	07 Mar,	18:57:09,	0.027
99,	07 Mar,	18:57:39,	0.011
100,	07 Mar,	18:58:09,	0.022
101,	07 Mar,	18:58:39,	0.043
102,	07 Mar,	18:59:09,	0.034
103,	07 Mar,	18:59:39,	0.046
104,	07 Mar,	19:00:09,	0.019
105,	07 Mar,	19:00:39,	0.064
106,	07 Mar,	19:01:09,	0.041
107,	07 Mar,	19:01:39,	0.016
108,	07 Mar,	19:02:09,	0.039
109,	07 Mar,	19:02:39,	0.035
110,	07 Mar,	19:03:09,	0.055
111,	07 Mar,	19:03:39,	0.038
112,	07 Mar,	19:04:09,	0.025
113,	07 Mar,	19:04:39,	0.013
114,	07 Mar,	19:05:09,	0.022
115,	07 Mar,	19:05:39,	0.013
116,	07 Mar,	19:06:09,	0.033
117,	07 Mar,	19:06:39,	0.045
118,	07 Mar,	19:07:09,	0.046
119,	07 Mar,	19:07:39,	0.035
120,	07 Mar,	19:08:09,	0.028
121,	07 Mar,	19:08:39,	0.007
122,	07 Mar,	19:09:09,	0.006
123,	07 Mar,	19:09:39,	0.014
124,	07 Mar,	19:10:09,	0.014
125,	07 Mar,	19:10:39,	0.017
126,	07 Mar,	19:11:09,	0.036
127,	07 Mar,	19:11:39,	0.008
128,	07 Mar,	19:12:09,	0.009
129,	07 Mar,	19:12:39,	0.007

130,	07 Mar,	19:13:09,	0.009
131,	07 Mar,	19:13:39,	0.007
132,	07 Mar,	19:14:09,	0.009
133,	07 Mar,	19:14:39,	0.007
134,	07 Mar,	19:15:09,	0.005
135,	07 Mar,	19:15:39,	0.023
136,	07 Mar,	19:16:09,	0.026
137,	07 Mar,	19:16:39,	0.032
138,	07 Mar,	19:17:09,	0.037
139,	07 Mar,	19:17:39,	0.032
140,	07 Mar,	19:18:09,	0.033
141,	07 Mar,	19:18:39,	0.035
142,	07 Mar,	19:19:09,	0.028
143,	07 Mar,	19:19:39,	0.012
144,	07 Mar,	19:20:09,	0.038
145,	07 Mar,	19:20:39,	0.035
146,	07 Mar,	19:21:09,	0.037
147,	07 Mar,	19:21:39,	0.035
148,	07 Mar,	19:22:09,	0.062
149,	07 Mar,	19:22:39,	0.027
150,	07 Mar,	19:23:09,	0.032
151,	07 Mar,	19:23:39,	0.018
152,	07 Mar,	19:24:09,	0.023
153,	07 Mar,	19:24:39,	0.046
154,	07 Mar,	19:25:09,	0.022
155,	07 Mar,	19:25:39,	0.028
156,	07 Mar,	19:26:09,	0.011
157,	07 Mar,	19:26:39,	0.035
158,	07 Mar,	19:27:09,	0.046
159,	07 Mar,	19:27:39,	0.042
160,	07 Mar,	19:28:09,	0.049
161,	07 Mar,	19:28:39,	0.034
162,	07 Mar,	19:29:09,	0.026
163,	07 Mar,	19:29:39,	0.029
164,	07 Mar,	19:30:09,	0.033
165,	07 Mar,	19:30:39,	0.029
166,	07 Mar,	19:31:09,	0.029
167,	07 Mar,	19:31:39,	0.092
168,	07 Mar,	19:32:09,	0.081
169,	07 Mar,	19:32:39,	0.045
170,	07 Mar,	19:33:09,	0.040
171,	07 Mar,	19:33:39,	0.033
172,	07 Mar,	19:34:09,	0.056
173,	07 Mar,	19:34:39,	0.051
174,	07 Mar,	19:35:09,	0.076
175,	07 Mar,	19:35:39,	0.054
176,	07 Mar,	19:36:09,	0.045
177,	07 Mar,	19:36:39,	0.042
178,	07 Mar,	19:37:09,	0.041
179,	07 Mar,	19:37:39,	0.040
180,	07 Mar,	19:38:09,	0.019
181,	07 Mar,	19:38:39,	0.019
182,	07 Mar,	19:39:09,	0.026
183,	07 Mar,	19:39:39,	0.052
184,	07 Mar,	19:40:09,	0.040
185,	07 Mar,	19:40:39,	0.025
186,	07 Mar,	19:41:09,	0.047
187,	07 Mar,	19:41:39,	0.041
188,	07 Mar,	19:42:09,	0.046
189,	07 Mar,	19:42:39,	0.056
190,	07 Mar,	19:43:09,	0.022
191,	07 Mar,	19:43:39,	0.020
192,	07 Mar,	19:44:09,	0.018
193,	07 Mar,	19:44:39,	0.020
194,	07 Mar,	19:45:09,	0.054
195,	07 Mar,	19:45:39,	0.046
196,	07 Mar,	19:46:09,	0.038
197,	07 Mar,	19:46:39,	0.063
198,	07 Mar,	19:47:09,	0.036
199,	07 Mar,	19:47:39,	0.045
200,	07 Mar,	19:48:09,	0.141
201,	07 Mar,	19:48:39,	0.124

202,	07 Mar,	19:49:09,	0.042
203,	07 Mar,	19:49:39,	0.046
204,	07 Mar,	19:50:09,	0.041
205,	07 Mar,	19:50:39,	0.045
206,	07 Mar,	19:51:09,	0.034
207,	07 Mar,	19:51:39,	0.052
208,	07 Mar,	19:52:09,	0.083
209,	07 Mar,	19:52:39,	0.037
210,	07 Mar,	19:53:09,	0.030
211,	07 Mar,	19:53:39,	0.044
212,	07 Mar,	19:54:09,	0.043
213,	07 Mar,	19:54:39,	0.044
214,	07 Mar,	19:55:09,	0.078
215,	07 Mar,	19:55:39,	0.050
216,	07 Mar,	19:56:09,	0.051
217,	07 Mar,	19:56:39,	0.031
218,	07 Mar,	19:57:09,	0.064
219,	07 Mar,	19:57:39,	0.069
220,	07 Mar,	19:58:09,	0.027
221,	07 Mar,	19:58:39,	0.061
222,	07 Mar,	19:59:09,	0.027
223,	07 Mar,	19:59:39,	0.052
224,	07 Mar,	20:00:09,	0.033
225,	07 Mar,	20:00:39,	0.061
226,	07 Mar,	20:01:09,	0.034
227,	07 Mar,	20:01:39,	0.056
228,	07 Mar,	20:02:09,	0.034
229,	07 Mar,	20:02:39,	0.067
230,	07 Mar,	20:03:09,	0.070
231,	07 Mar,	20:03:39,	0.044
232,	07 Mar,	20:04:09,	0.032
233,	07 Mar,	20:04:39,	0.014
234,	07 Mar,	20:05:09,	0.058
235,	07 Mar,	20:05:39,	0.031
236,	07 Mar,	20:06:09,	0.030
237,	07 Mar,	20:06:39,	0.038
238,	07 Mar,	20:07:09,	0.028
239,	07 Mar,	20:07:39,	0.063
240,	07 Mar,	20:08:09,	0.052
241,	07 Mar,	20:08:39,	0.028
242,	07 Mar,	20:09:09,	0.054
243,	07 Mar,	20:09:39,	0.033
244,	07 Mar,	20:10:09,	0.037
245,	07 Mar,	20:10:39,	0.030
246,	07 Mar,	20:11:09,	0.061
247,	07 Mar,	20:11:39,	0.239
248,	07 Mar,	20:12:09,	0.050
249,	07 Mar,	20:12:39,	0.055
250,	07 Mar,	20:13:09,	0.054
251,	07 Mar,	20:13:39,	0.039
252,	07 Mar,	20:14:09,	0.049
253,	07 Mar,	20:14:39,	0.017
254,	07 Mar,	20:15:09,	0.041
255,	07 Mar,	20:15:39,	0.062
256,	07 Mar,	20:16:09,	0.049
257,	07 Mar,	20:16:39,	0.157
258,	07 Mar,	20:17:09,	0.033
259,	07 Mar,	20:17:39,	0.028
260,	07 Mar,	20:18:09,	0.025
261,	07 Mar,	20:18:39,	0.052
262,	07 Mar,	20:19:09,	0.028
263,	07 Mar,	20:19:39,	0.024
264,	07 Mar,	20:20:09,	0.021
265,	07 Mar,	20:20:39,	0.021
266,	07 Mar,	20:21:09,	0.021
267,	07 Mar,	20:21:39,	0.027
268,	07 Mar,	20:22:09,	0.025
269,	07 Mar,	20:22:39,	0.020
270,	07 Mar,	20:23:09,	0.023
271,	07 Mar,	20:23:39,	0.021
272,	07 Mar,	20:24:09,	0.059
273,	07 Mar,	20:24:39,	0.063

274,	07 Mar,	20:25:09,	0.018
275,	07 Mar,	20:25:39,	0.028
276,	07 Mar,	20:26:09,	0.041
277,	07 Mar,	20:26:39,	0.023
278,	07 Mar,	20:27:09,	0.035
279,	07 Mar,	20:27:39,	0.076
280,	07 Mar,	20:28:09,	0.024
281,	07 Mar,	20:28:39,	0.023
282,	07 Mar,	20:29:09,	0.055
283,	07 Mar,	20:29:39,	0.023
284,	07 Mar,	20:30:09,	0.085
285,	07 Mar,	20:30:39,	0.027
286,	07 Mar,	20:31:09,	0.025
287,	07 Mar,	20:31:39,	0.022
288,	07 Mar,	20:32:09,	0.022
289,	07 Mar,	20:32:39,	0.022
290,	07 Mar,	20:33:09,	0.022
291,	07 Mar,	20:33:39,	0.023
292,	07 Mar,	20:34:09,	0.024
293,	07 Mar,	20:34:39,	0.023
294,	07 Mar,	20:35:09,	0.023
295,	07 Mar,	20:35:39,	0.022
296,	07 Mar,	20:36:09,	0.023
297,	07 Mar,	20:36:39,	0.022
298,	07 Mar,	20:37:09,	0.023
299,	07 Mar,	20:37:39,	0.022
300,	07 Mar,	20:38:09,	0.020
301,	07 Mar,	20:38:39,	0.020
302,	07 Mar,	20:39:09,	0.024
303,	07 Mar,	20:39:39,	0.021
304,	07 Mar,	20:40:09,	0.023
305,	07 Mar,	20:40:39,	0.026
306,	07 Mar,	20:41:09,	0.031
307,	07 Mar,	20:41:39,	0.023
308,	07 Mar,	20:42:09,	0.024
309,	07 Mar,	20:42:39,	0.021
310,	07 Mar,	20:43:09,	0.022
311,	07 Mar,	20:43:39,	0.024
312,	07 Mar,	20:44:09,	0.024
313,	07 Mar,	20:44:39,	0.024
314,	07 Mar,	20:45:09,	0.026
315,	07 Mar,	20:45:39,	0.024
316,	07 Mar,	20:46:09,	0.025
317,	07 Mar,	20:46:39,	0.025
318,	07 Mar,	20:47:09,	0.023
319,	07 Mar,	20:47:39,	0.029
320,	07 Mar,	20:48:09,	0.023
321,	07 Mar,	20:48:39,	0.022
322,	07 Mar,	20:49:09,	0.021
323,	07 Mar,	20:49:39,	0.025
324,	07 Mar,	20:50:09,	0.025
325,	07 Mar,	20:50:39,	0.026
326,	07 Mar,	20:51:09,	0.022
327,	07 Mar,	20:51:39,	0.027
328,	07 Mar,	20:52:09,	0.025
329,	07 Mar,	20:52:39,	0.021
330,	07 Mar,	20:53:09,	0.023
331,	07 Mar,	20:53:39,	0.026
332,	07 Mar,	20:54:09,	0.024
333,	07 Mar,	20:54:39,	0.024
334,	07 Mar,	20:55:09,	0.024
335,	07 Mar,	20:55:39,	0.024
336,	07 Mar,	20:56:09,	0.023
337,	07 Mar,	20:56:39,	0.024
338,	07 Mar,	20:57:09,	0.026
339,	07 Mar,	20:57:39,	0.028
340,	07 Mar,	20:58:09,	0.021
341,	07 Mar,	20:58:39,	0.029
342,	07 Mar,	20:59:09,	0.031
343,	07 Mar,	20:59:39,	0.024
344,	07 Mar,	21:00:09,	0.038
345,	07 Mar,	21:00:39,	0.037

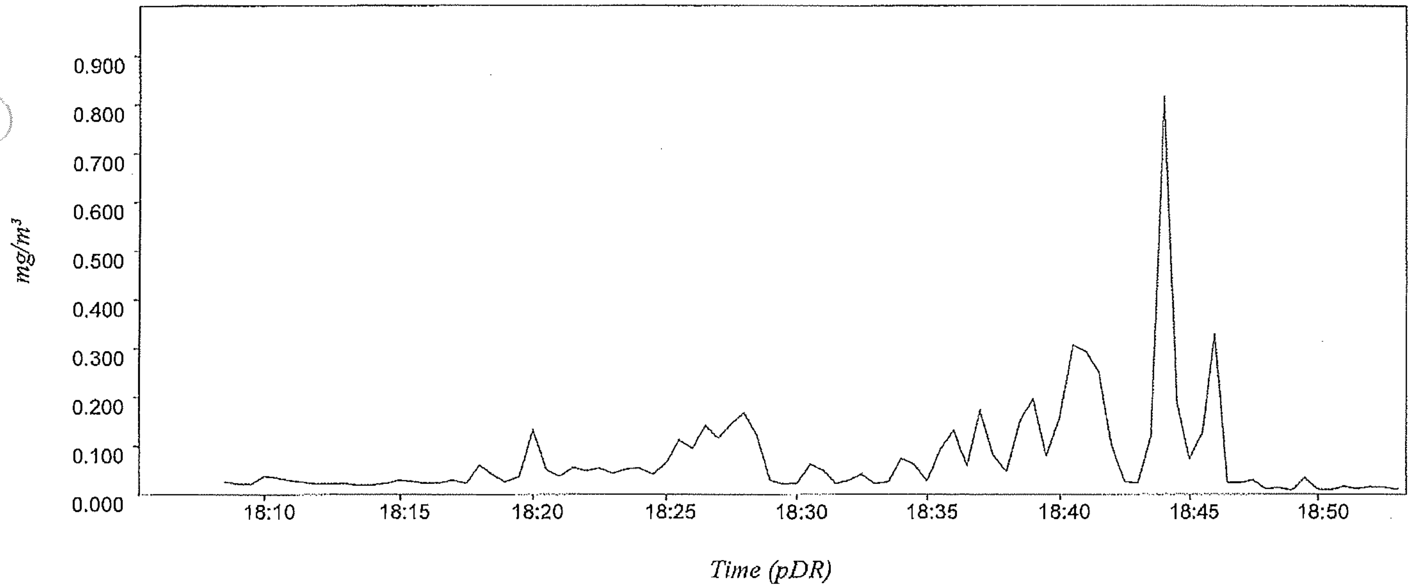
346,	07	Mar,	21:01:09,	0.044
347,	07	Mar,	21:01:39,	0.032
348,	07	Mar,	21:02:09,	0.039
349,	07	Mar,	21:02:39,	0.037
350,	07	Mar,	21:03:09,	0.025
351,	07	Mar,	21:03:39,	0.040
352,	07	Mar,	21:04:09,	0.037
353,	07	Mar,	21:04:39,	0.033
354,	07	Mar,	21:05:09,	0.149
355,	07	Mar,	21:05:39,	0.026
356,	07	Mar,	21:06:09,	0.031
357,	07	Mar,	21:06:39,	0.039
358,	07	Mar,	21:07:09,	0.026
359,	07	Mar,	21:07:39,	0.032
360,	07	Mar,	21:08:09,	0.053
361,	07	Mar,	21:08:39,	0.098
362,	07	Mar,	21:09:09,	0.079
363,	07	Mar,	21:09:39,	0.080
364,	07	Mar,	21:10:09,	0.074
365,	07	Mar,	21:10:39,	0.051
366,	07	Mar,	21:11:09,	0.070
367,	07	Mar,	21:11:39,	0.100
368,	07	Mar,	21:12:09,	0.088
369,	07	Mar,	21:12:39,	0.058
370,	07	Mar,	21:13:09,	0.422
371,	07	Mar,	21:13:39,	0.032
372,	07	Mar,	21:14:09,	0.071
373,	07	Mar,	21:14:39,	0.053
374,	07	Mar,	21:15:09,	0.056
375,	07	Mar,	21:15:39,	0.062
376,	07	Mar,	21:16:09,	0.062
377,	07	Mar,	21:16:39,	0.063
378,	07	Mar,	21:17:09,	0.051
379,	07	Mar,	21:17:39,	0.045
380,	07	Mar,	21:18:09,	0.043
381,	07	Mar,	21:18:39,	0.038
382,	07	Mar,	21:19:09,	0.017
383,	07	Mar,	21:19:39,	0.027
384,	07	Mar,	21:20:09,	0.021
385,	07	Mar,	21:20:39,	0.015
386,	07	Mar,	21:21:09,	0.016
387,	07	Mar,	21:21:39,	0.024
388,	07	Mar,	21:22:09,	0.019
389,	07	Mar,	21:22:39,	0.019
390,	07	Mar,	21:23:09,	0.026
391,	07	Mar,	21:23:39,	0.020
392,	07	Mar,	21:24:09,	0.036
393,	07	Mar,	21:24:39,	0.061
394,	07	Mar,	21:25:09,	0.200
395,	07	Mar,	21:25:39,	0.040
396,	07	Mar,	21:26:09,	0.032
397,	07	Mar,	21:26:39,	0.027
398,	07	Mar,	21:27:09,	0.031
399,	07	Mar,	21:27:39,	0.030
400,	07	Mar,	21:28:09,	0.028
401,	07	Mar,	21:28:39,	0.026
402,	07	Mar,	21:29:09,	0.064
403,	07	Mar,	21:29:39,	0.032
404,	07	Mar,	21:30:09,	0.039
405,	07	Mar,	21:30:39,	0.040
406,	07	Mar,	21:31:09,	0.046
407,	07	Mar,	21:31:39,	0.049
408,	07	Mar,	21:32:09,	0.149
409,	07	Mar,	21:32:39,	0.255
410,	07	Mar,	21:33:09,	0.169
411,	07	Mar,	21:33:39,	0.084
412,	07	Mar,	21:34:09,	0.043
413,	07	Mar,	21:34:39,	0.046
414,	07	Mar,	21:35:09,	0.031
415,	07	Mar,	21:35:39,	0.024
416,	07	Mar,	21:36:09,	0.019
417,	07	Mar,	21:36:39,	0.060

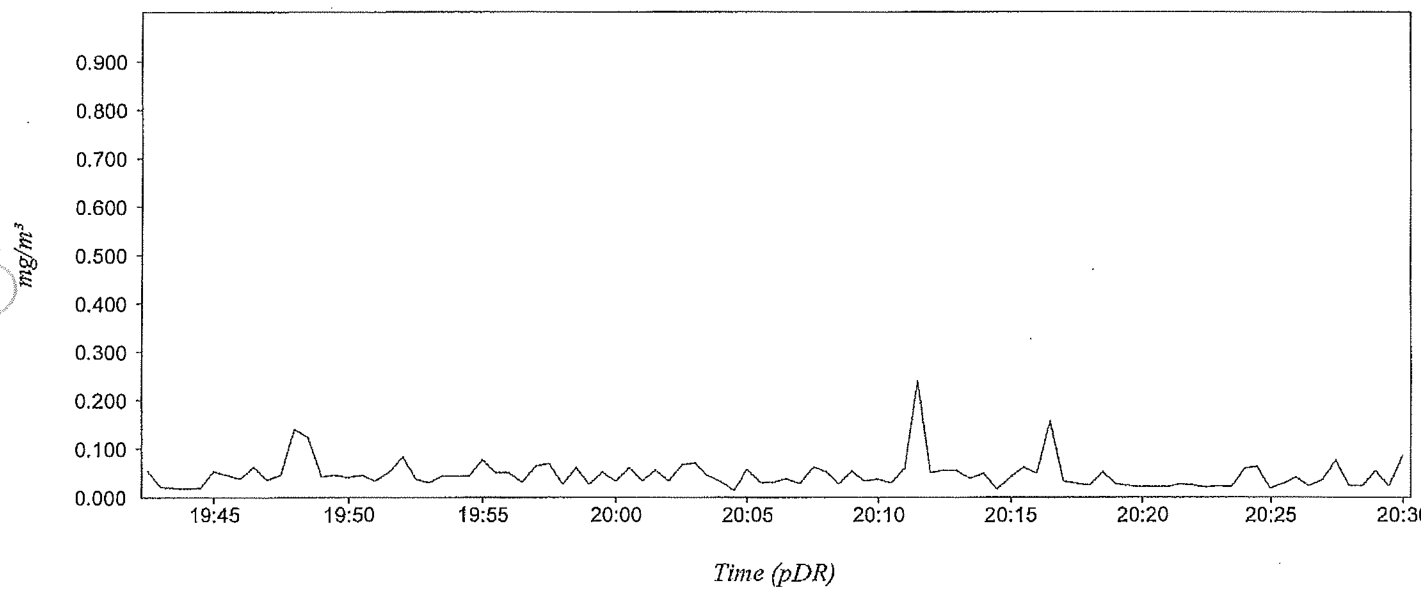
418,	07 Mar,	21:37:09,	0.099
419,	07 Mar,	21:37:39,	0.042
420,	07 Mar,	21:38:09,	0.036
421,	07 Mar,	21:38:39,	0.020
422,	07 Mar,	21:39:09,	0.034
423,	07 Mar,	21:39:39,	0.023
424,	07 Mar,	21:40:09,	0.035
425,	07 Mar,	21:40:39,	0.040
426,	07 Mar,	21:41:09,	0.216
427,	07 Mar,	21:41:39,	0.229
428,	07 Mar,	21:42:09,	0.149
429,	07 Mar,	21:42:39,	0.071
430,	07 Mar,	21:43:09,	0.115
431,	07 Mar,	21:43:39,	0.065
432,	07 Mar,	21:44:09,	0.060
433,	07 Mar,	21:44:39,	0.046
434,	07 Mar,	21:45:09,	0.038
435,	07 Mar,	21:45:39,	0.078
436,	07 Mar,	21:46:09,	0.023
437,	07 Mar,	21:46:39,	0.115
438,	07 Mar,	21:47:09,	0.079
439,	07 Mar,	21:47:39,	0.103
440,	07 Mar,	21:48:09,	0.073
441,	07 Mar,	21:48:39,	0.054
442,	07 Mar,	21:49:09,	0.015
443,	07 Mar,	21:49:39,	0.017
444,	07 Mar,	21:50:09,	0.071
445,	07 Mar,	21:50:39,	0.031
446,	07 Mar,	21:51:09,	0.037
447,	07 Mar,	21:51:39,	0.110
448,	07 Mar,	21:52:09,	0.137
449,	07 Mar,	21:52:39,	0.070
450,	07 Mar,	21:53:09,	0.037
451,	07 Mar,	21:53:39,	0.071
452,	07 Mar,	21:54:09,	0.137
453,	07 Mar,	21:54:39,	0.150
454,	07 Mar,	21:55:09,	0.277
455,	07 Mar,	21:55:39,	0.542
456,	07 Mar,	21:56:09,	0.093
457,	07 Mar,	21:56:39,	0.019
458,	07 Mar,	21:57:09,	0.040
459,	07 Mar,	21:57:39,	0.024
460,	07 Mar,	21:58:09,	0.041
461,	07 Mar,	21:58:39,	0.021
462,	07 Mar,	21:59:09,	0.019
463,	07 Mar,	21:59:39,	0.018
464,	07 Mar,	22:00:09,	0.017
465,	07 Mar,	22:00:39,	0.018
466,	07 Mar,	22:01:09,	0.067
467,	07 Mar,	22:01:39,	0.046
468,	07 Mar,	22:02:09,	0.019
469,	07 Mar,	22:02:39,	0.024
470,	07 Mar,	22:03:09,	0.017
471,	07 Mar,	22:03:39,	0.019
472,	07 Mar,	22:04:09,	0.030
473,	07 Mar,	22:04:39,	0.016
474,	07 Mar,	22:05:09,	0.034
475,	07 Mar,	22:05:39,	0.019
476,	07 Mar,	22:06:09,	0.022
477,	07 Mar,	22:06:39,	0.018
478,	07 Mar,	22:07:09,	0.025
479,	07 Mar,	22:07:39,	0.021
480,	07 Mar,	22:08:09,	0.022
481,	07 Mar,	22:08:39,	0.036
482,	07 Mar,	22:09:09,	0.028
483,	07 Mar,	22:09:39,	0.140
484,	07 Mar,	22:10:09,	0.065
485,	07 Mar,	22:10:39,	0.082
486,	07 Mar,	22:11:09,	0.077
487,	07 Mar,	22:11:39,	0.016
488,	07 Mar,	22:12:09,	0.020
489,	07 Mar,	22:12:39,	0.018

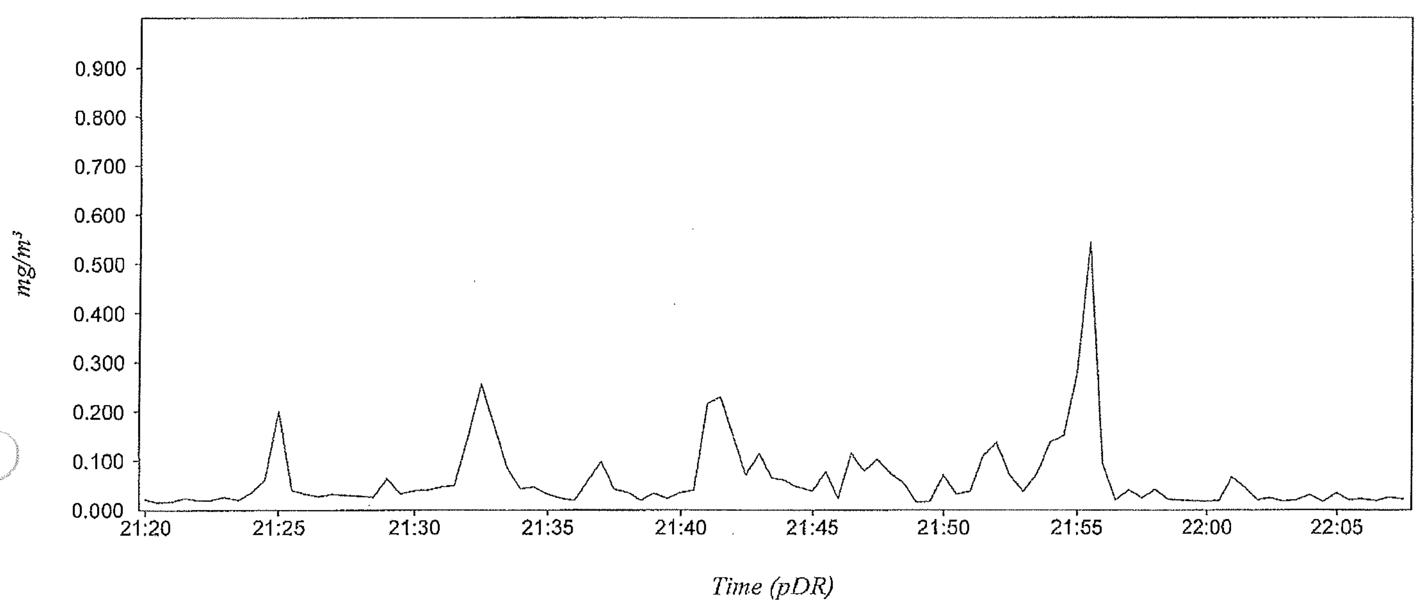
490,	07 Mar,	22:13:09,	0.022
491,	07 Mar,	22:13:39,	0.032
492,	07 Mar,	22:14:09,	0.020
493,	07 Mar,	22:14:39,	0.017
494,	07 Mar,	22:15:09,	0.019
495,	07 Mar,	22:15:39,	0.020
496,	07 Mar,	22:16:09,	0.022
497,	07 Mar,	22:16:39,	0.020
498,	07 Mar,	22:17:09,	0.023
499,	07 Mar,	22:17:39,	0.037
500,	07 Mar,	22:18:09,	0.019
501,	07 Mar,	22:18:39,	0.028
502,	07 Mar,	22:19:09,	0.019
503,	07 Mar,	22:19:39,	0.021
504,	07 Mar,	22:20:09,	0.017
505,	07 Mar,	22:20:39,	0.022
506,	07 Mar,	22:21:09,	0.015
507,	07 Mar,	22:21:39,	0.020
508,	07 Mar,	22:22:09,	0.019
509,	07 Mar,	22:22:39,	0.029
510,	07 Mar,	22:23:09,	0.017
511,	07 Mar,	22:23:39,	0.135
512,	07 Mar,	22:24:09,	0.034
513,	07 Mar,	22:24:39,	0.018
514,	07 Mar,	22:25:09,	0.025
515,	07 Mar,	22:25:39,	0.022
516,	07 Mar,	22:26:09,	0.021
517,	07 Mar,	22:26:39,	0.020
518,	07 Mar,	22:27:09,	0.019
519,	07 Mar,	22:27:39,	0.021
520,	07 Mar,	22:28:09,	0.019
521,	07 Mar,	22:28:39,	0.019
522,	07 Mar,	22:29:09,	0.015
523,	07 Mar,	22:29:39,	0.013
524,	07 Mar,	22:30:09,	0.017
525,	07 Mar,	22:30:39,	0.013
526,	07 Mar,	22:31:09,	0.017
527,	07 Mar,	22:31:39,	0.015
528,	07 Mar,	22:32:09,	0.013
529,	07 Mar,	22:32:39,	0.017
530,	07 Mar,	22:33:09,	0.016
531,	07 Mar,	22:33:39,	0.016
532,	07 Mar,	22:34:09,	0.013
533,	07 Mar,	22:34:39,	0.018
534,	07 Mar,	22:35:09,	0.016
535,	07 Mar,	22:35:39,	0.014
536,	07 Mar,	22:36:09,	0.013
537,	07 Mar,	22:36:39,	0.014
538,	07 Mar,	22:37:09,	0.026
539,	07 Mar,	22:37:39,	0.024
540,	07 Mar,	22:38:09,	0.025
541,	07 Mar,	22:38:39,	0.090
542,	07 Mar,	22:39:09,	0.081
543,	07 Mar,	22:39:39,	0.117
544,	07 Mar,	22:40:09,	0.176
545,	07 Mar,	22:40:39,	0.211
546,	07 Mar,	22:41:09,	0.345
547,	07 Mar,	22:41:39,	0.141
548,	07 Mar,	22:42:09,	0.117
549,	07 Mar,	22:42:39,	0.190
550,	07 Mar,	22:43:09,	0.141
551,	07 Mar,	22:43:39,	0.112
552,	07 Mar,	22:44:09,	0.061
553,	07 Mar,	22:44:39,	0.032
554,	07 Mar,	22:45:09,	0.042
555,	07 Mar,	22:45:39,	0.041
556,	07 Mar,	22:46:09,	0.074
557,	07 Mar,	22:46:39,	0.063
558,	07 Mar,	22:47:09,	0.060
559,	07 Mar,	22:47:39,	0.053
560,	07 Mar,	22:48:09,	0.042
561,	07 Mar,	22:48:39,	0.050

562,	07 Mar,	22:49:09,	0.040
563,	07 Mar,	22:49:39,	0.025
564,	07 Mar,	22:50:09,	0.033
565,	07 Mar,	22:50:39,	0.070
566,	07 Mar,	22:51:09,	0.018
567,	07 Mar,	22:51:39,	0.038
568,	07 Mar,	22:52:09,	0.078
569,	07 Mar,	22:52:39,	0.047
570,	07 Mar,	22:53:09,	0.090
571,	07 Mar,	22:53:39,	0.032
572,	07 Mar,	22:54:09,	0.032
573,	07 Mar,	22:54:39,	0.063
574,	07 Mar,	22:55:09,	0.035
575,	07 Mar,	22:55:39,	0.027
576,	07 Mar,	22:56:09,	0.059
577,	07 Mar,	22:56:39,	0.080

pDR-1000 S/N: 06082 / Tag # 01 / Start time: Mar 07, 18:08:09







pDR-1000 S/N: 06082
User ID: 6082
Tag Number: 01
Number of logged points: 620
Start time and date: 19:02:25 07-Mar
Elapsed time: 05:10:00
Logging period (sec): 30
Calibration Factor (%): 100
Max Display Concentration: 2.880 mg/m³
Time at maximum: 21:30:52 Mar 07
Max STEL Concentration: 0.105 mg/m³
Time at max STEL: 21:42:55 Mar 07
Overall Avg Conc: 0.055 mg/m³

upwind

Logged Data:

Point	Date	Time	Avg.(mg/m³)
1	07 Mar	19:02:55	0.011
2	07 Mar	19:03:25	0.023
3	07 Mar	19:03:55	0.009
4	07 Mar	19:04:25	0.018
5	07 Mar	19:04:55	0.020
6	07 Mar	19:05:25	0.038
7	07 Mar	19:05:55	0.047
8	07 Mar	19:06:25	0.040
9	07 Mar	19:06:55	0.028
10	07 Mar	19:07:25	0.020
11	07 Mar	19:07:55	0.016
12	07 Mar	19:08:25	0.017
13	07 Mar	19:08:55	0.018
14	07 Mar	19:09:25	0.019
15	07 Mar	19:09:55	0.015
16	07 Mar	19:10:25	0.014
17	07 Mar	19:10:55	0.013
18	07 Mar	19:11:25	0.014
19	07 Mar	19:11:55	0.015
20	07 Mar	19:12:25	0.012
21	07 Mar	19:12:55	0.013
22	07 Mar	19:13:25	0.011
23	07 Mar	19:13:55	0.012
24	07 Mar	19:14:25	0.013
25	07 Mar	19:14:55	0.017
26	07 Mar	19:15:25	0.020
27	07 Mar	19:15:55	0.015
28	07 Mar	19:16:25	0.011
29	07 Mar	19:16:55	0.014
30	07 Mar	19:17:25	0.013
31	07 Mar	19:17:55	0.011
32	07 Mar	19:18:25	0.016
33	07 Mar	19:18:55	0.015
34	07 Mar	19:19:25	0.022
35	07 Mar	19:19:55	0.036
36	07 Mar	19:20:25	0.014
37	07 Mar	19:20:55	0.013
38	07 Mar	19:21:25	0.018
39	07 Mar	19:21:55	0.012
40	07 Mar	19:22:25	0.013
41	07 Mar	19:22:55	0.010
42	07 Mar	19:23:25	0.013
43	07 Mar	19:23:55	0.011
44	07 Mar	19:24:25	0.016
45	07 Mar	19:24:55	0.050
46	07 Mar	19:25:25	0.076
47	07 Mar	19:25:55	0.031
48	07 Mar	19:26:25	0.020
49	07 Mar	19:26:55	0.016
50	07 Mar	19:27:25	0.011
51	07 Mar	19:27:55	0.017
52	07 Mar	19:28:25	0.016
53	07 Mar	19:28:55	0.022
54	07 Mar	19:29:25	0.023
55	07 Mar	19:29:55	0.012
56	07 Mar	19:30:25	0.009
57	07 Mar	19:30:55	0.014

58,	07 Mar,	19:31:25,	0.010
59,	07 Mar,	19:31:55,	0.091
60,	07 Mar,	19:32:25,	0.054
61,	07 Mar,	19:32:55,	0.023
62,	07 Mar,	19:33:25,	0.016
63,	07 Mar,	19:33:55,	0.014
64,	07 Mar,	19:34:25,	0.023
65,	07 Mar,	19:34:55,	0.054
66,	07 Mar,	19:35:25,	0.045
67,	07 Mar,	19:35:55,	0.070
68,	07 Mar,	19:36:25,	0.074
69,	07 Mar,	19:36:55,	0.020
70,	07 Mar,	19:37:25,	0.011
71,	07 Mar,	19:37:55,	0.012
72,	07 Mar,	19:38:25,	0.021
73,	07 Mar,	19:38:55,	0.030
74,	07 Mar,	19:39:25,	0.015
75,	07 Mar,	19:39:55,	0.024
76,	07 Mar,	19:40:25,	0.021
77,	07 Mar,	19:40:55,	0.016
78,	07 Mar,	19:41:25,	0.011
79,	07 Mar,	19:41:55,	0.021
80,	07 Mar,	19:42:25,	0.053
81,	07 Mar,	19:42:55,	0.030
82,	07 Mar,	19:43:25,	0.029
83,	07 Mar,	19:43:55,	0.081
84,	07 Mar,	19:44:25,	0.056
85,	07 Mar,	19:44:55,	0.028
86,	07 Mar,	19:45:25,	0.112
87,	07 Mar,	19:45:55,	0.031
88,	07 Mar,	19:46:25,	0.059
89,	07 Mar,	19:46:55,	0.092
90,	07 Mar,	19:47:25,	0.108
91,	07 Mar,	19:47:55,	0.026
92,	07 Mar,	19:48:25,	0.038
93,	07 Mar,	19:48:55,	0.076
94,	07 Mar,	19:49:25,	0.104
95,	07 Mar,	19:49:55,	0.073
96,	07 Mar,	19:50:25,	0.030
97,	07 Mar,	19:50:55,	0.018
98,	07 Mar,	19:51:25,	0.036
99,	07 Mar,	19:51:55,	0.055
100,	07 Mar,	19:52:25,	0.273
101,	07 Mar,	19:52:55,	0.216
102,	07 Mar,	19:53:25,	0.050
103,	07 Mar,	19:53:55,	0.154
104,	07 Mar,	19:54:25,	0.203
105,	07 Mar,	19:54:55,	0.113
106,	07 Mar,	19:55:25,	0.076
107,	07 Mar,	19:55:55,	0.175
108,	07 Mar,	19:56:25,	0.068
109,	07 Mar,	19:56:55,	0.098
110,	07 Mar,	19:57:25,	0.017
111,	07 Mar,	19:57:55,	0.029
112,	07 Mar,	19:58:25,	0.065
113,	07 Mar,	19:58:55,	0.061
114,	07 Mar,	19:59:25,	0.041
115,	07 Mar,	19:59:55,	0.055
116,	07 Mar,	20:00:25,	0.070
117,	07 Mar,	20:00:55,	0.071
118,	07 Mar,	20:01:25,	0.151
119,	07 Mar,	20:01:55,	0.150
120,	07 Mar,	20:02:25,	0.029
121,	07 Mar,	20:02:55,	0.064
122,	07 Mar,	20:03:25,	0.026
123,	07 Mar,	20:03:55,	0.225
124,	07 Mar,	20:04:25,	0.035
125,	07 Mar,	20:04:55,	0.024
126,	07 Mar,	20:05:25,	0.019
127,	07 Mar,	20:05:55,	0.096
128,	07 Mar,	20:06:25,	0.043
129,	07 Mar,	20:06:55,	0.067

130,	07	Mar,	20:07:25,	0.087
131,	07	Mar,	20:07:55,	0.017
132,	07	Mar,	20:08:25,	0.095
133,	07	Mar,	20:08:55,	0.038
134,	07	Mar,	20:09:25,	0.052
135,	07	Mar,	20:09:55,	0.109
136,	07	Mar,	20:10:25,	0.100
137,	07	Mar,	20:10:55,	0.032
138,	07	Mar,	20:11:25,	0.175
139,	07	Mar,	20:11:55,	0.149
140,	07	Mar,	20:12:25,	0.135
141,	07	Mar,	20:12:55,	0.025
142,	07	Mar,	20:13:25,	0.021
143,	07	Mar,	20:13:55,	0.022
144,	07	Mar,	20:14:25,	0.028
145,	07	Mar,	20:14:55,	0.028
146,	07	Mar,	20:15:25,	0.089
147,	07	Mar,	20:15:55,	0.051
148,	07	Mar,	20:16:25,	0.018
149,	07	Mar,	20:16:55,	0.028
150,	07	Mar,	20:17:25,	0.040
151,	07	Mar,	20:17:55,	0.088
152,	07	Mar,	20:18:25,	0.261
153,	07	Mar,	20:18:55,	0.135
154,	07	Mar,	20:19:25,	0.101
155,	07	Mar,	20:19:55,	0.189
156,	07	Mar,	20:20:25,	0.086
157,	07	Mar,	20:20:55,	0.122
158,	07	Mar,	20:21:25,	0.079
159,	07	Mar,	20:21:55,	0.038
160,	07	Mar,	20:22:25,	0.096
161,	07	Mar,	20:22:55,	0.050
162,	07	Mar,	20:23:25,	0.071
163,	07	Mar,	20:23:55,	0.085
164,	07	Mar,	20:24:25,	0.045
165,	07	Mar,	20:24:55,	0.048
166,	07	Mar,	20:25:25,	0.016
167,	07	Mar,	20:25:55,	0.020
168,	07	Mar,	20:26:25,	0.015
169,	07	Mar,	20:26:55,	0.036
170,	07	Mar,	20:27:25,	0.022
171,	07	Mar,	20:27:55,	0.024
172,	07	Mar,	20:28:25,	0.019
173,	07	Mar,	20:28:55,	0.017
174,	07	Mar,	20:29:25,	0.017
175,	07	Mar,	20:29:55,	0.045
176,	07	Mar,	20:30:25,	0.102
177,	07	Mar,	20:30:55,	0.069
178,	07	Mar,	20:31:25,	0.056
179,	07	Mar,	20:31:55,	0.113
180,	07	Mar,	20:32:25,	0.033
181,	07	Mar,	20:32:55,	0.094
182,	07	Mar,	20:33:25,	0.066
183,	07	Mar,	20:33:55,	0.071
184,	07	Mar,	20:34:25,	0.025
185,	07	Mar,	20:34:55,	0.024
186,	07	Mar,	20:35:25,	0.036
187,	07	Mar,	20:35:55,	0.023
188,	07	Mar,	20:36:25,	0.021
189,	07	Mar,	20:36:55,	0.039
190,	07	Mar,	20:37:25,	0.055
191,	07	Mar,	20:37:55,	0.021
192,	07	Mar,	20:38:25,	0.021
193,	07	Mar,	20:38:55,	0.023
194,	07	Mar,	20:39:25,	0.040
195,	07	Mar,	20:39:55,	0.031
196,	07	Mar,	20:40:25,	0.038
197,	07	Mar,	20:40:55,	0.066
198,	07	Mar,	20:41:25,	0.050
199,	07	Mar,	20:41:55,	0.031
200,	07	Mar,	20:42:25,	0.023
201,	07	Mar,	20:42:55,	0.032

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203,	07	Mar,	20:43:55,	0.019
204,	07	Mar,	20:44:25,	0.032
205,	07	Mar,	20:44:55,	0.019
206,	07	Mar,	20:45:25,	0.100
207,	07	Mar,	20:45:55,	0.118
208,	07	Mar,	20:46:25,	0.083
209,	07	Mar,	20:46:55,	0.091
210,	07	Mar,	20:47:25,	0.056
211,	07	Mar,	20:47:55,	0.064
212,	07	Mar,	20:48:25,	0.077
213,	07	Mar,	20:48:55,	0.046
214,	07	Mar,	20:49:25,	0.019
215,	07	Mar,	20:49:55,	0.123
216,	07	Mar,	20:50:25,	0.073
217,	07	Mar,	20:50:55,	0.123
218,	07	Mar,	20:51:25,	0.044
219,	07	Mar,	20:51:55,	0.054
220,	07	Mar,	20:52:25,	0.050
221,	07	Mar,	20:52:55,	0.049
222,	07	Mar,	20:53:25,	0.061
223,	07	Mar,	20:53:55,	0.046
224,	07	Mar,	20:54:25,	0.052
225,	07	Mar,	20:54:55,	0.032
226,	07	Mar,	20:55:25,	0.046
227,	07	Mar,	20:55:55,	0.055
228,	07	Mar,	20:56:25,	0.178
229,	07	Mar,	20:56:55,	0.022
230,	07	Mar,	20:57:25,	0.134
231,	07	Mar,	20:57:55,	0.063
232,	07	Mar,	20:58:25,	0.052
233,	07	Mar,	20:58:55,	0.023
234,	07	Mar,	20:59:25,	0.023
235,	07	Mar,	20:59:55,	0.021
236,	07	Mar,	21:00:25,	0.023
237,	07	Mar,	21:00:55,	0.026
238,	07	Mar,	21:01:25,	0.022
239,	07	Mar,	21:01:55,	0.082
240,	07	Mar,	21:02:25,	0.042
241,	07	Mar,	21:02:55,	0.043
242,	07	Mar,	21:03:25,	0.058
243,	07	Mar,	21:03:55,	0.077
244,	07	Mar,	21:04:25,	0.137
245,	07	Mar,	21:04:55,	0.052
246,	07	Mar,	21:05:25,	0.040
247,	07	Mar,	21:05:55,	0.037
248,	07	Mar,	21:06:25,	0.085
249,	07	Mar,	21:06:55,	0.037
250,	07	Mar,	21:07:25,	0.107
251,	07	Mar,	21:07:55,	0.057
252,	07	Mar,	21:08:25,	0.066
253,	07	Mar,	21:08:55,	0.421
254,	07	Mar,	21:09:25,	0.217
255,	07	Mar,	21:09:55,	0.076
256,	07	Mar,	21:10:25,	0.212
257,	07	Mar,	21:10:55,	0.073
258,	07	Mar,	21:11:25,	0.085
259,	07	Mar,	21:11:55,	0.046
260,	07	Mar,	21:12:25,	0.032
261,	07	Mar,	21:12:55,	0.030
262,	07	Mar,	21:13:25,	0.040
263,	07	Mar,	21:13:55,	0.081
264,	07	Mar,	21:14:25,	0.063
265,	07	Mar,	21:14:55,	0.135
266,	07	Mar,	21:15:25,	0.139
267,	07	Mar,	21:15:55,	0.039
268,	07	Mar,	21:16:25,	0.035
269,	07	Mar,	21:16:55,	0.059
270,	07	Mar,	21:17:25,	0.033
271,	07	Mar,	21:17:55,	0.042
272,	07	Mar,	21:18:25,	0.070
273,	07	Mar,	21:18:55,	0.066

274,	07	Mar,	21:19:25,	0.037
275,	07	Mar,	21:19:55,	0.042
276,	07	Mar,	21:20:25,	0.041
277,	07	Mar,	21:20:55,	0.040
278,	07	Mar,	21:21:25,	0.036
279,	07	Mar,	21:21:55,	0.046
280,	07	Mar,	21:22:25,	0.111
281,	07	Mar,	21:22:55,	0.051
282,	07	Mar,	21:23:25,	0.032
283,	07	Mar,	21:23:55,	0.035
284,	07	Mar,	21:24:25,	0.034
285,	07	Mar,	21:24:55,	0.040
286,	07	Mar,	21:25:25,	0.036
287,	07	Mar,	21:25:55,	0.031
288,	07	Mar,	21:26:25,	0.027
289,	07	Mar,	21:26:55,	0.032
290,	07	Mar,	21:27:25,	0.031
291,	07	Mar,	21:27:55,	0.043
292,	07	Mar,	21:28:25,	0.172
293,	07	Mar,	21:28:55,	0.056
294,	07	Mar,	21:29:25,	0.031
295,	07	Mar,	21:29:55,	0.025
296,	07	Mar,	21:30:25,	0.044
297,	07	Mar,	21:30:55,	1.087
298,	07	Mar,	21:31:25,	0.063
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301,	07	Mar,	21:32:55,	0.076
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303,	07	Mar,	21:33:55,	0.083
304,	07	Mar,	21:34:25,	0.063
305,	07	Mar,	21:34:55,	0.094
306,	07	Mar,	21:35:25,	0.083
307,	07	Mar,	21:35:55,	0.086
308,	07	Mar,	21:36:25,	0.040
309,	07	Mar,	21:36:55,	0.030
310,	07	Mar,	21:37:25,	0.069
311,	07	Mar,	21:37:55,	0.088
312,	07	Mar,	21:38:25,	0.051
313,	07	Mar,	21:38:55,	0.080
314,	07	Mar,	21:39:25,	0.055
315,	07	Mar,	21:39:55,	0.066
316,	07	Mar,	21:40:25,	0.042
317,	07	Mar,	21:40:55,	0.045
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319,	07	Mar,	21:41:55,	0.030
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321,	07	Mar,	21:42:55,	0.216
322,	07	Mar,	21:43:25,	0.033
323,	07	Mar,	21:43:55,	0.032
324,	07	Mar,	21:44:25,	0.035
325,	07	Mar,	21:44:55,	0.194
326,	07	Mar,	21:45:25,	0.047
327,	07	Mar,	21:45:55,	0.039
328,	07	Mar,	21:46:25,	0.074
329,	07	Mar,	21:46:55,	0.036
330,	07	Mar,	21:47:25,	0.032
331,	07	Mar,	21:47:55,	0.225
332,	07	Mar,	21:48:25,	0.041
333,	07	Mar,	21:48:55,	0.037
334,	07	Mar,	21:49:25,	0.032
335,	07	Mar,	21:49:55,	0.030
336,	07	Mar,	21:50:25,	0.032
337,	07	Mar,	21:50:55,	0.078
338,	07	Mar,	21:51:25,	0.036
339,	07	Mar,	21:51:55,	0.034
340,	07	Mar,	21:52:25,	0.029
341,	07	Mar,	21:52:55,	0.028
342,	07	Mar,	21:53:25,	0.028
343,	07	Mar,	21:53:55,	0.029
344,	07	Mar,	21:54:25,	0.031
345,	07	Mar,	21:54:55,	0.030

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349,	07 Mar,	21:56:55,	0.030
350,	07 Mar,	21:57:25,	0.030
351,	07 Mar,	21:57:55,	0.031
352,	07 Mar,	21:58:25,	0.028
353,	07 Mar,	21:58:55,	0.025
354,	07 Mar,	21:59:25,	0.029
355,	07 Mar,	21:59:55,	0.028
356,	07 Mar,	22:00:25,	0.033
357,	07 Mar,	22:00:55,	0.032
358,	07 Mar,	22:01:25,	0.030
359,	07 Mar,	22:01:55,	0.027
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362,	07 Mar,	22:03:25,	0.030
363,	07 Mar,	22:03:55,	0.026
364,	07 Mar,	22:04:25,	0.030
365,	07 Mar,	22:04:55,	0.031
366,	07 Mar,	22:05:25,	0.031
367,	07 Mar,	22:05:55,	0.028
368,	07 Mar,	22:06:25,	0.028
369,	07 Mar,	22:06:55,	0.031
370,	07 Mar,	22:07:25,	0.029
371,	07 Mar,	22:07:55,	0.027
372,	07 Mar,	22:08:25,	0.029
373,	07 Mar,	22:08:55,	0.026
374,	07 Mar,	22:09:25,	0.026
375,	07 Mar,	22:09:55,	0.028
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378,	07 Mar,	22:11:25,	0.033
379,	07 Mar,	22:11:55,	0.032
380,	07 Mar,	22:12:25,	0.032
381,	07 Mar,	22:12:55,	0.034
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383,	07 Mar,	22:13:55,	0.038
384,	07 Mar,	22:14:25,	0.032
385,	07 Mar,	22:14:55,	0.028
386,	07 Mar,	22:15:25,	0.032
387,	07 Mar,	22:15:55,	0.031
388,	07 Mar,	22:16:25,	0.033
389,	07 Mar,	22:16:55,	0.032
390,	07 Mar,	22:17:25,	0.035
391,	07 Mar,	22:17:55,	0.027
392,	07 Mar,	22:18:25,	0.029
393,	07 Mar,	22:18:55,	0.026
394,	07 Mar,	22:19:25,	0.030
395,	07 Mar,	22:19:55,	0.038
396,	07 Mar,	22:20:25,	0.033
397,	07 Mar,	22:20:55,	0.028
398,	07 Mar,	22:21:25,	0.027
399,	07 Mar,	22:21:55,	0.030
400,	07 Mar,	22:22:25,	0.039
401,	07 Mar,	22:22:55,	0.032
402,	07 Mar,	22:23:25,	0.028
403,	07 Mar,	22:23:55,	0.031
404,	07 Mar,	22:24:25,	0.031
405,	07 Mar,	22:24:55,	0.029
406,	07 Mar,	22:25:25,	0.027
407,	07 Mar,	22:25:55,	0.037
408,	07 Mar,	22:26:25,	0.026
409,	07 Mar,	22:26:55,	0.030
410,	07 Mar,	22:27:25,	0.070
411,	07 Mar,	22:27:55,	0.039
412,	07 Mar,	22:28:25,	0.069
413,	07 Mar,	22:28:55,	0.033
414,	07 Mar,	22:29:25,	0.044
415,	07 Mar,	22:29:55,	0.035
416,	07 Mar,	22:30:25,	0.071
417,	07 Mar,	22:30:55,	0.058

418,	07 Mar,	22:31:25,	0.043
419,	07 Mar,	22:31:55,	0.073
420,	07 Mar,	22:32:25,	0.070
421,	07 Mar,	22:32:55,	0.043
422,	07 Mar,	22:33:25,	0.037
423,	07 Mar,	22:33:55,	0.044
424,	07 Mar,	22:34:25,	0.041
425,	07 Mar,	22:34:55,	0.046
426,	07 Mar,	22:35:25,	0.051
427,	07 Mar,	22:35:55,	0.150
428,	07 Mar,	22:36:25,	0.040
429,	07 Mar,	22:36:55,	0.146
430,	07 Mar,	22:37:25,	0.091
431,	07 Mar,	22:37:55,	0.063
432,	07 Mar,	22:38:25,	0.082
433,	07 Mar,	22:38:55,	0.107
434,	07 Mar,	22:39:25,	0.062
435,	07 Mar,	22:39:55,	0.106
436,	07 Mar,	22:40:25,	0.094
437,	07 Mar,	22:40:55,	0.054
438,	07 Mar,	22:41:25,	0.049
439,	07 Mar,	22:41:55,	0.038
440,	07 Mar,	22:42:25,	0.053
441,	07 Mar,	22:42:55,	0.070
442,	07 Mar,	22:43:25,	0.048
443,	07 Mar,	22:43:55,	0.651
444,	07 Mar,	22:44:25,	0.157
445,	07 Mar,	22:44:55,	0.043
446,	07 Mar,	22:45:25,	0.077
447,	07 Mar,	22:45:55,	0.054
448,	07 Mar,	22:46:25,	0.048
449,	07 Mar,	22:46:55,	0.048
450,	07 Mar,	22:47:25,	0.039
451,	07 Mar,	22:47:55,	0.036
452,	07 Mar,	22:48:25,	0.042
453,	07 Mar,	22:48:55,	0.064
454,	07 Mar,	22:49:25,	0.117
455,	07 Mar,	22:49:55,	0.132
456,	07 Mar,	22:50:25,	0.037
457,	07 Mar,	22:50:55,	0.066
458,	07 Mar,	22:51:25,	0.114
459,	07 Mar,	22:51:55,	0.069
460,	07 Mar,	22:52:25,	0.048
461,	07 Mar,	22:52:55,	0.061
462,	07 Mar,	22:53:25,	0.079
463,	07 Mar,	22:53:55,	0.076
464,	07 Mar,	22:54:25,	0.041
465,	07 Mar,	22:54:55,	0.071
466,	07 Mar,	22:55:25,	0.061
467,	07 Mar,	22:55:55,	0.091
468,	07 Mar,	22:56:25,	0.045
469,	07 Mar,	22:56:55,	0.046
470,	07 Mar,	22:57:25,	0.035
471,	07 Mar,	22:57:55,	0.035
472,	07 Mar,	22:58:25,	0.047
473,	07 Mar,	22:58:55,	0.035
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475,	07 Mar,	22:59:55,	0.073
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486,	07 Mar,	23:05:25,	0.120
487,	07 Mar,	23:05:55,	0.115
488,	07 Mar,	23:06:25,	0.202
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491,	07 Mar,	23:07:55,	0.035
492,	07 Mar,	23:08:25,	0.029
493,	07 Mar,	23:08:55,	0.034
494,	07 Mar,	23:09:25,	0.076
495,	07 Mar,	23:09:55,	0.038
496,	07 Mar,	23:10:25,	0.032
497,	07 Mar,	23:10:55,	0.044
498,	07 Mar,	23:11:25,	0.030
499,	07 Mar,	23:11:55,	0.038
500,	07 Mar,	23:12:25,	0.047
501,	07 Mar,	23:12:55,	0.068
502,	07 Mar,	23:13:25,	0.071
503,	07 Mar,	23:13:55,	0.044
504,	07 Mar,	23:14:25,	0.259
505,	07 Mar,	23:14:55,	0.033
506,	07 Mar,	23:15:25,	0.039
507,	07 Mar,	23:15:55,	0.033
508,	07 Mar,	23:16:25,	0.028
509,	07 Mar,	23:16:55,	0.081
510,	07 Mar,	23:17:25,	0.067
511,	07 Mar,	23:17:55,	0.072
512,	07 Mar,	23:18:25,	0.081
513,	07 Mar,	23:18:55,	0.047
514,	07 Mar,	23:19:25,	0.043
515,	07 Mar,	23:19:55,	0.034
516,	07 Mar,	23:20:25,	0.034
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518,	07 Mar,	23:21:25,	0.036
519,	07 Mar,	23:21:55,	0.044
520,	07 Mar,	23:22:25,	0.036
521,	07 Mar,	23:22:55,	0.033
522,	07 Mar,	23:23:25,	0.034
523,	07 Mar,	23:23:55,	0.037
524,	07 Mar,	23:24:25,	0.119
525,	07 Mar,	23:24:55,	0.038
526,	07 Mar,	23:25:25,	0.032
527,	07 Mar,	23:25:55,	0.041
528,	07 Mar,	23:26:25,	0.037
529,	07 Mar,	23:26:55,	0.082
530,	07 Mar,	23:27:25,	0.034
531,	07 Mar,	23:27:55,	0.049
532,	07 Mar,	23:28:25,	0.032
533,	07 Mar,	23:28:55,	0.034
534,	07 Mar,	23:29:25,	0.039
535,	07 Mar,	23:29:55,	0.035
536,	07 Mar,	23:30:25,	0.043
537,	07 Mar,	23:30:55,	0.038
538,	07 Mar,	23:31:25,	0.039
539,	07 Mar,	23:31:55,	0.060
540,	07 Mar,	23:32:25,	0.047
541,	07 Mar,	23:32:55,	0.040
542,	07 Mar,	23:33:25,	0.039
543,	07 Mar,	23:33:55,	0.050
544,	07 Mar,	23:34:25,	0.107
545,	07 Mar,	23:34:55,	0.050
546,	07 Mar,	23:35:25,	0.037
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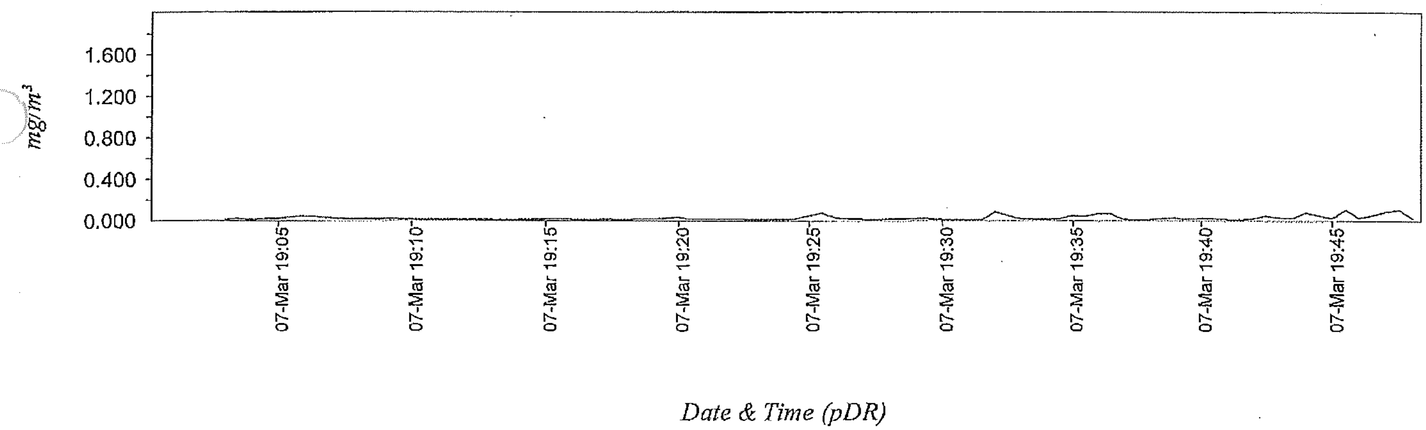
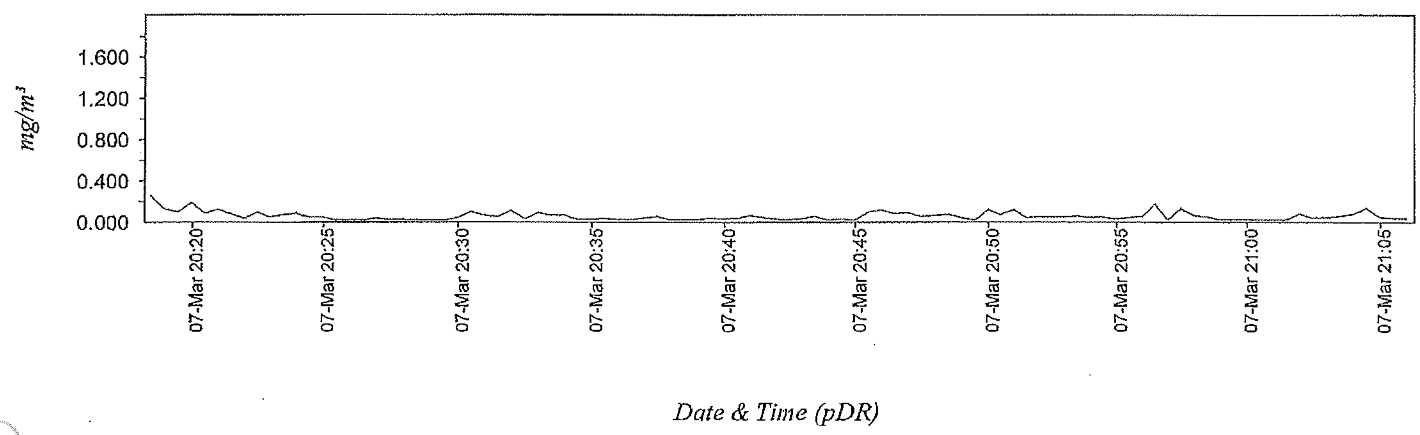
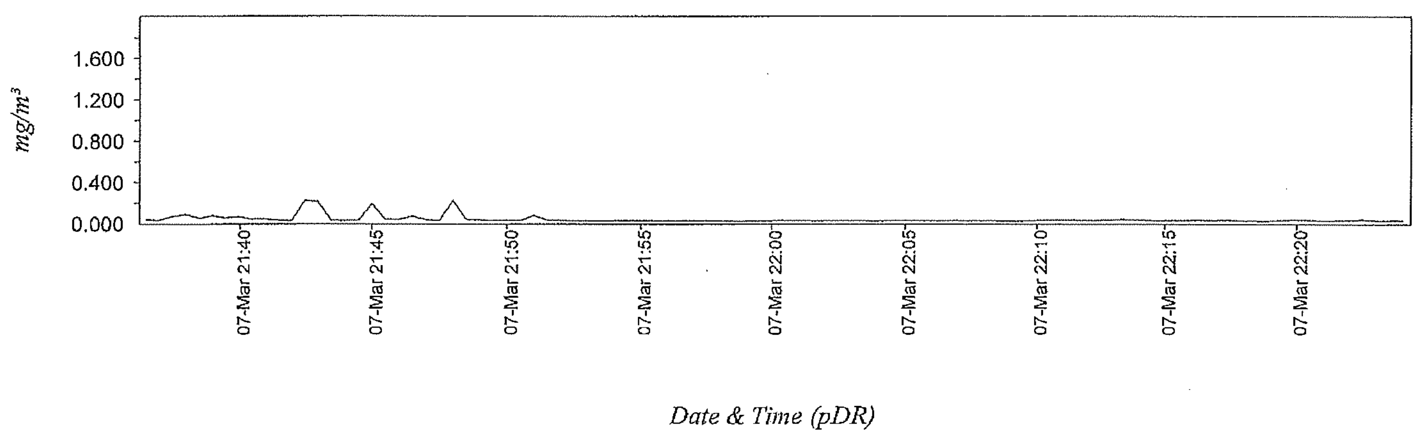
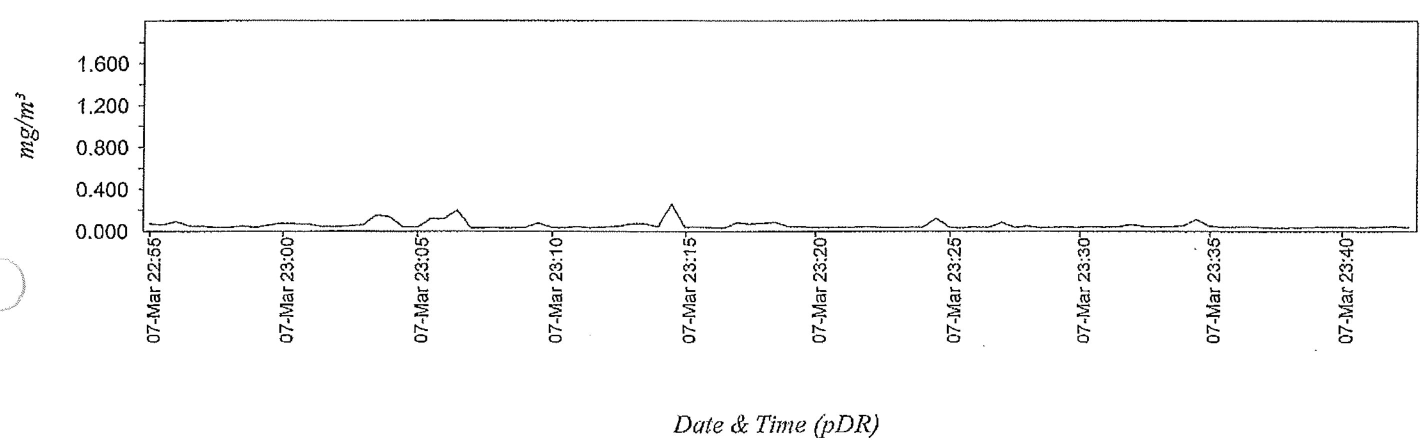
pDR-1000 S/N: 06082 / Tag # 01 / Start time: Mar 07, 19:02:25









pDR-1000 S/N: 05567 Rov 05
User ID: 5338
Tag Number: 01
Number of logged points: 569
Start time and date: 19:18:59 07-Mar
Elapsed time: 04:44:30
Logging period (sec): 30
Calibration Factor (%): 100
Max Display Concentration: 3.584 mg/m³
Time at maximum: 21:47:01 Mar 07
Max STEL Concentration: 0.164 mg/m³
Time at max STEL: 20:03:29 Mar 07
Overall Avg Conc: 0.051 mg/m³
Logged Data:

Point	Date	Time	Avg.(mg/m³)
1	07 Mar	19:19:29	0.014
2	07 Mar	19:19:59	0.012
3	07 Mar	19:20:29	0.012
4	07 Mar	19:20:59	0.011
5	07 Mar	19:21:29	0.011
6	07 Mar	19:21:59	0.010
7	07 Mar	19:22:29	0.011
8	07 Mar	19:22:59	0.015
9	07 Mar	19:23:29	0.013
10	07 Mar	19:23:59	0.011
11	07 Mar	19:24:29	0.010
12	07 Mar	19:24:59	0.013
13	07 Mar	19:25:29	0.013
14	07 Mar	19:25:59	0.040
15	07 Mar	19:26:29	0.030
16	07 Mar	19:26:59	0.010
17	07 Mar	19:27:29	0.024
18	07 Mar	19:27:59	0.022
19	07 Mar	19:28:29	0.011
20	07 Mar	19:28:59	0.050
21	07 Mar	19:29:29	0.055
22	07 Mar	19:29:59	0.032
23	07 Mar	19:30:29	0.029
24	07 Mar	19:30:59	0.020
25	07 Mar	19:31:29	0.026
26	07 Mar	19:31:59	0.027
27	07 Mar	19:32:29	0.024
28	07 Mar	19:32:59	0.030
29	07 Mar	19:33:29	0.043
30	07 Mar	19:33:59	0.062
31	07 Mar	19:34:29	0.070
32	07 Mar	19:34:59	0.065
33	07 Mar	19:35:29	0.105
34	07 Mar	19:35:59	0.085
35	07 Mar	19:36:29	0.069
36	07 Mar	19:36:59	0.016
37	07 Mar	19:37:29	0.009
38	07 Mar	19:37:59	0.017
39	07 Mar	19:38:29	0.036
40	07 Mar	19:38:59	0.032
41	07 Mar	19:39:29	0.012
42	07 Mar	19:39:59	0.015
43	07 Mar	19:40:29	0.015
44	07 Mar	19:40:59	0.011
45	07 Mar	19:41:29	0.014
46	07 Mar	19:41:59	0.036
47	07 Mar	19:42:29	0.035
48	07 Mar	19:42:59	0.013
49	07 Mar	19:43:29	0.044
50	07 Mar	19:43:59	0.078
51	07 Mar	19:44:29	0.050
52	07 Mar	19:44:59	0.117
53	07 Mar	19:45:29	0.058
54	07 Mar	19:45:59	0.030
55	07 Mar	19:46:29	0.094
56	07 Mar	19:46:59	0.134
57	07 Mar	19:47:29	0.050

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343,	07 Mar,	22:10:29,	0.013
344,	07 Mar,	22:10:59,	0.024
345,	07 Mar,	22:11:29,	0.016

346,	07 Mar,	22:11:59,	0.009
347,	07 Mar,	22:12:29,	0.008
348,	07 Mar,	22:12:59,	0.007
349,	07 Mar,	22:13:29,	0.008
350,	07 Mar,	22:13:59,	0.008
351,	07 Mar,	22:14:29,	0.008
352,	07 Mar,	22:14:59,	0.008
353,	07 Mar,	22:15:29,	0.011
354,	07 Mar,	22:15:59,	0.007
355,	07 Mar,	22:16:29,	0.006
356,	07 Mar,	22:16:59,	0.034
357,	07 Mar,	22:17:29,	0.019
358,	07 Mar,	22:17:59,	0.009
359,	07 Mar,	22:18:29,	0.030
360,	07 Mar,	22:18:59,	0.020
361,	07 Mar,	22:19:29,	0.016
362,	07 Mar,	22:19:59,	0.059
363,	07 Mar,	22:20:29,	0.031
364,	07 Mar,	22:20:59,	0.016
365,	07 Mar,	22:21:29,	0.018
366,	07 Mar,	22:21:59,	0.033
367,	07 Mar,	22:22:29,	0.042
368,	07 Mar,	22:22:59,	0.016
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396,	07 Mar,	22:36:59,	0.038
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426,	07 Mar,	22:51:59,	0.023
427,	07 Mar,	22:52:29,	0.016
428,	07 Mar,	22:52:59,	0.009
429,	07 Mar,	22:53:29,	0.023
430,	07 Mar,	22:53:59,	0.011
431,	07 Mar,	22:54:29,	0.042
432,	07 Mar,	22:54:59,	0.052
433,	07 Mar,	22:55:29,	0.062
434,	07 Mar,	22:55:59,	0.039
435,	07 Mar,	22:56:29,	0.022
436,	07 Mar,	22:56:59,	0.010
437,	07 Mar,	22:57:29,	0.008
438,	07 Mar,	22:57:59,	0.011
439,	07 Mar,	22:58:29,	0.012
440,	07 Mar,	22:58:59,	0.013
441,	07 Mar,	22:59:29,	0.038
442,	07 Mar,	22:59:59,	0.078
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444,	07 Mar,	23:00:59,	0.028
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484,	07 Mar,	23:20:59,	0.014
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487,	07 Mar,	23:22:29,	0.009
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520,	07 Mar,	23:38:59,	0.013
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522,	07 Mar,	23:39:59,	0.012
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524,	07 Mar,	23:40:59,	0.008
525,	07 Mar,	23:41:29,	0.009
526,	07 Mar,	23:41:59,	0.007
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558,	07 Mar,	23:57:59,	0.016
559,	07 Mar,	23:58:29,	0.012
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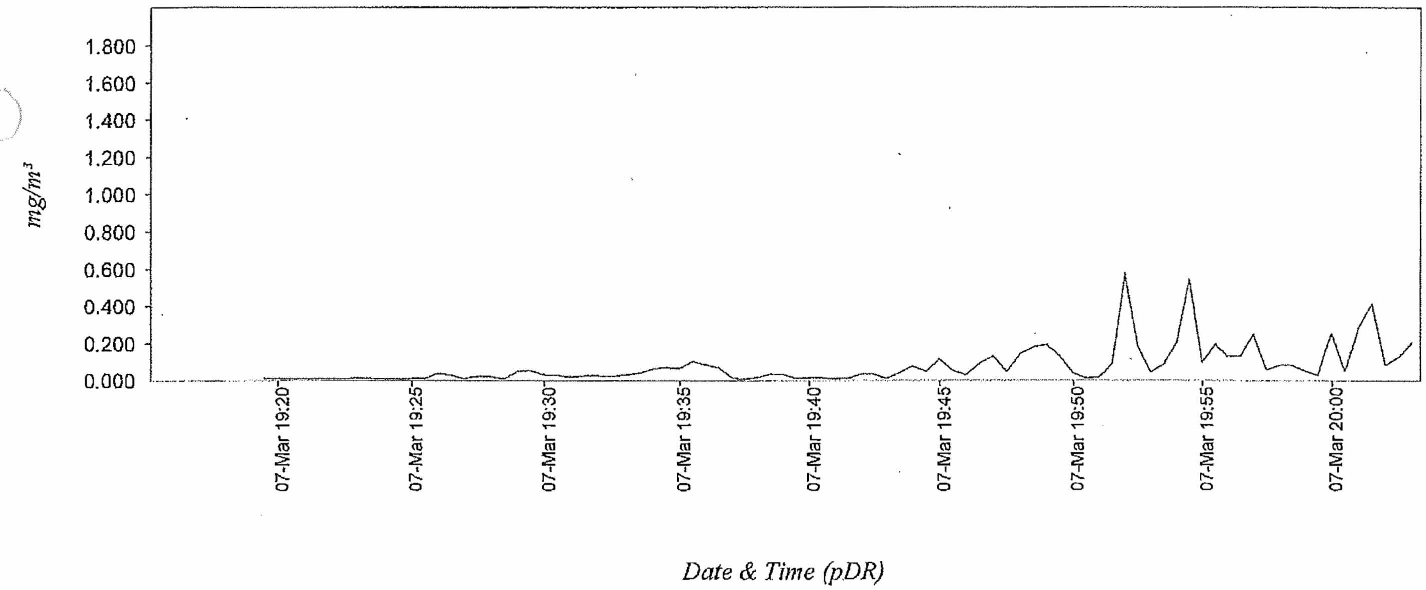

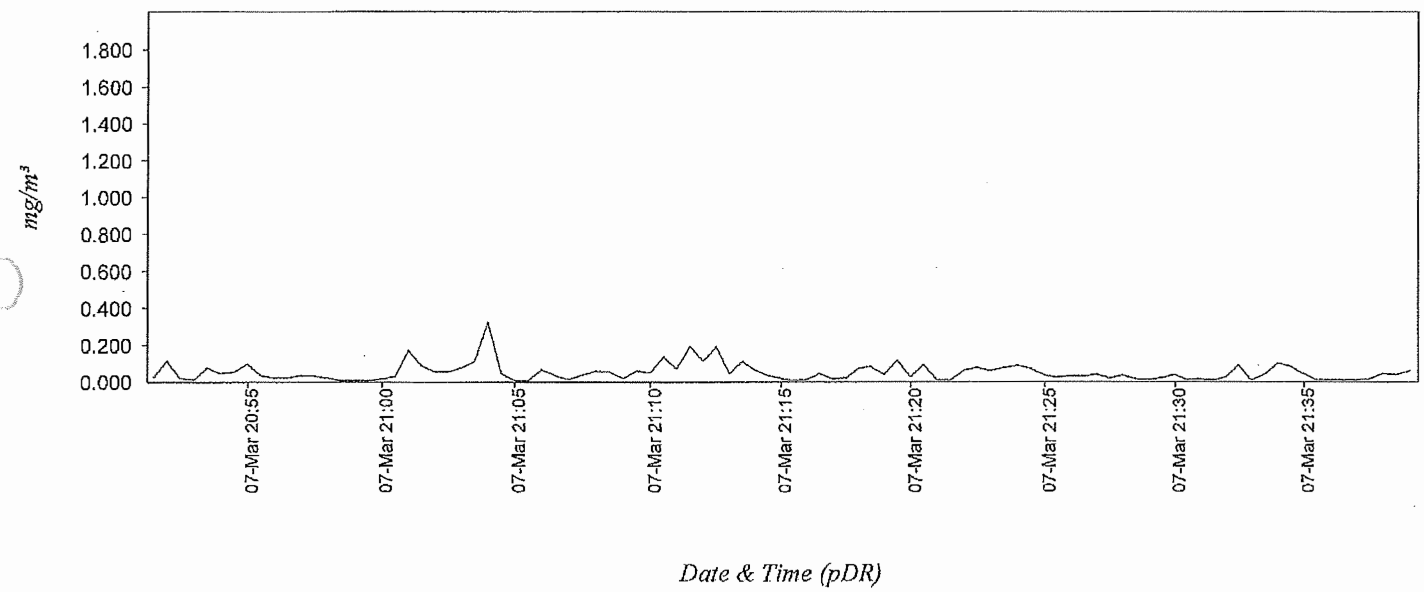

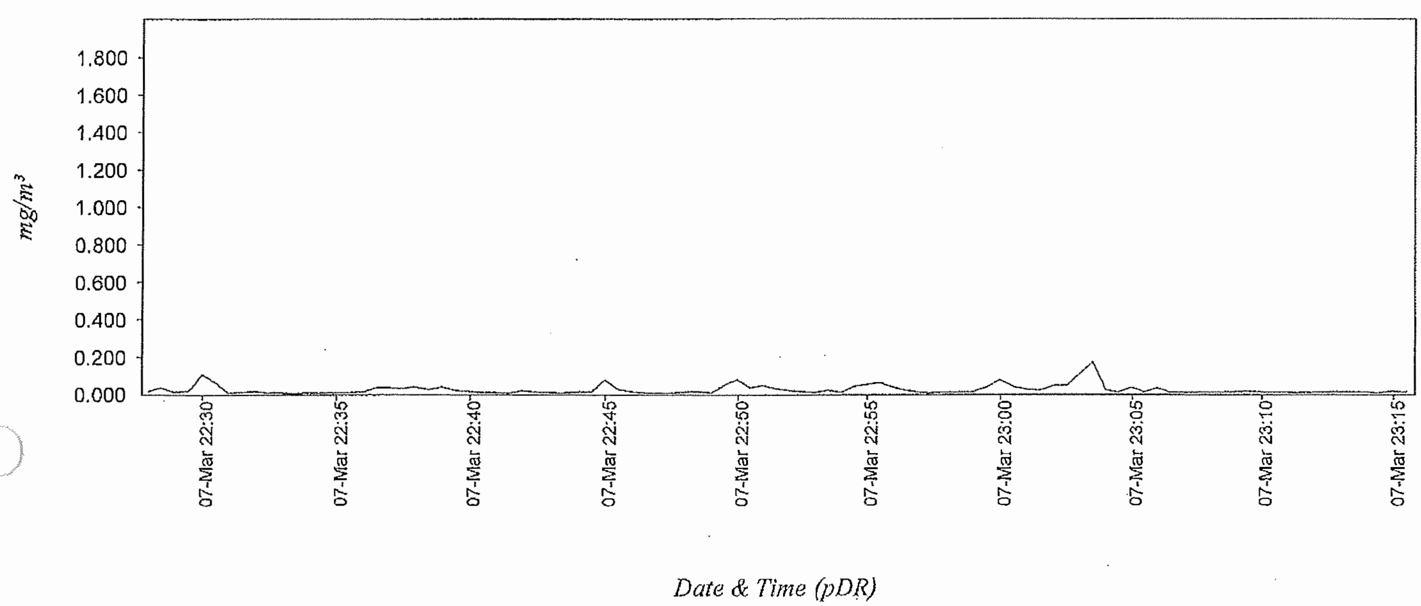

APPENDIX D

AES Ash Analytical Results Table

AES Hawaii, Inc. Conditioned Ash Results and Statistics

Composite Sample		Sb (Antimony) mg/kg	As (Arsenic) mg/kg	Ba (Barium) mg/kg		Be (Berylium) mg/kg	B (Boron) mg/kg		Cd (Cadmium) mg/kg
Limit		31	75	5400		150	12000		37
17-3-1-1		0.741	23.8	1060		2.25	1030	ND	0.608
17-3-1-2		1.20	27.1	1450		3.33	716	ND	0.678
17-3-2-1		0.519	16.3	462	ND	4.90	1100	ND	0.490
17-3-2-2	ND	0.631	18.5	517	ND	12.6	1020	ND	0.631
17-3-3-1	ND	0.515	18.1	326	ND	2.58	766	ND	0.515
17-3-3-2	ND	0.727	13.9	797		1.54	1170	ND	0.727
17-4-4-1	ND	0.634	16.4	873		1.62	830	ND	0.634
17-4-4-2	ND	0.66	10.6	442		1.02	660	ND	0.661
17-4-5-1		0.219	14.7	806		2.16	863		0.542
17-4-5-2	ND	0.515	11.7	1250		1.5	297		0.603
17-4-6-1	ND	0.706	11.5	535		0.96	513	ND	0.706
17-4-6-2	ND	0.495	16.0	893	ND	2.48	528		0.520
18-1-7-1	ND	0.485	14.9	587	ND	2.43	521	ND	0.485
18-1-7-2	ND	0.628	9.91	400	ND	6.28	385	ND	0.628
18-1-8-1	ND	6.25	10.8	424	ND	6.25	534	ND	6.25
18-1-8-2	ND	6.47	16.4	560	ND	6.47	515	ND	6.47
18-1-9-1		0.780	14.4	540	ND	0.678	562	ND	0.678
18-1-9-2	ND	0.698	18.1	556	ND	6.98	596	ND	0.698
18-2-10-1	ND	0.695	17.9	485	ND	6.95	653	ND	0.695
18-2-10-2	ND	0.661	14.1	445		1.63	616	ND	0.661
18-2-11-1	ND	0.635	21.7	431		2.53	490	ND	0.64
18-2-11-2	ND	1.35	21.4	495		2.20	859	ND	0.68
18-2-12-1		0.506	28.8	421		5.06	659	ND	0.126
18-2-12-2		0.184	23.7	318		4.90	451	ND	0.134
18-3-1-1		0.990	9.2	1310		1.73	151	ND	0.115
18-3-1-2		1.200	29.2	735		6.80	492	ND	1.150
18-3-2-1		1.330	23.5	791		4.20	404	ND	1.08
18-3-2-2	ND	0.86	15.0	193		3.59	188	ND	0.86
18-3-3-1	ND	0.856	14.9	333		3.19	488	ND	0.856
18-3-3-2	ND	1.100	9.9	407		2.45	372	ND	1.100
18-4-4-1		0.395	10.9	369		1.05	500	ND	0.21
18-4-4-2		0.178	12.0	386		2.71	528	ND	0.28
18-4-5-1	ND	0.254	6.7	288		1.39	426	ND	0.25
18-4-5-2	ND	0.203	2.5	334		1.24	360	ND	0.20
18-4-6-1	ND	0.282	7.6	493		4.05	921	ND	0.28
18-4-6-2		0.344	11.3	347		1.41	658	ND	0.25
19-1-7-1	ND	0.262	14.9	446		2.02	955	ND	0.26
19-1-7-2		0.313	45.0	908		7.86	2190	ND	0.29
19-1-8-1	ND	0.286	12.5	280		2.37	699	ND	0.29
19-1-8-2	ND	0.287	22.7	484		3.55	1140	ND	0.29
19-1-9-1	ND	0.288	13.2	470		2.72	1200	ND	0.29
19-1-9-2	ND	0.233	11.3	317		1.24	574	ND	0.23
Mean +95% Confidence		**0.75**	**18.6**	**661**		**3.22**	**791**		**0.62**

AES Hawaii, Inc. Conditioned Ash Results and Statistics

Composite Sample	Cr (Chromium) mg/kg	Cu (Copper) mg/kg	Fe (Iron) mg/kg	Pb (Lead) mg/kg	Hg (Mercury) mg/kg	Mo (Molybdenum) mg/kg
Limit	58	3100	N/A	400	13	390
17-3-1-1	36.5	32.8	26300	18.2	0.292	9.88
17-3-1-2	30.2	39.3	26000	28.6	ND 0.0913	12.0
17-3-2-1	27.7	24.1	28800	14.9	0.376	6.01
17-3-2-2	29.2	21.1	31800	14.8	0.430	ND 3.16
17-3-3-1	25.7	16.2	31000	10.0	0.423	4.67
17-3-3-2	35.3	31.9	28500	16.3	0.329	7.20
17-4-4-1	35.3	25.8	27300	17.1	0.244	6.84
17-4-4-2	17.1	14.5	22400	9.85	0.335	4.28
17-4-5-1	33.1	29.9	18800	18.1	0.366	7.84
17-4-5-2	23.3	20.9	10900	17.2	0.303	6.84
17-4-6-1	16.5	14.8	17900	7.1	0.348	3.83
17-4-6-2	22.8	22.2	17700	13.0	0.472	7.87
18-1-7-1	19.0	18.6	19600	11.0	0.418	6.56
18-1-7-2	32.9	28.5	15800	12.8	0.282	3.29
18-1-8-1	33.4	42.1	17200	18.0	ND 0.117	ND 31.3
18-1-8-2	36.9	41.5	18500	15.1	ND 0.117	ND 32.3
18-1-9-1	33.9	40.0	27100	20.3	0.586	4.94
18-1-9-2	34.7	36.8	34500	24.7	0.613	5.43
18-2-10-1	32.4	30.0	38000	23.5	0.589	4.71
18-2-10-2	32.6	33.5	30900	25.7	0.305	4.01
18-2-11-1	37.8	37.3	29700	21.2	ND 0.125	6.86
18-2-11-2	31.4	34.8	32600	16.7	0.262	6.95
18-2-12-1	34.6	49.1	28700	33.3	0.278	9.37
18-2-12-2	32.2	50.4	21000	33.9	0.336	6.19
18-3-1-1	47.1	59.8	17000	18.5	0.327	2.28
18-3-1-2	36.5	54.1	16200	36.2	ND 1.150	4.82
18-3-2-1	50.3	34.0	12400	15.1	ND 1.080	4.03
18-3-2-2	25.5	35.8	11300	35.4	ND 0.856	4.53
18-3-3-1	45.8	34.3	13400	12.9	ND 0.856	4.36
18-3-3-2	73.3	25.7	16000	14.9	ND 1.100	4.00
18-4-4-1	33.2	28.5	21000	20.5	0.355	3.93
18-4-4-2	36.0	39.2	16900	25.1	0.438	2.68
18-4-5-1	22.1	30.9	12600	15.1	0.296	2.84
18-4-5-2	22.0	30.0	11700	17.5	0.337	0.98
18-4-6-1	41.4	37.6	10600	17.5	0.448	3.57
18-4-6-2	36.5	27.5	12000	11.6	0.261	3.50
19-1-7-1	57.8	29.2	24600	19.0	0.352	4.19
19-1-7-2	240.0	54.1	58600	51.5	0.939	10.50
19-1-8-1	85.2	23.3	23700	14.0	0.301	4.27
19-1-8-2	40.4	28.1	30400	17.1	ND 0.287	6.87
19-1-9-1	43.1	47.3	31200	20.1	0.307	7.50
19-1-9-2	14.3	17.8	19900	13.7	0.332	3.12
Mean +95% Confidence	**50.6**	**36.1**	**25795**	**22.1**	**0.413**	**6.90**

AES Hawaii, Inc. Conditioned Ash Results and Statistics

Composite Sample	Ni (Nickel) mg/kg		Se (Selinium) mg/kg		Ag (Silver) mg/kg		Tl (Thallium) mg/kg	Zn (Zinc) mg/kg
Limit	1600		390		390		5.2	23000
17-3-1-1	50.2		1.88	ND	0.608		0.614	800
17-3-1-2	28.7		2.42	ND	0.678	ND	0.678	659
17-3-2-1	34.3		1.60	ND	0.490	ND	0.490	463
17-3-2-2	32.7		1.66	ND	0.631	ND	0.631	212
17-3-3-1	30.2		1.17	ND	0.515	ND	0.515	105
17-3-3-2	44.7		2.84	ND	0.727	ND	0.727	98
17-4-4-1	38.8		2.60	ND	0.634	ND	0.634	502
17-4-4-2	22.5		1.50	ND	0.661	ND	0.661	301
17-4-5-1	47.3		4.82		0.212		0.750	315
17-4-5-2	24.5		3.56	ND	0.515		0.603	84.8
17-4-6-1	21.6		1.90	ND	0.706		0.360	93.1
17-4-6-2	28.3		3.62	ND	0.495		0.837	293
18-1-7-1	23.7		2.30	ND	0.485		0.704	379
18-1-7-2	43.8		1.48	ND	0.628	ND	0.628	276
18-1-8-1	51.4	ND	6.25	ND	6.25		0.563	414
18-1-8-2	53.0	ND	6.47	ND	6.47	ND	0.388	607
18-1-9-1	48.5		2.30	ND	0.678	ND	0.407	959
18-1-9-2	45.2		2.38	ND	0.698		0.559	787
18-2-10-1	41.0		2.07	ND	0.695	ND	3.47	688
18-2-10-2	39.3		2.16	ND	0.661		0.727	330
18-2-11-1	50.5		2.83	ND	0.64		0.514	143
18-2-11-2	44.3		1.89	ND	0.68	ND	0.68	565
18-2-12-1	54.7		2.23		0.259		0.49	707
18-2-12-2	64.8		1.78	ND	0.134		0.46	457
18-3-1-1	69.2	ND	0.12	ND	0.115		0.97	88.3
18-3-1-2	45.8		2.07		2.280		1.190	465
18-3-2-1	81.1	ND	1.08	ND	1.08	ND	1.080	287
18-3-2-2	28.4		1.89	ND	0.86	ND	0.86	176
18-3-3-1	122	ND	0.86	ND	0.856	ND	0.86	370
18-3-3-2	134.0	ND	1.10	ND	1.100	ND	1.10	177
18-4-4-1	54.5		0.30		2.280		0.61	905
18-4-4-2	40.7		0.09	ND	1.395		0.682	479
18-4-5-1	35.5		0.43		0.41		0.422	830
18-4-5-2	40.6		0.45		0.27		0.53	272
18-4-6-1	60.7		0.53		0.402		0.47	331
18-4-6-2	49.0		0.40		0.528		0.33	263
19-1-7-1	116.0		0.61	ND	0.262		0.63	871
19-1-7-2	609	ND	0.29		1.050		1.650	1630
19-1-8-1	236.0	ND	0.29		0.41		0.524	146
19-1-8-2	63.3		0.88	ND	0.29		0.47	895
19-1-9-1	122		0.78	ND	0.288		0.54	1670
19-1-9-2	29.8		0.86	ND	0.233		0.53	779
Mean +95% Confidence	**98.4**		**1.99**		**0.796**		**0.66**	**612**

AES Hawaii, Inc. Conditioned Ash Results and Statistics

Composite Sample	Sb (Antimony) mg/kg	As (Arsenic) mg/kg	Ba (Barium) mg/kg	Be (Berylium) mg/kg	B (Boron) mg/kg	Cd (Cadmium) mg/kg
Limit	31	75	5400	150	12000	37
17-3-1-1	0.741	23.8	1060	2.25	1030	0.30
17-3-1-2	1.200	27.1	1450	3.33	716	0.34
17-3-2-1	0.519	16.3	462	2.45	1100	0.25
17-3-2-2	0.316	18.5	517	6.30	1020	0.32
17-3-3-1	0.258	18.1	326	1.29	766	0.26
17-3-3-2	0.364	13.9	797	1.54	1170	0.36
17-4-4-1	0.317	16.4	873	1.62	830	0.32
17-4-4-2	0.331	10.6	442	1.02	660	0.33
17-4-5-1	0.219	14.7	806	2.16	863	0.54
17-4-5-2	0.258	11.7	1250	1.48	297	0.60
17-4-6-1	0.353	11.5	535	0.96	513	0.35
17-4-6-2	0.248	16.0	893	1.24	528	0.52
18-1-7-1	0.243	14.9	587	1.22	521	0.24
18-1-7-2	0.314	9.9	400	3.14	385	0.31
18-1-8-1	3.125	10.8	424	3.13	534	3.13
18-1-8-2	3.235	16.4	560	3.24	515	3.24
18-1-9-1	0.780	14.4	540	0.34	562	0.34
18-1-9-2	0.349	18.1	556	3.49	596	0.35
18-2-10-1	0.348	17.9	485	3.48	653	0.35
18-2-10-2	0.331	14.1	445	1.63	616	0.33
18-2-11-1	0.318	21.7	431	2.53	490	0.32
18-2-11-2	0.675	21.4	495	2.20	859	0.34
18-2-12-1	0.506	28.8	421	5.06	659	0.06
18-2-12-2	0.184	23.7	318	4.90	451	0.07
18-3-1-1	0.990	9.2	1310	1.73	151	0.06
18-3-1-2	1.200	29.2	735	6.80	492	0.58
18-3-2-1	1.330	23.5	791	4.20	404	0.54
18-3-2-2	0.428	15.0	193	3.59	188	0.43
18-3-3-1	0.428	14.9	333	3.19	488	0.43
18-3-3-2	0.550	9.9	407	2.45	372	0.55
18-4-4-1	0.395	10.9	369	1.05	500	0.10
18-4-4-2	0.178	12.0	386	2.71	528	0.14
18-4-5-1	0.127	6.7	288	1.39	426	0.13
18-4-5-2	0.102	2.5	334	1.24	360	0.10
18-4-6-1	0.141	7.6	493	4.05	921	0.14
18-4-6-2	0.344	11.3	347	1.41	658	0.12
19-1-7-1	0.131	14.9	446	2.02	955	0.13
19-1-7-2	0.313	45.0	908	7.86	2190	0.14
19-1-8-1	0.143	12.5	280	2.37	699	0.14
19-1-8-2	0.144	22.7	484	3.55	1140	0.14
19-1-9-1	0.144	13.2	470	2.72	1200	0.14
19-1-9-2	0.117	11.3	317	1.24	574	0.12

Note: If the original composite sample was Non Detect, the assumed analytical value is ½ the detectable limit for that specific sample.

	Sb (Antimony)	As (Arsenic)	Ba (Barium)	Be (Berylium)	B (Boron)	Cd (Cadmium)
Mean	0.541202	16.26262	570.5714	2.703548	680.4762	0.421321
Standard Error	0.103257	1.150265	44.86308	0.253415	54.53046	0.099213
Standard Deviation	0.669181	7.454568	290.746	1.642315	353.3977	0.642974
Sample Variance	0.447803	55.57058	84533.23	2.697197	124890	0.413415
Range	3.1335	42.46	1257	7.521	2039	3.1775
Minimum	0.1015	2.54	193	0.339	151	0.0575
Maximum	3.235	45	1450	7.86	2190	3.235
Count	42	42	42	42	42	42
Confidence Level(95.0%)	0.208532	2.323007	90.60283	0.511781	110.1265	0.200365

AES Hawaii, Inc. Conditioned Ash Results and Statistics

Composite Sample	Cr (Chromium) mg/kg	Cu (Copper) mg/kg	Fe (Iron) mg/kg	Pb (Lead) mg/kg	Hg (Mercury) mg/kg	Mo (Molybdenum) mg/kg
Limit	58	3100	N/A	400	13	390
17-3-1-1	36.5	32.8	26300	18.2	0.292	9.88
17-3-1-2	30.2	39.3	26000	28.6	0.046	12.00
17-3-2-1	27.7	24.1	28800	14.9	0.376	6.01
17-3-2-2	29.2	21.1	31800	14.8	0.430	1.58
17-3-3-1	25.7	16.2	31000	10.0	0.423	4.67
17-3-3-2	35.3	31.9	28500	16.3	0.329	7.20
17-4-4-1	35.3	25.8	27300	17.1	0.244	6.84
17-4-4-2	17.1	14.5	22400	9.9	0.335	4.28
17-4-5-1	33.1	29.9	18800	18.1	0.366	7.84
17-4-5-2	23.3	20.9	10900	17.2	0.303	6.84
17-4-6-1	16.5	14.8	17900	7.1	0.348	3.83
17-4-6-2	22.8	22.2	17700	13.0	0.472	7.87
18-1-7-1	19.0	18.6	19600	11.0	0.418	6.56
18-1-7-2	32.9	28.5	15800	12.8	0.282	3.29
18-1-8-1	33.4	42.1	17200	18.0	0.059	15.65
18-1-8-2	36.9	41.5	18500	15.1	0.059	16.15
18-1-9-1	33.9	40.0	27100	20.3	0.586	4.94
18-1-9-2	34.7	36.8	34500	24.7	0.613	5.43
18-2-10-1	32.4	30.0	38000	23.5	0.589	4.71
18-2-10-2	32.6	33.5	30900	25.7	0.305	4.01
18-2-11-1	37.8	37.3	29700	21.2	0.063	6.86
18-2-11-2	31.4	34.8	32600	16.7	0.262	6.95
18-2-12-1	34.6	49.1	28700	33.3	0.278	9.37
18-2-12-2	32.2	50.4	21000	33.9	0.336	6.19
18-3-1-1	47.1	59.8	17000	18.5	0.327	2.28
18-3-1-2	36.5	54.1	16200	36.2	0.575	4.82
18-3-2-1	50.3	34.0	12400	15.1	0.540	4.03
18-3-2-2	25.5	35.8	11300	35.4	0.428	4.53
18-3-3-1	45.8	34.3	13400	12.9	0.428	4.36
18-3-3-2	73.3	25.7	16000	14.9	0.550	4.00
18-4-4-1	33.2	28.5	21000	20.5	0.355	3.93
18-4-4-2	36.0	39.2	16900	25.1	0.438	2.68
18-4-5-1	22.1	30.9	12600	15.1	0.296	2.84
18-4-5-2	22.0	30.0	11700	17.5	0.337	0.98
18-4-6-1	41.4	37.6	10600	17.5	0.448	3.57
18-4-6-2	36.5	27.5	12000	11.6	0.261	3.50
19-1-7-1	57.8	29.2	24600	19.0	0.352	4.19
19-1-7-2	240.0	54.1	58600	51.5	0.939	10.50
19-1-8-1	85.2	23.3	23700	14.0	0.301	4.27
19-1-8-2	40.4	28.1	30400	17.1	0.144	6.87
19-1-9-1	43.1	47.3	31200	20.1	0.307	7.50
19-1-9-2	14.3	17.8	19900	13.7	0.332	3.12

Note: If the original composite sample was Non Detect, the assumed analytical value is ½ the detectable limit for that specific sample.

	Cr	Cu	Fe	Pb	Hg	Mo
Mean	39.88095	32.69762	22869.05	19.45333	0.361182	5.879095
Standard Error	5.306354	1.693958	1448.955	1.318392	0.02588	0.506329
Standard Deviation	34.3891	10.9781	9390.303	8.54416	0.16772	3.281389
Sample Variance	1182.61	120.5188	88177799	73.00266	0.02813	10.76751
Range	225.7	45.3	48000	44.41	0.89335	15.168
Minimum	14.3	14.5	10600	7.09	0.04565	0.982
Maximum	240	59.8	58600	51.5	0.939	16.15
Count	42	42	42	42	42	42
Confidence Level(95.0%)	10.7164	3.421018	2926.225	2.662548	0.052265	1.022553

AES Hawaii, Inc. Conditioned Ash Results and Statistics

Composite Sample	Ni (Nickel) mg/kg	Se (Selinium) mg/kg	Ag (Silver) mg/kg	Tl (Thallium) mg/kg	Zn (Zinc) mg/kg
Limit	1600	390	390	5.2	23000
17-3-1-1	50.2	1.88	0.304	0.61	800
17-3-1-2	28.7	2.42	0.339	0.34	659
17-3-2-1	34.3	1.60	0.245	0.25	463
17-3-2-2	32.7	1.66	0.316	0.32	212
17-3-3-1	30.2	1.17	0.258	0.26	105
17-3-3-2	44.7	2.84	0.364	0.36	98
17-4-4-1	38.8	2.60	0.317	0.32	502
17-4-4-2	22.5	1.50	0.331	0.33	301
17-4-5-1	47.3	4.82	0.212	0.75	315
17-4-5-2	24.5	3.56	0.258	0.60	85
17-4-6-1	21.6	1.90	0.353	0.36	93
17-4-6-2	28.3	3.62	0.248	0.84	293
18-1-7-1	23.7	2.30	0.243	0.70	379
18-1-7-2	43.8	1.48	0.314	0.31	276
18-1-8-1	51.4	3.13	3.125	0.56	414
18-1-8-2	53.0	3.24	3.235	0.19	607
18-1-9-1	48.5	2.30	0.339	0.20	959
18-1-9-2	45.2	2.38	0.349	0.56	787
18-2-10-1	41.0	2.07	0.348	1.74	688
18-2-10-2	39.3	2.16	0.331	0.73	330
18-2-11-1	50.5	2.83	0.318	0.51	143
18-2-11-2	44.3	1.89	0.338	0.34	565
18-2-12-1	54.7	2.23	0.259	0.49	707
18-2-12-2	64.8	1.78	0.067	0.46	457
18-3-1-1	69.2	0.06	0.058	0.97	88
18-3-1-2	45.8	2.07	2.280	1.19	465
18-3-2-1	81.1	0.54	0.540	0.54	287
18-3-2-2	28.4	1.89	0.428	0.43	176
18-3-3-1	122.0	0.43	0.428	0.43	370
18-3-3-2	134.0	0.55	0.550	0.55	177
18-4-4-1	54.5	0.30	2.280	0.61	905
18-4-4-2	40.7	0.09	0.698	0.68	479
18-4-5-1	35.5	0.43	0.405	0.42	830
18-4-5-2	40.6	0.45	0.273	0.53	272
18-4-6-1	60.7	0.53	0.402	0.47	331
18-4-6-2	49.0	0.40	0.528	0.33	263
19-1-7-1	116.0	0.61	0.131	0.63	871
19-1-7-2	609.0	0.14	1.050	1.65	1630
19-1-8-1	236.0	0.14	0.412	0.52	146
19-1-8-2	63.3	0.88	0.144	0.47	895
19-1-9-1	122.0	0.78	0.144	0.54	1670
19-1-9-2	29.8	0.86	0.117	0.53	779

Note: If the original composite sample was Non Detect, the assumed analytical value is 1/2 the detectable limit for that specific sample.

	Ni (Nickel)	Se (Selinium)	Ag (Silver)	Tl (Thallium)	Zn (Zinc)
Mean	69.08571	1.630857	0.563619	0.56244	496.9571
Standard Error	14.4981	0.176264	0.114921	0.050155	56.94404
Standard Deviation	93.95845	1.142318	0.744772	0.325041	369.0396
Sample Variance	8828.19	1.304892	0.554685	0.105651	136190.2
Range	587.4	4.7625	3.1775	1.541	1585.2
Minimum	21.6	0.0575	0.0575	0.194	84.8
Maximum	609	4.82	3.235	1.735	1670
Count	42	42	42	42	42
Confidence Level(95.0%)	29.27951	0.355971	0.232087	0.10129	115.0008

APPENDIX E

Statistical Analysis

General UCL Statistics for Full Data Sets

User Selected Options

From File	C:\Documents and Settings\vincent.yanagita\My Documents\Projects\pvt\Risk Assessment\2008 - 2009 Condition
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Sb (Antimony)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	38

Raw Statistics		Log-transformed Statistics	
Minimum	0.102	Minimum of Log Data	-2.288
Maximum	3.235	Maximum of Log Data	1.174
Mean	0.541	Mean of log Data	-1.013
Median	0.331	SD of log Data	0.817
SD	0.669		
Coefficient of Variation	1.236		
Skewness	3.169		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.571	Shapiro Wilk Test Statistic	0.898
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	0.715	95% H-UCL	0.668
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.81
95% Adjusted-CLT UCL	0.765	97.5% Chebyshev (MVUE) UCL	0.944
95% Modified-t UCL	0.723	99% Chebyshev (MVUE) UCL	1.206

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	1.312	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.412		
nu star	110.2		
Approximate Chi Square Value (.05)	87.01	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	0.711
Adjusted Chi Square Value	86.28	95% Jackknife UCL	0.715
		95% Standard Bootstrap UCL	0.711
Anderson-Darling Test Statistic	2.106	95% Bootstrap-t UCL	0.871
Anderson-Darling 5% Critical Value	0.769	95% Hall's Bootstrap UCL	1.515
Kolmogorov-Smirnov Test Statistic	0.205	95% Percentile Bootstrap UCL	0.719
Kolmogorov-Smirnov 5% Critical Value	0.139	95% BCA Bootstrap UCL	0.778
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.991
		97.5% Chebyshev(Mean, Sd) UCL	1.186
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1.569
95% Approximate Gamma UCL	0.686		
95% Adjusted Gamma UCL	0.692		

Potential UCL to Use		Use 95% Chebyshev (Mean, Sd) UCL	0.991

As (Arsenic)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	37

Raw Statistics		Log-transformed Statistics	
Minimum	2.54	Minimum of Log Data	0.932
Maximum	45	Maximum of Log Data	3.807
Mean	16.26	Mean of log Data	2.689
Median	14.9	SD of log Data	0.474
SD	7.455		
Coefficient of Variation	0.458		
Skewness	1.535		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.871	Shapiro Wilk Test Statistic	0.911
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	18.2	95% H-UCL	18.92
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	21.89
95% Adjusted-CLT UCL	18.45	97.5% Chebyshev (MVUE) UCL	24.25
95% Modified-t UCL	18.24	99% Chebyshev (MVUE) UCL	28.9

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	4.808	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	3.382		
nu star	403.9		
Approximate Chi Square Value (.05)	358.3	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	18.15
Adjusted Chi Square Value	356.8	95% Jackknife UCL	18.2
		95% Standard Bootstrap UCL	18.14
Anderson-Darling Test Statistic	0.483	95% Bootstrap-t UCL	18.58
Anderson-Darling 5% Critical Value	0.752	95% Hall's Bootstrap UCL	18.93
Kolmogorov-Smirnov Test Statistic	0.101	95% Percentile Bootstrap UCL	18.17
Kolmogorov-Smirnov 5% Critical Value	0.137	95% BCA Bootstrap UCL	18.59
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	21.28
		97.5% Chebyshev(Mean, Sd) UCL	23.45
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	27.71
95% Approximate Gamma UCL	18.33		
95% Adjusted Gamma UCL	18.41		

Potential UCL to Use		Use 95% Approximate Gamma UCL	18.33

Ba (Barium)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	42

Raw Statistics		Log-transformed Statistics	
Minimum	193	Minimum of Log Data	5.263
Maximum	1450	Maximum of Log Data	7.279
Mean	570.6	Mean of log Data	6.241
Median	477	SD of log Data	0.45
SD	290.7		
Coefficient of Variation	0.51		
Skewness	1.485		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.809	Shapiro Wilk Test Statistic	0.918
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	646.1	95% H-UCL	647.5
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	744.9
95% Adjusted-CLT UCL	655.3	97.5% Chebyshev (MVUE) UCL	822
95% Modified-t UCL	647.8	99% Chebyshev (MVUE) UCL	973.4

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	4.573	Data do not follow a Discernable Distribution (0.05)	
Theta Star	124.8		
nu star	384.1		
Approximate Chi Square Value (.05)	339.7	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	644.4
Adjusted Chi Square Value	338.2	95% Jackknife UCL	646.1
		95% Standard Bootstrap UCL	645.2
Anderson-Darling Test Statistic	1.234	95% Bootstrap-t UCL	668
Anderson-Darling 5% Critical Value	0.752	95% Hall's Bootstrap UCL	658.7
Kolmogorov-Smirnov Test Statistic	0.17	95% Percentile Bootstrap UCL	644.4
Kolmogorov-Smirnov 5% Critical Value	0.137	95% BCA Bootstrap UCL	655.8
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	766.1
		97.5% Chebyshev(Mean, Sd) UCL	850.7
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1017
95% Approximate Gamma UCL	645.2		
95% Adjusted Gamma UCL	648		

Potential UCL to Use			
		Use 95% Student's-t UCL	646.1
		or 95% Modified-t UCL	647.8

Be (Berylium)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	39

Raw Statistics

Minimum	0.339
Maximum	7.86
Mean	2.704
Median	2.41
SD	1.642
Coefficient of Variation	0.607
Skewness	1.326

Log-transformed Statistics

Minimum of Log Data	-1.082
Maximum of Log Data	2.062
Mean of log Data	0.82
SD of log Data	0.619

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.853
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.93
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	3.13

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	3.176
95% Modified-t UCL	3.139

Assuming Lognormal Distribution

95% H-UCL	3.331
95% Chebyshev (MVUE) UCL	3.956
97.5% Chebyshev (MVUE) UCL	4.484
99% Chebyshev (MVUE) UCL	5.522

Gamma Distribution Test

k star (bias corrected)	2.819
Theta Star	0.959
nu star	236.8
Approximate Chi Square Value (.05)	202.2
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	201
Anderson-Darling Test Statistic	0.356
Anderson-Darling 5% Critical Value	0.755
Kolmogorov-Smirnov Test Statistic	0.0865
Kolmogorov-Smirnov 5% Critical Value	0.137

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	3.12
95% Jackknife UCL	3.13
95% Standard Bootstrap UCL	3.121
95% Bootstrap-t UCL	3.236
95% Hall's Bootstrap UCL	3.222
95% Percentile Bootstrap UCL	3.12
95% BCA Bootstrap UCL	3.175
95% Chebyshev(Mean, Sd) UCL	3.808
97.5% Chebyshev(Mean, Sd) UCL	4.286
99% Chebyshev(Mean, Sd) UCL	5.225

Assuming Gamma Distribution

95% Approximate Gamma UCL	3.167
95% Adjusted Gamma UCL	3.184

Potential UCL to Use

Use 95% Approximate Gamma UCL 3.167

B (Boron)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	41

Raw Statistics		Log-transformed Statistics	
Minimum	151	Minimum of Log Data	5.017
Maximum	2190	Maximum of Log Data	7.692
Mean	680.5	Mean of log Data	6.408
Median	585	SD of log Data	0.492
SD	353.4		
Coefficient of Variation	0.519		
Skewness	2.022		

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.823
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.935
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	772.2

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	788.3
95% Modified-t UCL	775.1

Assuming Lognormal Distribution

95% H-UCL	791.5
95% Chebyshev (MVUE) UCL	918.8
97.5% Chebyshev (MVUE) UCL	1021
99% Chebyshev (MVUE) UCL	1222

Gamma Distribution Test

k star (bias corrected)	4.198
Theta Star	162.1
nu star	352.7
Approximate Chi Square Value (.05)	310.2
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	308.7
Anderson-Darling Test Statistic	0.513
Anderson-Darling 5% Critical Value	0.752
Kolmogorov-Smirnov Test Statistic	0.106
Kolmogorov-Smirnov 5% Critical Value	0.137

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	773.8
95% Adjusted Gamma UCL	777.3

Nonparametric Statistics

95% CLT UCL	770.2
95% Jackknife UCL	772.2
95% Standard Bootstrap UCL	766.9
95% Bootstrap-t UCL	799.9
95% Hall's Bootstrap UCL	831.3
95% Percentile Bootstrap UCL	769.7
95% BCA Bootstrap UCL	790.7
95% Chebyshev(Mean, Sd) UCL	918.2
97.5% Chebyshev(Mean, Sd) UCL	1021
99% Chebyshev(Mean, Sd) UCL	1223

Potential UCL to Use: Use 95% Approximate Gamma UCL 773.8

Cd (Cadmium)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	39

Raw Statistics		Log-transformed Statistics	
Minimum	0.0575	Minimum of Log Data	-2.856
Maximum	3.235	Maximum of Log Data	1.174
Mean	0.421	Mean of log Data	-1.32
Median	0.316	SD of log Data	0.849
SD	0.643		
Coefficient of Variation	1.526		
Skewness	4.007		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.434	Shapiro Wilk Test Statistic	0.875
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	0.588	95% H-UCL	0.512
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.623
95% Adjusted-CLT UCL	0.65	97.5% Chebyshev (MVUE) UCL	0.728
95% Modified-t UCL	0.599	99% Chebyshev (MVUE) UCL	0.935

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	1.166	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.361		
nu star	97.92		
Approximate Chi Square Value (.05)	76.09	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	0.585
Adjusted Chi Square Value	75.4	95% Jackknife UCL	0.588
		95% Standard Bootstrap UCL	0.578
Anderson-Darling Test Statistic	2.634	95% Bootstrap-t UCL	1.032
Anderson-Darling 5% Critical Value	0.773	95% Hall's Bootstrap UCL	1.548
Kolmogorov-Smirnov Test Statistic	0.204	95% Percentile Bootstrap UCL	0.606
Kolmogorov-Smirnov 5% Critical Value	0.14	95% BCA Bootstrap UCL	0.649
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.854
		97.5% Chebyshev(Mean, Sd) UCL	1.041
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1.408
95% Approximate Gamma UCL	0.542		
95% Adjusted Gamma UCL	0.547		

Potential UCL to Use		Use 95% Chebyshev (Mean, Sd) UCL	0.854

Cr (Chromium)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	39

Raw Statistics		Log-transformed Statistics	
Minimum	14.3	Minimum of Log Data	2.66
Maximum	240	Maximum of Log Data	5.481
Mean	39.88	Mean of log Data	3.538
Median	33.65	SD of log Data	0.47
SD	34.39		
Coefficient of Variation	0.862		
Skewness	5.08		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.464	Shapiro Wilk Test Statistic	0.85
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	48.81	95% H-UCL	44.08
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	50.94
95% Adjusted-CLT UCL	53.05	97.5% Chebyshev (MVUE) UCL	56.41
95% Modified-t UCL	49.5	99% Chebyshev (MVUE) UCL	67.15

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	3.303	Data do not follow a Discernable Distribution (0.05)	
Theta Star	12.07		
nu star	277.4		
Approximate Chi Square Value (.05)	239.9	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	48.61
Adjusted Chi Square Value	238.6	95% Jackknife UCL	48.81
		95% Standard Bootstrap UCL	48.7
Anderson-Darling Test Statistic	2.897	95% Bootstrap-t UCL	62.76
Anderson-Darling 5% Critical Value	0.754	95% Hall's Bootstrap UCL	83.74
Kolmogorov-Smirnov Test Statistic	0.23	95% Percentile Bootstrap UCL	49.39
Kolmogorov-Smirnov 5% Critical Value	0.137	95% BCA Bootstrap UCL	55.22
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	63.01
		97.5% Chebyshev(Mean, Sd) UCL	73.02
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	92.68
95% Approximate Gamma UCL	46.13		
95% Adjusted Gamma UCL	46.37		

Potential UCL to Use			
		Use 95% Student's-t UCL	48.81
		or 95% Modified-t UCL	49.5

Cu (Copper)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	39

Raw Statistics		Log-transformed Statistics	
Minimum	14.5	Minimum of Log Data	2.674
Maximum	59.8	Maximum of Log Data	4.091
Mean	32.7	Mean of log Data	3.43
Median	31.4	SD of log Data	0.349
SD	10.98		
Coefficient of Variation	0.336		
Skewness	0.504		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.927	Shapiro Wilk Test Statistic	0.934
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	35.55	95% H-UCL	36.19
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	40.64
95% Adjusted-CLT UCL	35.62	97.5% Chebyshev (MVUE) UCL	44.05
95% Modified-t UCL	35.57	99% Chebyshev (MVUE) UCL	50.74

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	8.305	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	3.937		
nu star	697.6		
Approximate Chi Square Value (.05)	637.4	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	35.48
Adjusted Chi Square Value	635.3	95% Jackknife UCL	35.55
		95% Standard Bootstrap UCL	35.39
Anderson-Darling Test Statistic	0.166	95% Bootstrap-t UCL	35.73
Anderson-Darling 5% Critical Value	0.749	95% Hall's Bootstrap UCL	35.69
Kolmogorov-Smirnov Test Statistic	0.0628	95% Percentile Bootstrap UCL	35.37
Kolmogorov-Smirnov 5% Critical Value	0.136	95% BCA Bootstrap UCL	35.51
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	40.08
		97.5% Chebyshev(Mean, Sd) UCL	43.28
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	49.55
95% Approximate Gamma UCL	35.79		
95% Adjusted Gamma UCL	35.91		

Potential UCL to Use		Use 95% Approximate Gamma UCL	35.79

Fe (Iron)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	41

Raw Statistics		Log-transformed Statistics	
Minimum	10600	Minimum of Log Data	9.269
Maximum	58600	Maximum of Log Data	10.98
Mean	22869	Mean of log Data	9.961
Median	21000	SD of log Data	0.396
SD	9390		
Coefficient of Variation	0.411		
Skewness	1.317		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.857	Shapiro Wilk Test Statistic	0.912
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	25307	95% H-UCL	25642
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	29132
95% Adjusted-CLT UCL	25567	97.5% Chebyshev (MVUE) UCL	31845
95% Modified-t UCL	25357	99% Chebyshev (MVUE) UCL	37175

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	6.232	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	3669		
nu star	523.5		
Approximate Chi Square Value (.05)	471.5	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	25252
Adjusted Chi Square Value	469.7	95% Jackknife UCL	25307
		95% Standard Bootstrap UCL	25169
Anderson-Darling Test Statistic	0.472	95% Bootstrap-t UCL	25760
Anderson-Darling 5% Critical Value	0.751	95% Hall's Bootstrap UCL	25888
Kolmogorov-Smirnov Test Statistic	0.0846	95% Percentile Bootstrap UCL	25350
Kolmogorov-Smirnov 5% Critical Value	0.137	95% BCA Bootstrap UCL	25488
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	29185
		97.5% Chebyshev(Mean, Sd) UCL	31918
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	37286
95% Approximate Gamma UCL	25394		
95% Adjusted Gamma UCL	25489		

Potential UCL to Use	Use 95% Approximate Gamma UCL 25394

Pb (Lead)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	37

Raw Statistics

Minimum	7.09
Maximum	51.5
Mean	19.45
Median	17.35
SD	8.544
Coefficient of Variation	0.439
Skewness	1.732

Log-transformed Statistics

Minimum of Log Data	1.959
Maximum of Log Data	3.942
Mean of log Data	2.89
SD of log Data	0.39

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.83
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	21.67

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	22
95% Modified-t UCL	21.73

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.943
Shapiro Wilk Critical Value	0.942

Data appear Lognormal at 5% Significance Level

Assuming Lognormal Distribution

95% H-UCL	21.69
95% Chebyshev (MVUE) UCL	24.61
97.5% Chebyshev (MVUE) UCL	26.87
99% Chebyshev (MVUE) UCL	31.32

Gamma Distribution Test

k star (bias corrected)	6.099
Theta Star	3.19
nu star	512.3
Approximate Chi Square Value (.05)	460.8
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	459.1
Anderson-Darling Test Statistic	0.878
Anderson-Darling 5% Critical Value	0.751
Kolmogorov-Smirnov Test Statistic	0.141
Kolmogorov-Smirnov 5% Critical Value	0.137

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	21.63
95% Adjusted Gamma UCL	21.71

Data Distribution

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	21.62
95% Jackknife UCL	21.67
95% Standard Bootstrap UCL	21.58
95% Bootstrap-t UCL	22.21
95% Hall's Bootstrap UCL	22.57
95% Percentile Bootstrap UCL	21.64
95% BCA Bootstrap UCL	22.1
95% Chebyshev(Mean, Sd) UCL	25.2
97.5% Chebyshev(Mean, Sd) UCL	27.69
99% Chebyshev(Mean, Sd) UCL	32.57

Potential UCL to Use

Use 95% Student's-t UCL	21.67
or 95% Modified-t UCL	21.73
or 95% H-UCL	21.69

Hg (Mercury)

General Statistics

Number of Valid Observations	42
Number of Distinct Observations	40

Raw Statistics

Minimum	0.0457
Maximum	0.939
Mean	0.361
Median	0.337
SD	0.168
Coefficient of Variation	0.464
Skewness	0.695

Log-transformed Statistics

Minimum of Log Data	-3.087
Maximum of Log Data	-0.0629
Mean of log Data	-1.169
SD of log Data	0.647

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.903
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.405

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	0.407
95% Modified-t UCL	0.405

Gamma Distribution Test

k star (bias corrected)	3.25
Theta Star	0.111
nu star	273
Approximate Chi Square Value (.05)	235.7
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	234.5
Anderson-Darling Test Statistic	2.062
Anderson-Darling 5% Critical Value	0.754
Kolmogorov-Smirnov Test Statistic	0.205
Kolmogorov-Smirnov 5% Critical Value	0.137

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.418
95% Adjusted Gamma UCL	0.42

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.777
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Lognormal Distribution

95% H-UCL	0.469
95% Chebyshev (MVUE) UCL	0.559
97.5% Chebyshev (MVUE) UCL	0.636
99% Chebyshev (MVUE) UCL	0.788

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.404
95% Jackknife UCL	0.405
95% Standard Bootstrap UCL	0.404
95% Bootstrap-t UCL	0.41
95% Hall's Bootstrap UCL	0.411
95% Percentile Bootstrap UCL	0.404
95% BCA Bootstrap UCL	0.404
95% Chebyshev(Mean, Sd) UCL	0.474
97.5% Chebyshev(Mean, Sd) UCL	0.523
99% Chebyshev(Mean, Sd) UCL	0.619

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 0.474

Mo (Molybdenum)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	41

Raw Statistics		Log-transformed Statistics	
Minimum	0.982	Minimum of Log Data	-0.0182
Maximum	16.15	Maximum of Log Data	2.782
Mean	5.879	Mean of log Data	1.63
Median	4.765	SD of log Data	0.553
SD	3.281		
Coefficient of Variation	0.558		
Skewness	1.486		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.842	Shapiro Wilk Test Statistic	0.935
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	6.731	95% H-UCL	7.024
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	8.251
95% Adjusted-CLT UCL	6.836	97.5% Chebyshev (MVUE) UCL	9.26
95% Modified-t UCL	6.751	99% Chebyshev (MVUE) UCL	11.24

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	3.438	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	1.71		
nu star	288.8		
Approximate Chi Square Value (.05)	250.4	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	6.712
Adjusted Chi Square Value	249.1	95% Jackknife UCL	6.731
		95% Standard Bootstrap UCL	6.714
Anderson-Darling Test Statistic	0.482	95% Bootstrap-t UCL	6.89
Anderson-Darling 5% Critical Value	0.753	95% Hall's Bootstrap UCL	6.931
Kolmogorov-Smirnov Test Statistic	0.106	95% Percentile Bootstrap UCL	6.706
Kolmogorov-Smirnov 5% Critical Value	0.137	95% BCA Bootstrap UCL	6.795
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	8.086
		97.5% Chebyshev(Mean, Sd) UCL	9.041
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	10.92
95% Approximate Gamma UCL	6.78		
95% Adjusted Gamma UCL	6.814		

Potential UCL to Use	Use 95% Approximate Gamma UCL 6.78

Ni (Nickel)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	41

Raw Statistics		Log-transformed Statistics	
Minimum	21.6	Minimum of Log Data	3.073
Maximum	609	Maximum of Log Data	6.412
Mean	69.09	Mean of log Data	3.929
Median	45.5	SD of log Data	0.645
SD	93.96		
Coefficient of Variation	1.36		
Skewness	4.99		

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.428
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	93.48

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	104.9
95% Modified-t UCL	95.34

Gamma Distribution Test

k star (bias corrected)	1.67
Theta Star	41.38
nu star	140.3
Approximate Chi Square Value (.05)	113.9
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	113
Anderson-Darling Test Statistic	3.554
Anderson-Darling 5% Critical Value	0.763
Kolmogorov-Smirnov Test Statistic	0.255
Kolmogorov-Smirnov 5% Critical Value	0.138

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	85.08
95% Adjusted Gamma UCL	85.72

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.835
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Lognormal Distribution

95% H-UCL	76.65
95% Chebyshev (MVUE) UCL	91.4
97.5% Chebyshev (MVUE) UCL	104
99% Chebyshev (MVUE) UCL	128.8

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	92.93
95% Jackknife UCL	93.48
95% Standard Bootstrap UCL	93.11
95% Bootstrap-t UCL	139.2
95% Hall's Bootstrap UCL	186.3
95% Percentile Bootstrap UCL	95.72
95% BCA Bootstrap UCL	109.6
95% Chebyshev(Mean, Sd) UCL	132.3
97.5% Chebyshev(Mean, Sd) UCL	159.6
99% Chebyshev(Mean, Sd) UCL	213.3

Potential UCL to Use	Use 95% Chebyshev (Mean, Sd) UCL 132.3

Se (Selinium)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	39

Raw Statistics		Log-transformed Statistics	
Minimum	0.0575	Minimum of Log Data	-2.856
Maximum	4.82	Maximum of Log Data	1.573
Mean	1.631	Mean of log Data	0.103
Median	1.72	SD of log Data	1.064
SD	1.142		
Coefficient of Variation	0.7		
Skewness	0.539		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.892	Shapiro Wilk Test Statistic	0.848
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	1.927	95% H-UCL	2.916
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	3.535
95% Adjusted-CLT UCL	1.936	97.5% Chebyshev (MVUE) UCL	4.237
95% Modified-t UCL	1.93	99% Chebyshev (MVUE) UCL	5.616

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	1.353	Data do not follow a Discernable Distribution (0.05)	
Theta Star	1.205		
nu star	113.6		
Approximate Chi Square Value (.05)	90.04	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	1.921
Adjusted Chi Square Value	89.29	95% Jackknife UCL	1.927
		95% Standard Bootstrap UCL	1.913
Anderson-Darling Test Statistic	0.965	95% Bootstrap-t UCL	1.943
Anderson-Darling 5% Critical Value	0.768	95% Hall's Bootstrap UCL	1.928
Kolmogorov-Smirnov Test Statistic	0.162	95% Percentile Bootstrap UCL	1.931
Kolmogorov-Smirnov 5% Critical Value	0.139	95% BCA Bootstrap UCL	1.922
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	2.399
		97.5% Chebyshev(Mean, Sd) UCL	2.732
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	3.385
95% Approximate Gamma UCL	2.059		
95% Adjusted Gamma UCL	2.076		

Potential UCL to Use	Use 99% Chebyshev (Mean, Sd) UCL 3.385

Ag (Silver)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	37

Raw Statistics		Log-transformed Statistics	
Minimum	0.0575	Minimum of Log Data	-2.856
Maximum	3.235	Maximum of Log Data	1.174
Mean	0.564	Mean of log Data	-1.019
Median	0.334	SD of log Data	0.854
SD	0.745		
Coefficient of Variation	1.321		
Skewness	2.795		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.533	Shapiro Wilk Test Statistic	0.869
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	0.757	95% H-UCL	0.697
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.848
95% Adjusted-CLT UCL	0.806	97.5% Chebyshev (MVUE) UCL	0.992
95% Modified-t UCL	0.765	99% Chebyshev (MVUE) UCL	1.275

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	1.189	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.474		
nu star	99.91		
Approximate Chi Square Value (.05)	77.85	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	0.753
Adjusted Chi Square Value	77.15	95% Jackknife UCL	0.757
		95% Standard Bootstrap UCL	0.755
Anderson-Darling Test Statistic	3.891	95% Bootstrap-t UCL	0.864
Anderson-Darling 5% Critical Value	0.772	95% Hall's Bootstrap UCL	0.768
Kolmogorov-Smirnov Test Statistic	0.282	95% Percentile Bootstrap UCL	0.772
Kolmogorov-Smirnov 5% Critical Value	0.14	95% BCA Bootstrap UCL	0.828
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	1.065
		97.5% Chebyshev(Mean, Sd) UCL	1.281
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1.707
95% Approximate Gamma UCL	0.723		
95% Adjusted Gamma UCL	0.73		

Potential UCL to Use		Use 95% Chebyshev (Mean, Sd) UCL	1.065

Tl (Thallium)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	41

Raw Statistics		Log-transformed Statistics	
Minimum	0.194	Minimum of Log Data	-1.64
Maximum	1.735	Maximum of Log Data	0.551
Mean	0.562	Mean of log Data	-0.697
Median	0.519	SD of log Data	0.479
SD	0.325		
Coefficient of Variation	0.578		
Skewness	2.219		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.751	Shapiro Wilk Test Statistic	0.926
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.647	95% H-UCL	0.643
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.744
95% Adjusted-CLT UCL	0.663	97.5% Chebyshev (MVUE) UCL	0.826
95% Modified-t UCL	0.65	99% Chebyshev (MVUE) UCL	0.985

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	3.974	Data Follow Appr. Gamma Distribution at 5% Significance Level	
Theta Star	0.142		
nu star	333.8		
Approximate Chi Square Value (.05)	292.5	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	0.645
Adjusted Chi Square Value	291.1	95% Jackknife UCL	0.647
		95% Standard Bootstrap UCL	0.643
Anderson-Darling Test Statistic	0.911	95% Bootstrap-t UCL	0.682
Anderson-Darling 5% Critical Value	0.753	95% Hall's Bootstrap UCL	0.682
Kolmogorov-Smirnov Test Statistic	0.128	95% Percentile Bootstrap UCL	0.651
Kolmogorov-Smirnov 5% Critical Value	0.137	95% BCA Bootstrap UCL	0.661
Data follow Appr. Gamma Distribution at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.781
		97.5% Chebyshev(Mean, Sd) UCL	0.876
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1.061
95% Approximate Gamma UCL	0.642		
95% Adjusted Gamma UCL	0.645		

Potential UCL to Use		Use 95% Approximate Gamma UCL	0.642

Zn (Zinc)

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	42

Raw Statistics		Log-transformed Statistics	
Minimum	84.8	Minimum of Log Data	4.44
Maximum	1670	Maximum of Log Data	7.421
Mean	497	Mean of log Data	5.937
Median	396.5	SD of log Data	0.782
SD	369		
Coefficient of Variation	0.743		
Skewness	1.478		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.823	Shapiro Wilk Test Statistic	0.912
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	592.8	95% H-UCL	666.5
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	806.9
95% Adjusted-CLT UCL	604.5	97.5% Chebyshev (MVUE) UCL	935.6
95% Modified-t UCL	595	99% Chebyshev (MVUE) UCL	1189

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	1.863	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	266.8		
nu star	156.5		
Approximate Chi Square Value (.05)	128.6	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	590.6
Adjusted Chi Square Value	127.7	95% Jackknife UCL	592.8
		95% Standard Bootstrap UCL	589.5
Anderson-Darling Test Statistic	0.303	95% Bootstrap-t UCL	604.4
Anderson-Darling 5% Critical Value	0.76	95% Hall's Bootstrap UCL	613.9
Kolmogorov-Smirnov Test Statistic	0.067	95% Percentile Bootstrap UCL	596.7
Kolmogorov-Smirnov 5% Critical Value	0.138	95% BCA Bootstrap UCL	603.6
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	745.2
		97.5% Chebyshev(Mean, Sd) UCL	852.6
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1064
95% Approximate Gamma UCL	604.9		
95% Adjusted Gamma UCL	609.1		

Potential UCL to Use		Use 95% Approximate Gamma UCL	604.9

APPENDIX F

Air Dispersion Modeling

Emission Rate Calculations - Sample PVT-EndCap-PM10

Soil Disposal Emission Rate

$$Q = (E_{10} \times h \times u_{mean})/(L \times 10^6)$$

where:	Q:	PM_{10} emission rate ($g/s\text{-}m^2$)
	E10:	PM_{10} concentration ($\mu g/m^3$)
	h:	mixing height
	u_{mean}:	mean wind speed (m/s), and
	L:	landfill length.

E_{10} =	1100	
L =	45	site-specific
h =	2	
u_{mean} =	2.8	site-specific
Q=	0.000136889	

Unlimited Erosion Model Emission Rate

$$Q=0.036 \times (1-V) \times (u_{mean}/u_t)^3 \times F(y) \times (1/3600)$$

where:	Q:	PM_{10} emission rate ($g/s\text{-}m^2$)
	V:	fraction of surface vegetation cover, V = 0 (assumption)
	u_{mean}:	mean wind speed (m/s), umean = 2.8m/s (site-specific data)
	u_t:	threshold value of wind speed at 7m (m/s)
	y:	$y = 0.886\ u_t / u_{mean}$ (dimentionless ratio), and
	F(y):	function of y (USEPA 1985)

V =	0	
u_{mean} =	2.8	site-specific
u_t =	11.32	default (USEPA 1996)
F(y) =	0.194	default (USEPA 1996)
Q=	2.93587E-08	

USEPA 1996 Soil Screening Guidance: User's Guide. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4-23

SCREEN3 - Soil Disposal PM10 Emission Rate

```
 ******  SCREEN3 MODEL  ******
 **** VERSION DATED 96043 ****

ENTER TITLE FOR THIS RUN (UP TO 79 CHARACTERS):
MAX

ENTER SOURCE TYPE: P     FOR POINT
                   F     FOR FLARE
                   A     FOR AREA
                   V     FOR VOLUME
   ALSO ENTER ANY OF THE FOLLOWING OPTIONS ON THE SAME LINE:

     N       TO USE THE NON REGULATORY BUT CONSERVATIVE BRODE 2
             MIXING HEIGHT OPTION,
     nn.n    TO USE AN ANEMOMETER HEIGHT OTHER THAN THE REGULATORY
             (DEFAULT) 10 METER HEIGHT.
     SS      TO USE A NON REGULATORY CAVITY CALCULATION ALTERNATIVE
  Example    PN 7.0 SS (entry for a point source)

 ENTER SOURCE TYPE AND ANY OF THE ABOVE OPTIONS:
a
ENTER EMISSION RATE (G/(S M**2)):
.0001306857
ENTER SOURCE RELEASE HEIGHT (M):
.1
ENTER LENGTH OF LARGER SIDE FOR AREA (M):
45
ENTER LENGTH OF SMALLER SIDE FOR AREA (M):
45
ENTER RECEPTOR HEIGHT ABOVE GROUND (FOR FLAGPOLE RECEPTOR) (M):
1.8
ENTER URBAN/RURAL OPTION (U URBAN, R RURAL):
r
SEARCH THROUGH RANGE OF DIRECTIONS TO FIND THE MAXIMUM?
ENTER Y OR N:
y
ENTER CHOICE OF METEOROLOGY;
1    FULL METEOROLOGY (ALL STABILITIES & WIND SPEEDS)
2    INPUT SINGLE STABILITY CLASS
3    INPUT SINGLE STABILITY CLASS AND WIND SPEED
3
ENTER STABILITY CLASS, 1( A) TO 6( F):
1
ENTER ANEMOMETER HEIGHT WIND SPEED (M/S):
2.8
USE AUTOMATED DISTANCE ARRAY? ENTER Y OR N:
y
ENTER MIN AND MAX DISTANCES TO USE (M):
200
8047

***********************************
*** SCREEN AUTOMATED DISTANCES ***
***********************************

*** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

   DIST      CONC              U10M   USTK  MIX HT   PLUME  MAX DIR
   (M)     (UG/M**3)    STAB   (M/S)  (M/S)   (M)    HT (M)   (DEG)
 -------  ----------    ----   -----  -----  ------  ------  -------
   200.    21.02          1     2.8    2.8   896.0     .10     40.
   300.    9.134          1     2.8    2.8   896.0     .10     35.
   400.    4.726          1     2.8    2.8   896.0     .10     14.
   500.    2.644          1     2.8    2.8   896.0     .10      6.
   600.    1.547          1     2.8    2.8   896.0     .10     12.
   700.    .9674          1     2.8    2.8   896.0     .10     12.
   800.    .6481          1     2.8    2.8   896.0     .10     12.
   900.    .4553          1     2.8    2.8   896.0     .10     11.
  1000.    .3327          1     2.8    2.8   896.0     .10      6.
  1100.    .2524          1     2.8    2.8   896.0     .10      6.
  1200.    .2028          1     2.8    2.8   896.0     .10      6.
  1300.    .1745          1     2.8    2.8   896.0     .10      7.
  1400.    .1584          1     2.8    2.8   896.0     .10     10.
  1500.    .1428          1     2.8    2.8   896.0     .10      9.
  1600.    .1374          1     2.8    2.8   896.0     .10     10.
  1700.    .1322          1     2.8    2.8   896.0     .10     11.
  1800.    .1257          1     2.8    2.8   896.0     .10     12.
  1900.    .1199          1     2.8    2.8   896.0     .10     10.
  2000.    .1146          1     2.8    2.8   896.0     .10     12.
  2100.    .1099          1     2.8    2.8   896.0     .10     10.
  2200.    .1055          1     2.8    2.8   896.0     .10     10.
  2300.    .1015          1     2.8    2.8   896.0     .10     11.
  2400.    .9776E-01      1     2.8    2.8   896.0     .10     12.
  2500.    .9434E-01      1     2.8    2.8   896.0     .10     10.
  2600.    .9117E-01      1     2.8    2.8   896.0     .10     12.
  2700.    .8822E-01      1     2.8    2.8   896.0     .10     10.
  2800.    .8547E-01      1     2.8    2.8   896.0     .10     11.
  2900.    .8290E-01      1     2.8    2.8   896.0     .10     10.
  3000.    .8049E-01      1     2.8    2.8   896.0     .10     10.
  3500.    .7040E-01      1     2.8    2.8   896.0     .10     10.
  4000.    .6220E-01      1     2.8    2.8   896.0     .10      8.
  4500.    .5663E-01      1     2.8    2.8   896.0     .10      8.
  5000.    .5170E-01      1     2.8    2.8   896.0     .10     14.
  5500.    .4752E-01      1     2.8    2.8   896.0     .10      8.
  6000.    .4419E-01      1     2.8    2.8   896.0     .10      8.
  6500.    .4125E-01      1     2.8    2.8   896.0     .10     14.
  7000.    .3871E-01      1     2.8    2.8   896.0     .10      8.
  7500.    .3648E-01      1     2.8    2.8   896.0     .10      8.
  8000.    .3452E-01      1     2.8    2.8   896.0     .10     13.
ITERATING TO FIND MAXIMUM CONCENTRATION . . .

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND   200. M:
   200.    21.02          1     2.8    2.8   896.0     .10     40.

USE DISCRETE DISTANCES?  ENTER Y OR N:
y
TO CEASE, ENTER A DISTANCE OF ZERO (0).

***********************************
*** SCREEN DISCRETE DISTANCES ***
***********************************

*** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

   DIST      CONC              U10M   USTK  MIX HT   PLUME  MAX DIR
   (M)     (UG/M**3)    STAB   (M/S)  (M/S)   (M)    HT (M)   (DEG)
 -------  ----------    ----   -----  -----  ------  ------  -------
ENTER DISTANCE (M) (0 TO EXIT):
402
   402.    4.669          1     2.8    2.8   896.0     .10      9.
ENTER DISTANCE (M) (0 TO EXIT):
```

APPENDIX G

Risk Characterization Spreadsheets

Summary of Dose-Response Information
Activity Description

Constituent	EPC Concentration in Ash (mg/kg)	Oral CSF (mg/kg-d)^-1		Inhalation CSF (mg/kg-d)^-1		Inhalation URF (ug/m3)^-1		Oral TDI/RfD (mg/kg-d)		Inhalation TC/RfC (ug/m3)		Inhalation RFDi (mg/kg/day)		Inhalation RAF Cancer	Inhalation RAF Noncancer Chronic		Oral Soil/Sediment/Water Cancer	Oral Soil/Sediment/Water Noncancer Chronic		Dermal Soil/Sediment Cancer	Dermal Soil/Sediment Noncancer Chronic	
METALS																						
Antimony	0.719	NA		NA		NA		4.00E-04	a	NA		4.00E-04	d	1	1		NA	0.15	y	NA	1	
Arsenic	18.17	1.50E+00	a	1.51E+01	g	4.30E-03	a	3.00E-04	a	1.50E-02	a	4.29E-06	c	1	1		0.51	0.51	x	0.0004	0.0004	z
Barium	645.2	NA		NA		NA		2.00E-01	a	5.00E-01	b	1.43E-04	c	1	1		NA	0.07	y	NA	1	
Beryllium	3.121	NA		8.40E+00	g	2.40E-03	a	2.00E-03	a	2.00E-02	a	5.71E-06	c	1	1		NA	0.007	y	NA	0.14	y
Boron	769.7	NA		NA		NA		2.00E-01	a	2.00E+01	b	5.71E-03	c	1	1		NA	1	y	NA	1	
Cadmium	0.606	NA		6.62E+00	g	1.89E-03	a	1.00E-03	a	1.00E-03	e	2.86E-07	c	1	1		NA	0.025	y	NA	0.001	y
Chromium VI (1:6 VI:III Ratio	8.231666667	NA		NA		NA		3.00E-03	a	1.00E-01		2.86E-05	c	1	1		NA	0.025	w	NA	0.04	x
Copper	35.39	NA		NA		NA		NA		NA		NA		1	1		NA	1	y	NA	1	
Iron	25350	NA		NA		NA		NA		NA		NA		1	1		NA	1	y	NA	1	
Lead	21.64	NA		NA		NA		NA		NA		NA		1	1		NA	1	w	NA	NA	
Mercury, Divalent	0.404	NA		NA		NA		NA		3.00E-01	a	8.57E-05	c	1	1		NA	0.07	y	NA	0.01	y
Molybdenum	6.741	NA		NA		NA		5.00E-03	a	NA		5.00E-03	d	1	1		NA	1	y	NA	1	
Nickel	95.72	NA		9.10E-01		2.60E-04		2.00E-02	a	9.00E-02	e	2.57E-05	c	1	1		NA	0.04	y	NA	1	
Selenium	1.931	NA		NA		NA		5.00E-03	a	2.00E+01	f	5.71E-03	c	1	1		NA	1	y	NA	1	
Silver	0.772	NA		NA		NA		5.00E-03	a	NA		5.00E-03	d	1	1		NA	0.04	y	NA	1	
Thallium	0.651	NA		NA		NA		NA		NA		NA		1	1		NA	1	y	NA	1	
Zinc	596.7	NA		NA		NA		3.00E-01	a	NA		3.00E-01	d	1	1		NA	1	y	NA	0.003	x

NA - Not Applicable
(a) U.S. EPA (2009). IRIS.
(b) HEAST
(c) Derived from Inhalation RfC
(d) Derived from Oral RfD.
(e) ASTDR
(f) Cal EPA
(g) derived from Inhalation URF
(w) RAIS
(x) AMEC Derived
(y) EPA Region 9 RSL Table (2009)
(z) Hawaii DOH EAL Table H (2009)

WORKER - DUST INHALATION - ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Worker
Medium:	Dust from ash
Exposure Pathway:	Inhalation

Chemical Concentration in Air = CS * RP

$$\text{ADD (mg/kg/day)} = \frac{\text{Cdust} \times \text{IR} \times \text{RAF} \times \text{ET} \times \text{EF} \times \text{ED}}{\text{AT} \times \text{BW}}$$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value	
ADD: Average Daily Dose (mg/kg/day)	See Below	
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific	
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated	
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific	
ET: Exposure Time - dust (hr/d)	8	
EF: Exposure Frequency (days/year)	250	
ED: Exposure Duration (years)	25	
IR: Inhalation Rate (m3/hr)	0.833	
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	9125	
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550	
BW: Body Weight (kg)	70	
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific	
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific	
RP: Respirable particulate conc. in air (mg/m3)	5.90E-01	(Maximum PM10 Concentration)
CF: Conversion Factor (kg/mg)	1.00E-06	

			Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
METALS										
Antimony	7.19E-01	4.24E-07	1	2.77E-08	4.00E-04	6.92E-05	1	NA	NA	NA
Arsenic	1.82E+01	1.07E-05	1	6.99E-07	4.29E-06	1.63E-01	1	2.50E-07	1.51E+01	3.76E-06
Barium	6.45E+02	3.81E-04	1	2.48E-05	1.43E-04	1.74E-01	1	NA	NA	NA
Beryllium	3.12E+00	1.84E-06	1	1.20E-07	5.71E-06	2.10E-02	1	4.29E-08	8.40E+00	3.60E-07
Boron	7.70E+02	4.54E-04	1	2.96E-05	5.71E-03	5.18E-03	1	NA	NA	NA
Cadmium	6.06E-01	3.58E-07	1	2.33E-08	2.86E-07	8.16E-02	1	8.33E-09	6.62E+00	5.51E-08
Chromium VI (1:6 VI:III Ratio)*	8.23E+00	4.86E-06	1	3.17E-07	2.86E-05	1.11E-02	1	NA	NA	NA
Copper	3.54E+01	2.09E-05	1	NA	NA	NA	1	NA	NA	NA
Iron	2.54E+04	1.50E-02	1	NA	NA	NA	1	NA	NA	NA
Lead	2.16E+01	1.28E-05	1	NA	NA	NA	1	NA	NA	NA
Mercury, Divalent	4.04E-01	2.38E-07	1	1.55E-08	8.57E-05	1.81E-04	1	NA	NA	NA
Molybdenum	6.74E+00	3.98E-06	1	2.59E-07	5.00E-03	5.19E-05	1	NA	NA	NA
Nickel	9.57E+01	5.65E-05	1	3.68E-06	2.57E-05	1.43E-01	1	1.32E-06	9.10E-01	1.20E-06
Selenium	1.93E+00	1.14E-06	1	7.43E-08	5.71E-03	1.30E-05	1	NA	NA	NA
Silver	7.72E-01	4.55E-07	1	2.97E-08	5.00E-03	5.94E-06	1	NA	NA	NA
Thallium	6.51E-01	3.84E-07	1	NA	NA	NA	1	NA	NA	NA
Zinc	5.97E+02	3.52E-04	1	2.30E-05	3.00E-01	7.65E-05	1	NA	NA	NA
						5.99E-01				5.37E-06

WORKER - DUST INHALATION - 1 HR END CAP ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Worker
Medium:	Dust from ash
Exposure Pathway:	Inhalation

Chemical Concentration in Air = CS * RP

ADD (mg/kg/day) = $\frac{\text{Cdust x IR x RAF x ET x EF x ED}}{\text{AT x BW}}$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value	
ADD: Average Daily Dose (mg/kg/day)	See Below	
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific	
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated	
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific	
ET: Exposure Time - dust (hr/d)	1	
EF: Exposure Frequency (days/year)	250	
ED: Exposure Duration (years)	25	
IR: Inhalation Rate (m3/hr)	0.833	
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	9125	
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550	
BW: Body Weight (kg)	70	
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific	
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific	
RP: Respirable particulate conc. in air (mg/m3)	1.10E+00	(End Cap PM10 Concentration)
CF: Conversion Factor (kg/mg)	1.00E-06	

			Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
METALS										
Antimony	7.19E-01	7.91E-07	1	6.45E-09	4.00E-04	1.61E-05	1	NA	NA	NA
Arsenic	1.82E+01	2.00E-05	1	1.63E-07	4.29E-06	3.80E-02	1	5.82E-08	1.51E+01	8.76E-07
Barium	6.45E+02	7.10E-04	1	5.78E-06	1.43E-04	4.05E-02	1	NA	NA	NA
Beryllium	3.12E+00	3.43E-06	1	2.80E-08	5.71E-06	4.90E-03	1	9.99E-09	8.40E+00	8.39E-08
Boron	7.70E+02	8.47E-04	1	6.90E-06	5.71E-03	1.21E-03	1	NA	NA	NA
Cadmium	6.06E-01	6.67E-07	1	5.43E-09	2.86E-07	1.90E-02	1	1.94E-09	6.62E+00	1.28E-08
Chromium VI (1:6 VI:III Ratio)*	8.23E+00	9.05E-06	1	7.38E-08	2.86E-05	2.58E-03	1	NA	NA	NA
Copper	3.54E+01	3.89E-05	1	NA	NA	NA	1	NA	NA	NA
Iron	2.54E+04	2.79E-02	1	NA	NA	NA	1	NA	NA	NA
Lead	2.16E+01	2.38E-05	1	NA	NA	NA	1	NA	NA	NA
Mercury, Divalent	4.04E-01	4.44E-07	1	3.62E-09	8.57E-05	4.23E-05	1	NA	NA	NA
Molybdenum	6.74E+00	7.42E-06	1	6.04E-08	5.00E-03	1.21E-05	1	NA	NA	NA
Nickel	9.57E+01	1.05E-04	1	8.58E-07	2.57E-05	3.34E-02	1	3.07E-07	9.10E-01	2.79E-07
Selenium	1.93E+00	2.12E-06	1	1.73E-08	5.71E-03	3.03E-06	1	NA	NA	NA
Silver	7.72E-01	8.49E-07	1	6.92E-09	5.00E-03	1.38E-06	1	NA	NA	NA
Thallium	6.51E-01	7.16E-07	1	NA	NA	NA	1	NA	NA	NA
Zinc	5.97E+02	6.56E-04	1	5.35E-06	3.00E-01	1.78E-05	1	NA	NA	NA
						1.40E-01				1.25E-06

WORKER - DIRECT CONTACT - ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Industrial Worker
Medium:	Ash
Exposure Pathway:	Ingestion and Dermal Contact

ADD (mg/kg-day) = $\frac{CS \times [(IR \times FI \times RAF) + (SA \times AF \times FA \times RAF \times EFD)] \times EF \times ED \times CF}{BW \times AT}$

Hazard Quotient (HQ) = ADD (mg/kg-day) / RfD (mg/kg-day)
Cancer Risk (ELCR) = ADD (mg/kg-day) * CSF [1/(mg/kg-day)]

Parameter (units)	Value
ADD: Average Daily Dose (mg/kg-day)	See Below
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific
IR: Ingestion Rate (mg/day)	100
RAF: Relative Absorption Factor (Oral-Soil) (unitless)	Chemical-Specific
FI: Fraction Ingested from Site (unitless)	1
SA: Skin Surface Area (cm2)	3300
AF: Adherence Factor (mg/cm2/event)	0.29
RAF: Relative Absorption Factor (Dermal-Soil) (unitless)	Chemical-Specific
FA: Fraction Absorbed from Site (unitless)	1
EFD: Exposure Frequency - Dermal (event/day)	1
EF: Exposure Frequency (days/year)	250
ED: Exposure Duration (years)	25
BW: Body Weight (kg)	70
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	9125
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550
CF: Conversion factor (kg/mg)	1.00E-06
RfD: Reference Dose (mg/kg-day)	Chemical-Specific
CSF: Cancer Slope Factor [1/(mg/kg-day)]	Chemical-Specific

		Noncancer Hazard Quotient					Excess Lifetime Cancer Risk				
Compound	Soil Concentration (mg/kg)	Oral-Soil RAF (noncancer)	Dermal-Soil RAF (noncancer)	ADD (noncancer) (mg/kg-day)	Chronic TDI/RfD (mg/kg-day)	Soil HQ	Oral-Soil RAF (cancer)	Dermal-Soil RAF (cancer)	ADD (cancer) (mg/kg-day)	CSF [1/(mg/kg-day)]	Soil Risk
METALS											
Antimony	7.19E-01	0.15	1	6.84E-06	4.00E-04	1.71E-02	NA	NA	NA	NA	NA
Arsenic	1.82E+01	0.51	0.0004	9.14E-06	3.00E-04	3.05E-02	0.51	0.0004	3.26E-06	1.50E+00	4.89E-06
Barium	6.45E+02	0.07	1	6.09E-03	2.00E-01	3.04E-02	NA	NA	NA	NA	NA
Beryllium	3.12E+00	0.007	0.14	4.11E-06	2.00E-03	2.06E-03	NA	NA	NA	NA	NA
Boron	7.70E+02	1	1	7.96E-03	2.00E-01	3.98E-02	NA	NA	NA	NA	NA
Cadmium	6.06E-01	0.025	0.001	2.05E-08	1.00E-03	2.05E-05	NA	NA	NA	NA	NA
Chromium VI (1:6 VI:III Ratio)	8.23E+00	0.025	0.04	3.28E-06	3.00E-03	1.09E-03	NA	NA	NA	NA	NA
Copper	3.54E+01	1	1	NA	NA	NA	NA	NA	NA	NA	NA
Iron	2.54E+04	1	1	NA	NA	NA	NA	NA	NA	NA	NA
Lead	2.16E+01	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury, Divalent	4.04E-01	0.07	0.01	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	6.74E+00	1	1	6.97E-05	5.00E-03	1.39E-02	NA	NA	NA	NA	NA
Nickel	9.57E+01	0.04	1	9.00E-04	2.00E-02	4.50E-02	NA	NA	NA	NA	NA
Selenium	1.93E+00	1	1	2.00E-05	5.00E-03	3.99E-03	NA	NA	NA	NA	NA
Silver	7.72E-01	0.04	1	7.26E-06	5.00E-03	1.45E-03	NA	NA	NA	NA	NA
Thallium	6.51E-01	1	1	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	5.97E+02	1	0.003	6.01E-04	3.00E-01	2.00E-03	NA	NA	NA	NA	NA
						1.87E-01					4.89E-06

CHILD RESIDENT - DUST INHALATION - ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Child Resident
Medium:	Dust from ash
Exposure Pathway:	Inhalation

Chemical Concentration in Air = CS * RP

ADD (mg/kg/day) = $\frac{\text{Cdust x IR x RAF x ET x EF x ED}}{\text{AT x BW}}$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value	
ADD: Average Daily Dose (mg/kg/day)	See Below	
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific	
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated	
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific	
ET: Exposure Time - dust (hr/d)	24	
EF: Exposure Frequency (days/year)	350	
ED: Exposure Duration (years)	6	
IR: Inhalation Rate (m3/hr)	0.417	
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	2190	
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550	
BW: Body Weight (kg)	15	
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific	
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific	
RP: Respirable particulate conc. in air (mg/m3)	9.34E-04	(SCREEN 3 Results)
CF: Conversion Factor (kg/mg)	1.00E-06	

			Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
METALS										
Antimony	7.19E-01	6.71E-10	1	4.30E-10	4.00E-04	1.07E-06	1	NA	NA	NA
Arsenic	1.82E+01	1.70E-08	1	1.09E-08	4.29E-06	2.53E-03	1	9.30E-10	1.51E+01	1.40E-08
Barium	6.45E+02	6.02E-07	1	3.85E-07	1.43E-04	2.70E-03	1	NA	NA	NA
Beryllium	3.12E+00	2.91E-09	1	1.86E-09	5.71E-06	3.26E-04	1	1.60E-10	8.40E+00	1.34E-09
Boron	7.70E+02	7.19E-07	1	4.60E-07	5.71E-03	8.05E-05	1	NA	NA	NA
Cadmium	6.06E-01	5.66E-10	1	3.62E-10	2.86E-07	1.27E-03	1	3.10E-11	6.62E+00	2.05E-10
Chromium VI (1:6 VI:III Ratio)*	8.23E+00	7.69E-09	1	4.92E-09	2.86E-05	1.72E-04	1	NA	NA	NA
Copper	3.54E+01	3.30E-08	1	NA	NA	NA	1	NA	NA	NA
Iron	2.54E+04	2.37E-05	1	NA	NA	NA	1	NA	NA	NA
Lead	2.16E+01	2.02E-08	1	NA	NA	NA	1	NA	NA	NA
Mercury, Divalent	4.04E-01	3.77E-10	1	2.41E-10	8.57E-05	2.82E-06	1	NA	NA	NA
Molybdenum	6.74E+00	6.29E-09	1	4.03E-09	5.00E-03	8.05E-07	1	NA	NA	NA
Nickel	9.57E+01	8.94E-08	1	5.72E-08	2.57E-05	2.22E-03	1	4.90E-09	9.10E-01	4.46E-09
Selenium	1.93E+00	1.80E-09	1	1.15E-09	5.71E-03	2.02E-07	1	NA	NA	NA
Silver	7.72E-01	7.21E-10	1	4.61E-10	5.00E-03	9.22E-08	1	NA	NA	NA
Thallium	6.51E-01	6.08E-10	1	NA	NA	NA	1	NA	NA	NA
Zinc	5.97E+02	5.57E-07	1	3.56E-07	3.00E-01	1.19E-06	1	NA	NA	NA
						9.31E-03				2.00E-08

ADULT RESIDENT - DUST INHALATION - ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Adult Resident
Medium:	Dust from ash
Exposure Pathway:	Inhalation

Chemical Concentration in Air = CS * RP * CF

ADD (mg/kg/day) = $\frac{\text{Cdust x IR x RAF x ET x EF x ED}}{\text{AT x BW}}$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value	
ADD: Average Daily Dose (mg/kg/day)	See Below	
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific	
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated	
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific	
ET: Exposure Time - dust (hr/d)	24	
EF: Exposure Frequency (days/year)	350	
ED: Exposure Duration (years)	24	
IR: Inhalation Rate (m3/hr)	0.833	
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	8760	
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550	
BW: Body Weight (kg)	70	
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific	
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific	
RP: Respirable particulate conc. in air (mg/m3)	9.34E-04	(SCREEN 3 Results)
CF: Conversion Factor (kg/mg)	1.00E-06	

			Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
METALS										
Antimony	7.19E-01	6.71E-10	1	1.84E-10	4.00E-04	4.60E-07	1	NA	NA	NA
Arsenic	1.82E+01	1.70E-08	1	4.65E-09	4.29E-06	1.08E-03	1	1.59E-09	1.51E+01	2.40E-08
Barium	6.45E+02	6.02E-07	1	1.65E-07	1.43E-04	1.15E-03	1	NA	NA	NA
Beryllium	3.12E+00	2.91E-09	1	7.98E-10	5.71E-06	1.40E-04	1	2.74E-10	8.40E+00	2.30E-09
Boron	7.70E+02	7.19E-07	1	1.97E-07	5.71E-03	3.44E-05	1	NA	NA	NA
Cadmium	6.06E-01	5.66E-10	1	1.55E-10	2.86E-07	5.42E-04	1	5.31E-11	6.62E+00	3.51E-10
Chromium VI (1:6 VI:III Ratio)*	8.23E+00	7.69E-09	1	2.11E-09	2.86E-05	7.37E-05	1	NA	NA	NA
Copper	3.54E+01	3.30E-08	1	NA	NA	NA	1	NA	NA	NA
Iron	2.54E+04	2.37E-05	1	NA	NA	NA	1	NA	NA	NA
Lead	2.16E+01	2.02E-08	1	NA	NA	NA	1	NA	NA	NA
Mercury, Divalent	4.04E-01	3.77E-10	1	1.03E-10	8.57E-05	1.21E-06	1	NA	NA	NA
Molybdenum	6.74E+00	6.29E-09	1	1.72E-09	5.00E-03	3.45E-07	1	NA	NA	NA
Nickel	9.57E+01	8.94E-08	1	2.45E-08	2.57E-05	9.52E-04	1	8.39E-09	9.10E-01	7.64E-09
Selenium	1.93E+00	1.80E-09	1	4.94E-10	5.71E-03	8.64E-08	1	NA	NA	NA
Silver	7.72E-01	7.21E-10	1	1.97E-10	5.00E-03	3.95E-08	1	NA	NA	NA
Thallium	6.51E-01	6.08E-10	1	NA	NA	NA	1	NA	NA	NA
Zinc	5.97E+02	5.57E-07	1	1.53E-07	3.00E-01	5.09E-07	1	NA	NA	NA
						3.98E-03				3.43E-08

APPENDIX H

Relative Absorption Factors Derivation

ARSENIC

The oral reference dose for noncarcinogenic effects of arsenic is 3E-04 mg/kg-day, and the oral cancer slope factor for carcinogenic effects is 1.5 per mg/kg-day (IRIS-U.S. EPA, 2001). Both values are based on epidemiological studies that characterized health effects in a large population of Taiwanese who consumed drinking water containing arsenic. The exact form of the ingested arsenic is unknown.

Estimation of Absorption in the Dose-Response Study

The relevant dose-response study characterized health effects in a large population of Taiwanese who consumed drinking water containing arsenic. Several studies investigating the absorption of arsenic have been performed in humans and various animal species. Human studies are sufficiently extensive to strongly suggest that close to 100% of soluble inorganic arsenic in water is absorbed from the gastrointestinal tract. These human studies are reviewed in detail here.

One direct indication of absorption of an orally administered dose of a chemical is its urinary excretion. Several studies show that urinary excretion can account for the majority of an orally administered dose of arsenic. Buchet et al. (1981a) administered aqueous sodium arsenite (NaAsO2) as a single dose to three human volunteers. An average of 45% of the dose was excreted in the urine in four days. In a second study (Buchet et al., 1981b), four individuals given 125, 250, 500, or 1000 Ug As/day orally for five days excreted 54, 73, 74, and 64% of the dose in urine, respectively, over 14 days. The average urinary excretion of arsenic for the four subjects was 66% of the administered dose. Crecelius (1977) reports that approximately 50% and 80% of orally administered aqueous arsenic was excreted in urine within 61 hours by a single individual in two experiments. The results of these studies represent the minimum amount of arsenic absorbed since the balance of the dose was not accounted for.

Data for human fecal excretion of arsenic do exist. Pomroy et al. (1980) gave 6 male subjects radiolabelled arsenic acid ($[^{74}As]H_3AsO_4$) in gelatin capsules followed by a glass of water. The presence of arsenic in the body, urine, and feces was measured using a whole body radiation counter. The authors report that for the six subjects the average total excretion over 7 days was 6.1$\pm$2.8% in feces. It is not possible to determine how much of this arsenic was first absorbed and then excreted. The total recovery of arsenic (urine plus feces) was 68.4$\pm$4.0% of the single oral dose. The remaining arsenic was reported to be present in the body tissues; virtually the entire dose could be accounted for. This suggests a minimum absorption of 94% (100% - 6%) of orally ingested arsenic.

A study by Bettley and O'Shea (1975) also reports excretion of arsenic in both urine and feces. Three subjects were exposed to 8.52 mg As (as 1.25 ml of Liq. Arsenicalis B.P.) in three portions 8 hours apart on one day. They found that at most 3.5% of the dose was excreted in feces over ten days. This suggests a minimum absorption of 96%. Urinary excretion averaged 52$\pm$4% of the exposure dose over 10 days (n=3). The remaining half of the dose was unaccounted for, although small amounts of arsenic were found in blood and hair.

In the Coulson study (Coulson et al., 1935), results from two humans each ingesting two forms of arsenic are reported. Less than 5% of an oral dose was excreted in feces whether the arsenic was taken as arsenic trioxide (As_2O_3) or as natural arsenic present in shrimp.

The remainder of the dose, more than 95%, was recovered in urine in three experiments where total recoveries ranged from 74 to 115%. Based on the fecal excretion data from this study, it can be estimated that at least 95% of the ingested arsenic was absorbed. The fecal excretion data are consistent with those of Pomroy et al. (1980) and Bettley and O'Shea (1975).

Fecal excretion data from oral studies provide a minimum estimate of absorption, because it cannot be determined how much of the dose was first absorbed and then excreted into the feces. However, a study in humans injected intravenously with arsenic suggests that absorbed arsenic may be excreted, presumably from bile, into the feces. Mealy et al. (1959) administered radiolabelled arsenic by intravenous injection. Between 57% and 90% of the injected dose was recovered in urine in 10 days. Fecal excretion accounted for 1.3% of the dose after seventeen days in one individual. A second subject excreted 0.2% of the intravenous dose into the feces in one week. Both results indicate some excretion of arsenic into the feces. Virtually all of the remaining dose was recovered in the urine. Biliary excretion of arsenic has been demonstrated in rats, rabbits, and dogs (Klaassen, 1974; Gregus and Klaassen, 1986). This indicates that a portion of the arsenic found in feces in studies using oral dosing may have been first absorbed and then excreted.

The urinary excretion data from the oral studies discussed above provide minimum estimates of arsenic absorption ranging from 45% to 95%. The fecal excretion data suggest that, at a minimum, 95-96% of an orally administered dose of arsenic is absorbed. The study of intravenously administered arsenic suggest that biliary excretion can occur. Therefore, it can conservatively be concluded from the above studies that virtually 100% of an orally administered dose of soluble inorganic arsenic can be absorbed in humans.

RAF (Oral-Soil)

The oral-soil RAF for arsenic is defined as: (absorption of arsenic in humans from ingested soil) / (absorption of arsenic in humans in the epidemiological study from ingested water). There are many forms of inorganic arsenic, and these have widely varying solubilities. While it is appropriate to assume that arsenic present in water would be a soluble form of arsenic, this is not necessarily the case for arsenic present in soil or ash. Arsenic present in soils can either be in a relatively insoluble mineral form, such as would be expected in slags, mine tailings, and ash; or, the arsenic can be present in a more soluble form such as might be present at hazardous waste sites where arsenic salts were either disposed of or accidentally released. Even soluble species, however, become bound tightly to soils after years of weathering.

Ruby et al. (1999) Literature Review

Ruby et al. (1999) have recently summarized the available bioavailability studies from arsenic-containing media from metal mining and processing sites. Twenty two Relative Absorption Factors have been summarized from studies in swine, rats, rabbits and monkeys. The RAFs range from 0.03 to 0.51. It should be noted that two samples from Aspen, CO were rejected because the arsenic levels were too low to produce reliable estimates of the RAF by the method used. The mean value for arsenic RAF from these 22 studies was 0.26. The values are summarized below.

TABLE 1
SUMMARY OF ORAL-SOIL RAFS FOR ARSENIC FROM THE LITERATURE

Source of Sample	Study Type	Arsenic Level (mg/kg)	RAF
Aspen soil (berm)	EPA Region VIII Swine Study	67	Rejected as unreliable
Aspen soil (residential)	EPA Region VIII Swine Study	17	Rejected as unreliable
Bingham Creek tailings (channel)	EPA Region VIII Swine Study	149	0.37
Butte soil	EPA Region VIII Swine Study	239	0.10
Leadville soil (residential)	EPA Region VIII Swine Study	203	0.08
Leadville soil (Fe-Mn-Pb oxide)	EPA Region VIII Swine Study	110	0.28
Leadville soil (AV)	EPA Region VIII Swine Study	1050	0.15
Midvale slag	EPA Region VIII Swine Study	591	0.18
Murray Smelter (slag)	EPA Region VIII Swine Study	695	0.51
Murray Smelter (soil)	EPA Region VIII Swine Study	310	0.34
Palmerton soil (location 2)	EPA Region VIII Swine Study	110	0.39
Palmerton soil (location 4)	EPA Region VIII Swine Study	134	0.52
Clark Fork tailings (GK)	EPA Region VIII Swine Study	181	0.49
Oklahoma calcine/soil 1	U. MO. Swine Study	11300	0.03
Oklahoma calcine/soil 2	U. MO. Swine Study	17500	0.03
Oklahoma calcine/soil 3	U. MO. Swine Study	13500	0.08
Oklahoma calcine/soil 4	U. MO. Swine Study	11500	0.22
Oklahoma calcine/soil 5	U. MO. Swine Study	6250	0.30
Oklahoma iron slag 3	U. MO. Swine Study	1180	0.29
Oklahoma Iron slag 4	U. MO. Swine Study	5020	0.30
Oklahoma Iron slag 5	U. MO. Swine Study	4650	0.16
Anaconda soil	Battelle Rabbit Study	3900	0.48
Anaconda soil	Battelle Monkey	410	0.20

(residential)	Study		
Anaconda House Dust	Battelle Monkey Study	170	0.28
Pure arsenic trioxide in rat food	Harrison et al. (1956) Rat Study	Not known	0.11
Soil in vicinity of historical sheep dip	Ng et al. (1998) Rat Study	32-295	0.10

There are few studies in the literature of the bioavailability of arsenic from aged soil matrices into which soluble arsenic compounds were historically released. It is known that such compounds bind to soil. For instance, WHO (1981) states:

> Arsenate ions are readily sorbed by hydrous oxides of iron and aluminum and thus leaching of arsenate is slow. Absorption appears to be a major factor in the retention of arsenic in soils. Similarly, Hindmarsh and McCurdy (1986) state:
>
> These arsenicals form very insoluble and stable complexes in soil systems which contribute to their long residence time (9400 years). Organic and inorganic arsenicals in soil behave similarly. They react with iron in conjunction wit clay and other particles or with various cations in soil to form insoluble complexes.

Only four studies were found in the literature. As presented below, RAFs are derived from each.

Harrison et al. (1956) Study

Harrison et al. (1956) determined the LD_{50} in albino rats of crude arsenic trioxide (97.7% pure) and purearsenic trioxide (99.999+% pure). In one experiment, the arsenic trioxide was dissolved in water and given by gavage to 40 animals in four dose groups of ten animals each. In another experiment, the arsenic trioxide was given in dry form as a supplement to the food in 140 animals in seven dose groups of twenty each. The 96-hour LD_{50} was determined for each of the four experiments. As shown below, the LD_{50} was markedly reduced when given in food as compared to aqueous solution. All animals in the highest dose groups were dead at 96 hours, so sufficient time was allowed for the acute toxic effects of trivalent arsenic to manifest.

TABLE 2
COMPARISON OF LETHAL DOSES TO RATS OF ARSENIC TRIOXIDE

Compound Tested	**LD_{50} Aqueous Solution**	**LD_{50} Food Supplement**
Crude Arsenic Trioxide	23.6 mg/kg	214 mg/kg
Pure Arsenic Trioxide	15.1 mg/kg	145.2 mg/kg

Because the dose-response values for arsenic are based on ingestion of dissolved arsenic in drinking water, estimates of relative bioavailability of trivalent arsenic can be made from the above data. For the crude arsenic trioxide, the ratio of the lethal dose for food administration versus administration of an aqueous solution is 0.11. For the pure arsenic, the ratio is similar, 0.10. Accordingly, the estimate of the RAF for pure trivalent arsenic compounds is 0.11.

In this experiment, no soil was used, but the addition of the soluble arsenic species to food and administered immediately to animals without aging greatly overestimates the binding that would be expected to soil after years of ageing. Accordingly, this estimate is appropriate to use for the RAF of soluble arsenicals in soil.

Ng et al. (1998) Study

Ng et al. (1998) measured the absolute absorption of arsenic in soils near a former sheep dip. Five soil samples near the sheep dip site contained arsenic at concentrations of 55, 32, 165, 295, and 67 mg/kg total arsenic. It should be noted that native soils in this area may also be naturally high in arsenic due to the presence of specific geological formations that are known to occur elsewhere in Australia.

Male Wistar rats were given soil suspended in water by gavage in groups of five rats at a dose of 0.5 mg As/kg body weight. As positive controls, groups of four rats were given the equivalent dose of arsenic by intravenous injection of 0.5 mg As/kg body weight in the form od a solution of sodium arsenite (As III) or sodium arsenate (As III). All animals were given water and food *ad libitum.* 24- hour urine samples free from fecal contamination were collected daily for four days post dosing. Absolute absorption was determined by calculating the area under the urinary arsenic curve (AUC) for measurements taken at 0, 24, 48 , 72 and 96 hours. The absolute absorption was determined as:

% Absolute Absorption (Bioavailabilty) = 100 x AUC_{oral} / $AUC_{intravenous}$

TABLE 3
ABSOLUTE ABSORPTION OF ARSENIC IN SOIL NEAR SHEEP DIP

Soil Sample Near Sheep Dip	Absolute Absorption (%)
C1	10.81
C2	5.57
C3	12.55
C4	7.00
C5	12.56

The average absolute absorption (absolute bioavailability) of arsenic from soils near a former sheep dip site is 10%. Because the estimated absolute absorption of arsenic in humans from drinking water in the dose-response studies is 100%, the RAF is 10%/100% = 0.10.

This RAF is based on an animal study of aged soils in which soluble trivalent arsenic compounds were released due to the former use of the area as a sheep dip. However, it cannot be ruled out that some of the arsenic present in the soil was naturally present from rock and soil formations.

Roberts, et al. (2002) Study

Roberts, et al. (2002) measured arsenic bioavailability from soils affected by releases of soluble arsenic salts in Cebus apella monkeys in a study for the Florida Department of Environmental Protection. Soil samples were taken from five sites with arsenic contaminated soil from different sources, but all from arsenical salts: (1) electrical substation, (2) cattle dip site, (3) pesticide site #1, (4) wood treatment site, and (5) pesticide site #2. Relative bioavailability was assessed based on urinary excretion following an oral dose in solution. Relative bioavailability for the five sites was: (1) 0.146 +/ 0.05, (2) 0.247 +/- 0.03, (3) 0.107 +/- 0.05, (4) 0.163 +/- 0.07, and (5) 0.17 +/- 0.10. The mean of these five soil types was 0.17. Relative bioavailability of the soil from the wood treatment site was 0.16.

Casteel et al. (2001) Study

Casteel et al. measured the relative bioavailability of arsenic in soils affected by a release of the arsenical herbicide PAX in swine in a study for the U.S. EPA. The relative bioavailability compared to arsenic salts in water varied from 0.18 to 0.45 in five samples.

Summary

RAFs presented above range from 0.03 to 0.51. The most health-protective use of the above data is to use the maximum value listed above, 0.51, as a conservative default oral-soil RAF.

RAF (Dermal-Soil)

The RAF (dermal-soil) for this chemical is defined as: (absorption in humans from dermal contact with soil) / (absorption of arsenic in humans in the epidemiological study from ingested water). The RAF (dermal-soil) of 0.009 is derived below.

To derive the RAF (dermal-soil), AMEC uses the estimates of the fractional dermal absorption of arsenic from soil reported by Wester et al. (1993). Wester et al. (1993) measured the skin uptake of soluble arsenic (H_3AsO_4) from soil in monkey skin *in vivo* and in human skin *in vitro.* Radiolabelled arsenic was mixed with Yolo County 65-California-57-8 soil at two concentrations: 0.001 mg/kg and 15 mg/kg. The soil retained by an 80-mesh sieve was 26% sand, 26% clay, 48% silt, and 0.9% organic matter. Soil load on the skin was 40 mg/cm^2. For each dose of arsenic, four female Rhesus monkeys were administered the arsenic containing soil on abdominal skin. The area was covered with a nonocclusive cover. After 24 hours, the soil was removed from the skin, and the area was washed with soap and water. Urine was collected for 7 days. *In vivo* percutaneous absorption was determined by the ratio of urinary excretion following topical administration to that following intravenous administration. Percutaneous absorption of arsenic from soil was 4.5 +/- 3.2% from the low dose and 3.2 +/- 1.9% from the high dose. Soap and water washes removed most of the admistered dose after the 24 hour exposure period.

Percutaneous absorption was also measured in viable human cadaver skin dermatomed to 500 um. The skin was preserved and used within five days of collection. Measurements were taken in triplicate for each of three skin samples. The arsenic dose was 0.001 mg/kg and the soil loading was 40 mg/cm^2. After a 24-hour exposure period, the amount of arsenic present in the receptor fluid (phosphate buffered saline) plus the amount in the skin that was not removed by a surface wash was 0.76% of the administered dose.

The dermal-soil RAF is calculated by using all three results from Wester et al. (1993):

4.5% monkey *in vivo*, low dose
3.2% monkey *in vivo*, high dose
0.8% human *in vitro,* low dose

The average fractional absorption over 24 hours is 2.8%. Typical exposures at industrial sites are not 24 hours in length. Thus, the above data are prorated to a more reasonable exposure period of 8 hours. The average fractional absorption over 8 hours is 0.94%. The dermal-soil RAF is calculated as follows:

RAF (Dermal-Soil) = (0.944%) / (100%) = 0.009.

Summary of Derived RAFs for Arsenic

Oral-Soil	0.51
Dermal-Soil	0.009

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