**ENVIRONMENTAL
MANAGEMENT**

**Environmental Management
Waste Management Facility
Waste Lot Profile For
K-770 Scrap Yard Soils and
Miscellaneous Debris
East Tennessee Technology Park
Oak Ridge, Tennessee**

EMWMF Waste Lot 4.12

This document is approved for public
release per review by:

AK M
BJC ETP Classification &
Information Office

4/16/09
Date

**BECHTEL JACOBS COMPANY LLC
ACCELERATED CLEANUP CONTRACT
WITH THE UNITED STATES
U.S. DEPARTMENT OF ENERGY**

Interoffice Memorandum

To: G. J. Hampshire
Waste Management Project; 241-1312

From: J. M. Davenport *J.M.D.*
ETTP D&D/RA Project

Date: April 30, 2009

File: ETDD-09-014

Subject: DE-AC05-98OR22700: Environmental Management Waste Management Facility Waste Lot Profile for K-770 Scrap Yard Soils and Miscellaneous Debris, East Tennessee Technology Park, Oak Ridge, Tennessee EMWMF Waste Lot 4.12 (BJC/OR-3174)

The purpose of this memorandum is to transmit one copy of the subject Environmental Management Waste Management Facility (EMWMF) profile to the EMWMF Waste Acceptance Criteria Attainment Board for approval.

The ETTP D&D/RA Project looks forward to approval of this profile. Please call if you have any questions.

JMD:sp

Enclosure: EMWMF Waste Lot 4.12 Profile

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**Environmental Management
Waste Management Facility
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K-770 Scrap Yard Soils and Miscellaneous Debris
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Oak Ridge, Tennessee**

EMWMF Waste Lot 4.12

Date Issued—April 2009

Prepared for the
U.S. Department of Energy
Office of Environmental Management

BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at the
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for the
U.S. DEPARTMENT OF ENERGY

APPROVALS

ENVIRONMENTAL MANAGEMENT
WASTE MANAGEMENT FACILITY
WASTE LOT PROFILE FOR
K-770 SCRAP YARD SOILS AND MISCELLANEOUS DEBRIS
EAST TENNESSEE TECHNOLOGY PARK
OAK RIDGE, TENNESSEE
EMWMF WASTE LOT 4.12

BJC/OR-3174

April 2009

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ACRONYMS

ACM	asbestos-containing material
ASA	Auditable Safety Analysis
BIC	Bechtel Jacobs Company LLC
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
<i>CFR</i>	<i>Code of Federal Regulations</i>
CROET	Community Reuse Organization of East Tennessee
D&D	Decontamination and Demolition
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EMWMF	Environmental Management Waste Management Facility
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
LCP	Limited Characterization Plan
LLW	low-level waste
PCB	polychlorinated biphenyl
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act of 1976
SOF	sum of fractions
SRC	site-related contaminant
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TDEC	Tennessee Department of Environment and Conservation
TRU	transuranic
TSCA	Toxic Substances Control Act of 1976
TVA	Tennessee Valley Authority
UCL ₉₅	95% upper confidence limit on the mean
VWSF	volume-weighted sum of fractions
WAC	waste acceptance criteria
WACFACS	Waste Acceptance Criteria Forecasting Analysis Capability System
WHP	Waste Handling Plan

1. INTRODUCTION

Waste Lot 4.12 consists of approximately 17,500 yd³ of low-level, radioactively contaminated soil, concrete, and incidental metal and debris generated from remedial actions at the K-770 Scrap Metal Yard and Contaminated Debris Site (the K-770 Scrap Yard) at the East Tennessee Technology Park (ETTP). The excavated soil will be transported by dump truck to the Environmental Management Waste Management Facility (EMWMF). This profile provides project-specific information to demonstrate compliance with *Attainment Plan for Risk/Toxicity-based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2001).

The K-770 Scrap Yard is an approximately 36-acre storage area located southwest of the main portion of ETTP, outside the security perimeter fence in the Powerhouse Area adjacent to the Clinch River. The K-770 area was used to store radioactively contaminated or suspected contaminated materials during and previous to the K-25 Site cascade upgrading program. The waste storage facility began operation in the 1960s and is estimated to at one time contain in excess of 40,000 tons of low-level, radioactively contaminated scrap metal. Scrap metal was taken to the site when it was found to contain alpha or beta/gamma activity on the surface or if the scrap metal originated from a process building.

The segregated metal debris was removed from the site as part of the K-770 Scrap Removal Action (RA) Project that was completed in fiscal year (FY) 2007 by Bechtel Jacobs Company LLC (BJC). An area of approximately 10 acres is located in EUs 29 and 31 where the scrap was originally located in the 100-year floodplain. In the process of moving the materials around and establishing segregated waste piles above the 100-year floodplain, the footprint of the site was expanded by 10-15 acres in EUs 30 and 32. The area in EUs 29 and 31 that was cleared of metallic debris in the floodplain was sown with grass. The areas in EUs 30 and 32 have some scattered vegetation but are generally open and accessible.

With limited exception, all materials contained in the scrap yard have been removed and disposed at the EMWMF. Soils that underlay the original waste storage area in EUs 29 and 31 as well as soils that underlay the scrap piles in EUs 30 and 32 show substantially elevated radioactivity. In addition to soils present at the site, remaining portions of foundations/floor slabs for Bldgs. K-725, K-726, and K-736 as well as the unnamed pad at the northeast corner of the site constructed to support the sort and segregation operations at the K-770 Scrap Removal Project in 2006 and several other small, unnamed concrete pads are included in this waste lot. While many of these foundations/floor slabs will be removed because they are contaminated, some of the smaller unnamed concrete pads will be removed in order to access contaminated soils that are around and under the pads and regrade the site. Appendix E contains a map showing the areas of soil and concrete pads that are expected to be excavated. Soils in the areas indicated on this map will be removed to approximately one foot below the surface. (This corresponds to the soil interval sampled and analyzed to characterize this waste lot.) Contaminants present in the soils are directly derived from metallic debris and rubbish handled by the waste storage operations, are concentrated in the top few inches, and include the predominant constituents of concern associated with the metallic waste already disposed at EMWMF. Additionally, some residual metallic debris remains embedded in the shallow soils that underlay the former debris piles. This residual metallic debris is eligible for disposal in the EMWMF WAC criteria as defined in *Waste Profile for: Disposal of the Scrap Removal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004a). This waste, however, has been included in Waste Lot 4.12 to conform to the more rigorous profiling requirements currently contained in *Waste Acceptance Criteria Attainment Team Project Execution Plan Environmental Management Waste Management Facility, Oak Ridge Reservation, Tennessee* (BJC 2008a). It comprises approximately 5% of the total mass of material that will be generated under this RA. Incidental amounts of wood and other debris items and secondary waste generated during the RA are also included in this waste lot.

Supporting documentation for this waste lot profile is included in the following appendices:

Appendix A: Waste Anomaly Detection Plan and Checklist;

Appendix B: Detailed Process Knowledge Description,

Appendix C: Controlled Data Set,

Appendix D: Environmental Compliance Assessment,

Appendix E: Waste Handling Plan Crosswalk, Sampling Approach, Calculation/Measurement Methods,

Appendix F: Data Quality Objectives Checklist,

Appendix G: Data Quality Assessment,

Appendix H: Waste Acceptance Criteria Forecasting Analysis Capability System (WACFACS)
Attachment 3 and VWSF Transmittal Letter,

Appendix I: Approved Variance Requests,

Appendix J: CERCLA documentation, and

Appendix K: EMWMF Nuclear Criticality Compliance Documentation.

2. ADMINISTRATIVE WAC COMPLIANCE

2.1 CERCLA ACTION

This RA will be executed in accordance with *Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2002). The soil and remaining portions of foundations/floor slabs (with the exception of the K-725 concrete slab) in this waste lot will be managed in accordance with *Waste Handling Plan, Part II for the K-770 Soils within Zone 1 East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2006), the remaining metal debris will be managed in accordance with *Waste Handling Plan, Part II for the East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2004), and the K-725 concrete foundation slab will be managed in accordance with *Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2005). Core Team approval documentation for the waste handling plans is provided in Appendix B and applicable CERCLA documentation is provided in Appendix J of this profile.

2.2 PROHIBITED WASTE TYPES

The characterization data and the results described in this waste profile demonstrate that Waste Lot 4.12 is not transuranic (TRU) waste. Through process knowledge, the waste is not high-level radioactive waste, spent nuclear fuel, or 11e(2) byproduct wastes and is LLW as defined in DOE Manual 435.1-1. Soil/concrete samples were not collected for Am-241, Pu-238, or Pu-239/240 analysis as part of Waste Lot 4.12 because these TRU isotopes were eliminated as SRCs based on process knowledge and historical analytical data provided in the Waste Lot 65.1 profile (2004a). Soil/concrete samples collected for Waste Lot 4.12 characterization were analyzed for Np-237, which was eliminated as a SRC due to "less than 20% J-flag detection rate for all detected results." However, in order to demonstrate compliance with EMWMF Administrative Waste Acceptance Criteria (WAC), Table 1 conservatively incorporates the maximum concentrations from the Waste Lot 65.1 profile for the TRU isotopes that were eliminated as SRCs in this waste lot and assumes the maximum detection limit (DL) or estimated J-flagged result bounds the TRU isotope's activity/mass concentration in this waste lot. The sum of the TRU isotopes maximum DL or estimated J-flagged concentration of the waste is approximately 3.54E-04 nCi/g, which is approximately 6 orders of magnitude below the TRU waste criterion of 100 nCi/g. This waste lot will be managed and disposed as LLW.

Table 1. Total transuranics in Waste Lot 4.12

Isotope	Maximum concentration (pCi/g)	TRU isotopes (nCi/g)
Americium-241 ¹	2.13E-02	2.13E-05
Neptunium-237 ²	3.20E-01	3.20E-4
Plutonium-238 ¹	1.70E-03	1.73E-06
Plutonium-239/240 ¹	1.11E-02	1.11E-05
Sum of TRU isotopes	3.54E-01	3.54E-04

¹ Data taken from Waste Lot 65.1 profile

² Data taken from Waste Lot 4.12 Controlled Data Set

2.3 PROHIBITION OF FREE LIQUIDS

Waste Lot 4.12 contains radioactively contaminated soil, concrete, and incidental miscellaneous debris (vegetation, wood, scrap metal). Free liquids are not acceptable within individual waste packages or conveyances (dump trucks) offered for disposal at EMWTF. As a control measure, the Waste Packaging Specialist will perform a visual inspection for all waste containers/conveyances prior to shipment to ensure all waste meets the description provided in the approved waste profile and the waste and container meet applicable WAC and DOT requirements. Notwithstanding, prior to shipment, containers will be visually inspected to confirm the absence of free liquids.

2.4 RESOURCE CONSERVATION AND RECOVERY ACT

Based on analytical data and process knowledge, the waste for disposal at EMWTF does not contain listed wastes, nor was it mixed with or derived from a listed hazardous waste (see Appendix D). In addition, based on analytical data, waste included in Waste Lot 4.12 will not exhibit any Resource Conservation and Recovery Act characteristics as defined under 40 *Code of Federal Regulations (CFR)* 261.10–261.33. The cumulative evaluation of sampling and analysis data, prior knowledge of sources of the waste, and current sorting and segregation administrative controls in place have been thoroughly documented in this profile package. Since the waste lot has been determined to be RCRA non-hazardous low level waste (i.e., does not exhibit a RCRA-characteristic and is not RCRA-listed), the restrictions for disposing of waste containing concentrations of contaminants (i.e., Underlying Hazardous Constituents) listed in 40 CFR 268.48 do not apply.

2.4.1 Characteristics of Ignitability

The waste lot does not exhibit the characteristic of ignitability as defined by 40 CFR 261.21. The waste will not be a liquid or compressed gas and will not be capable, under standard temperature and pressure, of causing fire through friction, adsorption of moisture, or spontaneous combustion.

2.4.2 Characteristics of Corrosivity

The waste lot does not exhibit the characteristic of corrosivity as defined by 40 *CFR* 261.22. The waste will not be aqueous, nor will it be a liquid that corrodes steel at a rate greater than 6.35 mm/year.

2.4.3 Characteristics of Reactivity

The waste lot does not exhibit the characteristic of reactivity as defined by 40 *CFR* 261.23.

2.4.4 Characteristics of Toxicity

The waste lot does not exhibit the characteristic of toxicity as defined by 40 *CFR* 261.24. Table 2 summarizes the toxicity characteristic waste determination. Table 2 provides the maximum concentration for each RCRA constituent and compares it to the constituent's regulatory limit. Maximum concentration values are presented even if the constituent was not detected. (If the constituent was not detected, then the maximum detection limit was used for the comparison.) In cases where chemicals were analyzed for Total concentration rather than TCLP, the comparison was performed using the "20 times rule." Table 2 does not contain the results of concrete sampling. Fourteen Total Metal samples were collected from the concrete foundations/floor slabs. None of the metal concentrations in concrete exceeded 20 times the TCLP limit. Therefore, collection of TCLP Metal samples from concrete was not warranted.

Based on review of process knowledge information, the Waste Lot 4.12 Controlled Data Set, and Total/TCLP Metal/VOA/SVOA statistical summaries, ETTP D&D/RA Project Environmental Compliance has determined that this waste lot is not RCRA listed- or characteristic hazardous waste as attested by signature on the Waste Lot 4.12 profile approval page and information provided in Appendix D.

Table 2. RCRA Toxicity Characterization for Waste Lot 4.12

Contaminant	Units	Samples	Detects	Maximum Conc. ¹	Converted Maximum Result ²	Regulatory Limit (mg/L)	Exceeds TCLP Limit
Arsenic	mg/L	43	0	0.0317	N/A	5.0	N
Barium	mg/L	43	43	1.77	N/A	100.0	N
Benzene	mg/kg	42	4	0.006	0.0003	0.5	N
Cadmium	mg/L	43	25	0.096	N/A	1.0	N
Carbon tetrachloride	mg/kg	42	0	0.006	0.0003	0.5	N
Chlorobenzene	mg/kg	42	0	0.006	0.0003	100.0	N
Chloroform	mg/kg	42	6	0.003	0.00015	6.0	N
Chromium	mg/L	43	7	0.03	N/A	5.0	N
Cresol ³	mg/kg	43	4	0.58	0.029	200.0	N
1,4-Dichlorobenzene	mg/L	43	0	0.05	N/A	7.5	N
1,2-Dichloroethane	mg/kg	42	0	0.006	0.0003	0.5	N
1,1-Dichloroethylene	mg/kg	42	0	0.006	0.0003	0.7	N
2,4-Dinitrotoluene	mg/L	43	0	0.05	N/A	0.13	N
Hexachlorobenzene	mg/L	43	0	0.05	N/A	0.13	N
Hexachlorobutadiene	mg/L	43	0	0.05	N/A	0.5	N
Hexachloroethane	mg/L	43	0	0.05	N/A	3.0	N
Lead	mg/L	43	11	0.599	N/A	5.0	N
Mercury	mg/L	43	6	0.00015	N/A	0.2	N
Methyl ethyl ketone	mg/kg	42	14	0.045	0.00225	200.0	N
Nitrobenzene	mg/L	43	0	0.05	N/A	2.0	N
Pentachlorophenol	mg/L	43	0	0.12	N/A	100.0	N
Pyridine	mg/L	43	0	0.05	N/A	5.0	N
Selenium	mg/L	43	0	0.0413	N/A	1.0	N
Silver	mg/L	43	1	0.0074	N/A	5.0	N
Tetrachloroethylene	mg/kg	42	1	0.006	0.0003	0.7	N

Contaminant	Units	Samples	Detects	Maximum Conc. ¹	Converted Maximum Result ²	Regulatory Limit (mg/L)	Exceeds TCLP Limit
Trichloroethene	mg/kg	42	0	0.006	0.0003	0.5	N
2,4,5-Trichlorophenol	mg/L	43	0	0.12	N/A	400.0	N
2,4,6-Trichlorophenol	mg/L	43	0	0.05	N/A	2.0	N
Vinyl chloride	mg/kg	42	0	0.01	0.0005	0.2	N

¹ Maximum concentration reported regardless of detect or non-detect.

² Maximum Totals (mg/kg) result divided by 20 to produce RCRA TCLP comparison.

³ Represents collective assessment of 2-Methylphenol and 3- & 4-Methylphenol TCLP data.

2.5 TOXIC SUBSTANCES CONTROL ACT LAND DISPOSAL REQUIREMENTS

This waste lot does not include TSCA-regulated polychlorinated biphenyl (PCB) waste. Analytical data from both soil and concrete samples provided in Appendices C and G of this profile confirm the presence of PCBs, specifically Aroclor-1248, Aroclor-1254, and Aroclor-1260, with Total PCB concentrations of < 23 parts per million (ppm). All other aroclors were non-detects (i.e., U-flagged) or were screened out as a site related contaminant (SRC) per Appendix C of DOE 2001b.

2.6 INFECTIOUS WASTE PROHIBITIONS

As determined through process knowledge there is no evidence that infectious wastes is associated with Waste Lot Profile 4.12, nor will infectious waste be generated during the execution of this removal action.

2.7 PYROPHORIC MATERIALS PROHIBITION

As determined through process knowledge and historical data, there is no evidence that pyrophoric materials are present in Waste Lot Profile 4.12, nor will pyrophoric materials be generated during the execution of this removal action.

2.8 EXCLUSION OF WASTES CAPABLE OF DETONATION OR EXPLOSIVE DECOMPOSITION

As determined through process knowledge and historical data, there is no evidence that wastes capable of detonation or explosive decomposition are present in Waste Lot Profile 4.12 nor will wastes capable of detonation or explosion be generated during the execution of this removal action.

2.9 TOXIC GASES, VAPORS, OR FUMES PROHIBITION

There is no historical knowledge or sampling data evidence that wastes containing or capable of producing toxic gases, vapors, or fumes are included in this waste lot.

2.10 STRUCTURAL STABILITY DETERMINATION

Waste consisting of soil, concrete, miscellaneous debris, wood, miscellaneous metal, etc. will be packaged in lined dump trucks, for bulk disposal at EMWMF. Packaging and transportation of these items will not introduce additional external or internal void space. This material can be processed at EMWMF with heavy equipment (i.e., a D7 bulldozer) to achieve stability requirements listed in Table A.3 of the EMWMF administrative WAC (DOE 2001).

2.11 VOID SPACE REQUIREMENTS

Waste consisting of soil, concrete, miscellaneous debris, wood, miscellaneous metal, etc. will be packaged in lined dump trucks, for direct disposal at EMWMF. Packaging and transportation of these items will not introduce additional external or internal void space. This waste will not contain significant void space when disposed at EMWMF and will meet the void space requirements listed in Table A.3 of the EMWMF administrative WAC (DOE 2001).

2.12 CONTAINER VOID SPACE REQUIREMENTS

This waste lot consists of non-containerized waste transported to EMWMF dump trucks. This waste does not include containerized waste. Therefore, this requirement is not applicable.

2.13 AVERAGE TOTAL URANIUM LIMITS

The average total uranium activity concentrations present in the waste lot, as indicated by statistical analysis of radiological analytical data in Table 6 and Appendix F of this document, are summarized in Table 3. Average Total Uranium pCi/g concentrations do not exceed the respective limits defined in Table A.3 of the EMWMF administrative WAC (DOE 2001). Equations used to derive average ug/g or ppm from average pCi/g values are provided in Appendix E of this document.

Table 3. Total uranium concentration in Waste Lot 4.12

Isotope	Average concentration (pCi/g)	Concentration (ppm)
Uranium-233/234	39.45	6.4E-03
Uranium-235	5.07	2.30
Uranium-238	33.45	98.38
Total	77.97	100.69
WAC limits	7.14E+02	1.03E+03

2.14 CRITICALITY SAFETY EVALUATION

Criticality safety is not a concern for bulk shipments (i.e., dump trucks) based on the results of the Nuclear Criticality Safety EMWMF Material Screening Form shown in Appendix K. The requirements identified in Table A.3 of the EMWMF administrative WAC (DOE 2001) to maintain the containerized and bulk shipped waste in a subcritical condition during all phases of cell operation will be met. A formal NCSD is not required as indicated on the EMWMF Material Screen form.

2.15 TDEC WASTE CLASS

This waste offered for disposal at the EMWMF is classified as TDEC Class A waste based on Tennessee LLW regulations in TN1200-2-11-.17(6). The sampling data results (maximum concentration) were compared with the regulatory limits in the above regulations for both long-lived and short-lived radionuclides. The SOF is shown in Table 4 and Table 5. Given that the SOF for long-lived and short-lived radionuclides is less than 0.1 and 1.0, respectively, the appropriate waste classification is Class A.

Table 4. Tennessee LLW classification of long-lived radionuclides for Waste Lot 4.12

Radionuclide	Class A limit (pCi/g)	Maximum concentration (pCi/g)	Fraction
Carbon-14	4.70E+06	Not present	N/A
Carbon-14 in activated metal	4.70E+07	Not present	N/A
Nickel-59 in activated metal	1.38E+08	Not present	N/A
Niobium-94 in activated metal	1.20E+05	Not present	N/A
Technetium-99	1.80E+06	6.29E+02	3.49E-04
Iodine-129	4.70E+04	Not present	N/A
Alpha emitting transuranics ¹	1.00E+05	3.54E-01	3.54E-06
Plutonium-241	3.50E+06	Not present	N/A
Curium-242	2.00E+07	Not present	N/A
Sum of fractions			3.53E-04

¹ Alpha emitting transuranics is summation of Am-241, Np-237, Pu-238, and Pu-239/240 maximum DL concentrations; LLW = low-level waste; N/A = not applicable

Table 3. Tennessee LLW classification of short-lived radionuclides for Waste Lot 4.12

Radionuclide	Class A Limit (pCi/g)	Maximum concentration (pCi/g)	Fraction
Total all nuclides $T_{1/2} < 5$ years	4.50E+08	N/A	N/A
Hydrogen-3	2.60E+07	Not present	N/A
Cobalt-60	4.50E+08	1.87E+00	4.16E-09
Nickel-63	2.20E+06	Not present	N/A
Nickel-63 in activated metal	4.10E+09	Not present	N/A
Strontium-90	4.10E+09	Not present	NA
Cesium-137	2.70E+09	2.86E+01	1.06E-08
Sum of fractions			1.58E-08

LLW = low-level waste

N/A = Not applicable

UCL = upper confidence limit on the mean

3. ANALYTIC WAC COMPLIANCE

This waste lot was characterized in accordance with *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2008b), provided in Appendix E of this profile. Appendix E also contains a map showing the locations of the samples used to characterize this waste lot. This sample and analysis plan (SAP) was developed to provide data of known quality for use in determining the final disposal path for the waste in this waste lot using the historical data and process knowledge summarized in Appendix B and was approved by the Remedial Action Core Team (see Appendix B). A comprehensive set of analyses was performed on the samples collected from the waste in this waste lot. Project personnel performed a cross-check of sampling and analysis prescribed in the SAP with the analytical results performed upon receipt of the analyses from the laboratories.

All samples prescribed in the SAP were collected and analyzed, with the exception of one (1) random composite soil sample that was to be collected for Total VOA analysis. The ETTP D&D/RA Project Core Team was notified of this deviation and the results of the Data Quality Assessment (DQA) performed on data used to characterize this waste lot. Core Team meeting minutes documenting this discussion are included in Appendix B of this profile. The evaluation of Data Quality Objectives (DQOs) in Appendix F and the DQA in Appendix G considered this deviation. It was concluded that the DQOs were met and this deviation had no impact on the ability to characterize this waste lot for EMWMF disposal. Also, since the decision to include the residual metallic debris in this waste lot was made after the characterization sampling was completed, it has been determined that the characterization sampling can serve as an upper-bound proxy for this small percentage of the waste lot (estimated at 5%). See Appendix B for the justification for this determination.

Additionally, soil samples collected to characterize this waste lot were not analyzed for the metals strontium and tin. Historical data indicate that these metals may be present in the waste lot soils at very low concentrations. However, for the reasons cited in Appendix B, historical data are not considered reliable and were not used to quantitatively characterize this waste lot. To characterize these two metals in the soils in this waste lot, the EMWMF Waste Lot 65.1 profile (BJC 2004) was reviewed (see Appendix B). Samples of metallic debris in the scrap yard were analyzed for strontium and tin in the EMWMF Waste Lot 65.1 profile. Strontium was not detected. Based on these results, the Project concluded that strontium was not present in the waste lot soils. Tin was detected in the EMWMF Waste Lot 65.1 profile. Based on these results, the Project concluded that tin was present in the waste lot soils. Tin was quantitatively characterized for this waste lot by incorporating the input values for tin in the Waste Lot 65.1 Waste Acceptance Criteria Forecasting Analysis Capability Systems (WACFACS) in the WACFACS input for this waste lot.

In general, 32 systematic random composite samples, 13 biased composite samples, and 4 field replicate composite samples were collected from the K-770 soils for individual/Total PCB analysis, Total/TCLP Semi-Volatile Organic Analysis (SVOA), Total/TCLP Metals analysis, and Radiological Parameters analysis. 31 of the 32 systematic random composite soil samples, 13 of the 13 biased composite soil samples, and 3 field replicate soil samples were collected for Total Volatile Organic Analysis (VOA). In addition, 14 systematic random samples and 1 field replicate sample were collected from K-770 Scrap Yard concrete pads for Total Metals analysis, individual/Total PCB analysis, and Radiological Parameters analysis. Total Pesticide/Herbicide samples were not collected based on process knowledge. Justification for sampling and analytical approaches is provided in SAP Sections 3.0 and 4.0, respectively.

Samples collected in accordance with the approved SAP were submitted to Sample Management Office-approved laboratories for analysis in accordance with the analytical methods presented in the SAP.

Results for solid matrices were required on a dry-weight basis. All data (i.e., 100%) were reviewed for quality assurance and quality control, and all data results used in this profile were validated. For the purposes of waste lot characterization and development of this waste lot profile, SAP chemical/radiological sample data were used to identify and delineate the extent of chemical and radiological contamination in the waste lot. Sample results for two biased composite soil samples (Z1-EU33BW-442 and Z1-EU33BW-445) were not included in the Controlled Dataset for this waste lot due to elevated Tc-99 pCi/g concentrations, and the soils associated with these sample locations have been identified as anomalous waste in Appendix A. Np-237 results for biased composite soil sample EU32BW-433 and its replicate sample were rejected due to the replicate sample Relative Percent Difference being out of range, possibly due to uranium interference. Review and analysis of Total VOA data identified 2-Butanone (MEK), and Acetone as SRCs with maximum and UCL95 concentrations below 0.5 mg/kg; therefore, the omission of 1 additional Total VOA result for the sample not collected does not have any impact on EMWMF Analytical WAC Sum of Fractions (SOF). All remaining sample data were complete, useable, and sufficient to adequately assess EMWMF Analytical WAC compliance (see Appendix G).

Analytical data and process knowledge are presented in the Controlled Data Set, Appendix G (Data Quality Assessment) and Appendix B (Process Knowledge) of this profile. The controlled data set has been provided to the EMWMF Waste Acceptance Criteria Attainment Team. The data were used to identify SRCs and incorporate the reported values into the Waste Acceptance Criteria Forecasting Analysis Capability System (WACFACS). Guidance prescribed in Appendix B of the EMWMF WAC Attainment Plan (DOE 2001) was used exclusively to demonstrate analytical WAC compliance. The output of WACFACS provides evidence that this waste is within acceptable limits, as discussed below. The Shapiro-Wilk (S-W) Test, as described in Appendix C of the EMWMF WAC Attainment plan, was used for evaluating all analytes containing under 50 data points to demonstrate analytic WAC compliance. For all PERT beta-distributed data sets "Upper 95th Confidence Interval Calculations for a PERT Beta PDF", Redus & Associates, was used to determine UCL₉₅ values. The test results, sample calculations, and raw data spreadsheets, created from the analytical data sets, have been included in Appendix G for reference.

Table 6 provides the specific number of samples and detects for SRCs related to this waste lot. Appendix E has the complete data set used to develop Table 6.

Table 6. Waste Lot 4.12 K-770 Scrap Yard Soils EMWMF SRC Summary Statistics

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	E(X)	UCL95
Tc-99	pCi/g	57	37	1.290	4.310	629.000	20.26	B			107.92	287.20
U-233/234	pCi/g	57	56	0.110	10.200	1360.000	39.45	LN	2.061	1.626	29.50	54.43
U-235	pCi/g	57	44	0.050	1.080	185.000	5.07	LN	-0.120	1.647	3.44	6.45
U-238	pCi/g	57	57	0.430	7.650	1150.000	33.45	LN	1.841	1.659	25.00	47.09
Antimony	mg/kg	57	35	0.115	0.500	65.100	2.01	B			11.20	29.79
Barium	mg/kg	57	57	31.300	71.500	395.000	80.37	B			118.72	231.87
Boron	mg/kg	57	57	1.900	5.900	39.100	7.43	LN	1.798	0.625	7.34	8.64
Chromium	mg/kg	57	57	9.700	26.000	2880.000	102.74	B			498.95	1319.51
Lead	mg/kg	57	57	2.900	38.800	733.000	60.60	LN	3.380	1.279	66.50	97.11
Manganese	mg/kg	57	57	59.200	496.000	2210.000	618.75	LN	6.192	0.734	640.00	781.20
Molybdenum	mg/kg	57	57	0.690	2.700	69.200	5.56	B			13.45	33.51
Selenium	mg/kg	57	12	0.230	0.275	25.700	0.82	B			4.51	11.75
Tin	mg/kg	42	14	15.500	23.200	232.000	37.400	B			56.700	120.000
Vanadium	mg/kg	57	57	8.000	21.800	52.900	22.29	N		9.428	22.29	24.38
2-Methylnaphthalene	mg/kg	43	30	0.020	0.071	0.300	0.10	B			0.10	0.19
3 & 4 Methylphenol	mg/kg	43	4	0.019	0.190	0.580	0.19	B			0.23	0.41
Acenaphthene	mg/kg	43	14	0.019	0.185	1.200	0.17	B			0.33	0.70
Acenaphthylene	mg/kg	43	5	0.019	0.190	0.205	0.17	B			0.16	0.20
Acetone	mg/kg	42	31	0.004	0.026	0.260	0.06	B			0.06	0.14
Benzoic Acid	mg/kg	43	17	0.022	0.185	0.290	0.15	B			0.18	0.25
Carbazole	mg/kg	43	16	0.021	0.190	1.100	0.16	B			0.31	0.66
Naphthalene	mg/kg	43	21	0.019	0.180	0.205	0.12	B			0.16	0.20
Phenol	mg/kg	43	7	0.023	0.190	1.100	0.19	B			0.31	0.66

EMWMF = Environmental Management Waste Management Facility; E(X) = expected concentration in waste lot; N = number of samples; LN = lognormal, N = normal, B = PERT beta; PDF = probability density function; SOF = sum of fractions SRC = site-related contaminant; UCL₉₅ = 95% upper confidence limit on the mean; MOC = Material of Construction; NA = Not Applicable; Standard Deviation = standard deviation of data for normal distribution and standard deviation of log transform for lognormal distribution

Appendix G (Data Quality Assessment) of this profile provides the basis for elimination of all EMWMF analytic WAC SRCs in accordance with the WAC Attainment Plan (DOE 2001). Numerous chemicals and radiological isotopes were eliminated either: 1) there were no detects (i.e., all U-flag data), 2) J-flags only were present in less than 20% of the "detected" samples, and 3) detected chemical and/or isotopes (non U- or J-flagged laboratory qualifier codes or data validation codes) were present in less than 5% of the sample data and the reported results were less than 2 times the detection limit ($2 \times \text{DL}$). Chemicals and/or isotopes eliminated based on process knowledge were: 1) either not identified in the SAP as potential contaminants of concern for disposition under this EMWMF waste lot or are not expected to be present in the debris waste, 2) based on process knowledge of past operations, or 3) certain SRCs were analyzed in other ETTP facilities and not detected thus there is logic that they would also not be present in this waste lot.

Data for the SRCs that were not eliminated based on analytical results were then evaluated statistically to determine concentrations (i.e., minimum, arithmetic mean, median, and maximum), probability distribution functions (i.e., normal, log-normal, or PERT beta), and the UCL₉₅ concentration. U.S. Environmental Protection Agency (EPA) software (ProUCL v4.00.02) and Redus & Associates QND software were used to analyze data. Statistical summaries and detail are provided in Appendix G. These data were used in WACFACS to determine the SOFs for the waste lot.

3.1 CARCINOGENIC WAC SRCs

The WACFACS data input sheet is included in Appendix G. The carcinogenic SOF is 0.67 and the UCL₉₅ SOF is 1.71. Tc-99, U-233/234, and U-238 contributes > 1% of its respective CA WAC limit. Refer to Appendix H for the WACFACS VWSF Transmittal letter.

3.2 HAZARD INDEX WAC

The WACFACS data input sheet is included in Appendix G. The Hazard Index SOF is 0.17 and the UCL₉₅ SOF is 0.37. U-238, antimony, lead, and tin each contribute 1% or greater of its respective HI WAC limit. Refer to Appendix H for the WACFACS VWSF Transmittal letter.

3.3 CARCINOGENIC WAC 3-YEAR VWSF COMPLIANCE

The expected carcinogenic volume-weighted SOF (VWSF) for this waste lot is 7.20E-03. Refer to Appendix H for the WACFACS VWSF Transmittal letter.

3.4 HAZARD INDEX WAC 3-YEAR VWSF COMPLIANCE

The expected Hazard Index VWSF for this waste lot is 1.84E-03. Refer to Appendix H for the WACFACS VWSF Transmittal letter.

4. ASA-DERIVED WAC COMPLIANCE

The Auditable Safety Analysis (ASA) Radiological SOF for this waste lot was calculated using the UCL₉₅ of each SRC (unless otherwise noted) in the waste and was divided by the ASA limits listed in Table A.2 of the EMWMF WAC (DOE 2001). Table 7 summarizes the SOFs of radionuclide SRC UCL₉₅ to the EMWMF ASA-derived WAC. The calculated ASA total SOF is 1.60E-03. Since the ASA total SOF is <0.05, no further consideration is needed.

Table 7. Radiological ASA sum of fractions for Waste Lot Profile 4.12

Isotope	UCL ₉₅ concentration (pCi/g)	ASA WAC concentration (pCi/g)	ASA SOF (UCL ₉₅ /WAC)
Cs-137	1.31E+01	1.50E+06	8.71E-06
Co-60	1.40E-01	6.90E+06	2.03E-08
K-40	1.44E+01	4.20E+06	3.44E-06
Tc-99	2.87E+02	4.20E+07	6.84E-06
Th-228	1.24E+00	2.5E+04	4.96E-05
Th-232	1.13E+00	2.5E+03	4.52E-04
U-233/234	5.44E+01	1.00E+05	5.44E-04
U-235	6.45E+00	1.00E+05	6.45E-05
U-238	4.71E+01	1.00E+05	4.71E-04
Total ASA Sum of UCL₉₅ Fractions			1.60E-03

ASA = Auditable Safety Analysis

SOF = sum of fractions

UCL₉₅ = 95% upper confidence limit on the mean

WAC = waste acceptance criteria

Chemical SRCs are shown in Table 8 below. This table presents the waste lot ASA chemicals of concern with Reportable Quantities and their respective UCL-95 mg/kg value.

**Table 8. Chemical SRC concentrations
for Waste Lot Profile 4.12**

Chemical	UCL ₉₅ value (mg/kg)
Antimony	29.79
Arsenic	8.10
Barium	231.67
Beryllium	1.12
Cadmium	3.56
Chromium	1,319.51
Copper	592.50
Lead	97.11
Mercury	7.80
Nickel	220.10

**Table 8. Chemical SRC concentrations
for Waste Lot Profile 4.12**

Chemical	UCL₉₅ value (mg/kg)
Selenium	11.75
Silver	0.66
Tin	120.7
Vanadium	24.38
Zinc	571.60
PCB-1248	3.96
PCB-1254	3.66
PCB-1260	1.45
Total PCBs	10.90
2-Butanone (MEK)	0.02
2-Methylnaphthalene	0.19
3&4 Methylphenol	0.41
Acenaphthene	0.70
Acenaphthalene	0.20
Acetone	0.14
Anthracene	1.54
Benz(a)anthracene	4.65
Benzo(a)pyrene	3.83
Benzo(b)fluorathene	3.46
Benzo(ghi)perylene	2.60
Benzo(k)fluoranthene	3.74
Benzoic Acid	0.25
Bis-(2-ethylhexyl)phthalate	63.20
Butyl benzyl phthalate	6.49
Carbazole	0.66
Chrysene	4.52
Dibenz(ah)anthracene	1.06
Dibenzofuran	0.38
Di-n-octylphthalate	0.41
Fluoranthene	11.9
Fluorene	0.70
Indeno(123cd)pyrene	2.36
Naphthalene	0.20
Phenanthrene	5.11
Phenol	0.66
Pyrene	7.39

SRC = site related contaminant

5. PHYSICAL WAC COMPLIANCE

To ensure compliance with the following physical WAC requirements and to ensure all waste meets the description provided in this waste lot profile, the ETTP D&D/RA Project will generate and manage waste in accordance with BJC project-specific and company-level plans and procedures, as follows:

- *Waste Management Plan for the ETTP Closure and ETTP D&D Projects at the East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004b),
- Oak Ridge Reservation Waste Certification Program Plan (BJC 2001),
- Generator Requirements for Transferring Waste (BJC-WM-2001), and
- *Technical Information for Delivery of Waste to the Environmental Management Waste Management Facility* (BJC 2007).

5.1 CONTAINER REQUIREMENTS

This waste lot will be transported to EMWMF primarily by use of bulk packages/conveyances (i.e., dump trucks, flat bed trucks, super sacks, and intermodal containers) for direct disposal at EMWMF. EMWMF WAC container requirements will be met.

5.2 SIZE REQUIREMENTS

This waste lot will meet the physical size requirements listed in the EMWMF WAC (BJC 2007). All materials shall fit within roll-offs, dump truck, intermodal, or supersack container. All single debris items shall have dimensions less than 4' x 4' x 6'.

5.3 WEIGHT REQUIREMENTS

This waste lot will meet the weight requirements listed in the EMWMF Physical WAC (BJC 2007). All single debris items will weigh less than 24,000 pounds

5.4 CONCRETE DEBRIS REQUIREMENTS

All concrete debris included in this waste lot will be transported by dump truck, intermodal container, or super sacks, and will be capable of direct placement in the cell. Concrete items will be reduced to a maximum dimension of 1 foot or be shipped as large blocks with the rebar cut flush with the concrete block surface to the maximum extent practical. Therefore, EMWMF WAC concrete debris requirements will be met.

5.5 STEEL PLATE REQUIREMENTS

This waste lot will contain steel plates. The maximum dimension of the steel plate will be less than the minimum inside dimensions of the haulage container. Further, the steel plates will not be bent or forced into a container and shall not extend above the top of the container. Therefore, EMWMF WAC steel plate requirements will be met.

5.6 PIPE REQUIREMENTS

All small diameter pipe (less than or equal to 6 inches diameter) generated under this waste lot will meet the EMWMF physical WAC (less than 8 feet in length, segregated, and transported in dump trucks or intermodal containers as unique shipments; or less than 15 feet length, segregated, bundled, secured to pallets, and transported by flat bed truck as unique shipment). Any pipe greater than 6 inches in diameter and any pipe greater than 12 inches in diameter will be managed in accordance with the EMWMF WAC. See Appendix I for the blanket variance EMWMF-BV-07-01 that will be invoked for Waste Lot 4.12.

5.7 ASBESTOS- AND BERYLLIUM DUST-CONTAINING WASTE REQUIREMENTS

Process knowledge indicates that this waste lot could include items containing friable and non-friable asbestos materials. Any asbestos-containing materials identified will be sent for disposal in accordance with the PWAC or an approved variance request. The project intends to invoke blanket variances EMWMF-BV-08-01 and EMWMF-BV-08-02, as applicable, for the packaging, transport, and disposal of items containing asbestos. These variances are included in Appendix I. Decisions regarding the generation and packaging of ACM will be made under the direction of a certified industrial hygienist/AHERA inspector.

No beryllium containing waste is present in this waste lot and the beryllium dust containing waste requirement is not applicable. [Some of the waste may contain very low concentrations of beryllium (<2 ppm). These concentrations are well below the level required to define this waste as "beryllium waste material" (>1000 ppm) under the appropriate BJC procedure.] Additional supporting information is provided in Appendix B.

5.8 MISCELLANEOUS DEBRIS REQUIREMENTS

Miscellaneous debris will be size-reduced to meet EMWMF physical WAC and strategically loaded for direct disposal (burial) at the EMWMF. The EMWMF miscellaneous debris requirement will be met.

5.9 CONTAINERIZED COMPACTABLE WASTE

Compactable debris waste generated as part of this waste lot is expected to be disposed of in bulk via dump truck or intermodal container or super sacks. Any empty containers will be crushed and/or size-reduced by the generator prior to delivery to EMWMF. Therefore, EMWMF WAC containerized compactable waste requirements will be met.

5.10 REBAR REQUIREMENTS

It is possible that rebar will be encountered during the demolition of the concrete slab foundations of the buildings. If rebar is encountered, it will be handled in accordance with approved variance EMWMF-VR-144 (included in Appendix I). This includes removing as much concrete as practicable from the rebar, cutting rebar to lengths less than 4-feet long, and shipping this waste with debris generated during this time.

5.11 NONCRUSHABLE CONTAINER REQUIREMENTS

Waste generated as part of this waste lot is expected to be disposed of in bulk via dump truck or intermodal container or super sacks. Any empty containers will be crushed and/or size-reduced by the generator prior to disposal. Non-crushable container will not be used, therefore this requirements is not applicable.

5.12 CONTAINER LINER REQUIREMENTS

Containers used to transport this waste lot will be lined in accordance with the requirements of the EMWMF physical WAC (BJC 2007).

5.13 DOSE RATE REQUIREMENTS

All unshielded contact dose rates for Waste Lot 4.12 containers will be below the EMWMF WAC limiting dose rate of 200 mrem/h on contact. The final DOT survey will document that no container exceeded 10 mrem/h at 2 meters from any surface of the container. Final dose rate measurements prior to shipment will be conducted to ensure compliance with DOT requirements and the EMWMF WAC.

6. CERCLA DOCUMENTATION

Applicable sections of Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE 2002), Waste Handling Plan, Part II for the K-770 Soils within Zone 1 East Tennessee Technology Park, Oak Ridge, Tennessee (DOE 2006), Waste Handling Plan, Part II for the East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE 2004), and Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE 2005) are provided in Appendix J.

7. REFERENCES

- BJC (Bechtel Jacobs Company LLC) 2001. *Oak Ridge Reservation Waste Certification Program Plan*, BJC/OR-57, Bechtel Jacobs Company LLC, Oak Ridge, TN.
- BJC 2004a. *Waste Profile for Disposal of the Scrap Metal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1857, Rev. 1, Bechtel Jacobs Company LLC, Oak Ridge, TN.
- BJC 2004b. *Waste Management Plan for the ETPP Closure and ETPP D&D Projects at the East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1678, Bechtel Jacobs Company LLC, Oak Ridge, TN.
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- BJC 2008a. *Waste Acceptance Criteria Attainment Team Project Execution Plan Environmental Management Waste Management Facility, Oak Ridge Reservation, Tennessee*, BJC/OR-1091, Rev. 4, Bechtel Jacobs Company LLC, Oak Ridge, TN.
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- DOE (US Department of Energy) 2001. *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1909&D3, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.
- DOE 2002. *Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-1997&D2, Office of Environmental Management, Oak Ridge, TN.
- DOE 2004. *Waste Handling Plan, Part II for the ETPP Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-2162&D2, Office of Environmental Management, Oak Ridge, TN.
- DOE 2005. *Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-2263&D2, Office of Environmental Management, Oak Ridge, TN.
- DOE 2006. *Waste Handling Plan, Part II for the K-770 Soils within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-2148&D2, Office of Environmental Management, Oak Ridge, TN.

APPENDIX A
WASTE ANOMALY DETECTION PLAN AND CHECKLIST

ANOMALY DETECTION PLAN FOR WASTE LOT 4.12

Introduction

This plan describes project personnel responsibilities and training requirements and identifies actions that the ETTP D&D/RA Project will conduct in order to ensure that no anomalous waste from the K-770 Scrap Yard is sent to the EMWMF. Any suspect, or identified, anomalous waste will be segregated and managed separately after review by trained project personnel with consultation from the EMWMF WAC Attainment Team as needed.

The wastes included in this waste lot are collectively referred to as the "K-770 Scrap Yard Soils" and consist of waste items as shown in the expected waste types in the Anomaly Detection Checklist. The anomaly detection process for this waste lot will rely principally on visual inspections, and sorting/segregation of the wastes prior to shipment. Additionally, an understanding of the remediation logic is important from an anomaly detection perspective because the approach that will be implemented minimizes the likelihood that EMWMF anomalous waste will be included in this waste. Most EMWMF anomalous waste is expected to be debris items. Debris items unearthed during soil excavation will be segregated and staged. Debris items will be sent for disposal upon conclusion of soil shipments. This allows for additional scrutiny of debris items for potentially-anomalous conditions, if necessary.

One example of an anomalous debris item is a Cs-137 cask. Three casks were discovered at random locations in the K-770 Scrap Yard area during the Scrap Remediation Project. These casks were cylindrical, nominally 20 in. in diameter, and 26-28 in. long. The casks were constructed of ½ in. to ¾ in. steel or poured concrete and were estimated to weigh 3,300-3,400 lbs. Photos of the steel cask and the suspected concrete cask are included in this ADP for reference. If a suspected cask is observed, work activities in the immediate area are to cease and workers removed. Project Waste Management will then be contacted.

Based on analytical data collected in accordance with BJC/OR-3088, *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee*, two distinct soil areas have been identified as anomalous waste due to elevated Tc-99 pCi/g concentrations. These soils areas are associated with Sample Locations Z1-EU33BW-442 (2,710 pCi/g Tc-99) and Z1-EU33BW-445 (40,600 pCi/g Tc-99). These locations are indicated on the site map included in this ADP. Soils within these areas will be excavated, packaged (in ST-90 containers), and controlled per BJC-WM-2001 before the generation of waste in this profile commences. Soil sampling will be performed to confirm that remaining soil is within the limits of this profile. This confirmation will be a comparison of Tc-99 levels in the soil with the UCL₉₅ values in the profile. The anomalous waste is expected to be included in off-site DOE or commercial site waste profiles for disposal.

An Anomalies Risk Scoring Checklist has been completed for this waste lot (see below). The risk score has concurrence from ETTP D&D/RA Project Quality Assurance and the Waste Packaging Specialist for this waste lot. This waste lot has been determined to have a high risk of anomalies. This high risk score is primarily due to the potential hazards and the potential impacts at the EMWMF of an undetected Cs-137 cask. Because of the size and weight of a cask, it is unlikely that it would be undetected during a shallow soil excavation project. This has been considered in the graded approach to the rigor and Quality Assurance implementation required by this plan. The anomalous waste detection process employed by the ETTP D&D/RA Project is depicted in Fig. A.1

ETTP D&D/RA Project
EMWMF Anomalous Waste Detection Process

Fig. A.1. EMWMF anomalous waste detection process

Responsibilities

Personnel roles and responsibilities associated with execution of this plan are listed below. All personnel shall report non-conformances.

Waste Coordinator (WC)

Identify via profile description and other available information waste items authorized for disposal under this profile;

Ensure that the Waste Packaging Specialist is aware of the waste items that are authorized under this waste lot and any associated secondary waste;

Ensure that waste items offered for disposal under the Waste Lot 4.12 profile have been subjected to 100% visual inspection, sorting, and segregation prior to packaging and shipment of the wastes; and

Ensure that non-conformance actions are implemented.

Waste Packaging Specialist (WPS)

Conduct 100% visual inspection of individual waste items prior to and during sorting/segregation/packaging activities;

Ensure waste is placed in proper packages;

Apply a tamper indication device (TID) to package after filling if being staged prior to shipment;

Complete and sign the waste certification statements.

Field Personnel

At the direct instruction and oversight from the WPS, place waste items into an approved package

Transportation Specialist (TS)

Prepare shipping papers based on information received from WC and WPS and coordinate shipment to the EMWMF.

Training

Prior to commencement of the waste packaging activities, all field personnel will be briefed on the Waste Profile Anomaly Detection Plan, Waste Lot Anomaly Detection Checklist, list of items authorized for disposal, and Work Package or other requirements document(s) used to execute fieldwork associated with waste disposal under this profile. This training will include:

- Potential anomalies for this waste lot (using pictures and/or physical examples),
- How to identify anomalous waste, and

- How to respond to anomalous waste (e.g., segregate anomalous waste from remaining items or suspend work until the potential anomaly can be addressed by qualified Waste Management project personnel).

Workers performing the waste packaging activities, and generating this waste lot, will be periodically trained to recognize anomalous waste. This training may be conducted in the “plan-of-the-day meetings or tailgate briefings. In addition to the above training, workers will be directed to review:

Lessons Learned

- posted materials in break rooms and other traffic areas to maximize recognition and awareness of anomalous waste issues and response actions, and
- review of photographs and other visual aids associated with non-conforming waste items found or potentially present.
- Workers will be prompted at these meetings to inform managers of the number and types of anomalies that required removal prior to packaging the waste for transport the previous day.

Additionally, the WC and each WPS will be required to read the EMWMF Waste Lot 4.12 profile and the WAC Attainment Plan (DOE/OR/01-1909&D3) prior to certifying the waste in this waste lot for disposal.

Anomalies Risk Scoring Checklist for EMWMF Waste Lot 4.12		Date 4/1/09	
Risk Criteria		Score (1 to 9)	
<p>Likelihood of waste lot to have anomalies.</p> <p>9 – Extremely likely -0.95 probability of anomalies in the waste lot</p> <p>7 – Very likely – 0.75 probability</p> <p>5 – Likely – 0.5 probability (50 – 50 chance)</p> <p>3 – Unlikely – 0.25 probability</p> <p>1 – Very unlikely – 0.05 probability (almost no probability of anomalous waste)</p>		<p>9– Walk-downs, review of process knowledge (including previously approved/drafted waste profiles) confirm that anomalous waste items are in this waste lot.</p>	
<p>Difficulty in detecting anomalies in the waste lot. The likelihood of a failure to detect an anomaly. Examples of factors that affect this are presence of soils or other conditions that minimize visual differences and the amount of different types of materials combined together.</p> <p>9 – Extremely likely -0.95 probability of an anomaly could be undetected</p> <p>7 – Very likely – 0.75 probability</p> <p>5 – Likely – 0.5 probability (50 – 50 chance)</p> <p>3 – Unlikely – 0.25 probability</p> <p>1 – Very unlikely – 0.05 probability (almost no probability of detection failure)</p>		<p>3– Anomalous waste items are easily detected (especially Cs-137 casks), based on visual inspections (size and weight of anticipated anomalous waste items, no evidence of intentional burial at the site, etc.), radiological surveys, excavations will be shallow, and, sorting/segregation of residual metallic debris items.</p>	
<p>Potential hazards associated with likely anomalies. The likelihood of the potential hazards, if brought in contact with workers could cause significant harm to those workers.</p> <p>9 – Extremely likely -0.95 probability to cause extreme worker harm</p> <p>7 – Very likely – 0.75 probability</p> <p>5 – Likely – 0.5 probability (50 – 50 chance)</p> <p>3 – Unlikely – 0.25 probability</p> <p>1 – Very unlikely – 0.05 probability (almost no probability of any harm to workers)</p>		<p>9– An undetected Cs-137 cask could result in a significant potential hazard. However, the other K-770 Scrap Yard Soils materials contain only minor amounts or residual surface contamination. Safety documentation and Radiological Work Permits (RWPs) will define PPE requirements and administrative/ engineering controls to ensure protection of workers involved in waste packaging, transportation, and disposal activities.</p>	
<p>Potential impact of likely anomalies on cell performance and the environment. The likelihood that undetected anomalies, if found in EMWMF would require EMWMF shutdown for removal to minimize environmental insult and/or noncompliance with regulations.</p> <p>9 – Extremely likely -0.95 probability</p> <p>7 – Very likely – 0.75 probability</p> <p>5 – Likely – 0.5 probability (50 – 50 chance)</p> <p>3 – Unlikely – 0.25 probability</p> <p>1 – Very unlikely – 0.05 probability</p>		<p>9 – An undetected Cs-137 cask would likely result in a noncompliance with regulations governing the EMWMF. However, other anomalies would have minimal impact on cell performance or environment expected from undetected anomalous waste items being received at the EMWMF.</p>	
Total		30	
Prepared by	Marshall Davenport <i>MD</i>	Date	4/1/09
Quality Engineer Review	<i>Jim Moore</i>	Date	4/2/09
Waste Packaging Specialist Review	<i>Jim Moore</i>	Date	4-2-9

Waste Packaging, Inspection, And Certification

All waste items will be subjected to a process consisting of 100% visual inspection by the WPS to identify anomalous wastes. Anomalous waste items will be sorted and segregated from acceptable waste items. Waste inspection, screening, packaging, and certification activities will be implemented using a graded approach based on risk to workers, the environment, and the public. All waste generation activities and loading of each container/shipment will be conducted under the supervision of a qualified WPS. The WPS will ensure that packaging requirements (e.g., minimization of void space, weight limits, conveyances are lined, as required, etc.) are met and that no anomalous waste is present in each shipment. If necessary, an absorbent material will be added to waste items and/or bulk shipment loads to prevent the buildup of free liquids during subsequent staging and/or transport to EMWMF.

Specific debris waste items in Waste Lot 4.12 will be identified and segregated. Visual inspection will be used to confirm the absence of free liquids or other prohibited items. Field verification screening methods that will be used to detect anomalies will primarily involve: visual inspection of the waste items to confirm that free liquids have not been introduced and to confirm EMWMF physical WAC compliance.

All anomalous waste items will be segregated from this waste lot, evaluated, and disposed accordingly. In the event that an anomalous item is identified after packaging and during loading of a conveyance to EMWMF, waste packaging operations will be suspended and the anomalous item will be removed and set aside for further evaluation by the project Waste Coordinator. An Anomaly Detection Checklist will be completed for each shipment of Waste Lot 4.12 wastes, certifying that all waste is in compliance with this profile. The WPS will sign the checklist prior to the waste leaving the site.

Process Validation Assessments

Process validation assessments will consist of two activities: examination of leading indicators and waste generation assessments. Leading indicators will be compiled when anomalous waste is detected and removed from packages or identified at the EMWMF. Documentation of items removed will be compiled into an ETPP D&D/RA Project "anomalous waste list." As the anomalous waste list is updated, the Project Waste Coordinator (or designee) will examine the types and number of anomalous waste items removed, and the time intervals between items requiring removal. This examination should also include information relayed through informal communications from those individuals involved in waste segregation/loading activities. An example of this type of information could concern significant or numerous potentially anomalous waste items requiring segregation for additional evaluation. The results of these examinations determine if this ADP needs to be revised, if the waste lot requires additional characterization, and/or more frequent waste generation assessments need to be conducted. The results of these examinations will also be provided to the Waste Packaging Specialists and other field personnel via updated training and/or plan of the day meetings.

An initial waste generation assessment/walk-down will be conducted by the ETPP D&D/RA Project Waste Coordinator, or designee, prior to the initial shipments of the waste to the EMWMF. A representative from ETPP D&D/RA Project Quality Assurance and Environmental Compliance will be invited to participate in these assessments/walk-downs, but because this is considered a high-risk waste lot only because of the impacts of an undetected Cs-137 cask, this participation is not required. This assessment/walk-down is expected to consist of an inspection of the preparation of the first two bulk containers for receipt of waste and inspection/observation of the waste to be loaded into the bulk containers. Prior to the initial bulk container leaving the site, the Waste Coordinator (or designee) will hold informal discussions with the Waste Packaging Specialist and the Transportation Specialist to ensure they are confident that: the waste conforms to the EMWMF WAC and the Waste Lot 4.12 profile requirements; shipping paperwork is in order; and any concerns have been satisfactorily addressed. In

addition to the assessment/walk-down stated above, the project expects to conduct additional assessments/walk-downs:

- Quarterly,
- Upon restart of waste loading activities that were terminated for a significant period of time (over one month);
- If it is determined, based on worker input (or other leading indicators), that the character of the waste lot has changed; or
- If activities required by a corrective action plan, written in response to significant or repeated undetected anomalies are discovered at the EMWMF.

These additional assessments are expected to be similar in scope to the initial assessments described in this plan with one additional evaluation. Waste Packaging Specialists will be interviewed regarding the types and numbers of anomalous items identified and removed during the packaging of waste. At this time, documentation of anomalous waste (using the completion of the BJCF-860 documentation of items removed) will also be reviewed. The results of this assessment will be evaluated to determine if this ADP needs to be revised, if the waste lot itself needs additional characterization, and/or more frequent assessments (focusing on anomalous waste) need to be conducted.

Waste Lot Anomaly Detection Checklist:

Waste Lot 4.12: K-770 Scrap Yard Soils

Expected Waste Types: This waste lot includes soils, residual metallic and other debris, and secondary wastes (tyvek, gloves, used personal protection equipment, wipes, used radiological signage, etc.). Expected waste items may include: soil, metallic debris items, concrete, rebar, asbestos-containing material (e.g. exterior transite panels, pipe insulation), small diameter pipe (with and without insulation), structural and miscellaneous wood (railroad ties, lumber), conduit and/or wire, incidental plastic, paper, glass, and vegetation.

Physical Indicators of Potential Anomalies:

- Waste material not generated during the K-770 Scrap Yard Soils remedial action
- Soils associated with elevated Tc-99 concentrations surrounding sample locations Z1-EU33BW-442 and Z1-EU33BW-445 (see map in this ADP)
- Containerized waste (the Tc-99 contaminated soils are expected to be containerized)
- Universal Waste (mercury containing equipment [thermostats and switches], batteries, lamps [fluorescent bulbs], equipment known or suspected of containing freon, and pesticides)
- RCRA waste (lead shapes, metal turnings, large concentrated quantities of small metallic debris, circuit boards, computer monitors/components, etc.)
- Free liquids (water, oil, etc.) or equipment known or suspected of containing liquids/fluids
- Used or unused chemicals (petroleum products, lube oils, dielectric fluids)
- Process Equipment (valves, piping, from process gas operations)
- Sealed sources (including those within manufactured products)
- PCB transformers
- Any suspect or confirmed high-activity materials
- Cs-137 casks (see description and photographs in this ADP)
- Yellow cake or other evidence of uranium product material (green- or yellow-colored residue)
- Any unusual odors, such as solvent or acrid
- Un-bagged PPE
- Concrete blocks greater than 1-foot X 1-foot X 1-foot
- Rebar that has not been sized and packaged in accordance with variance in profile (sheared from concrete, less than 4-feet in length, commingled with soil in dump trucks)
- ACM waste that has not been packaged in accordance with PWAC or variances in profile
- Any area identified as RCRA Hazardous or Universal Waste by Waste Management (spray paint, flagging, etc.)
- Un-opened containers and aerosol cans, intact tanks or cylinders (sampling cylinders)
- Any item that has not been subjected to visual inspection

Field Instrument Indicators of Potential Anomalies:

Industrial Hygiene –Process knowledge eliminates the need for VOA/SVOA screens or continuous air monitoring
Radiological Controls – Process Knowledge eliminates the need for radiological airborne continuous monitoring.
Health Physics Survey Results that indicate unusual readings that would trigger ES&H and transportation concerns will be brought to the attention of the Waste Coordinator for evaluation.

Certification Statement (to be completed and sent with each waste shipment):

I certify that the wastes in this shipment conform to the descriptions found in the waste profile for Waste Lot _____. For question regarding the contents of this shipment, call _____.

Printed name _____

Signature _____

Date _____

(Note: the phone number and printed name for this form may be electronically inserted. However, the waste lot number, signature, and date shall be handwritten in ink.)

PHOTOGRAPHS OF CESIUM-137 CASKS (W. L. 4.12 ANOMALOUS WASTE)

Approximate dimensions: 20" in diameter, 26-28" in length. Approximate weight: 3,300-3,400 lbs. Photographs below are of a steel cask and a suspected concrete cask from the K-770 Scrap Removal Project.

APPENDIX B
WASTE LOT 4.12 PROCESS KNOWLEDGE

Appendix B: Waste Information, Facilities History, and Profile Documentation (Process Knowledge)

This appendix contains the process knowledge that supports the characterization of the waste in Waste Lot 4.12. It also contains documentation for statements and determinations in the profile. This appendix is sub-divided into sections that group similar sets of information. The following describes the organization of sections in this appendix and the information contained in each.

Section B.1, Waste Information for EMWMF Waste Lot 4.12 describes the K-770 Scrap Yard area and history. It also details the waste in the waste lot and previous characterization efforts in the K-770 Scrap Yard.

Section B.2 contains the Core Team approval documentation for the three waste handling plans that cover the waste in this waste lot (*Waste Handling Plan, Part II for the K-770 Soils within Zone 1 East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2006), *Waste Handling Plan, Part II for the East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2004), and *Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2005). This section also contains documentation of notification of the ETTP D&D/RA Core Team of deviations from the approved sample and analysis plan.

Section B.3 contains comments and responses from the EMWMF WAT review the profile received during its development.

B. 1. WASTE INFORMATION FOR EMWMF WASTE LOT 4.12

This section of Appendix B contains the description of the waste in this waste lot, the historical information, and process knowledge used in preparing this Environmental Management Waste Management Facility (EMWMF) profile. Most of the following information is from *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2008a), provided in Appendix E of this profile. The detailed process knowledge on the K-725 Building is from *K-770 Scrap Metal Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a).

SITE DESCRIPTION

The K-770 Scrap Metal Yard and Contaminated Debris Site (the K-770 Scrap Yard) is a storage area located southwest of the main portion of East Tennessee Technology Park, outside the security perimeter fence in the Powerhouse Area adjacent to the Clinch River. The site is located upstream from the confluence of the Clinch River with Poplar Creek. The scrap yard is surrounded by a locked fence and scrap metal is stored on the ground in piles and as loose objects in the area. The K-770 Scrap Yard occupies an approximately 21-acre tract of land. Remaining portions of foundations/floor slabs for Bldgs. K-725, K-725-B, K-726, and K-736, as well as several other small concrete pads, are also located within this area.

The K-770 area was used to store radioactively contaminated or suspected contaminated materials during and previous to the cascade upgrading program. Other known or suspected contaminants include PCBs, mercury, and asbestos incidental to scrap metal operations that were stored at the site prior to initiation of a waste management tracking program in 1977. The waste storage facility began operation in the 1960s and is estimated to at one time contain in excess of 40,000 tons of low-level, radioactively contaminated scrap metal. Also, the scrap metal piles contained approximately 20,000 ft² of asbestos-containing material, which consisted primarily of metal pipe. Scrap metal was taken to the site when it was found to contain alpha or beta/gamma activity on the surface or if the scrap metal originated from a process building.

Prior to 1984, there was no segregation of the low-level, radioactively contaminated scrap metal brought to the K-770 Scrap Yard. Cleanup of the scrap yard was initiated when Martin Marietta Energy Systems, Inc. contracted Quadrex Corporation (Quadrex) to relocate the material out of the 100-year floodplain, reduce the size of the material in an on-site processing unit, and segregate the material into piles separated by metal type. Quadrex performed the Health Physics activities of the contract and subcontracted the task of material handling to Southern Alloy. All material Quadrex was permitted to handle was removed from the floodplain and segregated into piles. The segregated metal debris was removed from the site as part of the K-770 Scrap Removal RA Project that was completed in fiscal year (FY) 2007 by Bechtel Jacobs Company LLC (BJC). An area of approximately 10 acres is located in EUs 29 and 31 where the scrap was originally located in the 100-year floodplain. In the process of moving the materials around and establishing segregated waste piles above the 100-year floodplain, the footprint of the site was expanded by 10-15 acres in EUs 30 and 32. The area in EUs 29 and 31 that was cleared of metallic debris in the floodplain was sown with grass. The areas in EUs 30 and 32 have some scattered vegetation but are generally open and accessible. A concrete pad was constructed in the northeast portion of the site in 2006 to support waste sort and segregation activities associated with this RA (see site map in Appendix E).

Several material categories established for waste at the K-770 Site during the segregation phase include the following [more detailed information on these categories is in *K-770 Scrap Metal Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a)]:

- Asbestos-containing material
- Rubbish
- Items with hot spots above acceptable limits
- Segregated metal
- Class 004
- Cooling tower wood

With limited exception, all materials contained in these segregated piles have been removed and disposed of at EMWMF during the Scrap Removal Project. Soils that underlay the original waste storage area in EUs 29 and 31 as well as soils that underlay the scrap piles in EUs 30 and 32 show substantially elevated radioactivity. In addition to soils present at the site, the remaining portions of foundations/floor slabs for Bldgs. K-725, K-726, and K-736, as well as the unnamed pad at the northeast corner of the site constructed to support the sort and segregation operations at the K-770 Scrap Removal Project and the several small, unnamed concrete pads are included in this waste lot. Contaminants present in these soils are directly derived from metallic debris and rubbish handled by the waste storage operations and include the predominant constituents of concern associated with the metallic waste already disposed of at EMWMF. Residual metallic debris embedded in the soils that underlay the debris piles comprise approximately 5% of the total mass of material that will be generated under this remedial action (RA).

Three Cs-137 casks were discovered at random locations in the K-770 Scrap Yard area during the Scrap Remediation Project. These casks were cylindrical, nominally 20 in. in diameter, and 26-28 in. long. The casks were constructed of ½ in. to ¾ in. steel or poured concrete and were estimated to weigh 3,300-3,400 lbs. For this reason Cs-137 casks are addressed in Appendix A of this profile (the ADP). Photos of the steel cask and the suspected concrete cask are also included in the ADP for reference while the waste in this waste lot is being generated.

SITE HISTORY

Beginning in 1944-45, this area was the site of a tank farm designated F-22 and used for storing Bunker C oil (No. 3 grade fuel oil). This oil was stored in 13 tanks, each with a 470,000-gal capacity adjacent to the Clinch River. Each tank was individually isolated by an earthen dike and a secondary dike around each group of three tanks. Fuel oil usage at the Powerhouse extended from 1944 through the end of 1953 and the tanks remained in place until 1954.

Scrap metal storage in this area began in the 1960s and waste management tracking operations began in 1977. From 1984 to 1986, the metals were segregated under a contract to Quadrex. The waste materials were separated by metal type and reduced in volume by shearing. Categories of metals were ACM, rubbish, items with radiological hot spots, and Class 004 (too large to shear). A Resource Conservation and Recovery Act of 1976 (RCRA) assessment was performed on this site in FY 1994 and all readily identified and accessible RCRA-regulated materials were removed.

The majority of metal at the K-770 Scrap Yard was generated during the Cascade Improvement Program/Cascade Upgrade Program. Most of the scrap metal passed through the K-1420 decontamination facility, where it was vacuumed and washed using water with dilute nitric acid or an alkaline detergent. This decontamination process removed transferable uranium prior to outside storage. In the 1980s, much of the scrap metal was segregated and size reduced. The metal was segregated into groupings of ferrous metals, non-ferrous metals, and other metals with potential recycle value. In addition to material from the ETTP Site (formerly known as the K-25 Site), materials from the Y-12 Site, Savannah River Site, and Oak Ridge National Laboratory (ORNL) were received at this scrap yard. Material from the Y-12 and

K-25 Sites was contaminated with uranium, the SRS material contained scrap metal released as part of a recycling program, and the ORNL waste included four heat exchangers. The total non-uranium based waste (i.e., non-K-25 Site or Y-12 Site waste) was < 0.5% of the total waste. The scrap yard material consisted of five primary waste piles of scrap metal that comprised approximately 40% of the waste by weight and were disposed of at EMWMF. All building structures within the area of the site have been demolished to the building slabs, which remain in place. All scrap metal that was not embedded in the surface soils has been removed and disposed of at EMWMF. All physical samples collected by the Zone 1 Dynamic Verification Sampling (DVS) Soils Characterization Program were analyzed for the presence of PCBs and metals. Results of these analyses indicated the metal concentrations in some samples could exceed the land disposal regulations. No volatile organic compounds (VOCs) were reported in any DVS samples above the industrial use preliminary remediation goals (PRGs), and only two DVS samples reported semivolatile organic compounds (SVOCs) present above the industrial use PRGs. Two samples were reported with PCBs above the Zone 1 average remediation levels (RLs).

K-725 Building

The K-725 Beryllium Building (now demolished, but with a remaining concrete pad) is located within Zone 1 and the Powerhouse Peninsula, in exposure unit (EU) 30. The remaining concrete pad is located adjacent to the K-770 Scrap Metal Yard and within the K-770 Scrap Metal Yard perimeter fence. For purposes of this process knowledge statement, the K-725 site is defined as the area that is bounded on the northwest by double parallel railroad tracks, on the southwest by the single railroad track spur, on the south and southeast by Thompson Road, and extends on the northeast and north approximately 50 feet beyond the perimeter of the concrete slab that remains after building demolition. The site includes an additional small area extending from the southeast corner of the building slab north of Thompson Road in order to include sample locations that were sampled subsequent to the sitewide remedial investigation.

K-725 Site History

The K-725 Beryllium Building was a concrete slab on grade with concrete walls and covered an area of 21,614 ft². The K-725 Building was originally a machine shop as part of the S-50 Thermal Diffusion Plant and for beryllium machining and experimentation (original building area 160 ft x 84 ft = 13,440 ft²). The K-725 Building is sometimes referred to as Building F-10. From 1946 to 1951 the K-725 Building was used by the Fairchild Engines and Aircraft Corporation for the Nuclear Energy Propulsion for Aircraft project. The K-725 Building was also used for support activities for the Oak Ridge Gaseous Diffusion Plant, ORNL, and Hanford reactors. In April 1951, General Electric took over operations at the K-725 site and continued the NEPFA project and various other projects until September 1952. The K-725 site was found heavily contaminated with radionuclides in 1953. A concrete "skin coat" was placed over the original floor because of high alpha counts from depleted uranium handled in the building. Union Carbide took over operations after General Electric, and in the early 1970s they attempted to decontaminate the K-725 Building. This cleaning effort did not achieve acceptable levels. The building was then defined as a contamination area and was not made available for further use. The building was demolished in 1998. The concrete slab remains.

Hazardous materials used at the K-725 Beryllium Building included beryllium, beryllium oxides, beryllium carbides, depleted uranium, and mercury. Interviews revealed that traps containing mercury occasionally released mercury, which was swept down the floor drains in the cleanup.

According to historical reports, the ground between the K-725 Beryllium Building and the railroad tracks was "highly contaminated with beryllium powders, chips, oxides, carbides, etc." There was considerable steam cleaning of beryllium and radioactively contaminated equipment in front of the building where the railroad tracks cross the road. The area was suspected of contamination at "fairly high levels."

K-726 Building

The K-726 building was originally built as a boiler house to burn bunker C oil to support the Fercleve Thermal Diffusion experiments. The single-story, concrete/cinder block structure with a steel truss-supported metal corrugated roof is believed to have been constructed in 1944. It measured approximately 75 ft by 35 ft and had a concrete floor. Operations at this building were discontinued in 1945. Beginning in 1978, the building was used to store PCB-containing liquids and solids. The facility was diked with a sealed concrete floor and inspected weekly. The PCB materials were removed in 1994 and the building cleaned according to PCB regulations. It stood vacant from 1994 to 2006 (BJC 2000). The structure (including the concrete slab floor) was demolished in 2006 and only the subsurface portions of the foundation remain (see the attached K-726 Fact Sheet). This was visually confirmed by Project Waste Management and Environmental Compliance and Protection on January 8, 2009. [One could incorrectly conclude from the SAP (BJC 2008a) that the concrete floor of this facility is included in this waste lot.] Based on visual inspections following demolition, there is no evidence of PCB contamination on the remaining portions of the K-726 foundation (see the attached fact sheet).

K-736 Scrap Storage

K-736 was a steel-frame building with a corrugated metal shell on an asphalt pad. The building was built in 1986 to support metal recycling and decontamination activities at the K-770 Scrap Metal Storage Yard. These activities included a Tc-99 decontamination demonstration project, a negative-pressure decontamination demonstration, and surface decontamination by electrolytic separation. From the mid-1990s until it was demolished, it was used to store contaminated equipment from ETTP (BJC 2000). The asphalt pad remains at the K-770 Scrap Yard site.

PREVIOUS CHARACTERIZATION ACTIVITIES

K-770 Site Summary Document

The purpose of this report [*K-770 Scrap Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a)] was to present a succinct summary of all available data for the K-770 Scrap Metal Yard and contaminated debris. The K-770 area was located in Exposure Units 29, 31, 32, 33, and part of 30. The report noted that the boundaries of the K-770 Scrap Yard had been expanded to include adjacent areas that may have been impacted by site operations. The data and information in this report was intended to support the remedial action decision-making process. The report included an analysis of aerial photographs and a summary of data for various media. The data for the K-770 soils are summarized in the following paragraphs. The data summary focused on the contaminants of concern (COCs) identified in the the Record of Decision (ROD) for selected contaminated areas in Zone 1 (DOE 2002).

In 1990, a sampling and radiological survey was performed to determine the presence, nature, and extent of contamination within the fenced boundaries of the K-770 Scrap Yard. A total of 99 soil samples were collected from 39 boring locations during the two rounds of sampling activities. Samples were collected from 0 to 2 ft below ground surface and analyzed for inorganic elements, gross alpha, beta, and gamma radioactivity; radionuclides, PCBs, and semi-volatile organic compounds. An additional sample was analyzed for VOCs. The results indicated that radionuclides were widely dispersed across the site. In particular, the results for uranium and thorium, as well as metals and PCBs, revealed scattered contamination.

Sixty-five surface soil samples were collected in the area of the scapyard as part of the 1994 radiological survey conducted by Martin Marietta Energy Systems. In this survey, a systematic walkover and RADMULE surveys were conducted over 11 grids covering approximately 23 acres of the scrap yard. Thirty-four of the soils samples were collected at locations that were biased by the results of the walkover and RADMULE surveys (samples were collected at locations having high radiation counts). The systematic walkover survey data file contained 20,391 data points and an additional 6,437 data points in the southeast corner of the site. The RADMULE collected 72,318 data points from the sodium iodide detectors. As in the previous investigation, the contamination appeared to be widely dispersed and scattered.

Soil samples were collected from five borings excavated for the sitewide RL. The borings were excavated to the water table at surface "hot spots" identified during the 1994 radiological walkover survey. Samples were collected from three depth intervals and analyzed for radionuclides and inorganic elements. Three depth intervals were sampled from each boring between the surface and 10-ft depth. A total of nine surface samples were also collected.

The COC data for samples taken within the site boundaries from all of these studies are combined into Tables 1 and 2 and Figures 2 through 4 of *K-770 Scrap Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a). No PCBs were detected in the soil. Arsenic was detected in 24 samples with a maximum concentration of 33.3 mg/kg, beryllium was detected in all 35 samples with a maximum concentration of 0.87 mg/kg, and mercury was detected in 34 out of 35 samples analyzed for metals. The maximum mercury concentration detected was 4.1 mg/kg (estimated value). None of the metals exceeded its respective RL calculated in the ROD.

Radionuclides were detected at concentrations exceeding background criteria only in surface soil samples at the K-770 Scrap Yard. Cesium-137 was detected in 55 of the 86 samples analyzed. Cesium-137 exceeded its average RL (the average concentration to which EU must be remediated) of 2 pCi/g in 8 of the 55 detections. The maximum RL was exceeded in only 3 of the 55 detections. Neptunium-237 was detected in all of the 55 samples analyzed. Radium-226 was detected in all of the 55 samples analyzed, and no sample exceeded average RL of 5 pCi/g. Thorium-232 was detected in 83 out of 86 samples. Its average RL of 5 pCi/g was exceeded in seven samples, but no sample exceeded the maximum RL. Uranium-234 was detected in 85 out of the 86 samples. Its average RL of 700 pCi/g was exceeded in 9 samples, and the maximum allowable concentration was exceeded in 5 of the 85 detections. The average U-234 concentration was 1030 pCi/g. Uranium-235 was detected in 65 out of 86 samples. It was detected above its average RL (8 pCi/g) in 27 samples. Ten samples contained concentrations greater than the maximum RL. Uranium-238 was detected in 85 out of 86 samples. It was detected above its average RL in 31 samples and above the maximum RL in 9 samples. The average concentration was 840 pCi/g. Four samples contained uranium in excess of 10,000 pCi/g and three were located near each other in the central portion of the site. These four samples were determined to have skewed the average for uranium concentration high due to their very high levels of activity.

The information and data in this summary report were used to confirm the process knowledge contained in the sample and analysis report and the waste handling plans. However, the data were not used in the characterization of the waste in this waste lot because of its age, and it was not collected to support waste disposal decisions.

K-725 Beryllium Building Site Summary Document

The purpose of this report [*K-725 Beryllium Building Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003b)] was to present a succinct summary of all available data for the K-725 Beryllium Building Site. For purposes of this document, the K-725 site is defined as

the area that is bounded on the northwest by double parallel railroad tracks, on the southwest by the single railroad track spur, on the south and southeast by Thompson Road, and extends on the northeast and north approximately 50 feet beyond the perimeter of the concrete slab that remains after building demolition. The site includes an additional small area extending from the southeast corner of the building slab north of Thompson Road in order to include sample locations that were sampled subsequent to the site-wide remedial investigation. This data summary report was intended to provide all pertinent data and information for this site to support remedial action decision-making process.

Forty-four surface soil samples (0 to 0.5 ft) were collected from 40 locations in 1990 as part of the RCRA Facility Investigation. These soils were composited and analyzed for radiologicals and beryllium. Subsequently, surface soil sampling for radionuclides was included in a site-wide radiological walkover of Zone 1 in 1994 and 1995. Since the RI was drafted, the Reindustrialization Program at ETTP has taken numerous surface and subsurface soil samples in Zone 1. During 1998 and 2000, soils were sampled for metals, PCBs, radionuclides, volatile organic compounds and semi-volatile organic compounds. A total of 55 locations at the K-725 site have surface soil data (0 to 2 feet bgs), and 59 locations have subsurface soil data (0 to 10 feet bgs, which also includes all surface soil data locations). No surface water, sediment, or groundwater samples have been taken at the K-725.

COCs for the K-725 Beryllium Building included beryllium, PCBs, benzo(a)pyrene, dibenz(a,h)anthracene, cesium-137, thorium-232, uranium-235, and uranium-238. Analytical results for the K-725 Beryllium Building indicate that the contaminants are scattered around the building in an irregular pattern, and there appears to be no discernible distribution pattern except that the contaminants are found primarily in surface soil. There are a few hot spots around the building that may be related to past process activities or located near vents and drains that may have been points of releases from the building during accidental spills. Although both surface and subsurface soil samples were collected (see Table 1 of BJC 2003b), the only COCs of note at the K-725 site were in samples from the 0 – 0.5 ft sample depth.

Summaries of the analytical results and corresponding sampling locations and sample identifiers are presented in Table 1 of BJC 2003b. Sampling locations at the K-725 Beryllium Building site are shown in Figure 2 (BJC 2003b). Figure 3 (BJC 2003b) shows the relative uranium activity at the K-725 site, and Figure 4 (BJC 2003b) shows other radionuclide relative activity. Figure 5 (BJC 2003b) indicates the relative chemical concentrations at the K-725 site, and sample locations identified for remediation at the K-725 site are shown in Figure 6 (BJC 2003b).

The highest beryllium concentration of 442 mg/kg was located on the southwestern side of the building slab. Samples from adjacent sampling locations along the southwestern side of the building slab, also had elevated beryllium concentrations ranging from 6.2 mg/kg to 100 mg/kg. Two sampling locations the same area, also had slightly elevated concentrations (2.47 and 4.24 mg/kg, respectively). However, sampling locations on either side of these had low concentrations (0.9 mg/kg) as did all other sampling locations at the K-725 site (all other beryllium sample concentrations were <1.8 mg/kg).

Unlike beryllium, which was localized in one area along the southwestern side of the building slab, high radionuclide activity levels were distributed irregularly around the building slab. The highest cesium-137 level was 181 pCi/g near the southeastern corner of the building slab. The highest level of thorium-232 was 528 pCi/g on the opposite (southwestern) side of the building slab from the high cesium sample. No other thorium-232 activity level was higher than 19 pCi/g. The highest uranium-235 concentration was 11.84 pCi/g at the same location as the highest uranium-238 concentration (129.5 pCi/g). That location was in the northwest corner of the K-725 site, between the northwest corner of the building slab and the double railroad tracks. Sample locations in that vicinity had elevated, though not the highest, cesium-137

concentrations (50.8 pCi/g and 24.6 pCi/g, respectively). Uranium activity levels for adjacent samples were much lower.

The highest total PCB concentration (14.26 mg/kg) was found in surface soil at the same sampling location with the highest cesium-137 activity as well as slightly elevated thorium-232 (3.6 pCi/g) and uranium-238 (64.5 pCi/g) activities. The other location with notable uranium-238 activity (56.2 pCi/g) was on the northeastern side of the building slab. One sampling location, on the northeast side of the building slab, had elevated concentrations of cesium-137 (2.61 pCi/g) and thorium-232 (19.1 pCi/g).

Three subsurface samples required drilling through the demolished K-725 Building's concrete slab to obtain samples at 3 to 10 ft bgs. Additional subsurface samples were collected at another location. Although COCs were detected in these subsurface samples, chemical concentrations and radionuclide activities were generally low.

In addition to the inorganics (arsenic, beryllium, and mercury) and radionuclides (Cs-137, Np-237, Ra-226, Tc-99, Th-232, U-234, U-235, U-238) that were analyzed and detected, several organics (1,1,1-TCA, 1,1,2-TCA, 1,1-DCE, carbon tetrachloride, and TCE) were analyzed for but were not detected.

Semi-volatile organic compounds were also sampled. The highest level of dibenz(a,h)anthracene was 51 mg/kg collected in surface soil (0 to 0.5 ft) in October 2000. The next highest level was 7.33 mg/kg. All other dibenz(a,h)anthracene concentrations were less than 2 mg/kg. The highest level of benzo(a)pyrene was 169 mg/kg with the next highest level (20.8 mg/kg) also at K725-01. All other benzo(a)pyrene concentrations were less than 2 mg/kg.

The information and data in this summary report were used to confirm the process knowledge contained in the sample and analysis report and the waste handling plans. The beryllium results in this report as well as *K-770 Scrap Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a) were also used to support the conclusion in Section 5.7 of this profile that the waste in this waste lot is not a beryllium containing waste. However, the data were not used in the characterization of the waste in this waste lot because of its age, and it was not collected to support waste disposal decisions.

2008 Sampling and Analysis Plan for K-770 Soils

Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee (BJC 2008a) (see Appendix E of this profile) describes the following characterization activities.

Two investigative programs have been performed in EUs 29 and 31. An investigation conducted by CDM Federal Programs (CDM) under the Radiological Characterization of Inactive Waste Sites Program was performed in the mid-1990s, and Dynamic Verification Strategy (DVS) characterization of the area was performed in late 2004 and early 2005. Both programs used a combination of radiological walkover surveys and subsequent physical sampling to provide an assessment of this portion of the K-770 Waste Storage Site.

Radiation Walkover Surveys

A full-coverage survey of all open and accessible areas in EUs 29 and 31 and the southwestern portion of EU 33 were performed by CDM in the mid-1990s. This survey used a 2X2 NaI probe with geographic positioning equipment to obtain activity data coverage of the accessible areas. One large area of elevated activity and several smaller anomalies within the site were defined.

In 2004, BJC and Restoration Services Inc. conducted a walkover survey in EU 29 of the large area of elevated activity defined by the CDM survey. The more recent survey used a field instrument for detection of low-energy radiation (FIDLER) and was conducted to confirm the extent of elevated activity could be defined using a different field instrument. The FIDLER survey was successful in defining the same approximate boundary as defined by the CDM survey. The use of these survey instruments was to define areas of anomalous conditions and not to estimate quantitative radioisotopic concentrations.

Soil Sampling

Thirty-four surface soil samples were collected under the 1994 CDM assessment program. These were all biased samples selected to provide laboratory analyses in areas of significantly elevated radioactivity. Also, all of these samples were analyzed by gamma spectroscopy [U.S. Environmental Protection Agency (EPA) Method 901.1]. Concentrations of many of the primary Zone 1 radioisotopic contaminants of concern (COCs) cannot be accurately determined by this method; therefore, the radioisotopic concentrations results are considered unreliable and are not used in the assessment of the proposed waste lot.

Under the DVS Soils Characterization Program, the entire areas of EUs 29 and 31 were classified as Class 1 soil units. Based on the historic radiation walkover survey and historic sampling, there was a high degree of confidence that soil contamination in portions of the EUs was above Zone 1 maximum RLs and an RA was required. The sampling plan, as defined in the K-770 DQO Summary Report, defined a base program of 40 sample locations placed on a systematic grid over the two EUs. In addition, 21 biased sampling locations were added to the base program sample set. These additional locations were selected within areas of elevated activity as defined by the radiation walkover surveys and, in some cases, in proximity to the historic sample locations to determine the concentration of radioactive contaminants present and compare to the reported historic sample results.

As prescribed under the DVS characterization DQOs, the sampling methodology is biased to high radioactive contaminant areas and intervals. The sampling approach was designed to provide data to support an action/no-action determination as a program objective and produce a high biased data set. The analytical methods are designated in the Zone 1 Remedial Action Work Plan (DOE 2007) and are appropriate for all the respective radioisotopes. The data are 100% validated and are considered accurate to meet program DQO requirements.

The predominant radiological contaminants identified by the DVS data set include cesium-137 (maximum result = 27 pCi/g), technetium-99 (maximum result = 695 pCi/g), thorium-232 (maximum result = 60.7 pCi/g), uranium-234 (maximum result = 2090 pCi/g), uranium-235 (maximum result = 110 pCi/g), and uranium-238 (maximum result = 1660 pCi/g). With the exception of technetium-99, all of these isotopes are Zone 1 contaminants of concern. It is noted that neptunium was not detected in any DVS samples and radium-226 was detected at very low concentrations, with a maximum reported result of 3.1 pCi/g. These results are in contrast to very high reported concentrations in the historic data set analyzed by gamma spectroscopy. This substantial discrepancy supports the conclusion that the CDM data set is unreliable.

Other possible contaminants that may be present based on historic information include beryllium associated with the K-725 building slab, PCBs and wrapped pipe that contained asbestos. PCBs were stored in Bldg. K-726 prior to incineration.

A summary of sample results for U-238 from the DVS data set are presented in Table 1 of *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2008a). These data represent a high bias set and are not considered

representative of average concentrations present in the waste in this waste lot. Therefore, the data are not considered appropriate for an EMWMF waste acceptance criteria (WAC) determination.

Concrete

No samples were collected from the concrete slabs/foundations during earlier investigations.

Residual Miscellaneous Metal

The residual metallic debris that remains embedded in the shallow soils that underlay the former debris piles was characterized for EMWMF disposal in the approved *Waste Profile for: Disposal of the Scrap Removal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004a). However, this residual metallic debris has been included in this waste lot to meet the more rigorous profiling requirements currently contained in *Waste Acceptance Criteria Attainment Team Project Execution Plan Environmental Management Waste Management Facility, Oak Ridge Reservation, Tennessee* (BJC 2008a). This waste is expected to comprise approximately 5% of the total volume of waste in this waste lot. It has been characterized using the data collected for the soil and concrete in this profile as an upper-bound proxy.

To justify that the characterization data for the remainder of the waste in this waste lot can serve as an upper-bound proxy for the residual metallic debris, the characterization information in the Waste Lot 65.1 profile was compared to the characterization data in this waste lot. [EMWMF Waste Lot profiles 65.2 (BJC 2004b) and 65.3 (BJC 2005) characterized portions of the metallic debris in the K-770 Scrap Yard. However, because the scope of the characterization in these profiles was limited to small portions of the debris (aluminum and containerized waste), the Waste Lot 65.1 profile (BJC 2004a), which characterized most of the K-770 Scrap Yard debris was determined to be more representative of the metallic debris.] The initial comparison was of the carcinogenic (CA) and hazard index (HI) sums of fractions (SOFs) for the two waste lots. Waste Lot 4.12 had the higher sums-of fractions, with a CA SOF of 0.668 and an HI SOF of 0.147 (compared to a CA SOF of 0.120 and an HI SOF of 0.080 for Waste Lot 65.1). This indicates that, in general, the levels of contamination contributing to both SOFs are higher in Waste Lot 4.12.

A more detailed comparison of site related contaminants (SRCs) in the two waste lots was then performed. Waste Lot 65.1 identified five radiological SRCs (Tc-99, U-234, U-235, U-236, and U-238) with Tc-99 and U-238 as the only contributors to the CA SOF. Nine radiological SRCs were identified in Waste Lot 4.12. However, only four (Tc-99, U-234, U-235, and U-238) contributed to the CA SOF. Uranium-236 was eliminated as a potential SRC in Waste Lot 4.12 based on process knowledge. Uranium-236 was present at extremely low concentrations in Waste Lot 65.1 (a maximum value 0.0288 pCi/g) and did not contribute to the CA SOF in that profile. All four radionuclide SRCs that contributed to the CA SOF in Waste Lot 4.12 were present at significantly higher concentrations than the same four SRCs in Waste Lot 65.1. In fact, the expected value for each of these radionuclide SRCs in Waste Lot 4.12 exceeded their corresponding maximum value in Waste Lot 65.1. Waste Lot 65.1 identified five metal SRCs (barium, chromium, lead, tin, and vanadium) with chromium, lead, and tin, along with U-238, contributing to the HI SOF. Waste Lot 4.12 also identified barium, chromium, lead, tin and vanadium as SRCs (along with 21 additional metal SRCs). The primary contributors to the HI SOF in Waste Lot 4.12 were antimony (0.07), followed by lead (0.04), tin (0.03), and then U-238 (0.02). Lead was present at a maximum value ten times higher in Waste Lot 4.12 than in Waste Lot 65.1 (733 mg/kg versus 70.8 mg/kg). Barium was present at a maximum value of over two and a half times higher in Waste Lot 4.12 than in Waste Lot 65.1 (80.4 mg/kg versus 29 mg/kg). Chromium and vanadium were present at higher levels in Waste Lot 65.1 than Waste Lot 4.12. These are considered exceptions and do

not affect the conclusion that Waste Lot 4.12 data can be used to represent the small amount of residual metallic debris in this waste lot.

A final comparison was performed on the levels of polychlorinated biphenyls (PCBs) in the two waste lots although neither profile identified PCBs as SRCs. Even though PCBs are present at low levels in both waste lots and neither waste lot is TSCA-regulated, levels of PCB contamination are greater in Waste Lot 4.12. Analyses for volatile and semi-volatile organics were not performed for Waste Lot 65.1 because the waste was scrap metal. Therefore, a comparison of specific organic compounds between the waste lots could not be performed. Waste Lot 4.12 did, however, identify nine organic compounds as SRCs (although none contributed to the HI SOF for the waste lot).

Characterization of Strontium and Tin in the Waste Lot

Soil samples collected to characterize this waste lot were not analyzed for the metals strontium and tin. Historical data indicate that these metals may be present in the waste lot soils at very low concentrations. However, for the reasons cited above, historical data are not considered reliable and were not used to quantitatively characterize this waste lot. Consistent with the radioactive contaminants in the soils, the metals in the soils were directly derived from the materials of construction in the metallic debris handled by the waste storage operations in the scrap yard. To characterize these two metals in the soils in this waste lot, the EMWMF Waste Lot 65.1 profile (BJC 2004a) was reviewed. [EMWMF Waste Lot profiles 65.2 (BJC 2004b) and 65.3 (BJC 2005) characterized portions of the metallic debris in the K-770 Scrap Yard. However, because the scope of the characterization in these profiles was limited to discrete portions of the debris (aluminum and containerized waste), the Waste Lot 65.1 profile (BJC 2004a), which characterized most of the K-770 Scrap Yard debris was determined to be more representative of the metallic debris.] Samples of metallic debris in the scrap yard were analyzed for strontium and tin in the EMWMF Waste Lot 65.1 profile. Strontium was not detected. [This is also supported with results from EMWMF Waste Lot profiles 65.2 (BJC 2004b) and 65.3 (BJC 2005).] Based on these results, the Project concluded that strontium was not present in the waste lot soils. Tin was detected in the EMWMF Waste Lot 65.1 profile. Based on these results, the Project concluded that tin was present in the waste lot soils.

Tin was quantitatively characterized for this waste lot by incorporating the input values for tin in the Waste Lot 65.1 Waste Acceptance Criteria Forecasting Analysis Capability Systems (WACFACS) in the WACFACS input for this waste lot. The WACFACS input for Waste Lot 65.1 are as follows:

Number of samples: 42

Number of detects: 14

Minimum detection value: 15.5 mg/kg

Median detection value: 23.2 mg/kg

Maximum detection value: 232 mg/kg

Arithmetic mean: 37.4 mg/kg

UCL₉₅ value: 120.7 mg/kg

Data distribution: PERTBeta.

History and Background

K-726 is a former PCB storage facility (formerly K-1088) (Area 10). It is a one-story building (approximate dimensions 75 x 35 ft) that was constructed circa 1944 with concrete/cinder block interior and exterior walls (130 yd³), steel truss-supported corrugated metal sheet roof (est. 94 yd³), and concrete floor slab (est. 282 yd³). It has a concrete floor that was added post-construction to raise the building floor elevation above the 100-year flood plain. The raised concrete floor was reported to be 3-ft-thick concrete but other indications were that fill material was placed before pouring the raised concrete floor.

The building previously contained low-level uranium contaminated materials and, following the discovery of a leaking PCB container in 1992, underwent floor decontamination efforts to reduce the contamination levels. Following several decontamination attempts, the floor was still above 10-µg/100-cm² clean up criteria. The EPA agreed in 1996 that the building could be closed with restrictions on utilization and that the facility be added to the list of Environmental Restoration units on the Federal Facility Agreement for future D&D.

Building Hazards/Contaminants

The primary contaminants of concern are residual PCB contamination, low-level radioactive contamination, and non-friable asbestos isolated parts of the roofing materials.

Waste Management

Waste characterization has been performed and documented as part of the DQO process. Based on this information, no further characterization is required for disposition of the K-726 building demolition debris. A total of 546 yd³ of demolition debris and concrete slab was disposed at EMWMF under Waste Lot 997.1. The forecasted demolition debris volume was 506 yd³. The non-friable asbestos roofing material, 30 yd³ of the total volume, was loaded into a double lined intermodal for disposal. The building demolition debris and the concrete slab, 516 yd³ of the total volume, was loaded into a double lined dump truck for disposal as PCB remediation waste.

Description of Demolition

Portions of the roofing material with the non-friable asbestos was sprayed with an encapsulant prior to demolition. The building debris and the concrete slab was demolished, size reduced and removed using an excavator with a shear attachment and an excavator with a bucket and thumb.

End State

The remaining subsurface concrete foundation and soils are left in an as-is condition and are scheduled for remediation under a separate contract. There is no presence of chemical contamination based on visual inspections, and therefore, no environmental monitoring is required. The radiological survey of the subsurface concrete foundation is above the release limits of the DOE Order 5400.5. Radiological controls boundary has been established around the perimeter to restrict access.

Deviations from the Action Memorandum

All ARARS were met, and there were no deviations from the Action Memorandum or the Waste Handling Plan.

Land Use Controls

None are required.

K-726 Building prior to Demolition

K-726 Building during Demolition

K-726 Building during Demolition

K-726 Building after Demolition

REFERENCES

- BJC (Bechtel Jacobs Company LLC) 2000. *Baseline Environmental Analysis Report for the K-725 Pad, K-1093, K-1545-A, and Adjacent Areas at the East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-819, Bechtel Jacobs Company LLC, Oak Ridge, TN. Draft.
- BJC 2003a. *K-770 Scrap Metal Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1296, Bechtel Jacobs Company LLC, Oak Ridge, TN.
- BJC 2003b. *K-725 Beryllium Building Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1298/D1, Bechtel Jacobs Company LLC, Oak Ridge, TN. Draft.
- BJC 2004a. *Waste Profile for: Disposal of the Scrap Metal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1857, Rev. 1, Bechtel Jacobs Company LLC, Oak Ridge, TN. July.
- BJC 2004b. *Waste Profile for: Disposal of the Scrap Metal Project Waste Lot 65.2 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1859, Rev. 1, Bechtel Jacobs Company LLC, Oak Ridge, TN. August.
- BJC 2005. *Waste Profile for: Disposal of the Scrap Metal Project Waste Lot 65.3 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1857, Rev. 4, Bechtel Jacobs Company LLC, Oak Ridge, TN. May.
- BJC 2008a. *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-3088, Bechtel Jacobs Company LLC, Oak Ridge, TN.
- BJC 2008b. *Waste Acceptance Criteria Attainment Team Project Execution Plan Environmental Management Waste Management Facility, Oak Ridge Reservation, Tennessee*, BJC/OR-1091, Rev. 4, Bechtel Jacobs Company LLC, Oak Ridge, TN.
- DOE 2002. *Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-1997&D2, Office of Environmental Management, Oak Ridge, TN.
- DOE 2004. *Waste Handling Plan, Part II for the ETTP Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-2162&D2, Office of Environmental Management, Oak Ridge, TN.
- DOE 2005. *Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-2263&D2, Office of Environmental Management, Oak Ridge, TN.
- DOE 2006. *Waste Handling Plan, Part II for the K-770 Soils within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-2148&D2, Office of Environmental Management, Oak Ridge, TN.
-
-

INEL 1993. Memorandum AMU-101-93 from A.M. Umak dated July 20, 1993. Subject: "RCRA Scrap Metal." Westinghouse Idaho Nuclear Company, Inc. Idaho Falls, ID. (Referenced in WAT Comment Response Table.)

fyi

#1

AMU-101-93
from - A. M. Umak
Phone - 6-9690/MS-5108
Date - July 20, 1993
Subject - RCRA Scrap Metal

To Distribution

All types of metal when discarded are considered to be RCRA solid waste. If the material is considered to be scrap metal as defined by RCRA and is recycled, then the scrap metal is exempt from regulation. If it is not recycled, then the metal must be characterized to determine if it is hazardous or non-hazardous as defined by RCRA.

Several types of metals (see Attachment 1) present at ICPP were analyzed. Based upon data available at this time, all the metals listed in Column A, Attachment 1, with all dimensions being greater than 1/4 inch, are considered to be non-hazardous and thus are exempt from regulations. Disposal of any metal with dimensions less than or equal to 1/4 inch, such as metal filings, shavings, turnings, grindings, etc., will have to be evaluated to determine if analysis is required before disposal. This will be necessary because evidence from characterization activities at ICPP and from information obtained by EPA suggest that the RCRA hazardous constituents may be more readily leached when metals are in these forms.

Data for metals listed in Column B, Attachment 1, are inconclusive at this time. Therefore, additional analyses will be required before disposal of these types of metal can occur. These metals should continue to be handled in accordance with WINCO procedure WH-3 "Handling Unknown Materials."

Post-It™ brand fax transmittal memo 7671		pages 3
To: <i>Idaho Scrap W</i>	From: <i>ANR</i>	
Cc:	Cc:	
Date:	Phone #:	
Fax #:	Fax #:

Westinghouse Idaho Nuclear Company, Inc.

Distribution
AMU-101-93
Page 2
July 20, 1993

All other types of metals regardless of size not listed in Attachment 1 must also be characterized prior to disposal. This would include such items as cadmium plated bolts.

If you have any questions please call Chris Kent at 526-3809.

A. M. Umek
Vice President and Manager
Westinghouse Idaho Nuclear Company

JCK:mf

Attachment

ATTACHMENT 1

NON-HAZARDOUS METALS
(if greater than 1/4")

Column A

174 PH Stainless Steel
304 Stainless Steel
304 L Stainless Steel
308 L Stainless Steel
316 Stainless Steel
347 Stainless Steel
Carpenter 20-35
Hastelloy C-4
Hastelloy C-22
Hastelloy C-276
Hastelloy X
Monel 400
Nitronic 50
Titanium

INCONCLUSIVE-FURTHER ANALYSIS
REQUIRED

Column B

440 C Stainless Steel
Carpenter 20
Nitronic 60

B.2. SUPPORTING REGULATORY DOCUMENTATION

I-10033-0183

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8980

November 7, 2005

Certified Mail
Return Receipt Requested

4WD-FFB

Mr. David G. Adler, Project Manager
Federal Facility Agreement
Oak Ridge Remediation Management Group
Department of Energy
P.O. Box 2001
Oak Ridge, TN 37831

SUBJ: EPA Review of the Waste Handling Plan, Part 2 for the K-710 Facilities
and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park,
Oak Ridge, Tennessee (DOE/OR/01-2263&D2)

Dear Mr. Adler:

The Environmental Protection Agency (EPA) has completed the review of the
above referenced document. The review of this document did not generate any adverse
comments. Therefore, EPA is approving the document as submitted.

If you have any questions regarding this matter, please feel free to contact me at
(404) 562-8551.

Sincerely,

A handwritten signature in cursive script that reads "Constance Allison Jones".

Constance Allison Jones, Senior RPM
KY/TN Federal Oversight Section
Federal Facilities Branch
Waste Management Division

cc: R. Doug McCoy, TDEC
Patricia Halsey, DOE
James Kopotic, DOE
Thomas Gebhart, TDEC
✓ John Lea, Bechtel Jacobs
SSAB

RECEIVED NOV 14 2005

bcc: Lawrence Neville, OEA
Reading File
Site File

C.Jones/caj:4WD-FFB-404-562-8551/11-7-2005/C:\Old C
Drive\Backup\Zone1\Approval of D2 WHP Part 2

Jones_____

*Janet Sylvia***I-10033-0188**

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY ROAD
OAK RIDGE, TENNESSEE 37830-7072

November 21, 2005

David Adler
DOE FFA Project Manager
PO Box 2001
Oak Ridge, TN 37830

Dear Mr. Adler

**TDEC Approval Letter
Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within
Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee
(DOE/OR/01-2263&D2)
August 2005**

The Tennessee Department of Environment and Conservation, DOE Oversight Division has reviewed the above referenced document pursuant to the Federal Facility Agreement for the Oak Ridge Reservation. Because this document effectively addresses the concerns of the Core Team, the State approves the D2 version of this Waste Handling Plan as presented.

Questions or comments concerning the contents of this letter should be directed to Erin Dixon or Thomas Gebhart at the above address or by phone at (865) 481-0995.

Sincerely

Doug McCoy
Doug McCoy, FFA Manager
Environmental Restoration Program

cc Jeff Crane, EPA
Pat Halsey, DOE
Donna Perez, DOE

Er684 01

NOV 21 2005

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

July 23, 2004

Certified MailReturn Receipt Requested

4WD-FFB

Mr. David G. Adler
Federal Facility Agreement Manager
Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37831

SUBJ: Correction to Approval of the Waste Handling Plan, Part II, for the East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE/OR/01-2162&D2)

Dear Mr. Adler:

This letter serves to correct the approval given to the Department of Energy on June 30, 2004. The Environmental Protection Agency (EPA) incorrectly identified the approval for the K-770 Scrap Metal Yard Waste Handling Plan, Part 2. The correct reference should have been given to the Waste Handling Plan, Part II, for the East Tennessee Technology Park Scrap Removal Project. As the scrap removal project also includes scrap metal located at the K-1064 Peninsula, this also approval applies to this activity.

If you have any questions, please feel free to contact me at (404) 562-8551 or electronically at jones.constance@epa.gov.

Sincerely,

A handwritten signature in black ink, reading "Constance Allison Jones", is written over the typed name.

Constance Allison Jones, Senior RPM
KY/TN Federal Oversight Section
Federal Facilities Branch

04 JUL 29 14:33

cc: R. Doug McCoy, TDEC
Patricia Halsey, DOE
James Kopotic, DOE
SSAB
LOC

AUG 10 2004

I-10033-0054

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8880

June 30, 2004

Certified Mail
Return Receipt Requested

4WD-FFB

Mr. David G. Adler
Federal Facility Agreement Manager
Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37831

SUBJ: EPA Approval of the K-770 Scrap Metal Yard Waste Handling Plan Part 2, East
Tennessee Technology Park, Oak Ridge, Tennessee

Dear Mr. Adler:

The U.S. Environmental Protection Agency (EPA) has completed its review of the above-referenced document. All of the changes requested by EPA have been incorporated. Therefore, EPA is approving the document as submitted.

If you have any questions regarding this matter, please feel free to contact me at (404) 562-8551 or electronically at jones.constance@epa.gov.

Sincerely,

A handwritten signature in cursive script, reading "Constance Allison Jones", is written over the typed name.

Constance Allison Jones, Senior RPM
KY/TN Federal Oversight Section
Federal Facilities Branch

cc: R.Doug McCoy, TDEC
Patricia Halsey, DOE
SSAB
LOC

JUL 9 2004

Janie
I-10033-0052

**STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY ROAD
OAK RIDGE, TENNESSEE 37830-7072**

June 17, 2004

David Adler
DOE FFA Project Manager
PO Box 2001
Oak Ridge, TN 37830

Dear Mr. Adler

**TDEC Approval Letter
Waste Handling Plan, Part II ETPP Scrap Removal Project, East Tennessee Technology
Park, Oak Ridge, Tennessee, (DOE/OR/01-2162&D1)
May 2004**

The Tennessee Department of Environment and Conservation, DOE Oversight Division has reviewed the above referenced document pursuant to the Federal Facility Agreement for the Oak Ridge Reservation and approves the document as presented.

Questions or comments concerning the contents of this letter should be directed to Thomas Gebhart at the above address or by phone at (865) 481-0995.

Sincerely

Doug McCoy, FFA Manager
Environmental Restoration Program

cc Jeff Crane, EPA
Pat Halsey, DOE
Donna Perez, DOE

JUN 29 2004

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I-10033-0240

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY ROAD
OAK RIDGE, TENNESSEE 37830-7072

September 28, 2006

Mr. David Adler
DOE FFA Project Manager
PO Box 2001
Oak Ridge, TN 37830

Dear Mr. Adler

**TDEC Approval Letter
Waste Handling Plan, Part II for the
K-770 Soils within Zone 1
East Tennessee Technology Park
Oak Ridge, Tennessee
DOE/OR/01-2148&D2
August, 2006**

The Tennessee Department of Environment and Conservation, DOE Oversight Division has reviewed the above referenced document pursuant to the Federal Facility Agreement for the Oak Ridge Reservation and approves the document as presented.

Questions or comments concerning the contents of this letter should be directed to Erin Dixon or Thomas Gebhart at the above address or by phone at (865) 481-0995.

Sincerely

R. Doug McCoy
FFA Project Manager

cc: Jeff Crane - EPA
Pat Halsey - DOE
Donna Perez - DOE

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8980

September 18, 2006

Certified Mail
Return Receipt Requested

4WD-FFB

Mr. David G. Adler, Project Manager
Federal Facilities Agreement
Oak Ridge Remediation Group
Department of Energy
P.O. Box 2001
Oak Ridge, TN 37831

SUBJ: Waste Handling Plan, Part II for the K-770 Soils Within Zone 1, East Tennessee
Technology Park, Oak Ridge, Tennessee (DOE/OR/01-2148&D1)

Dear Mr. Adler:

The Environmental Protection Agency has completed the review of the above-referenced document which was submitted on August 22, 2006. Based on this review, the document is approved as submitted.

If you have any questions, please feel free to contact me at (404) 562-8551 or electronically at: Jones.Constance@epa.gov.

Sincerely,

Constance Allison Jones, Senior RPM
KY/TN Federal Oversight Section
Federal Facilities Branch
Waste Management Division

cc: R. Doug McCoy, TDEC
Patricia Halsey, DOE
James Kopotic, DOE
SSAB
LOC

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bcc: Reading File
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C.Jones/caj:4WD-FFB/404-562-8551/9-18-2006/My Documents\Backup\ORR\Zone
1\K-770 Scrap and Soils\EPA Approval of Part 2 K-770 WHP.doc

Jones caj 9/18/2006

REMEDIAL ACTION CORE TEAM
January 14, 2009 Meeting Minutes
2:00 p.m.

Attendees:

Lydia Birk (by phone)	Richard Lee, RSI
Jeff Cange, BJC-OR	Marie Meszaros, BJC-OR
Sid Garland, BJC-OR	Joy Sager, DOE-ORO
Thomas Gebhart, TDEC (by phone)	Ken Skinner, Matric
Douglas Hanahan, BJC-OR	Lisa Shipe, BJC-OR
Constance Jones, EPA	Mike Travaglini, DOE-ORO

Safety Topic—back safety.

Project Status

Zone 1

- Concurrence form FCN-ETTP-Zone 1-101 will be approved by EPA.
- K-770 WAC data have a single missing VOA analysis from that specific in the approved SAP. The missing sample result is only one out of 46 collected; none of the results show exceedances and the remaining data are statistically valid for WAC attainment. The EMWMF waste profile has been prepared and will be submitted to the EMWMF WAT for their review tomorrow. Since the deviation from the SAP does not affect a remediation decision, no approval is required by EPA and TDEC. However, there was no objection to the submittal of the profile with this deviation.
- Materials are being removed from K-1093 boxes to assess their disposition pathway.
- K-1093 SAP needs to refer to EUs. Jeff Cange will revise the document and resend as an MS Word file.
- K-1085 waste is still not removed but is being worked on.
- Contractor Spoils Area risk assessment is being prepared.

Zone 2

- K-1066 G yard SAP has been sent for comment.
- EU Z2-36 Technical Memorandum draft is complete.
- K-1070-B is behind schedule in shipping and actions are being taken to remedy the situation and increase the shipping rate.
- Additional sampling in EUs 11 and 18. Work packages are being prepared. A concurrence for the additional sampling in EU 18 is being prepared.
- EU Z2-33 PCCR letter will be sent from TDEC today. BJC will revise and submit a D2 version. Need to add a date when K-1006 will be decontaminated and decommissioned.

Documentation

- Concurrence Forms
 - Powerhouse Duct Bank water sampling—FCN-ETTP-Zone 1-100 was approved by the Core Team.
 - EU Z2-11 additional sample location—FCN-ETP-Zone 2-102 was approved by the Core Team.
 - Adding Zone 1 debris to Scrap Yard WHP—has been submitted for comment.
- Document Status—No change.

Special Topic

- The SAP for WAC attainment for K-1035 pipes and pits was discussed. The following was agreed to:
 - Revise concurrence form Zone 2-097 to include the sub-slab sampling text and to say it will be performed in accordance with the Zone 2 RAWP.
 - Revise the SAP for WAC attainment to eliminate sub-slab sampling text and to say it will be performed in accordance with the Zone 2 RAWP
 - Revise the response to comments from EPA.

Discussions were held on the scope of RA activities where incorporated with D&D actions. This distinction is necessary to maintain the integrity of both programs when approved documents describe the implementation of RA activities and sampling tools required.

Next Meeting

Core Team: January 28, 2009

B.3. COMMENTS AND RESPONSES FROM EMWMF WAC ATTAINMENT TEAM REVIEW

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

Page 1 of 19

DOCUMENT TITLE: Environmental management Waste Management Facility Waste Lot Profile for K-770 Scrap Yard Soils, East Tennessee Technology Park, EMWMF Waste Lot 4.12	Date Issued (on document): January 2008
DOCUMENT NUMBER: BJC-ES-2710, Draft	
NAME OF REVIEWER: WAC Attainment Team POC: John Hampshire, o57@bechteljacobs.org	DATE COMMENTS TRANSMITTED March 2009
ORGANIZATION: BJC/EMWMF WAC Attainment Team	

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
1	General	Are samples in the CDS that are outside of planned excavation area? Provide brief discussion in the introduction of what areas are included in the planned excavation including reference to an excavation map.	No samples in the CDS are outside of the planned excavation area. Text revised to clarify planned excavation and explain what is included in the waste lot. A reference to Appendix E map showing sample locations, concrete pad locations, and planned excavation areas has been added.	Accept
2	General	What is the process for controlling the excavations? How will additional soils be verified as complying with the profile? What screening level is associated with profile compliance?	Soil will be excavated from within the areas shown on the figure in Appendix E. No additional soils outside of these area are expected. However, it is possible that DVS results may indicate that additional soils outside of the areas may require excavation. If this happens, DVS results	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport
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OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			will be compared to the profile limits to determine if these soils comply with the profile. Additional waste volumes (up to the UCL ₉₅ volume in the profile) can be disposed in this manner.	
3	App B/D	Has EC explicitly agreed with the use of composite samples for RCRA characteristic determination given that historic samples indicated that some soils do not meet LDR? Pg 11 of SAP states, "Results of these analyses indicated that the metal concentrations in some samples could exceed the land disposal regulations."	Yes. The statement on Page 11 of the approved SAP refers to totals data (that is, the "20 times rule") not TCLP data.	Accept
4	App B/D	<p>Appendix D states records of operations indicated RCRA Listed waste could have been spilled, managed, or dispositioned at the former S-50 site. Did any of the areas inside the planned areas of excavation support this operation? Please identify where the affected areas are located should the excavation expand to these areas. Does the comparison to organic data referenced in this appendix indicate that a no-longer contains determination was done?</p> <p>What supporting evidence was found during the review of the 1994 RCRA Assessment?</p> <p>What supporting evidence was found from the RCRA RFI conducted at K-725?</p> <p>How were hot spots around K-725 that may be related to past process activities or located near vents and drains that may</p>	<p>No, the S-50 site is not on the site map in Appendix E. It is to the south of the map towards K-722 and not included in this action. There is no indication that any of this waste was ever used, staged, or stored at the K-770 Scrap Yard site or that it was ever in contact with the materials (waste) in this waste lot. A no longer contains determination was not performed. It is not needed.</p> <p>This RFI has been reviewed and no additional supporting evidence was identified. This RFI only covered the K-770 Scrap Metal.</p> <p>The only RCRA constituent in this RFI is mercury.</p> <p>The waste in this profile was characterized in accordance with the Core Team-approved SAP. Historical</p>	<p>Accept</p> <p>Accept</p> <p>Accept</p> <p>Accept</p>

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		have been points of releases from the building during accidental spills been addressed (see Appendix B)?	sampling and process knowledge such as this were used during the development of the SAP. Soils adjacent to the K-725 foundation slab are not planned to require remediation.	
5	General	Were the K-726 concrete samples representative of both layers of concrete, especially the "high alpha" concrete?	Yes. The top layer of concrete is only a fraction of an inch thick (a "skin coat"). This was visually confirmed by Project Waste Management and EC&P on 3/25/2009. Concrete samples extended 3" into the slab. This was confirmed with the organization that performed the sampling (K. Skinner of RSI on 4/2/2009).	Accept
6	General	What is the basis for declaring 225 ft ² of Tc-99 hot spots? Note that the excavation plan stated 500 ft ² , which itself would still have to be justified.	These references have been removed. The Tc-99 hot spots will have been removed and the surrounding soils, confirmed to meet the profile limits (expected to be a comparison of Tc-99 concentrations in the soil to the UCL ₉₅ concentrations in the profile) prior to the waste in this waste lot being generated. Text explaining this is in Appendix A. Appendix A also includes potential indicators of this waste being anomalous to this EMWMF waste lot such as it being placed in containers (expected to be ST-90s), marked, and controlled (per BJC-WM-2001).	Accept
7	General	If you want to use FIDLER to guide Tc-99 areas, you need formal correlation between U and Tc-99.	Tc-99 analysis on intrusive samples will be used for confirmation that the Tc-99 hot spots have been completely removed.	Accept

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

April 14, 2009

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			See response to above comment.	
8	General	Why was there significant Cs-137 near the K-726 building?	<p>There is no specific process knowledge to explain the presence of cesium in/near the former K-726 Building. Recent characterization does not confirm significant Cs-137 near K-726. <i>K-770 Scrap Metal Yard Site Summary Document</i> (BJC 2003a in profile) shows the highest Cs-137 concentrations in soil (18.9, 32.4, 53.3, and 193 pCi/g) about 200 feet southwest of the K-726 foundation. Samples collected 100 feet SW of K-726 show Cs-137 levels between 2 and 3 pCi/g. The 2004-2005 DVS site characterization effort included a broad suite of radionuclides and eliminated all fission products as COCs except Cs-137. Cs-137 results in the soil characterization data for this profile indicates Cs-137 is evenly distributed over the entire site at very low concentrations (<.75 pCi/g) with the exception of three samples (2.05, 3.48, and 28.6 pCi/g). None of these samples is within 150 feet of the K-726 pad and the two concrete samples of the remaining portions of the pad did not detect Cs-137. The soil location with the highest Cs-137 levels is very close to the location where one of the Cs-137 casks was located during the previous Scrap Removal Project. The sample location with the 3.48 pCi/g corresponds to the area showing the highest concentrations</p>	Accept

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

April 14, 2009

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			in BJC 2003a. A map showing waste lot characterization concentrations of Cs-137 in soil across the site is attached to this comment response table.	
9	General	Need to acknowledge that Cs-137 sources were found during scrap metal removal; do the areas of excavation in this waste lot include the soils associated with that portion of the site?	Text has been added to Appendices A and B. See responses to Comments 38, 41, and 42.	Accept
10	General	Does the BJC SOP still define beryllium waste as >1000 ppm?	Yes.	Accept
11	Title	Revise...Soils and <u>Miscellaneous Debris</u> "	Title revised.	Accept
12	Sec. 1	1 st par. Add to contaminated soil, <u>concrete, and incidental metal and debris.</u>	Text added.	Accept
13	Sec. 1	3 rd par. Address concrete pads in this paragraph and refer to a map that shows these pads within the area of excavation. Need to explain why these pads are included...because they are in the way?	Concrete pads are addressed in the 4 th paragraph. Text has been revised to clarify which pads will be removed as a part of the removal action and clarify that some of the other pads will need to be removed to facilitate the action and regrading of the site. A reference to the map in Appendix E has also been added to Section 1.	Accept
14	Sec. 1	General – a brief paragraph describing the removal action would be beneficial with reference to B.3 for more details. For example, within the excavation bounds found in Map X, shallow soils will be removed to a depth of 1-foot...etc. Need to refer to map that shows limits of excavation. General – a table in this section that identifies the volume of soil, concrete, residual material, and wood/incidental waste is	A reference to the map has been added. Work description in Section B.3 has been removed. There is no requirement in the PEP for this table. The approximate volumes are	Accept Accept

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		required. What is the technical basis for the 7,000 CY in this waste lot? What verification data will be generated and how will verification data be used should additional material (both vertical and horizontal) be included in this waste lot?	contained in the text in this section and Section 3. The volume has been revised based on excavating the areas shown on the map in Appendix E to an assumed depth of 1 foot (consistent with the soil sampling interval) and removing the K-725, K-726, K-770 Scrap Removal Support pad and the two small, unnamed concrete pads. Statement added to Section 1. The predicted waste volume is 17,500 yd ³ (including approximately 1,300 yd ³ of concrete). Any verification will be performed in accordance with the regulator-approved RAWP for Zone 1 DVS (also see response to Comment 2).	Accept Accept
15	Sec. 1	4 th par. Paragraph needs to state that remaining metallic debris is included in this waste lot based on the review that the underlying soils data bounds the radiological and chemical characteristics found in scrap metal presented in WL 65.1. Provide a summary comparison of SRCs to demonstrate soils bound the debris.	The requested information concerning the metallic debris is included in Section 3 and the detailed comparison is in Appendix B. (This comparison is referenced in Section 3.)	Accept
16	Sec. 2	Break up paragraph to show what waste each WHPs is covering. Please provide evidence (e.g., excerpts from WHPs) that all pads are covered. Does any communication between the Core Team and the project exist about what waste is to be included under WL 4.12?	The paragraph clearly explains what part of the waste lot is included in each WHP. The intent of this section is to demonstrate that the waste lot will be generated by a CERCLA action. Language in the ROD indicates that all	Accept Accept

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			wastes in the waste lot (including concrete pads) are part of the remediation. Applicable portions of the ROD have been added to Appendix J.	
17	Sec. 2.2	Are you trying to state that all TRU constituents were eliminated with PK, historical data, and non-detects for Np-237?	Yes. Data collected for W.L. 65.1 supplemented by Np-237 elimination due to < 20% j-flagged results was used as the basis for TRU isotope elimination.	Accept
18	Section 2.3	Remove "control measure" since WPS visual inspections are requirements per BJC-WM-2001. Delete last sentence that is redundant. Note: This discussion can be cleaned up to state Yes or No to the WAC requirement and why.	Annotated outline in PEP requires plans to confirm compliance with WAC be summarized.	Accept
19	Section 2.4	What is meant by adding "material size"? The RCRA assessment and removal activities that took place in 1994 should be added either here or in Appendix D.	Term removed. It is assumed that small pieces of metallic debris were included in the soil samples (and therefore characterized with the soil) The larger pieces of metallic debris would not be a hazardous concern based on the results of the INEL study that concluded that pieces of metal larger than 1/4" by 1/4" would not leach in amounts that would result in them being a hazardous waste. The INEL memorandum documenting the results of the study (INEL 1993) has been added to Appendix B. This 1994 RFI assessment covered only the scrap metal on this site. Also see response to Comment 4.	Accept Accept
20	Sec.	Provide brief discussion as to what waste matrices (soil, metal,	There were 42 Total VOAs samples	Accept

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
	2.4.4	<p>scrap, concrete) were sampled <u>as required by SAP</u>. It would be helpful to explain why there N=30 (VOC) and N=43 (metals & SVOCs).</p> <p>Is does not appear that concrete metal sample results were included in this summary or N=57. Explain why.</p>	collected from soils, 43 Total SVOA/TCLP SVOA samples collected from soils, and 43 Total Metal/TCLP Metal samples from soils. In addition, there were 14 Total Metal samples only collected from concrete. None of the metal concentrations in concrete exceeded 20 times the TCLP limit; therefore, collection of TCLP Metal samples from concrete is not warranted. Therefore, the maximum N = 43 for TCLP Metals and TCLP SVOAs. Tables in Appendix E show what medium was sampled.	
21	Sec. 2.5	PK suggests that PCBs from sources greater than 50 ppm were stored at the site including liquids staged for incineration. This section needs to discuss that the "as-found" concentration as characterized by the approved SAP is below 50 ppm; therefore, may be considered as non-regulated PCBs. Discuss that both soils and concrete were characterized for PCBs (N=57).	CERCLA ARARs do not require consideration of the source concentrations when making this determination. Both soils and concrete were characterized for PCBs.	Agree, which is why the clarification text was requested. The inclusion of these responses to comments in the profile is sufficient to accept this response.
22	Sec. 2.11	Revise "the waste will not contain significant void space when disposed at EMWMF."	Text revised.	Accept
23	Sec. 2.12	2 nd sentence. Add "This waste lot does not include containerized waste; therefore, this requirement is not applicable."	Text revised.	Accept

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
24	Sec. 2.13	Change Table 7 reference to Table 6? Table 6 – why do some SVOCs have only 42 samples?	Reference to Table 6 changed. Table corrected- all SVOCs have 43 samples.	Accept Accept
25	Sec. 3	2 nd par. The Core Team Meeting Minutes in Appendix B were not found.	Minutes have been added.	Accept
26	Sec. 3	2 nd par., last sentence. The decision to not characterize the residual metallic debris in this waste lot was included in the SAP (see Page 6), so why do you state this decision was made after characterization?	The decision to <i>include</i> the metal debris in this waste lot was made after characterization. Prior to that decision, the Project was planning to dispose of that waste under the approved scrap metal profile (Waste Lot 65.1). A justification for including the metal debris in this profile without characterizing it was then required. The Project justified the inclusion by comparing the profile limits for the scrap metal in the Waste Lot 65.1 with the limits for the soil in this profile to demonstrate that the metal was not as contaminated as the soil and therefore, the soil could act as an upper-bound proxy for the metal. This comparison is in Appendix B.	Accept
27	Sec. 3	The introductory material is confusing. If the intent is to discuss the relationship between historical data and current data, describe in a tabular format (1) when and where this historical data was collected relative to the current sampling location, (2) what the results of the historical data are (min, median, max, PDF, E(X), and UCL-95, and (3) why the data were or were not used as part of the DQA. If the intent is to summarize the sampling and the data collected, a table can summarize this	Historical data were only used in the development of the SAP and were not used for quantitative characterization of this waste lot. The characterization was performed in accordance with the Core Team-approved SAP. Revisions to this section were made to clarify	Accept

REVIEWED BY: EMWMP WAC Attainment Team

RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		information. Revise paragraph to explain the 32 random and 13 biased composite samples and refer to SAP with map. Also discuss why the total equals 59 samples when summed but 2 of them were removed due to hot spots therefore the total N=57.	Section 3 explains why the results for 42 VOA samples (31 random samples plus 13 biased samples minus the 2 anomalous Tc-99 samples equals 42), 43 SVOA (32 random plus 13 biased minus 2 Tc-99 equals 43), and 57 radiological and Total Metals (43 random plus biased samples plus 14 concrete samples equal 57) samples are presented in Table 6, and details the two sample locations removed due to elevated Tc-99 pCi/g results. This is also included in Appendix E and Appendix G. No additional delineation is required.	Accept
		Explain the 5-point composite scheme that was followed, including how VOCs were collected. Provide the reference in the SAP that defines the systematic random sample and how they were collected?	Section 4.8 of the SAP contains this information. The options for obtaining concrete samples are contained in Section 4.9 of the SAP.	Accept
		The SAP was not specific on the radioisotopes or chemicals that are considered as potential SRCs. Is this presented somewhere in the SAP or profile?	Section 4.7 of the SAP refers to the Zone 1 Quality Assurance Project Plan. That plan specifies the analytical information. The ETP Site Zone 1 Lab SOW specifies the analytical methods to be performed and the analytes that will be included in the analyses. The lab work has been audited by EPA. The Lab SOW has been added to Appendix E.	Accept
28	Sec. 3	Page 13. It appears that PK does not preclude presence of fission products...is this sentence valid?	Sentence revised.	Accept

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
29	Sec 3.1 and 3.2	The UCL-95 for each SOF incorrect. It is not the sum of the UCL-95 for each SRC as calculated in App G on page 2 of 2 of the spreadsheet "WL 4.12 K-770 Scrap Yard Soils EMWMF SRC Summary Statistics."	This section will be updated when results of WACFACS are received.	Accept
30	Sec. 4	Table 7-- K-40 value should be 14.45 based on data set. Also, correct the statement in the last sentence of the 1 st paragraph; it should be <0.05, not >0.5, to signal insignificant ASA SOFs.	Corrected in Table 7 as 1.44E+01. Corrected.	Accept Accept
31	Sec 5.2 and 5.3	Correct reference to be DOE 2001 instead of BJC 2007.	BJC 2007, <i>Technical Information for Delivery of Waste to the Environmental Management Waste Management Facility</i> is the correct reference for the citations in these sections.	Accept
32	Sec. 5.7	Is any ACM present of the surface currently? 2 nd par. Revise..."No beryllium-dust containing waste is present. Based on sampling and analysis data in accordance with approved SAP, this waste lot contains a maximum Be concentration of < 2 ppm..."	None has been observed. Section 3 stated that sampling and analysis was in accordance with the SAP. The <2 ppm maximum value was confirmed to be correct.	Accept Accept
33	Sec. 5.9	Supersacks may be used for ACM in accordance with approved blanket variances.	This is true and that packaging option is available because the Project has included the appropriate blanket variance in Section 5.7	Accept
34	Sec. 5.10	Need to add PWAC variance that addresses rebar in final waste profile.	Variance added.	Accept
35	Sec. 5.11	Revise..."Noncrushable containers will not be used therefore	Text revised.	Accept

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		this requirement is not applicable.		
36	App A	How are high Tc-99 areas delineated in the field? Appendix B states that the high Tc-99 areas are 500 ft ² ... which is correct? Upon what is the size of these areas based?	See responses to Comments 6 and 7. See responses to Comments 6 and 7.	Accept
37	App A	Intro – states that anomalies are likely to be debris items. What screening basis will be used to identify anomalous debris? Suggest referring to the data comparison that indicated that the debris concentrations were less than the soils, and it is the soils that have the high Tc-99 results.	None, potentially anomalous debris items will be primarily identified visually. Although ADP states that instrument readings from RadCon could be used to identify potentially anomalous items. See responses to Comments 6 and 7.	Accept Accept
38	App A	The ADP needs to tackle head-on the problems encountered in the one area of the site that yielded the smoking pipes and the Cs-137 sources. Mark that area on the excavation maps, and explain that no excavation in this area is expected.	Cs-137 casks were not encountered in one specific area that is outside of the Scrap Yard. Therefore, these casks have been identified as potential anomalies that could be encountered during waste generation activities. These casks have been described (shape, approximate dimensions, approximate weight, etc.) and pictures have been included in this appendix.	Accept
39	App A	Responsibilities – Do WPS provide direction? Where does the AHERA inspector/CIH fit into R/R?	No, the WPSs do not provide direction. Text revised. The job description/work instructions specifies the roles and responsibilities of the AHERA inspector with regard to identifying ACM (before and during	Accept Accept

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

Page 13 of 19

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			demolition). It specifies when and where CIH requirements apply. It then specifies, during every phase of demolition, that inspections for anomalous waste will be conducted or waste will be observed for potentially anomalous waste.	
40	App A	Risk Scoring Checklist – what radiological screening will be conducted on debris items and soils? Also, since there is confirmation of anomalous items being present (the text of the likelihood checklist item), the score should be 9. On the other hand, the profile indicates that the other three items (difficulty and impacts) are not a problem at all, so perhaps these should be scored as "1"?	No radiological screening for anomalous waste is planned. See response to Comment 37. This checklist has been revised to address this comment and reflect the potential impacts of an undetected Cs-137 cask.	Accept
41	App A	<p>Anomaly detection checklist:</p> <ul style="list-style-type: none"> How will WPS be able to identify process equipment? Introduce Cs-137 casks in Anomaly Detection Plan. Add metal shavings and/or turnings as anomalous waste items (experience gained from David Whited Spoon Site). Areas associated with S-50 TDP past operations (listed waste). 	<p>Any potential process piping and equipment will be preliminarily identified visually. All Project WPSs have experience demolishing buildings that contain(ed) process equipment.</p> <p>See response to Comment 38. They have been included as a separate line-item that references photos.</p> <p>Added.</p> <p>These areas are outside of the Scrap Yard (not even on the map showing the area to be remediated).</p>	<p>Accept</p> <p>Accept</p> <p>Accept</p> <p>Accept</p>

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		<ul style="list-style-type: none"> How will Tc-99 areas be marked/controlled? What does "high-mass/high-enriched" materials mean? Do you mean high-activity? 	<p>See response to Comments 6 and 7.</p> <p>Yes, text revised per comment.</p>	<p>Accept</p> <p>Accept</p>
42	App B	Address the difference between the area that yielded the Cs-137 sources and the rest of the site.	There is no difference. See response to Comment 38.	Accept
43	App B	(bullet list) Define "Class 004" material.	This section contains a reference that contains the detail for the wastes contained on this list (including Class 004 material). Additionally, this term is defined ("too large to shear") on Page 11 of the SAP and in the "Site History" section in Appendix B.	Accept
44	App B	Site History – how have areas that were characterized by DVS that may fail LDRs been addressed?	See response to Comment 3. The waste in this waste lot was characterized in accordance with the approved SAP in Appendix E. As explained in Section 3 and Appendix B, all other historical data and information was used only to support that characterization in a qualitative manner.	Accept
45	App B	<p>K-725 Site History – Define "NEPFA"</p> <p>PK states that a second concrete pad was placed over the original floor. Was the original pad sampled? What were the radionuclides that were found?</p>	<p>Nuclear Energy Propulsion for Aircraft added.</p> <p>See response to Comment 5. Text revised to include "skin coat" and clarify. Based on that response, the original pad was sampled (eight samples of the K-725 pad were collected) and analyzed for radionuclides. The results are in the</p>	<p>Accept</p> <p>Accept</p>

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COMMENT NO.	SECT/PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		<p>Where were degreasing operations performed? The discussion in Appendix D was not found in Appendix B.</p> <p>Last par. Was the area between K-725 and RR tracks sampled since these areas are suspected to contain high levels of Be powders, chips, and radiological contamination? Could this area be potentially included in this waste lot?</p> <p>Where is PK on K-725-B?</p> <p>What about miscellaneous concrete pads that were sampled? Is there any PK on these pads (e.g., size, past operations, etc.) Are these pads marked in the excavation map?</p>	<p>Controlled Dataset.</p> <p>Appendix D states that degreasing operations were not performed in K-725. Appendix B does not normally describe what did not occur in the facilities is describes.</p> <p>Yes, two samples were collected between the K-725 pad and the railroad tracks. The maximum level of beryllium for these areas (from historic data) is less than one-half the value used by BJC to define beryllium waste. A portion of this area is included in the waste lot (it was sampled).</p> <p>Pad K-736 was erroneously labeled K-725-B. The map has been revised. There is no K-725-B pad.</p> <p>K-726 and one of the small unnamed pads were sampled. With one exception (the pad that supported the K-770 Scrap Removal Project's sort and segregation operation, there is no process knowledge on any of the small, unnamed pads). Project Waste Management and EC&P visually inspected these pads on 4/2/2009 to confirm that there were no EC&P concerns with their inclusion in this waste lot.</p>	<p>Accept</p> <p>Accept</p> <p>Accept</p> <p>Accept</p>
46	App B	Why is a statement made that K-726 slab could be incorrectly concluded as being included in this waste lot?	Concerns with the K-726 slab were raised by Project EC&P, but stated that the slab had been removed during a previous	Accept

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			demolition. The Project visually confirmed that the slab had been removed. Process knowledge did not clearly state this (and this could be misinterpreted). The remaining subsurface "footers" from beneath the slab are in this waste lot.	
47	App B	Building K-770 Site Summary – How were the areas containing > 10,000 pCi/g U-238 addressed in characterization?	Information such as this was considered when the SAP was prepared (and approved by the Core Team).	Accept
48	App B	Are the areas with high Be areas along the SW side of the building slab included in this profile?	See response to the fourth comment in Comment 45.	Accept
49	App B	Residual Misc. Metal – Has a comparison table been developed that shows how WL 4.14 bounds metal from WL 65.1? Since the SAP lists WL 65.2 and WL 65.3, explain why these were not included in the analysis.	No, the comparison is detailed in the text. The W.L. 65.2 and 65.3 profiles applied to much smaller (volumetrically) waste lots, segregated materials such as aluminum and waste staged at the site in B-25 containers. It was assumed that W.L. 65.1 was the most representative of the scrap metal at the site.	Accept
		How does historical data in table with no non-detects support the elimination of strontium and tin?	The summary statements at the bottom of the table conclude that historical detections are at levels that do not come close to challenging the EMWMF WAC.	Accept
	App B.3	Page 5, 3 rd par. How will newly identified areas found after metal removal address profile conformance? What screening is proposed and how will these data be used to verify removed waste meets profile? General (Figure 3) – what is the screening level criteria used in	This section has been removed from the profile.	Accept

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		<p>the surveys to identify soil contamination (hot spots)?</p> <p>General (Figure 5) – what is excavation criteria? Was this criteria used to eliminate the 225 sq ft of soil around the two Tc-99 samples of 2710 pCi/g and 40,600 pCi/g?</p> <p>Page 7 – How will verification data be used to ensure 100% removal of hot spots from this waste lot? Verification samples need to be compared to profile limits.</p> <p>Page 10 – Are K-725-A and K-726 slabs in or out of this waste lot?</p>		
50	App C	<p>Referring to concrete samples provided in the Controlled Data Set, explain in Appendix G how these samples could have a sample depth of 0 ft to 3 ft which is different from Table E.3 in Appendix E and also different from Table A.1 in the SAP.</p> <p>Why are some XY locations labeled as 1 or 2, respectively</p>	<p>Sample depth in March 2009 version of CDS has been revised to be 0 – 0.25 feet in depth since 3-inch concrete cores were collected.</p> <p>Sample Location IDs in CDS, Table E.3 of Appendix E, and Statistical Summaries in Appendix G have been revised to be consistent with those in the SAP.</p>	<p>Accept</p> <p>Accept</p>
51	App E	<p>Table E.3 – Concrete sample IDs do not match SAP. Concrete sample intervals are not identified in SAP, but they are identified in the Controlled Data Set.</p> <p>Was sample compositing methods assessed by the project? Was there any project or QA oversight during the sampling to verify that composite samples were collected properly?</p> <p>How were VOC samples collected?</p>	<p>Sample Location IDs in CDS, Table E.3 of Appendix E, and Statistical Summaries in Appendix G have been revised to be consistent with those in the SAP.</p> <p>RSI prepared the SAP and RSI performed the sampling SAP (there was project oversight during sampling).</p> <p>Section 4.9 contains this information.</p>	<p>Accept</p> <p>Accept</p> <p>Accept</p>

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		What is meant by "extraneous...results were rejected due to varying dilution factors?"	The term "extraneous" refers to several reported analytical values for the same sample that were due to differing dilutions based on sample medium. These extra results were assigned a "N" Data Usage flag by the SMO and were not included in the CDS or any statistical summaries.	Accept
		The SAP does not identify analysis methods. How were these identified and communicated to the laboratory?	The labs that performed these analyses had been working on this project for several years and had the analysis methods, detection limits, etc. RSI also performed 100% verification and validation on the results of the analyses.	Accept
52	App F	Step 4 – was data subject to 10% or 100% data validation?	100% of the data were validated (verified with RSI). Text revised to clarify.	Accept
53	App G	Provide a table that identifies the manner in which proxy values were applied for the combined validation and laboratory flags; e.g., a Val Q = UJ and Lab Val = J indicates a Proxy value is not required for the result assuming no transformation of units is required.	Appendix E provides the rationale for selection and transformation of data used in Appendix G. This information is in that appendix. No additional tables are required.	Accept
		What is the spatial distribution of Tc-99 (X,Y) and how will this be used to determine excavation screening criteria?	See responses to Comments 6 and 7.	Accept
54	App G	The ProUCL runs need to be adjusted for a 10% significance level. NOTE: it is <u>not</u> necessary to re-run all tests; only the ones that concluded that a normal or lognormal distribution was acceptable.	All SRCs have been subjected to 10% significance testing using Pro-UCL. The U-234, U-235, and U-238 and Total Lead populations remained lognormal even at the 10% significance level due to the homodasticity of the data. Changes were made to Total Aluminum (from normal to	Accept

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			Pert-Beta); to Total Arsenic (from normal to lognormal); to Total Mercury (from Pert-Beta to Lognormal); and to Total Sodium (from Pert-Beta to Lognormal). None of these changes involved Analytical WAC or Administrative WAC. UCL95 values for Total Aluminum, Total Arsenic, and Total mercury were adjusted in Table 8 for ASA chemical consideration only.	

REVIEWED BY: EMWMF WAC Attainment Team

RESPONSE BY: J.M. Davenport

APPENDIX C
WASTE LOT 4.12 CONTROLLED DATA SET

Davenport, John M (MDN)

From: Redus, Kenneth S (3KR)
Sent: Tuesday, April 14, 2009 10:11 AM
To: Davenport, John M (MDN); Hampshire, G John (O57)
Cc: Hanahan, Douglas W. (HGG); Hopper Jr, James Guy (HPZ)
Subject: RE: K-770 Scrap Yard Soils and Misc Debris

Received and acknowledged

From: Davenport, John M (MDN)
Sent: Monday, April 13, 2009 5:01 PM
To: Redus, Kenneth S (3KR); Hampshire, G John (O57)
Cc: Hanahan, Douglas W. (HGG)
Subject: K-770 Scrap Yard Soils and Misc Debris

Attached are the controlled data set and WACFACS input for the subject profile.

Thank you
Marshall

<< File: WL 4 12_Controlled Data Set (Final 032909).xls >> << File: WL 4 12_Appendix H_WACFACS Input Sheet (041309 Revision).xls >>

APPENDIX D
ENVIRONMENTAL COMPLIANCE ASSESSMENT

APPENDIX D: ENVIRONMENTAL COMPLIANCE ASSESSMENT FOR K-770 SCRAP YARD

Waste Acceptance Criteria Attainment Team Project Execution Plan (BJC/OR-1091-R3) states that project environmental personnel should be consulted for RCRA and TSCA compliance determinations, and calculations that are performed to support regulatory compliance shall be reviewed and approved by project environmental compliance staff. The purpose of this assessment is to provide clear and succinct documentation that all aspects of the RCRA and TSCA compliance for the waste from the remedial action performed at the K-770 Scrap Yard (including the removal of the K-725, K-726, and other small concrete foundations) was reviewed by the Environmental Compliance and Protection (EC&P) organization and the EC&P organization concurs with these determinations. It also provides documentation that the EC&P organization has reviewed the process knowledge used to characterize the waste in this waste lot, concurs that it is accurate, and no significant gaps exist.

Excluded from EMWMF Disposal

Two distinct soil areas within the K-770 Scrap Yard have been identified as anomalous waste due to elevated Tc-99 pCi/g concentrations (see Appendix A). Soils in these areas are excluded from this EMWMF waste lot. These soils are expected to be excavated, packaged in ST-90s, segregated, and managed in accordance with BJC-WM-2001 prior to waste in this waste lot being generated. This anomalous waste is expected to be included in off-site commercial or DOE waste profiles for disposal.

The S-50 Site (which is not in the K-770 Scrap Yard area) will not be remediated during this action.

RCRA Characteristic Waste Compliance

The RCRA waste characteristic determination was documented in Sections 2.4 through 2.4.4 of this profile. A review of the information in this section indicates that this waste lot was determined to not be hazardous waste based up a review of the criteria for ignitability, corrosivity, reactivity, and toxicity in accordance with 40 CFR 261.21-261.24 requirements.

The toxicity characteristic TCLP sampling results for the controlled data set are documented in Table 1 of Section 2.4.4. The results of this data set indicate that all parameters for waste lot soils are less than levels that would trigger hazardous waste determinations.

The EC&P organization has reviewed the hazardous waste determination in Sections 2.4 through 2.4.4 of this profile and concurs that this waste lot is not a hazardous waste stream.

RCRA Listed Waste Compliance

The RCRA listed waste determination was documented in Section 2.4.5 of this profile. A review of the information in this section indicates that this waste lot was determined to not be a listed hazardous waste.

The Project EC&P representative conducted a due diligence RCRA listed waste review for the K-770 Soils and concrete in 2008. A review of this listed waste determination indicates that records of operations indicated RCRA listed wastes could have been spilled, managed, or dispositioned at the former S-50 Liquid Media Thermal Diffusion Plant (LMTDP). This plant was located to the south of the K-770 area near where soils will be removed for this profile. Operating records indicate the columns and lines were degreased with tetrachloroethylene or carbon tetrachloride. An operations manual for the facility states that solvents were drained and captured in a drain tank at the F-01 building but no disposal records for the organic solvents were located during this listed waste review. Organic data for the soils show no

contamination for listed constituents and therefore are deemed to not be a RCRA listed waste for this waste lot.

Records on Building K-725 state that "degreasing was not performed in the F-10 Machine Shop," therefore, there are no associated RCRA listed uses identified in the building.

The K-726 Concrete and the asphalt K-736 pad were deemed to not be RCRA listed waste since no additional records or information are available that would indicate listed wastes were spilled, managed, or dispositioned associated with the concrete and pad.

The due diligence good faith review questions that were asked of the project team and the consensus responses provided for the Waste Lot 4.12 are noted in the following discussion.

- Are you aware of any RCRA listed wastes located in the subject waste streams?
 - No
- Are there operational waste disposal records (manifests, vouchers, bills of lading, waste storage records) or investigation reports that provide specific information on the industry processes that generated the waste in Waste Lot 4.12?
 - No
- Are there operational records or investigation reports for the K-770 Scrap Yard where the waste stream is being excavated that provide information on spills or releases of listed hazardous waste?
 - No
- Are there project records that indicate a specific industrial operation with the potential to generate RCRA listed hazardous waste was ever located on this site (i.e. F code degreasing operations, plating shop treatment sludge, P and U waste discarded commercial chemicals)?
 - Yes – see explanation above.
- Does the chemical analysis provide any definitive waste fingerprint that would provide strong evidence on the waste generation processes that were the likely sources of the waste stream?
 - No

Based upon the historical listed waste due diligence reviews for the soil and concrete area addressed in this profile, the EC&P organization concurs with the waste determination documented in Section 2.4.5 that this is not a listed RCRA hazardous waste stream.

TSCA PCB Compliance

The TSCA PCB waste characteristic determination was documented in Section 2.5 of this profile. A review of the information in this section indicates that this waste lot was not determined to be Bulk PCB remediation waste in accordance with 40 CFR 761.61 requirements. The PCB sampling results for the controlled data set are documented in Table 2 of Section 2.5

The EC&P organization has reviewed the TSCA PCB waste determination in Section 2.5 this profile, and concurs that Waste Lot 4.12 is not being characterized and managed as a Bulk PCB remediation waste stream.

Asbestos NESHAP Compliance

The National Emission Standard for Hazardous Air Pollutants (NESHAP) for asbestos waste determination was documented in Section 5.7 of this profile. A review of the information in this section indicates that this waste lot was determined to not be an asbestos waste stream in accordance with 40 CFR 61 requirements.

If any asbestos suspect material is discovered, a project asbestos inspector (who has the commensurate training) would conduct an evaluation to determine if the waste contains asbestos material and the waste would be handled appropriately.

The waste included in this waste lot does not include any transite or any suspect asbestos material and does not include material that would potentially be characterized as friable or non-friable asbestos containing material. The Anomaly Detection Plan includes criteria to review and identify any asbestos waste that might be uncovered during the waste loading steps. In the event asbestos waste is discovered during the waste loading steps, the asbestos waste would be segregated and disposed in accordance with asbestos packaging and waste transport regulations per the EMWMF Physical WAC guidelines.

The EC&P organization has reviewed the asbestos waste determination in Section 5.7 and concurs that this waste lot is not an asbestos waste stream.

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Statistical Summary for Th-232 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	B	REG	1.36	-	-	0.12	1.36	0.3074847
Z1-EU29W-401	S	REG	0.36	-	-	0.13	0.36	-1.021681248
Z1-EU29W-402	S	REG	1.4	-	-	0.17	1.4	0.385472237
Z1-EU29W-403	S	REG	1.27	-	-	0.08	1.27	0.2390169
Z1-EU29W-404	S	REG	1.19	-	-	0.09	1.19	0.173953307
Z1-EU29W-405 + Dup	S	FR	3.33	-	J	0.08	3.33	1.202972304
Z1-EU29W-406	S	REG	1.57	-	-	0.04	1.57	0.451075519
Z1-EU29W-407	S	REG	1.6	-	-	0.19	1.6	0.470003629
Z1-EU29W-408	S	REG	1.7	-	-	0.12	1.7	0.530628261
Z1-EU29W-409	S	REG	1.2	-	-	0.11	1.2	0.182321557
Z1-EU30BW-411	B	REG	0.87	-	-	0.11	0.87	-0.139282057
Z1-EU30C-444	C	REG	0.42	-	-	0.12	0.42	-0.547500548
Z1-EU30C-445	C	REG	0.2	-	-	0.08	0.2	-1.589437912
Z1-EU30C-446	C	REG	0.3	-	-	0.11	0.3	-1.303972804
Z1-EU30C-447	C	REG	0.49	-	-	0.07	0.49	-0.713349888
Z1-EU30C-448 + Dup	C	REG	0.4	-	-	0.06	0.4	-0.916290732
Z1-EU30C-449	C	REG	0.39	-	-	0.08	0.39	-0.94150884
Z1-EU30C-450	C	REG	0.28	-	-	0.06	0.29	-1.237874356
Z1-EU30C-451	C	REG	0.3	-	-	0.07	0.3	-1.203872804
Z1-EU30C-452	C	REG	0.65	-	-	0.1	0.65	-0.430782915
Z1-EU30C-453	C	REG	0.33	-	-	0.11	0.33	-1.108662628
Z1-EU30C-454	C	REG	0.35	-	-	0.09	0.35	-1.049822124
Z1-EU31BW-415	B	REG	1.15	-	-	0.11	1.15	0.139781842
Z1-EU31BW-416	B	REG	1.15	-	-	0.06	1.15	0.148420005
Z1-EU31BW-417	B	REG	1.23	-	-	0.09	1.23	0.207014166
Z1-EU31W-412	S	REG	0.97	-	-	0.07	0.97	-0.030459207
Z1-EU31W-413	S	REG	0.83	-	-	0.1	0.83	-0.634878272
Z1-EU31W-414	S	REG	1.77	-	-	0.11	1.77	0.570879547
Z1-EU32BW-431	B	REG	0.78	-	-	0.08	0.78	-0.248461359
Z1-EU32BW-432	B	REG	0.57	-	-	0.03	0.57	-0.582118818
Z1-EU32BW-433 + Dup	B	FR	2.39	-	-	0.21	2.39	0.871293368
Z1-EU32BW-434	B	REG	0.73	-	-	0.07	0.73	-0.314710745
Z1-EU32C-438	C	REG	0.33	-	-	0.04	0.33	-1.109882625
Z1-EU32C-458	C	REG	0.25	-	-	0.04	0.25	-1.388234261
Z1-EU32MW-420	S	REG	0.98	-	-	0.09	0.98	-0.020202707
Z1-EU32MW-426	S	REG	1.04	-	-	0.14	1.04	0.089220713
Z1-EU32W-418	S	REG	1.64	-	-	0.09	1.64	0.484886242
Z1-EU32W-419 + Dup	S	FR	1.61	-	-	0.1	1.61	0.412109881
Z1-EU32W-421	S	REG	1.33	-	-	0.14	1.33	0.285178342
Z1-EU32W-422	S	REG	0.99	-	-	0.18	0.99	-0.010050336
Z1-EU32W-423	S	REG	1.08	-	-	0.19	1.08	0.076061041
Z1-EU32W-424	S	REG	1.42	-	-	0.12	1.42	0.350094872
Z1-EU32W-425	S	REG	1	-	-	0.12	1	0
Z1-EU32W-427	S	REG	1.49	-	-	0.06	1.49	0.38877812
Z1-EU32W-428	S	REG	1.17	-	-	0.17	1.17	0.157009749
Z1-EU32W-429	S	REG	1.34	-	-	0.1	1.34	0.292858614
Z1-EU32W-430	S	REG	1.24	-	-	0.05	1.24	0.21511138
Z1-EU33BW-443	B	REG	1	-	-	0.08	1	0
Z1-EU33BW-444	B	REG	0.73	-	-	0.07	0.73	-0.314710745
Z1-EU33C-457	C	REG	0.29	-	-	0.1	0.29	-1.237874356
Z1-EU33W-438	S	REG	1.49	-	-	0.08	1.49	0.38877812
Z1-EU33W-435	S	REG	0.92	-	-	0.04	0.92	-0.083381609
Z1-EU33W-437	S	REG	0.8	-	-	0.08	0.8	-0.223143551
Z1-EU33W-438	S	REG	0.86	-	-	0.09	0.86	-0.450822799
Z1-EU33W-439	B	REG	0.93	-	-	0.11	0.93	-0.072670693
Z1-EU33W-440	S	REG	0.83	-	-	0.03	0.83	-0.185329578
Z1-EU33W-441	S	REG	1.19	-	-	0.12	1.19	0.173953307

Number of Samples 57
Number of Detects 57

Minimum 0.2
Median 0.98
Maximum 3.33
Average 1.0017544
Standard Deviation 0.5738253

PERT-Beta Mean 1.2483333

Lognormal Mean -0.173725
Lognormal Standard Deviation 0.6329407

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Th-232 pCi/g

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 50

Raw Statistics

Minimum 0.2
Maximum 3.33
Mean 1.002
Median 0.99
SD 0.574
Coefficient of Variation 0.573
Skewness 1.26

Log-transformed Statistics

Minimum of Log Data -1.609
Maximum of Log Data 1.203
Mean of log Data -0.174
SD of log Data 0.633

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.0812
Lilliefors Critical Value 0.117

Data appear Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.136
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 1.129
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 1.14
95% Modified-t UCL 1.131

Assuming Lognormal Distribution

95% H-UCL 1.212
95% Chebyshev (MVUE) UCL 1.426
97.5% Chebyshev (MVUE) UCL 1.601
99% Chebyshev (MVUE) UCL 1.944

Gamma Distribution Test

k star (bias corrected) 2.859
Theta Star 0.35
nu star 325.9

Approximate Chi Square Value (.05) 285.1
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 284.1

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 1.127
95% Jackknife UCL 1.129
95% Standard Bootstrap UCL 1.124
95% Bootstrap-t UCL 1.145
95% Hall's Bootstrap UCL 1.152
95% Percentile Bootstrap UCL 1.128
95% BCA Bootstrap UCL 1.127
95% Chebyshev (Mean, Sd) UCL 1.333
97.5% Chebyshev (Mean, Sd) UCL 1.476
99% Chebyshev (Mean, Sd) UCL 1.758

Assuming Gamma Distribution

95% Approximate Gamma UCL 1.145
95% Adjusted Gamma UCL 1.149

Follow Appr. Gamma Distribution at 5% Significance Level

Potential UCL to Use	Use 95% Student's-t UCL	1129
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Statistical Summary for U-234 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU28W-410	B	REG	17.7		-	0.10	17.7	2.87358404
Z1-EU29W-401	S	REG	9.78		J	0.11	9.78	2.286339484
Z1-EU29W-402	B	REG	36		J	0.29	36	3.583518938
Z1-EU29W-403	S	REG	6.62		=	0.11	6.62	1.89008637
Z1-EU29W-404	S	REG	18.5		-	0.11	18.5	2.917770732
Z1-EU29W-405 + Dup	S	FR	10.2		-	0.15	10.2	2.32238772
Z1-EU29W-406	S	REG	2.57		-	0.07	2.57	0.942078472
Z1-EU29W-407	S	REG	23.5		-	0.19	23.5	3.157000421
Z1-EU29W-408	S	REG	5.59		-	0.06	5.59	1.720979287
Z1-EU29W-409	S	REG	23.1		-	0.11	23.1	3.139832618
Z1-EU30W-411	B	REG	29		J	0.16	29	3.36729583
Z1-EU30C-444	C	REG	0.30		U	0.11	0.11	-2.207274913
Z1-EU30C-445	C	REG	1.19		=	0.12	1.19	0.173963307
Z1-EU30C-446	C	REG	0.85		J	0.14	0.85	-0.162518828
Z1-EU30C-447	C	REG	28.8		=	0.16	28.8	3.260374462
Z1-EU30C-448 + Dup	C	REG	1.25		-	0.08	1.25	0.223143551
Z1-EU30C-449	C	REG	0.82		J	0.12	0.82	-0.188450339
Z1-EU30C-450	C	REG	0.79		J	0.12	0.79	-0.235722334
Z1-EU30C-451	C	REG	0.74		J	0.11	0.74	-0.301106093
Z1-EU30C-452	C	REG	1.45		=	0.12	1.45	0.371503558
Z1-EU30C-453	C	REG	1.72		=	0.14	1.72	0.542364297
Z1-EU30C-454	C	REG	1.34		-	0.10	1.34	0.292559514
Z1-EU318W-415	B	REG	51.8		J	0.47	51.8	3.947390149
Z1-EU318W-416	B	REG	68.3		J	0.24	68.3	4.223009757
Z1-EU318W-417	B	REG	36		-	0.14	36	3.583518838
Z1-EU31W-412	B	REG	3.18		-	0.1	3.18	1.158881197
Z1-EU31W-413	S	REG	37.4		J	0.34	37.4	3.621670704
Z1-EU31W-414	S	REG	26.2		J	0.15	26.2	3.285759411
Z1-EU328W-431	B	REG	42.9		J	0.17	42.9	3.788871828
Z1-EU328W-432	B	REG	14.5		-	0.07	14.5	2.674148548
Z1-EU328W-433 + Dup	B	FR	1360		-	21.5	1360	7.215339979
Z1-EU328W-434	B	REG	2.94		-	0.15	2.94	1.078406581
Z1-EU32C-455	C	REG	1.28		-	0.14	1.28	0.2311711721
Z1-EU32C-456	C	REG	0.83		J	0.15	0.83	-0.186329578
Z1-EU32MW-420	S	REG	10.2		-	0.19	10.2	2.32238772
Z1-EU32MW-426	S	REG	19.8		-	0.14	19.8	2.985681938
Z1-EU32W-418	S	REG	17.1		J	0.16	17.1	2.839078484
Z1-EU32W-419 + Dup	S	REG	23.9		-	0.18	23.9	3.173878459
Z1-EU32W-421	S	REG	46.7		J	0.42	46.7	3.843744165
Z1-EU32W-422	S	REG	22.5		-	0.13	22.5	3.113515309
Z1-EU32W-423	S	REG	84.3		J	0.3	84.3	4.135559631
Z1-EU32W-424	S	REG	7.87		=	0.06	7.87	2.063056002
Z1-EU32W-425	S	REG	10.4		-	0.05	10.4	2.341808406
Z1-EU32W-427	S	REG	2.87		-	0.07	2.87	1.030184483
Z1-EU32W-428	S	REG	2.55		-	0.05	2.55	0.97458954
Z1-EU32W-429	S	REG	5.42		-	0.16	5.42	1.590095815
Z1-EU32W-430	S	REG	4.64		-	0.09	4.64	1.534714066
Z1-EU338W-443	B	REG	19.7		-	0.15	19.7	2.988618836
Z1-EU338W-444	B	REG	50.5		J	0.24	50.5	3.921973334
Z1-EU33C-457	C	REG	1.1		-	0.11	1.1	0.09531018
Z1-EU33W-435	S	REG	1.72		-	0.09	1.72	0.542324291
Z1-EU33W-436	S	REG	2.16		-	0.1	2.16	0.770108222
Z1-EU33W-437	S	REG	11.2		-	0.07	11.2	2.418913778
Z1-EU33W-438	S	REG	31.2		-	0.11	31.2	3.440416095
Z1-EU33W-439	S	REG	6.38		-	0.06	6.38	1.853168097
Z1-EU33W-440	S	REG	11.5		-	0.07	11.5	2.442347035
Z1-EU33W-441	S	REG	10.8		-	0.07	10.8	2.379545134

Number of Samples 57
Number of Detects 56

Minimum 0.11
Median 10.2
Maximum 1360
Average 38.448772
Standard Deviation 178.84992

PERT-Beta Mean 233.485

Lognormal Mean 2.0609718
Lognormal Standard Deviation 1.6261781

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheetwst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

U-234 pClip

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 54

Raw Statistics

Minimum 0.11
Maximum 1360
Mean 39.45
Median 10.2
SD 178.8
Coefficient of Variation 4.534
Skewness 7.445

Log-transformed Statistics

Minimum of Log Data -2.207
Maximum of Log Data 7.215
Mean of log Data 2.061
SD of log Data 1.626

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.42
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.0975
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 79.07
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 103.4
95% Modified-t UCL 82.96

Assuming Lognormal Distribution

95% H-UCL 54.43
95% Chebyshev (MVUE) UCL 64.3
97.5% Chebyshev (MVUE) UCL 80
99% Chebyshev (MVUE) UCL 110.8

Gamma Distribution Test

k star (bias corrected) 0.397
Theta Star 99.39
nu star 45.25

Approximate Chi Square Value (.05) 30.82
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 30.51

Anderson-Darling Test Statistic 3.838
Anderson-Darling 5% Critical Value 0.838
Kolmogorov-Smirnov Test Statistic 0.19
Kolmogorov-Smirnov 5% Critical Value 0.126

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 78.41
95% Jackknife UCL 79.07
95% Standard Bootstrap UCL 78.69
95% Bootstrap-t UCL 350.3
95% Hall's Bootstrap UCL 236.5
95% Percentile Bootstrap UCL 86.15
95% BCA Bootstrap UCL 132.6
95% Chebyshev(Mean, Sd) UCL 142.7
97.5% Chebyshev(Mean, Sd) UCL 187.4
99% Chebyshev(Mean, Sd) UCL 275.2

Assuming Gamma Distribution

95% Approximate Gamma UCL 57.92
95% Adjusted Gamma UCL 58.51

Potential UCL to Use	Use 95% H-UCL	54 43
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Statistical Summary for U-235 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	2.45		=	0.71	2.45	0.895088026
Z1-EU29BW-401	S	REG	0.96		=	0.13	0.96	-0.040821065
Z1-EU29BW-402	S	REG	3.21		J	0.27	3.21	1.166270937
Z1-EU29BW-403	S	REG	0.59		=	0.1	0.59	-0.527632742
Z1-EU29BW-404	S	REG	2.09		=	0.14	2.09	0.737164068
Z1-EU29BW-405 + Dup	S	PA	1.44		=	0.46	1.44	0.364643114
Z1-EU29BW-406	S	REG	0.38		=	0.09	0.38	-0.967664026
Z1-EU29BW-407	S	REG	2.38		=	0.09	2.38	0.867100488
Z1-EU29BW-408	S	REG	0.64		=	0.06	0.64	-0.448287100
Z1-EU29BW-409	S	REG	2.37		=	0.14	2.37	0.862989966
Z1-EU30BW-411	B	REG	2.86		=	0.1	2.86	1.050821625
Z1-EU30C-444	C	REG	0.1 J		U	0.05	0.05	-2.996732274
Z1-EU30C-445	C	REG	0.22		U	0.06	0.06	-2.813410717
Z1-EU30C-446	C	REG	0.11 J		U	0.11	0.11	-2.207274913
Z1-EU30C-447	C	REG	6.48		=	0.12	6.48	1.86872051
Z1-EU30C-448 + Dup	C	REG	0.51		U	0.1	0.1	-2.302666096
Z1-EU30C-449	C	REG	0.14 J		U	0.06	0.06	-2.813410717
Z1-EU30C-450	C	REG	0.13 J		U	0.16	0.16	-1.897119385
Z1-EU30C-451	C	REG	0.14 J		U	0.14	0.14	-1.965112858
Z1-EU30C-452	C	REG	0.6		U	0.08	0.08	-2.813410717
Z1-EU30C-453	C	REG	0.25		U	0.06	0.06	-2.813410717
Z1-EU30C-454	C	REG	0.41		U	0.14	0.14	-1.965112858
Z1-EU31BW-415	B	REG	6.96		=	0.79	6.96	1.93874108
Z1-EU31BW-416	B	REG	8.57		J	0.3	8.57	2.148267733
Z1-EU31BW-417	B	REG	4.15		=	0.66	4.15	1.423108034
Z1-EU31W-412	S	REG	0.32 J		J	0.17	0.32	-1.139434283
Z1-EU31W-413	S	REG	3.78		=	0.53	3.78	1.32072401
Z1-EU31W-414	S	REG	3.1		J	0.11	3.1	1.131402111
Z1-EU32BW-431	B	REG	4.97		J	0.13	4.97	1.60341984
Z1-EU32BW-432	B	REG	1.08		J	0.1	1.08	0.078961041
Z1-EU32BW-433 + Dup	B	REG	188 J		U	97	188	5.220355825
Z1-EU32BW-434	B	REG	0.2 J		J	0.21	0.21	-1.580647748
Z1-EU32C-455	C	REG	0.54		J	0.1	0.54	0.518185139
Z1-EU32C-456	C	REG	0.08 U		U	0.12	0.12	-2.190263636
Z1-EU32MW-420	S	REG	1.22		=	0.14	1.22	0.198850859
Z1-EU32MW-425	S	REG	1.77		=	0.46	1.77	0.570979647
Z1-EU32W-418	S	REG	2.63		J	0.32	2.63	1.040276712
Z1-EU32W-419 + Dup	S	REG	2.56		=	0.15	2.56	0.947789389
Z1-EU32W-421	S	REG	5.88		J	0.39	5.88	1.768149604
Z1-EU32W-422	S	REG	2.22		=	0.19	2.22	0.797507186
Z1-EU32W-423	S	REG	7.25		J	0.34	7.25	1.981001468
Z1-EU32W-424	S	REG	0.5		=	0.14	0.5	-0.510825624
Z1-EU32W-426	S	REG	0.92		=	0.06	0.92	-0.083381609
Z1-EU32W-427	S	REG	0.25		=	0.08	0.25	-1.368294361
Z1-EU32W-428	S	REG	0.25 J		J	0.13	0.25	-1.368294361
Z1-EU32W-429	S	REG	0.84		=	0.08	0.84	-0.061873404
Z1-EU32W-430	S	REG	0.78		=	0.09	0.78	-0.248461353
Z1-EU33BW-443	B	REG	2.51		=	0.53	2.51	0.920062783
Z1-EU33BW-444	B	REG	4.66		J	0.3	4.66	1.539015448
Z1-EU33C-457	C	REG	0.27 J		U	0.15	0.15	-1.897119386
Z1-EU33W-436	S	REG	0.16 J		J	0.08	0.16	-1.832581454
Z1-EU33W-436	S	REG	0.3		=	0.12	0.3	-1.203972804
Z1-EU33W-437	S	REG	1.13		=	0.82	1.13	0.122217833
Z1-EU33W-438	S	REG	4.02		=	0.86	4.02	1.391281908
Z1-EU33W-439	S	REG	0.5 J		J	0.56	0.5	-0.683147181
Z1-EU33W-440	S	REG	1.28		=	0.16	1.28	0.231111321
Z1-EU33W-441	S	REG	1.32 J		J	0.47	1.32	0.277821737

Number of Samples 57
Number of Detects 44

Minimum 0.05
Median 1.08
Maximum 185
Average 5.0710528
Standard Deviation 24.347791

PERT-Beta Mean 31.561667

Lognormal Mean -0.119993
Lognormal Standard Deviation 1.6472166

General UCL Statistics for Full Data Sets

User Selected Options

From File P:\Waste Generator Services\EMWMF Profiles\WL 4.12\March 2009 revision\revised rad to test distributi

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

U-235 pCi/g

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 51

Raw Statistics

Minimum 0.05
Maximum 185
Mean 5.071
Median 1.08
SD 24.35
Coefficient of Variation 4.801
Skewness 7.464

Log-transformed Statistics

Minimum of Log Data -2.996
Maximum of Log Data 5.22
Mean of log Data -0.12
SD of log Data 1.647

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.429
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.0846
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 10.46

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 13.78
95% Modified-t UCL 11

Assuming Lognormal Distribution

95% H-UCL 6.449

95% Chebyshev (MVUE) UCL 7.575
97.5% Chebyshev (MVUE) UCL 9.44
99% Chebyshev (MVUE) UCL 13.1

Gamma Distribution Test

k star (bias corrected) 0.372
Theta Star 13.63
nu star 42.42

Approximate Chi Square Value (.05) 28.49
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 28.2

Anderson-Darling Test Statistic 4.231

Anderson-Darling 5% Critical Value 0.844

Kolmogorov-Smirnov Test Statistic 0.194

Kolmogorov-Smirnov 5% Critical Value 0.127

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 10.38

95% Jackknife UCL 10.46

95% Standard Bootstrap UCL 10.34

95% Bootstrap-t UCL 52.33

95% Half's Bootstrap UCL 31.62

95% Percentile Bootstrap UCL 11.52

95% BCA Bootstrap UCL 15.01

95% Chebyshev(Mean, Sd) UCL 19.13

97.5% Chebyshev(Mean, Sd) UCL 25.21

99% Chebyshev(Mean, Sd) UCL 37.16

Assuming Gamma Distribution

95% Approximate Gamma UCL 7.551

95% Adjusted Gamma UCL 7.63

Potential UCL to Use

Use 95% H-UCL 6 449

Statistical Summary for U-235 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	15	-	-	0.16	15	2.708050201
Z1-EU29W-401	S	REG	9.4	J	-	0.1	9.4	2.240709680
Z1-EU29W-402	S	REG	38.7	J	-	0.20	38.7	3.676160688
Z1-EU29W-403	S	REG	5.82	=	-	0.11	5.82	1.761300262
Z1-EU29W-404	S	REG	22.1	-	-	0.13	22.1	3.095577609
Z1-EU29W-408 + Dup	S	FR	10.4	-	-	0.11	10.4	2.341905808
Z1-EU29W-406	S	REG	2.35	-	-	0.06	2.35	0.854415328
Z1-EU29W-407	S	REG	16.4	-	-	0.13	16.4	2.797281335
Z1-EU29W-408	S	REG	4.09	-	-	0.07	4.09	1.40854457
Z1-EU29W-409	S	REG	13.5	-	-	0.11	13.5	2.602669065
Z1-EU30BW-411	B	REG	18.7	J	-	0.08	18.7	2.928523524
Z1-EU30C-444	C	REG	0.43	-	-	0.06	0.43	-0.84387007
Z1-EU30C-445	C	REG	0.87	=	-	0.05	0.87	-0.139262067
Z1-EU30C-446	C	REG	0.48	-	-	0.07	0.48	-0.778628789
Z1-EU30C-447	C	REG	28.8	=	-	0.12	28.8	3.360375387
Z1-EU30C-448 + Dup	C	REG	1.29	-	-	0.06	1.29	0.254842218
Z1-EU30C-449	C	REG	0.48	=	-	0.1	0.48	-0.739969175
Z1-EU30C-450	C	REG	0.61	-	-	0.11	0.61	-0.673344553
Z1-EU30C-451	C	REG	0.43	=	-	0.09	0.43	-0.84387007
Z1-EU30C-452	C	REG	1.11	-	-	0.14	1.11	0.104380015
Z1-EU30C-453	C	REG	1.03	-	-	0.09	1.03	0.029568802
Z1-EU30C-454	C	REG	1.13	-	-	0.14	1.13	0.122217833
Z1-EU31BW-416	B	REG	38.8	J	-	0.3	38.8	3.658420247
Z1-EU31BW-416	B	REG	47.3	J	-	0.24	47.3	3.888510298
Z1-EU31BW-417	B	REG	28.4	-	-	0.08	28.4	3.346389146
Z1-EU31W-412	S	REG	1.59	-	-	0.06	1.59	0.453734018
Z1-EU31W-413	S	REG	40.1	J	-	0.29	40.1	3.691376334
Z1-EU31W-414	S	REG	18.4	J	-	0.16	18.4	2.912360565
Z1-EU32BW-431	B	REG	38.2	J	-	0.11	38.2	3.642835516
Z1-EU32BW-432	B	REG	11.4	-	-	0.06	11.4	2.433813366
Z1-EU32BW-433 + Dup	B	FR	1150	-	-	25.1	1150	7.047517221
Z1-EU32BW-434	B	REG	2.6	-	-	0.16	2.6	0.888811445
Z1-EU32C-456	C	REG	0.45	-	-	0.11	0.45	-0.778528789
Z1-EU32C-456	C	REG	0.89	-	-	0.11	0.89	-0.371063681
Z1-EU32W-420	S	REG	6.88	-	-	0.13	6.88	1.988619652
Z1-EU32W-426	S	REG	14.4	-	-	0.12	14.4	2.687228207
Z1-EU32W-418	S	REG	42.4	J	-	0.39	42.4	3.747148962
Z1-EU32W-419 + Dup	S	REG	17.5	J	-	0.11	17.5	2.862200681
Z1-EU32W-421	S	REG	55.4	J	-	0.24	55.4	4.014579584
Z1-EU32W-422	S	REG	17	=	-	0.13	17	2.833213344
Z1-EU32W-423	S	REG	48	J	-	0.21	48	3.828641396
Z1-EU32W-424	S	REG	6.75	=	-	0.08	6.75	1.909542505
Z1-EU32W-425	S	REG	7.66	-	-	0.08	7.66	2.034705648
Z1-EU32W-427	S	REG	1.82	=	-	0.04	1.82	0.482426149
Z1-EU32W-428	S	REG	1.47	-	-	0.05	1.47	0.385262401
Z1-EU32W-429	S	REG	6.8	-	-	0.15	6.8	1.887089649
Z1-EU32W-430	S	REG	3.64	-	-	0.07	3.64	1.291983882
Z1-EU32BW-440	B	REG	16.2	-	-	0.12	16.2	2.786011242
Z1-EU32BW-444	B	REG	44.4	J	-	0.14	44.4	3.793239469
Z1-EU33C-457	C	REG	0.92	-	-	0.05	0.92	-0.083381508
Z1-EU33W-435	S	REG	1.53	-	-	0.07	1.53	0.425267735
Z1-EU33W-436	S	REG	1.86	-	-	0.08	1.86	0.806817602
Z1-EU33W-437	S	REG	7.75	-	-	0.08	7.75	2.047698943
Z1-EU33W-438	S	REG	18.8	-	-	0.06	18.8	2.93385687
Z1-EU33W-439	S	REG	4.41	-	-	0.08	4.41	1.483874888
Z1-EU33W-440	S	REG	8.36	-	-	0.14	8.36	2.122261538
Z1-EU33W-441	S	REG	7.39	-	-	0.07	7.39	2.000127736

Number of Samples	57
Number of Detects	57
Minimum	0.43
Median	7.65
Maximum	1150
Average	33.450175
Standard Deviation	151.27378
PERT-Beta Mean	196.83833
Lognormal Mean	1.8407406
Lognormal Standard Deviation	1.8590547

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst
Full Precision OFF
Confidence Coefficient 95%
Number of Bootstrap Operations 2000

U-238 pCi/g

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 55

Raw Statistics

Minimum 0.43
Maximum 1150
Mean 33.45
Median 7.65
SD 151.3
Coefficient of Variation 4.522
Skewness 7.436

Log-transformed Statistics

Minimum of Log Data -0.844
Maximum of Log Data 7.048
Mean of log Data 1.841
SD of log Data 1.659

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.428
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.105
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 66.96
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 87.5
95% Modified-t UCL 70.25

Assuming Lognormal Distribution

95% H-UCL 47.09
95% Chebyshev (MVUE) UCL 55.13
97.5% Chebyshev (MVUE) UCL 68.75
99% Chebyshev (MVUE) UCL 95.51

Gamma Distribution Test

k star (bias corrected) 0.386
Theta Star 86.68
nu star 43.99
Approximate Chi Square Value (.05) 29.78
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 29.48

Data Distribution

Data appear Lognormal at 5% Significance Level

Approximate Chi Square Value (.05)

Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 29.48

Nonparametric Statistics

95% CLT UCL 66.41
95% Jackknife UCL 66.96
95% Standard Bootstrap UCL 65.97
95% Bootstrap-t UCL 281.4
95% Half's Bootstrap UCL 199.4
95% Percentile Bootstrap UCL 73.57
95% BCA Bootstrap UCL 98.27
95% Chebyshev (Mean, Sd) UCL 120.8
97.5% Chebyshev (Mean, Sd) UCL 158.6
99% Chebyshev (Mean, Sd) UCL 232.8

Anderson-Darling Test Statistic 3.71
Anderson-Darling 5% Critical Value 0.84
Kolmogorov-Smirnov Test Statistic 0.191
Kolmogorov-Smirnov 5% Critical Value 0.126

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL 49.41
95% Adjusted Gamma UCL 49.92

Statistical Summary for Aluminum mg/kg

Location ID	Sample Lot	Sample Type	Result	Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	18000 N	-	-	10.8	18000	9.80344001
Z1-EU29BW-401	S	REG	4400 N	-	-	8.4	4400	8.38936982
Z1-EU29BW-402	S	REG	19200 N	-	-	11.5	19200	9.86266658
Z1-EU29BW-403	S	REG	15400 N	-	-	9.6	15400	9.642122788
Z1-EU29BW-404	S	REG	15500 N	-	-	10.8	15500	9.646598303
Z1-EU29BW-405 + Dup	S	REG	12900 N	-	-	10.2	12900	9.45498259
Z1-EU29BW-406	S	REG	16800 N	-	-	9.5	16800	9.657768219
Z1-EU29BW-407	S	REG	20100 N	-	-	11	20100	9.908478094
Z1-EU29BW-408	S	REG	17700 N	-	-	10.8	17700	9.781319919
Z1-EU29BW-409	S	REG	16300 N	-	-	10.3	16300	9.699980887
Z1-EU30BW-411	B	REG	7910 N	-	-	10.4	7910	8.975883061
Z1-EU30C-444	C	REG	6520 N	-	-	3.9	6520	8.782629656
Z1-EU30C-445	C	REG	4510 N	-	-	3.8	4510	8.414082432
Z1-EU30C-446	C	REG	5320 N	-	-	4.1	5320	8.579229582
Z1-EU30C-447	C	REG	8810 N	-	-	4.2	8810	8.826147399
Z1-EU30C-448 + Dup	C	FA	6190 N	-	-	3.8	6190	8.610669177
Z1-EU30C-449	C	REG	7420 N	-	-	4	7420	8.911904336
Z1-EU30C-450	C	REG	6670 N	-	-	4	6670	8.642944397
Z1-EU30C-451	C	REG	7160 N	-	-	4	7160	8.874867638
Z1-EU30C-452	C	REG	7140 N	-	-	4	7140	8.873489055
Z1-EU30C-453	C	REG	7250 N	-	-	4.2	7250	8.888766748
Z1-EU30C-454	C	REG	6880 N	-	-	4.1	6880	8.836379931
Z1-EU31BW-415	B	REG	14800 N	-	-	10.8	14800	9.60238846
Z1-EU31BW-416	B	REG	18400 N	-	-	11.2	18400	9.820105944
Z1-EU31BW-417	B	REG	18100 N	-	-	9.7	18100	9.823667217
Z1-EU31W-412	S	REG	6350 N	-	-	10.7	6350	9.030918818
Z1-EU31W-413	S	REG	8380 N	-	-	9.3	8380	9.023963193
Z1-EU31W-414	S	REG	16400 N	-	-	11	16400	9.706098614
Z1-EU32BW-431	B	REG	10600 N	-	-	3.4	10600	9.26890628
Z1-EU32BW-432	B	REG	12300 N	-	-	3.1	12300	9.417354541
Z1-EU32BW-433 + Dup	B	REG	19800 N	-	-	3.6	19800	9.893437217
Z1-EU32BW-434	B	REG	8800 N	-	-	3.5	8800	9.082597
Z1-EU32C-455	C	REG	6520 N	-	-	4.1	6520	8.782629656
Z1-EU32C-456	C	REG	6400 N	-	-	4.3	6400	8.764053269
Z1-EU32MW-420	S	REG	12500 N	-	-	3.4	12500	9.430483923
Z1-EU32MW-428	S	REG	11300 N	-	-	3.5	11300	9.332559005
Z1-EU32W-418	S	REG	14400 N	-	-	4.2	14400	9.674583486
Z1-EU32W-419 + Dup	S	REG	20400 N	-	-	3.4	20400	9.92329018
Z1-EU32W-421	S	REG	13000 N	-	-	3.8	13000	9.472704638
Z1-EU32W-422	S	REG	9690 N	-	-	3.3	9690	9.178949705
Z1-EU32W-423	S	REG	12100 N	-	-	3.3	12100	9.400960732
Z1-EU32W-424	S	REG	12900 N	-	-	3.6	12900	9.45720046
Z1-EU32W-425	S	REG	11100 N	-	-	3.7	11100	9.314700387
Z1-EU32W-427	S	REG	16200 N	-	-	3.4	16200	9.692766621
Z1-EU32W-428	S	REG	11400 N	-	-	3.8	11400	9.341368834
Z1-EU32W-429	S	REG	13900 N	-	-	3.4	13900	9.539644119
Z1-EU32W-430	S	REG	11600 N	-	-	3	11600	9.388760377
Z1-EU32BW-443	B	REG	17900 N	-	-	10.1	17900	9.792555992
Z1-EU33BW-444	B	REG	11800 N	-	-	3.5	11800	9.384293678
Z1-EU33C-487	C	REG	7570 N	-	-	3.9	7570	8.931948346
Z1-EU33W-435	S	REG	21400 N	-	-	3.5	21400	9.571146301
Z1-EU33W-436	S	REG	13700 N	-	-	3.5	13700	9.526151112
Z1-EU33W-437	S	REG	16700 N	-	-	4	16700	9.723143898
Z1-EU33W-438	S	REG	15300 N	-	-	3.5	15300	9.636608107
Z1-EU33W-439	S	REG	15400 N	-	-	3.3	15400	9.642122788
Z1-EU33W-440	S	REG	11100 N	-	-	3.4	11100	9.314700387
Z1-EU33W-441	S	REG	14600 N	-	-	3.2	14600	9.586776808

Number of Samples 57
Number of Detects 57

Minimum 4400
Median 12300
Maximum 21400
Average 12261.053
Standard Deviation 4617.5352

PERT-Beta Mean 12500

Lognormal Mean 9.3350114
Lognormal Standard Deviation 0.4172184

Goodness-of-Fit Test Statistics for Full Data Sets without Non-Detects

User Selected Options

From File P:\Waste Generator Services\EM\WMF Profiles\WL 4.12\March 2009 revision\revised total metals to test.c
Full Precision OFF
Confidence Coefficient 0.9

Al mg/kg

Raw Statistics

Number of Valid Observations 57
Number of Distinct Observations 54
Minimum 4400
Maximum 21400
Mean of Raw Data 12261
Standard Deviation of Raw Data 4618
Kstar 6.148
Mean of Log Transformed Data 9.335
Standard Deviation of Log Transformed Data 0.417

Normal Distribution Test Results

Correlation Coefficient R 0.985
Lilliefors Test Statistic 0.115
Lilliefors Critical (0.9) Value 0.107

Data not Normal at (0.1) Significance Level

Gamma Distribution Test Results

Correlation Coefficient R 0.974
A-D Test Statistic 0.862
A-D Critical (0.9) Value 0.632
K-S Test Statistic 0.0968
K-S Critical(0.9) Value 0.108

Data follow Appr. Gamma Distribution at (0.1) Significance Level

Lognormal Distribution Test Results

Correlation Coefficient R 0.978
Lilliefors Test Statistic 0.112
Lilliefors Critical (0.9) Value 0.107

Data not Lognormal at (0.1) Significance Level

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Redus, 865.483.2715 kredus@cox.net

12/29/2005 R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

		WACFACS WLL SRC INPUT			Calculations							
		STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC		MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Aluminum (mg/kg)		4400.0000	1.23E+04	2.14E+04	12500.00	17857.28	1.43	17857.28	2.96	3.14	#####	17000.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < \text{Most likely} < MAX$$

$$F(x) = \frac{B((\alpha_1, \alpha_2), x)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times \text{Most Likely} + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_x(\alpha_1, \alpha_2)$ is the incomplete Beta Function
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel 6th Function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Arsenic mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	S	REG	1.7 N	=		0.27	1.7	0.530628251
Z1-EU29W-401	S	REG	0.82 B N	J		0.23	0.82	-0.186480938
Z1-EU29W-402	S	REG	0.58 B N	=		0.23	0.56	-0.579816495
Z1-EU29W-403	S	REG	0.5 B N	=		0.24	0.5	-0.693147181
Z1-EU29W-404	S	REG	0.84 B N	=		0.27	0.84	-0.174353387
Z1-EU29W-405 + Dup	S	FR	1.3 N	=		0.26	1.3	0.262354264
Z1-EU29W-406	S	REG	0.84 B N	=		0.24	0.84	-0.174353387
Z1-EU29W-407	S	REG	2.8 N	=		0.27	2.8	1.029619417
Z1-EU29W-408	S	REG	0.28 B N	=		0.26	0.28	-1.272865670
Z1-EU29W-409	S	REG	1.1 B N	=		0.28	1.1	0.09531018
Z1-EU30W-411	B	REG	1.3 B N	=		0.28	1.3	0.282364284
Z1-EU30C-444	C	REG	0.3 U N	UJ		0.3	0.15	-1.287119985
Z1-EU30C-445	C	REG	0.25 U N	U		0.28	0.13	-2.040220829
Z1-EU30C-446	C	REG	0.31 U N	U		0.31	0.155	-1.464330182
Z1-EU30C-447	C	REG	0.31 U N	U		0.31	0.155	-1.464330182
Z1-EU30C-448 + Dup	C	REG	0.29 U N	U		0.29	0.145	-1.301021537
Z1-EU30C-449	C	REG	0.3 U N	U		0.3	0.15	-1.487119985
Z1-EU30C-450	C	REG	0.3 U N	U		0.3	0.15	-1.487119985
Z1-EU30C-451	C	REG	0.3 U N	U		0.3	0.15	-1.487119985
Z1-EU30C-452	C	REG	0.3 U N	U		0.3	0.15	-1.487119985
Z1-EU30C-453	C	REG	0.32 U N	U		0.32	0.16	-1.532591464
Z1-EU30C-454	C	REG	0.3 U N	U		0.3	0.15	-1.487119985
Z1-EU31BW-415	B	REG	0.85 B N	=		0.27	0.85	-0.182514329
Z1-EU31BW-418	B	REG	0.74 B N	=		0.28	0.74	-0.301105093
Z1-EU31BW-417	B	REG	11.3 B N	=		0.24	11.3	2.424802725
Z1-EU31W-412	S	REG	0.42 B N	=		0.27	0.42	-0.967800558
Z1-EU31W-413	S	REG	2.1 N	=		0.23	2.1	0.741907345
Z1-EU31W-414	S	REG	0.51 B N	=		0.27	0.51	-0.673344553
Z1-EU32BW-431	B	REG	65.1 N	=		0.26	65.1	4.175924549
Z1-EU32BW-432	B	REG	1.8 N	=		0.23	1.8	0.470003829
Z1-EU32BW-433 + Dup	B	REG	0.27 B N	=		0.26	0.27	-1.30833332
Z1-EU32BW-434	B	REG	0.69 B N	=		0.24	0.56	-0.573818495
Z1-EU32C-455	C	REG	0.31 U N	U		0.31	0.188	-1.884330182
Z1-EU32C-456	C	REG	0.32 U N	U		0.32	0.16	-1.432581464
Z1-EU32W-420	S	REG	0.26 U N	U		0.28	0.13	-2.040220829
Z1-EU32W-426	S	REG	1.4 N	=		0.27	1.4	0.395472237
Z1-EU32W-418	S	REG	0.32 U N	UJ		0.32	0.18	-1.432581464
Z1-EU32W-419 + Dup	S	REG	1.4 N	=		0.28	1.4	0.395472237
Z1-EU32W-421	S	REG	0.83 B N	=		0.27	0.83	-0.185325578
Z1-EU32W-422	S	REG	0.69 B N	=		0.25	0.69	-0.371063591
Z1-EU32W-423	S	REG	0.98 B N	=		0.25	0.96	-0.040421928
Z1-EU32W-424	S	REG	0.27 U N	U		0.27	0.135	-2.003480501
Z1-EU32W-425	S	REG	0.52 B N	=		0.28	0.52	-0.653826487
Z1-EU32W-427	S	REG	0.26 U N	U		0.26	0.13	-2.040220829
Z1-EU32W-428	S	REG	0.26 U N	U		0.28	0.14	-1.988112884
Z1-EU32W-429	S	REG	0.26 U N	U		0.26	0.13	-2.040220829
Z1-EU32W-430	S	REG	0.23 U N	UJ		0.23	0.115	-2.182833181
Z1-EU33BW-443	B	REG	1.9 N	=		0.26	1.9	0.641953888
Z1-EU33BW-444	B	REG	0.28 B N	=		0.28	0.29	-1.237874358
Z1-EU33C-467	C	REG	0.29 U N	U		0.29	0.145	-1.301021537
Z1-EU33W-435	S	REG	0.27 U N	U		0.27	0.138	-2.002480501
Z1-EU33W-436	S	REG	0.31 B N	=		0.27	0.31	-1.171182982
Z1-EU33W-437	S	REG	0.83 B N	=		0.3	0.53	-0.072570693
Z1-EU33W-438	S	REG	2.9 N	=		0.26	2.9	1.084110737
Z1-EU33W-439	S	REG	0.48 B N	=		0.26	0.46	-0.778528789
Z1-EU33W-440	S	REG	2.5 N	=		0.25	2.5	0.918290732
Z1-EU33W-441	S	REG	0.68 B N	=		0.24	0.68	-0.395662481

Number of Samples 57
Number of Detects 35

Minimum 0.115
Median 0.5
Maximum 65.1
Average 2.0077193
Standard Deviation 8.649705

PERT-Beta Mean 11.2025

Lognormal Mean -0.723231
Lognormal Standard Deviation 1.2769656

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Sb mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	39
------------------------------	----	---------------------------------	----

Raw Statistics

Minimum	0.115
Maximum	65.1
Mean	2.008
Median	0.5
SD	8.65
Coefficient of Variation	4.308
Skewness	7.199

Log-transformed Statistics

Minimum of Log Data	-2.163
Maximum of Log Data	4.176
Mean of log Data	-0.723
SD of log Data	1.277

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic	0.424
Lilliefors Critical Value	0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic	0.193
Lilliefors Critical Value	0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	3.924
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	5.06
95% Modified-t UCL	4.106

Assuming Lognormal Distribution

95% H-UCL	1.601
95% Chebyshev (MVUE) UCL	2.07
97.5% Chebyshev (MVUE) UCL	2.503
99% Chebyshev (MVUE) UCL	3.354

Gamma Distribution Test

k star (bias corrected)	0.442
Theta Star	4.544
nu star	50.37

Approximate Chi Square Value (.05)	35.07
Adjusted Level of Significance	0.0458
Adjusted Chi Square Value	34.74

Anderson-Darling Test Statistic	6.604
Anderson-Darling 5% Critical Value	0.826
Kolmogorov-Smirnov Test Statistic	0.233
Kolmogorov-Smirnov 5% Critical Value	0.125

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	3.892
95% Jackknife UCL	3.924
95% Standard Bootstrap UCL	3.886
95% Bootstrap-t UCL	19.05
95% Hall's Bootstrap UCL	11.42
95% Percentile Bootstrap UCL	4.186
95% BCA Bootstrap UCL	6.246
95% Chebyshev(Mean, Sd) UCL	7.002
97.5% Chebyshev(Mean, Sd) UCL	9.162
99% Chebyshev(Mean, Sd) UCL	13.41

Assuming Gamma Distribution

95% Approximate Gamma UCL	2.883
95% Adjusted Gamma UCL	2.911

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Radius, 885.483.2715

ken@radiusinc.net

12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

	SRC	WACFACS WL L SRC INPUT			OUTPUT			Beta PDF Inverse		Calculations			
		STEP 10	STEP 11	STEP 12						PERT BETA			
		MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	0.95	α_1	α_2	Variance	Max - Min
Antimony (mg/kg)		0.1150	0.5000	05.1000	11.20	29.79	2.66	29.79		1.02	4.98	102.9316	65.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < Most Likely < MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_x(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters

1) Use the Microsoft Excel 2000 function BETAINV(0.95 or .95, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Arsenic mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection		Proxy Value	LN Proxy Value
						Limit			
Z1-EU28W-400	B	REG	8.4		✓	0.45		8.4	2.126231706
Z1-EU28W-401	S	REG	8.4		✓	0.39		8.4	1.823775432
Z1-EU28W-402	S	REG	10.2		=	0.48		10.2	2.32238772
Z1-EU28W-403	S	REG	7.6		✓	0.4		7.6	2.028148247
Z1-EU28W-404	S	REG	7.6		=	0.45		7.6	2.028148247
Z1-EU28W-405 + Dup	S	REG	6.2		✓	0.43		6.2	1.824546282
Z1-EU28W-406	S	REG	8		✓	0.39		8	2.079441542
Z1-EU28W-407	S	REG	9.6		✓	0.46		9.6	2.261753098
Z1-EU28W-408	S	REG	6.4		✓	0.44		6.4	2.128231706
Z1-EU28W-409	S	REG	8.7		=	0.43		8.7	2.163323026
Z1-EU30W-411	B	REG	8		✓	0.43		8	2.079441542
Z1-EU30C-444	C	REG	2.9		=	0.49		2.9	1.064710737
Z1-EU30C-446	C	REG	3.3		✓	0.43		3.3	1.193822468
Z1-EU30C-446	C	REG	5		=	0.51		5	1.609437972
Z1-EU30C-447	C	REG	3.8		✓	0.52		3.8	1.339001067
Z1-EU30C-448 + Dup	C	REG	3.1		=	0.49		3.1	1.131402111
Z1-EU30C-448	C	REG	3.4		✓	0.5		3.4	1.223775432
Z1-EU30C-450	C	REG	4.8		=	0.5		4.8	1.568615918
Z1-EU30C-451	C	REG	3.2		✓	0.5		3.2	1.16315081
Z1-EU30C-452	C	REG	4.1		=	0.5		4.1	1.410696974
Z1-EU30C-453	C	REG	4.3		✓	0.53		4.3	1.458515023
Z1-EU30C-454	C	REG	4		✓	0.51		4	1.396294361
Z1-EU31W-415	B	REG	11		✓	0.45		11	2.397985273
Z1-EU31W-416	B	REG	9.6		✓	0.47		9.6	2.251291759
Z1-EU31W-417	B	REG	7.6		✓	0.41		7.6	2.028148247
Z1-EU31W-412	S	REG	8.8		✓	0.44		8.8	1.757857918
Z1-EU31W-413	S	REG	5.9		✓	0.39		5.9	1.774852361
Z1-EU31W-414	S	REG	9		✓	0.48		9	2.197224577
Z1-EU32W-431	B	REG	9.5		✓	0.43		9.5	2.251291759
Z1-EU32W-432	B	REG	8.1		✓	0.39		8.1	2.208274414
Z1-EU32W-433 + Dup	B	FA	6.6		✓	0.44		6.6	1.897069649
Z1-EU32W-434	B	REG	5.2		✓	0.4		5.2	1.64888826
Z1-EU32C-455	C	REG	4.9		✓	0.51		4.9	1.589235206
Z1-EU32C-456	C	REG	3.8		✓	0.54		3.8	1.336001067
Z1-EU32W-420	S	REG	6.2		✓	0.43		6.2	1.824546282
Z1-EU32W-426	B	REG	10.2		✓	0.45		10.2	2.32238772
Z1-EU32W-418	S	REG	4.4		✓	0.53		4.4	1.481604541
Z1-EU32W-419 + Dup	B	REG	14.1		✓	0.43		14.1	2.646174797
Z1-EU32W-421	S	REG	7.2		✓	0.45		7.2	1.974081038
Z1-EU32W-422	S	REG	9.8		✓	0.41		9.8	2.282382386
Z1-EU32W-423	S	REG	7.6		✓	0.42		7.6	2.028148247
Z1-EU32W-424	S	REG	6		✓	0.45		6	1.791786489
Z1-EU32W-426	S	REG	6.6		✓	0.46		6.6	1.897069649
Z1-EU32W-427	S	REG	5.9		✓	0.43		5.9	1.774852361
Z1-EU32W-428	S	REG	7.7		✓	0.47		7.7	2.041220329
Z1-EU32W-429	S	REG	5.9		✓	0.43		5.9	1.774852361
Z1-EU32W-430	S	REG	5.3		✓	0.38		5.3	1.667706827
Z1-EU33W-443	B	REG	18.8		✓	0.42		18.8	2.821378888
Z1-EU33W-444	B	REG	5.8		✓	0.44		5.8	1.757857918
Z1-EU33C-457	C	REG	4.8		✓	0.49		4.8	1.608018818
Z1-EU33W-435	S	REG	5.8		✓	0.44		5.8	1.757857918
Z1-EU33W-436	B	REG	5.5		=	0.44		5.5	1.704748052
Z1-EU33W-437	S	REG	15.5		✓	0.5		15.5	2.740840024
Z1-EU33W-438	S	REG	11.1		✓	0.44		11.1	2.406948108
Z1-EU33W-439	S	REG	10.3		✓	0.41		10.3	2.32238772
Z1-EU33W-440	S	REG	18.4		✓	0.42		18.4	2.912850665
Z1-EU33W-441	S	REG	7.8		✓	0.4		7.8	2.054122734

Number of Samples 57
Number of Detects 57

Minimum 2.9
Median 8.8
Maximum 18.4
Average 7.2736842
Standard Deviation 3.3555139

PERT-Beta Mean 7.95

Lognormal Mean 1.8893793
Lognormal Standard Deviation 0.436757

Goodness-of-Fit Test Statistics for Full Data Sets without Non-Detects

User Selected Options

From File P:\Waste Generator Services\EMWMF Profiles\WL 4.12\March 2009 revision\revised total metals to test
Full Precision OFF
Confidence Coefficient 0.9

As mg/kg

Raw Statistics

Number of Valid Observations	57
Number of Distinct Observations	41
Minimum	2.9
Maximum	18.4
Mean of Raw Data	7.274
Standard Deviation of Raw Data	3.356
Kstar	5.156
Mean of Log Transformed Data	1.889
Standard Deviation of Log Transformed Data	0.437

Normal Distribution Test Results

Correlation Coefficient R	0.947
Lilliefors Test Statistic	0.117
Lilliefors Critical (0.9) Value	0.107

Data not Normal at (0.1) Significance Level

Gamma Distribution Test Results

Correlation Coefficient R	0.985
A-D Test Statistic	0.374
A-D Critical (0.9) Value	0.632
K-S Test Statistic	0.0772
K-S Critical(0.9) Value	0.108

Data appear Gamma Distributed at (0.1) Significance Level

Lognormal Distribution Test Results

Correlation Coefficient R	0.993
Lilliefors Test Statistic	0.0808
Lilliefors Critical (0.9) Value	0.107

Data appear Lognormal at (0.1) Significance Level

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Ba mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 52

Raw Statistics

Minimum 31.3
Maximum 395
Mean 80.37
Median 71.5
SD 52.88
Coefficient of Variation 0.658
Skewness 4.032

Log-transformed Statistics

Minimum of Log Data 3.444
Maximum of Log Data 5.979
Mean of log Data 4.264
SD of log Data 0.462

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.254
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.14
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 92.09
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 95.89
95% Modified-t UCL 92.71

Assuming Lognormal Distribution

95% H-UCL 88.6
95% Chebyshev (MVUE) UCL 100.9
97.5% Chebyshev (MVUE) UCL 110.4
99% Chebyshev (MVUE) UCL 129.1

Gamma Distribution Test

k star (bias corrected) 4.008
Theta Star 20.05
nu star 456.9

Approximate Chi Square Value (.05) 408.4

Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 407.2

Anderson-Darling Test Statistic 1.51
Anderson-Darling 5% Critical Value 0.754
Kolmogorov-Smirnov Test Statistic 0.18
Kolmogorov-Smirnov 5% Critical Value 0.118

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 91.9
95% Jackknife UCL 92.09
95% Standard Bootstrap UCL 92.12
95% Bootstrap-t UCL 99.21
95% Halfs Bootstrap UCL 145
95% Percentile Bootstrap UCL 93.52
95% BCA Bootstrap UCL 97.26
95% Chebyshev(Mean, Sd) UCL 110.9
97.5% Chebyshev(Mean, Sd) UCL 124.1
99% Chebyshev(Mean, Sd) UCL 150.1

Assuming Gamma Distribution

95% Approximate Gamma UCL 89.93
95% Adjusted Gamma UCL 90.19

Potential UCL to Use	Use 95% Student's-t UCL or 95% Modified-t UCL	92.09 92.71
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Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

		WACFACS WL L SRC INPUT			Calculations						
		STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA		
		MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance
Barium (mg/kg)	SRC	31.3000	71.9000	395.0000	118.72	231.67	1.95	231.67	1.44	4.58	4541.9202
		Max - Min									

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval (0, 1). The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MAX \text{ likely } < MAX$$

$$F(x) = \frac{B_1(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times \text{Most Likely} + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function

α_1 and α_2 are calculated parameters

Use the Microsoft Excel @Risk function RBT&INV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Barium mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU29BW-410		REG	363	=		3.1	0.363	-1.013352445
Z1-EU29W-401		REG	742	=		3.1	0.742	-0.298406038
Z1-EU29W-402		REG	270	=		3.1	0.27	-1.30933332
Z1-EU29W-403		REG	369	=		3.1	0.369	-0.996958635
Z1-EU29W-404		REG	358	=		3.1	0.358	-1.027222293
Z1-EU29W-405 + Dup		REG	311	=		3.1	0.311	-1.187962367
Z1-EU29W-406		REG	279	=		3.1	0.279	-1.276643487
Z1-EU29W-407		REG	360	=		3.1	0.36	-1.021651248
Z1-EU29W-408		REG	223	=		3.1	0.223	-1.500583508
Z1-EU29W-409		REG	672	=		3.1	0.672	-0.397496938
Z1-EU30BW-411		REG	638	=		3.1	0.638	-0.449416996
Z1-EU31BW-415		REG	305	=		3.1	0.305	-1.187443502
Z1-EU31BW-418		REG	244	=		3.1	0.244	-1.410587034
Z1-EU31BW-417		REG	276	=		3.1	0.276	-1.287354413
Z1-EU31W-412		REG	235	=		3.1	0.235	-1.448169765
Z1-EU31W-413		REG	470	=		3.1	0.47	-0.755022584
Z1-EU31W-414		REG	285	=		3.1	0.285	-1.255266099
Z1-EU32BW-431		REG	846	=		6	0.846	-0.167235919
Z1-EU32BW-432		REG	792	=		6	0.792	-0.233193887
Z1-EU32BW-433 + Dup		REG	474	=		6	0.474	-0.746547957
Z1-EU32BW-434		REG	674	=		3.1	0.674	-0.394525158
Z1-EU32MW-420		REG	1570	=		6	1.57	-0.451075819
Z1-EU32MW-426		REG	862	=		6	0.862	-0.148500008
Z1-EU32W-418		REG	436	=		6	0.436	-0.830113036
Z1-EU32W-419 + Dup		REG	795	=		6	0.795	-0.229413164
Z1-EU32W-421		REG	1090	=		6	1.09	-0.086177698
Z1-EU32W-422		REG	1400	=		6	1.4	-0.336472237
Z1-EU32W-423		REG	1240	=		6	1.24	-0.215111138
Z1-EU32W-424		REG	584	=		6	0.584	-0.537854296
Z1-EU32W-425		REG	933	=		6	0.933	-0.089350078
Z1-EU32W-427		REG	495	=		6	0.495	-0.703197516
Z1-EU32W-428		REG	492	=		6	0.492	-0.709276562
Z1-EU32W-429		REG	438	=		6	0.438	-0.825536369
Z1-EU32W-430		REG	603	=		6	0.603	-0.505838082
Z1-EU33BW-443		REG	499	=		3.1	0.499	-0.695149183
Z1-EU33BW-444		REG	511	=		6	0.511	-0.671385689
Z1-EU33W-435		REG	531	=		6	0.531	-0.632993258
Z1-EU33W-436		REG	626	=		6	0.626	-0.468404908
Z1-EU33W-437		REG	1770	=		6	1.77	-0.570879347
Z1-EU33W-438		REG	593	=		6	0.593	-0.52256088
Z1-EU33W-439		REG	831	=		6	0.831	-0.460449416
Z1-EU33W-440		REG	583	=		6	0.583	-0.539568093
Z1-EU33W-441		REG	1740	=		6	1.74	-0.553885113
Number of Samples			43					
Number of Detects			43					
Minimum			0.223					
Median			0.531					
Maximum			1.77					
Average			0.6420485					
Standard Deviation			0.3939569					
PERT-Beta Mean			0.6861687					
Lognormal Mean			-0.597219					
Lognormal Standard Deviation			0.5480201					

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Ba mg/L

General Statistics

Number of Valid Observations	43	Number of Distinct Observations	43
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Raw Statistics

Minimum	0.223
Maximum	1.77
Mean	0.642
Median	0.531
SD	0.394
Coefficient of Variation	0.614
Skewness	1.531

Log-transformed Statistics

Minimum of Log Data	-1.501
Maximum of Log Data	0.571
Mean of log Data	-0.597
SD of log Data	0.548

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.829
Shapiro Wilk Critical Value	0.943

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.959
Shapiro Wilk Critical Value	0.943

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.743
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	0.756
95% Modified-t UCL	0.745

Assuming Lognormal Distribution

95% H-UCL	0.753
95% Chebyshev (MVUE) UCL	0.882
97.5% Chebyshev (MVUE) UCL	0.989
99% Chebyshev (MVUE) UCL	1.197

Gamma Distribution Test

k star (bias corrected)	3.18
Theta Star	0.202
nu star	273.5

Approximate Chi Square Value (.05) 236.2

Adjusted Level of Significance	0.0444
Adjusted Chi Square Value	235

Anderson-Darling Test Statistic	0.73
Anderson-Darling 5% Critical Value	0.754
Kolmogorov-Smirnov Test Statistic	0.114
Kolmogorov-Smirnov 5% Critical Value	0.136

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	0.741
95% Jackknife UCL	0.743
95% Standard Bootstrap UCL	0.741
95% Bootstrap-t UCL	0.758
95% Halfs Bootstrap UCL	0.764
95% Percentile Bootstrap UCL	0.743
95% BCA Bootstrap UCL	0.758
95% Chebyshev(Mean, Sd) UCL	0.904
97.5% Chebyshev(Mean, Sd) UCL	1.017
99% Chebyshev(Mean, Sd) UCL	1.24

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.743
95% Adjusted Gamma UCL	0.747

Statistical Summary for Beryllium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	B	REG	0.14	B	=	0.05	0.14	1.988772956
Z1-EU29W-401	S	REG	0.31	=	=	0.04	0.31	1.171182982
Z1-EU29W-402	S	REG	0.44	=	=	0.05	0.44	0.820980552
Z1-EU29W-403	S	REG	0.47	=	=	0.04	0.47	-0.788022584
Z1-EU29W-404	S	REG	0.44	=	=	0.05	0.44	-0.820980552
Z1-EU29W-405 + Dup	S	FR	1.8	=	=	0.04	1.8	0.587788885
Z1-EU29W-406	S	REG	0.44	=	=	0.04	0.44	0.820980552
Z1-EU29W-407	S	REG	0.97	=	=	0.05	0.97	0.030453207
Z1-EU29W-408	S	REG	0.37	=	=	0.04	0.37	0.994252273
Z1-EU29W-409	S	REG	0.58	=	=	0.04	0.58	0.544727775
Z1-EU30BW-411	B	REG	0.43	=	=	0.04	0.43	0.843970007
Z1-EU30C-444	C	REG	0.26	=	=	0.05	0.26	-1.347073648
Z1-EU30C-445	C	REG	0.19	=	=	0.04	0.19	-1.680731207
Z1-EU30C-446	C	REG	0.2	B	=	0.05	0.2	-1.603437912
Z1-EU30C-447	C	REG	0.29	=	=	0.05	0.29	-1.237874356
Z1-EU30C-448 + Dup	C	FR	0.33	=	=	0.05	0.33	-1.108868625
Z1-EU30C-449	C	REG	0.32	=	=	0.05	0.32	-1.139434283
Z1-EU30C-450	C	REG	0.2	=	=	0.05	0.2	-1.603437912
Z1-EU30C-451	C	REG	0.31	=	=	0.05	0.31	-1.171182982
Z1-EU30C-452	C	REG	0.65	=	=	0.05	0.65	-0.527837001
Z1-EU30C-453	C	REG	0.68	=	=	0.05	0.68	-0.371083881
Z1-EU30C-454	C	REG	0.29	=	=	0.05	0.29	-1.237874356
Z1-EU31BW-415	B	REG	0.36	=	=	0.04	0.36	-1.049622124
Z1-EU31BW-416	B	REG	0.38	=	=	0.05	0.38	-0.967584026
Z1-EU31BW-417	B	REG	0.36	=	=	0.04	0.36	-1.021651248
Z1-EU31W-412	S	REG	0.42	=	=	0.04	0.42	0.857500568
Z1-EU31W-413	S	REG	0.39	=	=	0.04	0.39	-0.84180854
Z1-EU31W-414	S	REG	0.37	=	=	0.05	0.37	0.994252273
Z1-EU32BW-431	B	REG	0.42	=	=	0.04	0.42	0.857500568
Z1-EU32BW-432	B	REG	0.3	=	=	0.04	0.3	1.2039772804
Z1-EU32BW-433 + Dup	B	FR	0.44	=	=	0.04	0.44	0.820980552
Z1-EU32BW-434	B	REG	0.61	=	=	0.04	0.61	0.494296302
Z1-EU32C-455	C	REG	0.28	=	=	0.08	0.28	1.347073648
Z1-EU32C-456	C	REG	0.25	=	=	0.05	0.25	1.885294051
Z1-EU32MW-420	S	REG	0.34	=	=	0.04	0.34	-1.078816861
Z1-EU32MW-426	S	REG	0.44	=	=	0.05	0.44	0.820980552
Z1-EU32W-418	S	REG	0.37	=	=	0.05	0.37	0.994252273
Z1-EU32W-419 + Dup	S	REG	0.42	=	=	0.04	0.42	0.857500568
Z1-EU32W-421	S	REG	0.4	=	=	0.05	0.4	0.918290732
Z1-EU32W-422	S	REG	0.38	=	=	0.04	0.38	0.967584026
Z1-EU32W-423	S	REG	0.39	=	=	0.04	0.39	1.108868625
Z1-EU32W-424	S	REG	0.41	=	=	0.05	0.41	0.891598179
Z1-EU32W-428	S	REG	0.39	=	=	0.05	0.39	0.94180854
Z1-EU32W-427	S	REG	0.53	=	=	0.04	0.53	0.634878272
Z1-EU32W-428	S	REG	0.42	=	=	0.05	0.42	0.857500568
Z1-EU32W-429	S	REG	0.39	=	=	0.04	0.39	0.94180854
Z1-EU32W-430	S	REG	0.37	=	=	0.04	0.37	0.994252273
Z1-EU33BW-443	B	REG	0.47	=	=	0.04	0.47	-0.755022584
Z1-EU33BW-444	B	REG	0.48	=	=	0.04	0.48	0.733983175
Z1-EU33C-457	C	REG	0.44	=	=	0.05	0.44	0.820980552
Z1-EU33W-435	S	REG	0.83	=	=	0.04	0.83	0.185329878
Z1-EU33W-436	S	REG	0.45	=	=	0.04	0.45	0.778528789
Z1-EU33W-437	S	REG	0.64	=	=	0.05	0.64	-0.5151488139
Z1-EU33W-438	S	REG	0.4	=	=	0.04	0.4	-0.916290732
Z1-EU33W-439	S	REG	0.49	=	=	0.04	0.49	0.713349888
Z1-EU33W-440	S	REG	0.29	=	=	0.04	0.29	-1.237874356
Z1-EU33W-441	S	REG	0.46	=	=	0.04	0.46	0.778528789

Number of Samples 57
Number of Detects 57

Minimum 0.14
Median 0.4
Maximum 1.8
Average 0.4318298
Standard Deviation 0.2322056

PERT-Beta Mean 0.59

Lognormal Mean -0.926188
Lognormal Standard Deviation 0.3927134

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheetwst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Be mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 34

Raw Statistics

Minimum 0.14
Maximum 1.8
Mean 0.432
Median 0.4
SD 0.232
Coefficient of Variation 0.538
Skewness 4.003

Log-transformed Statistics

Minimum of Log Data -1.966
Maximum of Log Data 0.588
Mean of log Data -0.926
SD of log Data 0.393

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.243
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.138
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 0.483
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 0.5
95% Modified-t UCL 0.486

Assuming Lognormal Distribution

95% H-UCL 0.47
95% Chebyshev (MVUE) UCL 0.527
97.5% Chebyshev (MVUE) UCL 0.57
99% Chebyshev (MVUE) UCL 0.655

Gamma Distribution Test

k star (bias corrected) 5.629
Theta Star 0.0767
nu star 641.7

Approximate Chi Square Value (.05) 583.9
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 582.5

Anderson-Darling Test Statistic 2.011
Anderson-Darling 5% Critical Value 0.753
Kolmogorov-Smirnov Test Statistic 0.172
Kolmogorov-Smirnov 5% Critical Value 0.118

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 0.483
95% Jackknife UCL 0.483
95% Standard Bootstrap UCL 0.481
95% Bootstrap-t UCL 0.522
95% Hall's Bootstrap UCL 0.727
95% Percentile Bootstrap UCL 0.487
95% BCA Bootstrap UCL 0.504
95% Chebyshev (Mean, Sd) UCL 0.566
97.5% Chebyshev (Mean, Sd) UCL 0.624
99% Chebyshev (Mean, Sd) UCL 0.738

Assuming Gamma Distribution

95% Approximate Gamma UCL 0.475
95% Adjusted Gamma UCL 0.476

Potential UCL to Use	Use 95% Student's-t UCL	0.483
	or 95% Modified-t UCL	0.486

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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kredus@redus.net

12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

			WACFACS WL L SRC INPUT						Calculations				
			STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
			MIN	MED	MAX	EOX	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Beryllium (mg/kg)			0.1400	0.4000	1.8000	0.58	1.12	1.89	1.12	1.83	4.37	0.1067	1.7

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MAX \text{ and } x < MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_x(\alpha_1, \alpha_2)$ is the incomplete Beta Function
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel 98/99 function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Boron mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	3			0.45	3	1.098812289
Z1-EU29W-401	S	REG	5.2	-		0.39	5.2	1.948658526
Z1-EU29W-402	S	REG	3.4	-		0.48	3.4	1.223775432
Z1-EU29W-403	S	REG	3.5	-		0.4	3.5	1.252752994
Z1-EU29W-404	S	REG	4.5	-		0.48	4.5	1.504077397
Z1-EU29W-405 + Dup	S	FR	15.8	-		0.41	15.8	2.921378886
Z1-EU29W-406	S	REG	3.2	-		0.39	3.2	1.16315081
Z1-EU29W-407	S	REG	5.4	-		0.46	5.4	1.688396884
Z1-EU29W-408	S	REG	2.9	-		0.44	2.9	1.064710737
Z1-EU29W-409	S	REG	4.3	-		0.43	4.3	1.458618623
Z1-EU30BW-411	B	REG	15.4	-		0.43	15.4	2.734367509
Z1-EU30C-444	C	REG	9	-		0.49	9	2.197224577
Z1-EU30C-445	C	REG	5.9	-		0.43	5.9	1.774952351
Z1-EU30C-446	C	REG	10.9	-		0.51	10.9	2.386762789
Z1-EU30C-447	C	REG	10.8	-		0.52	10.8	2.379546134
Z1-EU30C-448 + Dup	C	FR	10.7	-		0.47	10.7	2.370243741
Z1-EU30C-449	C	REG	9.8	-		0.5	9.8	2.282367386
Z1-EU30C-450	C	REG	9.8	-		0.5	9.8	2.282367386
Z1-EU30C-451	C	REG	9.2	-		0.5	9.2	2.219203484
Z1-EU30C-452	C	REG	6.7	-		0.6	6.7	1.902107526
Z1-EU30C-453	C	REG	7.8	-		0.59	7.8	2.054123734
Z1-EU30C-454	C	REG	13.3	-		0.61	13.3	2.587764036
Z1-EU31BW-415	B	REG	3.5	-		0.45	3.5	1.252752994
Z1-EU31BW-416	B	REG	3	-		0.47	3	1.098812289
Z1-EU31BW-417	B	REG	3	-		0.41	3	1.098812289
Z1-EU31W-412	S	REG	21.2	-		0.44	21.2	3.054001782
Z1-EU31W-413	S	REG	7.9	-		0.39	7.9	2.065882759
Z1-EU31W-414	S	REG	3.2	-		0.46	3.2	1.16315081
Z1-EU32BW-431	B	REG	8.5	-		0.43	8.5	2.140066163
Z1-EU32BW-432	B	REG	7.2	-		0.39	7.2	1.974081025
Z1-EU32BW-433 + Dup	B	REG	4.2	-		0.44	4.2	1.435084525
Z1-EU32BW-434	B	REG	7.7	-		0.4	7.7	2.041220329
Z1-EU32C-455	C	REG	8.5	-		0.61	8.5	2.161762303
Z1-EU32C-456	C	REG	8.3	-		0.54	8.3	2.116285815
Z1-EU32NW-420	S	REG	5 N	-		0.43	5	1.609437912
Z1-EU32NW-425	B	REG	5.9 N	-		0.45	5.9	1.774952351
Z1-EU32W-418	S	REG	5.3 N	-		0.53	5.3	1.667706821
Z1-EU32W-419 + Dup	S	REG	11.4 N	-		0.43	11.4	2.433613365
Z1-EU32W-421	S	REG	7.7 N	-		0.45	7.7	2.041220329
Z1-EU32W-422	S	REG	8.4 N	-		0.41	8.4	2.128231706
Z1-EU32W-423	S	REG	16.3 N	-		0.42	16.3	2.791185108
Z1-EU32W-424	S	REG	2 N	-		0.45	2	0.693147181
Z1-EU32W-425	S	REG	5.8 N	-		0.45	5.8	1.757857918
Z1-EU32W-427	S	REG	2.2 N	-		0.43	2.2	0.79848736
Z1-EU32W-428	S	REG	4.5 N	-		0.47	4.5	1.504077397
Z1-EU32W-429	S	REG	3 N	-		0.43	3	1.098812289
Z1-EU32W-430	S	REG	1.9	-		0.38	1.9	0.641853885
Z1-EU32W-443	B	REG	8.5	-		0.42	8.5	2.140066163
Z1-EU32W-444	B	REG	3.2	-		0.44	3.2	1.16315081
Z1-EU33C-457	C	REG	39.1	-		0.49	39.1	3.669122467
Z1-EU33W-435	S	REG	3	-		0.44	3	1.098812289
Z1-EU33W-436	B	REG	2.5	-		0.44	2.5	0.958811448
Z1-EU33W-437	S	REG	7.9	-		0.5	7.9	2.065882759
Z1-EU33W-438	S	REG	8.8	-		0.44	8.8	1.918922612
Z1-EU33W-439	S	REG	4.2	-		0.41	4.2	1.435084525
Z1-EU33W-440	S	REG	5.9	-		0.42	5.9	1.774952351
Z1-EU33W-441	S	REG	5.1	-		0.4	5.1	1.62921054

Number of Samples 57
Number of Detects 57

Minimum 1.9
Median 5.9
Maximum 39.1
Average 7.4298246
Standard Deviation 5.8910939

PERT Beta Mean 10.786667

Lognormal Mean 1.7976234
Lognormal Standard Deviation 0.6246672

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

8 mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	42
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Raw Statistics

Minimum	1.9
Maximum	39.1
Mean	7.43
Median	5.9
SD	5.891
Coefficient of Variation	0.793
Skewness	3.175

Log-transformed Statistics

Minimum of Log Data	0.642
Maximum of Log Data	3.666
Mean of log Data	1.798
SD of log Data	0.625

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic	0.176
Lilliefors Critical Value	0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic	0.0892
Lilliefors Critical Value	0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	8.735
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	9.064
95% Modified-t UCL	8.79

Assuming Lognormal Distribution

95% H-UCL	8.635
95% Chebyshev (MVUE) UCL	10.15
97.5% Chebyshev (MVUE) UCL	11.38
99% Chebyshev (MVUE) UCL	13.79

Gamma Distribution Test

k star (bias corrected)	2.437
Theta Star	3.049
nu star	277.8
Approximate Chi Square Value (.05)	240.2
Adjusted Level of Significance	0.0458
Adjusted Chi Square Value	239.3

Anderson-Darling Test Statistic	0.795
Anderson-Darling 5% Critical Value	0.76
Kolmogorov-Smirnov Test Statistic	0.083
Kolmogorov-Smirnov 5% Critical Value	0.119

Data Distribution

Data Follow Appr. Gamma Distribution at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	8.713
95% Jackknife UCL	8.735
95% Standard Bootstrap UCL	8.663
95% Bootstrap-t UCL	9.326
95% Half's Bootstrap UCL	10.33
95% Percentile Bootstrap UCL	8.798
95% BCA Bootstrap UCL	9.196

follow Appr. Gamma Distribution at 5% Significance Level

95% Chebyshev(Mean, Sd) UCL 10.83

97.5% Chebyshev(Mean, Sd) UCL 12.3

99% Chebyshev(Mean, Sd) UCL 15.19

Assuming Gamma Distribution

95% Approximate Gamma UCL	8.593
95% Adjusted Gamma UCL	8.625

Statistical Summary for Cadmium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	B	REG	0.99 *		=	0.05	0.99	-0.010050396
Z1-EU29W-401	S	REG	3.1 *		J	0.04	3.1	1.131402117
Z1-EU29W-402	S	REG	0.66 *		=	0.05	0.66	-0.415515444
Z1-EU29W-403	S	REG	0.36 B *		=	0.04	0.36	-1.021851248
Z1-EU29W-404	S	REG	2.8 *		=	0.05	2.8	1.029619417
Z1-EU29W-405 + Dup	S	REG	0.97 *		=	0.04	0.97	-0.030458207
Z1-EU29W-406	S	REG	0.14 B *		=	0.04	0.14	-1.958112886
Z1-EU29W-407	S	REG	2.8 *		=	0.05	2.8	1.029619417
Z1-EU29W-408	S	REG	0.04 U *		U	0.04	0.02	-3.912023006
Z1-EU29W-409	S	REG	1.1 *		=	0.04	1.1	0.09531018
Z1-EU30BW-411	B	REG	2.7 *		=	0.04	2.7	0.993251773
Z1-EU30C-444	C	REG	0.05 U		U	0.05	0.025	-3.589879454
Z1-EU30C-445	C	REG	0.05 B		=	0.04	0.05	-2.995732274
Z1-EU30C-446	C	REG	0.18 B		=	0.05	0.18	-1.714798428
Z1-EU30C-447	C	REG	0.07 B		=	0.05	0.07	-2.859250037
Z1-EU30C-448 + Dup	C	FR	0.09 B		=	0.05	0.09	-2.813410717
Z1-EU30C-449	C	REG	0.06 B		=	0.05	0.06	-2.813410717
Z1-EU30C-450	C	REG	0.12 B		=	0.05	0.12	-2.120253336
Z1-EU30C-451	C	REG	0.06 B		=	0.05	0.06	-2.813410717
Z1-EU30C-452	C	REG	0.29 B		=	0.05	0.29	-1.347073648
Z1-EU30C-453	C	REG	0.38 B		=	0.05	0.38	-0.957584026
Z1-EU30C-454	C	REG	0.09 B		=	0.05	0.09	-2.407945809
Z1-EU31BW-415	B	REG	0.35 B *		=	0.04	0.35	-1.049822124
Z1-EU31BW-416	B	REG	1 *		=	0.05	1	0
Z1-EU31BW-417	B	REG	0.77 *		=	0.04	0.77	-0.251354754
Z1-EU31W-412	S	REG	0.57 *		=	0.04	0.57	-0.552118918
Z1-EU31W-413	S	REG	1.1 *		=	0.04	1.1	0.09531018
Z1-EU31W-414	S	REG	0.42 B *		=	0.05	0.42	-0.857500568
Z1-EU32BW-431	B	REG	3.3 N *		=	0.04	3.3	1.193922468
Z1-EU32BW-432	B	REG	3 N *		=	0.04	3	1.098812289
Z1-EU32BW-433 + Dup	B	REG	0.83 N *		=	0.04	0.83	-0.185329578
Z1-EU32BW-434	B	REG	0.45 *		=	0.04	0.45	-0.798507606
Z1-EU32C-455	C	REG	0.15 B		=	0.05	0.15	-1.897719985
Z1-EU32C-456	C	REG	0.05 U		U	0.05	0.025	-3.589879454
Z1-EU32NW-420	S	REG	1		=	0.04	1	0
Z1-EU32NW-426	S	REG	2.2		=	0.05	2.2	0.788457395
Z1-EU32W-418	S	REG	0.75		=	0.05	0.75	-0.287682072
Z1-EU32W-419 + Dup	S	REG	7.2		=	0.04	7.2	1.974081025
Z1-EU32W-421	S	REG	3.8		=	0.05	3.8	1.335001067
Z1-EU32W-422	S	REG	2.9		=	0.04	2.9	1.064710737
Z1-EU32W-423	S	REG	2.5		=	0.04	2.5	0.916290732
Z1-EU32W-424	S	REG	0.18 B		=	0.05	0.18	-1.832581454
Z1-EU32W-425	S	REG	2.8		=	0.05	2.8	0.916290732
Z1-EU32W-427	S	REG	0.25 B		=	0.04	0.25	-1.385354351
Z1-EU32W-428	S	REG	0.38 B		=	0.05	0.38	-0.897584026
Z1-EU32W-429	S	REG	0.23 B		=	0.04	0.23	-1.48967597
Z1-EU32W-430	S	REG	1.8 N *		J	0.04	1.8	0.587785865
Z1-EU33BW-443	B	REG	2.5 *		=	0.04	2.5	0.916290732
Z1-EU33BW-444	B	REG	1.3 N *		=	0.04	1.3	0.252364264
Z1-EU33C-457	C	REG	0.31 B		=	0.05	0.31	-1.771182982
Z1-EU33W-435	S	REG	0.2 B N *		=	0.04	0.2	-1.609437912
Z1-EU33W-436	S	REG	0.53 N *		=	0.04	0.53	-0.634878272
Z1-EU33W-437	S	REG	3.5 N *		=	0.05	3.5	1.252162958
Z1-EU33W-438	S	REG	4.9 N *		=	0.04	4.9	1.589235208
Z1-EU33W-439	S	REG	1.9 N *		=	0.04	1.9	0.641853866
Z1-EU33W-440	S	REG	14.2 N *		=	0.04	14.2	2.653241895
Z1-EU33W-441	S	REG	2.4 N *		=	0.04	2.4	0.875456737

Number of Samples	57
Number of Defects	54
Minimum	0.02
Median	0.75
Maximum	14.2
Average	1.5152832
Standard Deviation	2.2487826
PERT-Beta Mean	2.87
Lognormal Mean	-0.525047
Lognormal Standard Deviation	1.562501

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Cd mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 48

Raw Statistics

Minimum 0.02
Maximum 14.2
Mean 1.515
Median 0.75
SD 2.247
Coefficient of Variation 1.483
Skewness 3.663

Log-transformed Statistics

Minimum of Log Data -3.912
Maximum of Log Data 2.653
Mean of log Data -0.525
SD of log Data 1.563

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.253
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.098
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 2.013
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 2.159
95% Modified-t UCL 2.037

Assuming Lognormal Distribution

95% H-UCL 3.559
95% Chebyshev (MVUE) UCL 4.269
97.5% Chebyshev (MVUE) UCL 5.287
99% Chebyshev (MVUE) UCL 7.287

Gamma Distribution Test

k star (bias corrected) 0.627
Theta Star 2.417
nu star 71.46

Approximate Chi Square Value (.05) 53
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 52.59

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Anderson-Darling Test Statistic 0.582
Anderson-Darling 5% Critical Value 0.802
Kolmogorov-Smirnov Test Statistic 0.0843
Kolmogorov-Smirnov 5% Critical Value 0.123

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 2.005
95% Jackknife UCL 2.013
95% Standard Bootstrap UCL 2.01
95% Bootstrap-t UCL 2.301
95% Halfs Bootstrap UCL 4.161
95% Percentile Bootstrap UCL 2.036
95% BCA Bootstrap UCL 2.252
95% Chebyshev(Mean, Sd) UCL 2.812
97.5% Chebyshev(Mean, Sd) UCL 3.374
99% Chebyshev(Mean, Sd) UCL 4.476

Assuming Gamma Distribution

95% Approximate Gamma UCL 2.043
95% Adjusted Gamma UCL 2.059

Potential UCL to Use	Use 95% Approximate Gamma UCL	2.043
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Statistical Summary for Cadmium mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU28BW-410		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU28W-401		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU29W-402		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU29W-403		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU29W-404		REG	11.1	=		5.6	0.0111	-4.500810171
Z1-EU29W-405 + Dup		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU29W-406		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU29W-407		REG	26.4	=		5.6	0.0264	-3.634391269
Z1-EU29W-408		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU29W-409		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU30BW-411		REG	16.7	=		5.6	0.0167	-4.09234656
Z1-EU31BW-415		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU31BW-416		REG	7.5	=		5.6	0.0075	-4.892852258
Z1-EU31BW-417		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU31W-412		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU31W-413		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU31W-414		REG	12.4	=		5.6	0.0124	-4.390058806
Z1-EU32BW-431		REG	43.6	=		3	0.0436	-3.132696129
Z1-EU32BW-432		REG	21.7 B	=		3	0.0217	-3.830443016
Z1-EU32BW-433 + Dup		REG	10.4 B	=		3	0.0104	-4.565849473
Z1-EU32BW-434		REG	5.6 U	U		5.6	0.0028	-5.878135862
Z1-EU32MW-420		REG	7.8 B	=		3	0.0078	-4.863631545
Z1-EU32MW-426		REG	28.8 B	=		3	0.0288	-3.547379892
Z1-EU32W-418		REG	17.7 B	=		3	0.0177	-4.034190638
Z1-EU32W-419 + Dup		FA	30.8	=		3	0.0308	-3.480240588
Z1-EU32W-421		REG	58.6	=		3	0.0586	-2.637020582
Z1-EU32W-422		REG	25.1 B	=		3	0.0251	-3.684887433
Z1-EU32W-423		REG	46.5	=		3	0.0465	-3.026191481
Z1-EU32W-424		REG	3 U	U		3	0.0018	-6.502290171
Z1-EU32W-425		REG	7.8 B	=		3	0.0078	-4.879807032
Z1-EU32W-427		REG	3.7 B	=		3	0.0037	-5.599422459
Z1-EU32W-428		REG	3 U	U		3	0.0015	-6.502290171
Z1-EU32W-429		REG	3 U	U		3	0.0015	-6.502290171
Z1-EU32W-430		REG	7.7 B	=		3	0.0077	-4.86653495
Z1-EU33BW-443		REG	9.8	=		5.6	0.0098	-4.625372893
Z1-EU33BW-444		REG	12.5 B	=		3	0.0126	-4.374058455
Z1-EU33W-435		REG	3 U	U		3	0.0015	-6.502290171
Z1-EU33W-436		REG	3 U	U		3	0.0015	-6.502290171
Z1-EU33W-437		REG	19.1 B	=		3	0.0191	-3.958066944
Z1-EU33W-438		REG	17.7 B	=		3	0.0177	-4.034190639
Z1-EU33W-439		REG	16.4 B	=		3	0.0164	-4.110473944
Z1-EU33W-440		REG	96.1	=		3	0.0961	-2.342385983
Z1-EU33W-441		REG	22.2 B	=		3	0.0222	-3.80786299
Number of Samples			43					
Number of Detects			25					
Minimum			0.0015					
Median			0.0077					
Maximum			0.0961					
Average			0.0145093					
Standard Deviation			0.0185671					
PERT-Beta Mean			0.0214					
Lognormal Mean			-4.884374					
Lognormal Standard Deviation			1.1649097					

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Cd mg/L

General Statistics

Number of Valid Observations	43	Number of Distinct Observations	26
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Raw Statistics

Minimum	0.0015
Maximum	0.0961
Mean	0.0145
Median	0.0077
SD	0.0186
Coefficient of Variation	1.28
Skewness	2.611

Log-transformed Statistics

Minimum of Log Data	-6.502
Maximum of Log Data	-2.342
Mean of log Data	-4.884
SD of log Data	1.165

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.702
Shapiro Wilk Critical Value	0.943

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.915
Shapiro Wilk Critical Value	0.943

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.0193
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	0.0204
95% Modified-t UCL	0.0195

Assuming Lognormal Distribution

95% H-UCL	0.0235
95% Chebyshev (MVUE) UCL	0.0282
97.5% Chebyshev (MVUE) UCL	0.0341
99% Chebyshev (MVUE) UCL	0.0458

Gamma Distribution Test

k star (bias corrected)	0.851
Theta Star	0.0171
nu star	73.15

Approximate Chi Square Value (.05) 54.46

Adjusted Level of Significance 0.0444

Adjusted Chi Square Value 53.9

Anderson-Darling Test Statistic 1.533

Anderson-Darling 5% Critical Value 0.782

Kolmogorov-Smirnov Test Statistic 0.22

Kolmogorov-Smirnov 5% Critical Value 0.139

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.0192
95% Jackknife UCL	0.0193
95% Standard Bootstrap UCL	0.0192
95% Bootstrap-t UCL	0.021
95% Hall's Bootstrap UCL	0.0222
95% Percentile Bootstrap UCL	0.0192
95% BCA Bootstrap UCL	0.0209
95% Chebyshev(Mean, Sd) UCL	0.0269
97.5% Chebyshev(Mean, Sd) UCL	0.0322
99% Chebyshev(Mean, Sd) UCL	0.0427

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.0195
95% Adjusted Gamma UCL	0.0197

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

		WACFACS WL L SRC INPUT						Calculations				
		STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
		MIN	MED	MAX	BOX	UCL-95	UCL-95 ± E(X)	0.95	α_1	α_2	Variance	Max - Min
Cadmium (mg/L)	SRC	0.0015	0.0077	0.0861	0.02	0.05	2.33	0.05	1.26	4.74	0.0003	0.1

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - \text{MIN})^{\alpha_1 - 1} (\text{MAX} - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (\text{MAX} - \text{MIN})^{\alpha_1 + \alpha_2 - 1}} \quad \text{MIN} < \text{Minutely} < \text{MAX}$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{\text{MIN} + 4 \times \text{Most Likely} + \text{MAX}}{6}$$

$$\text{Var}(x) = \frac{(E(x) - \text{MIN}) \times (\text{MAX} - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - \text{MIN}}{\text{MAX} - \text{MIN}} \right]$$

$$\alpha_2 = 6 \times \left[\frac{\text{MAX} - E(x)}{\text{MAX} - \text{MIN}} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_x(\alpha_1, \alpha_2)$ is the Incomplete Beta Function

α_1 and α_2 are calculated parameters

Use the Microsoft Excel 98/01 function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Calcium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	S	REG	12700 N			10.8	12700	9.449357272
Z1-EU29W-401	S	REG	254000 N			37.5	254000	12.44508955
Z1-EU29W-402	S	REG	10300 N			11.5	10300	9.239899174
Z1-EU29W-403	S	REG	58200 N			9.6	58200	10.97184083
Z1-EU29W-404	S	REG	23700 N			10.8	23700	10.07323033
Z1-EU29W-405 + Dup	S	FR	233000 N			39.4	233000	12.35879873
Z1-EU29W-406	S	REG	28200 N			9.5	28200	10.17351489
Z1-EU29W-407	S	REG	28900 N			11	28900	10.19988157
Z1-EU29W-408	S	REG	7180 N			10.5	7180	8.879054852
Z1-EU29W-409	S	REG	86000 N			10.3	86000	11.05741002
Z1-EU30W-411	B	REG	155000 N			41.5	155000	11.9511804
Z1-EU30C-444	C	REG	107000 N			23.7	107000	12.02574909
Z1-EU30C-445	C	REG	143000 N			20.8	143000	11.87058891
Z1-EU30C-446	C	REG	148000 N			24.6	148000	11.90496755
Z1-EU30C-447	C	REG	134000 N			25	134000	11.90559508
Z1-EU30C-448 + Dup	C	REG	184000 N			22.9	184000	12.12289104
Z1-EU30C-449	C	REG	177000 N			24	177000	12.08390501
Z1-EU30C-450	C	REG	144000 N			24.1	144000	11.87756898
Z1-EU30C-451	C	REG	207000 N			23.9	207000	12.24047407
Z1-EU30C-452	C	REG	197000 N			24.2	197000	12.19038901
Z1-EU30C-453	C	REG	202000 N			25.5	202000	12.21602298
Z1-EU30C-454	C	REG	141000 N			24.4	141000	11.85651517
Z1-EU31W-415	B	REG	62800 N			10.8	62800	11.04452056
Z1-EU31W-416	B	REG	5990 N			11.2	5990	8.897846891
Z1-EU31W-417	B	REG	20100 N			9.7	20100	9.908475094
Z1-EU31W-412	S	REG	96800 N			10.7	96800	11.47833402
Z1-EU31W-413	S	REG	64700 N			9.3	64700	11.07751648
Z1-EU31W-414	S	REG	26800 N			11	26800	10.18890649
Z1-EU32W-431	B	REG	95000 N			10.2	95000	11.46163217
Z1-EU32W-432	B	REG	23100 N			3.1	23100	10.0475879
Z1-EU32W-433 + Dup	B	FR	11300 N			3.5	11300	9.332559005
Z1-EU32W-434	B	REG	98900 N			9.5	98900	11.60186462
Z1-EU32C-455	C	REG	148000 N			24.5	148000	11.80496755
Z1-EU32C-456	C	REG	132000 N			25.8	132000	11.7805572
Z1-EU32W-420	S	REG	41500 N			3.4	41500	10.63044871
Z1-EU32W-425	S	REG	22500 N			10.9	22500	10.02570519
Z1-EU32W-418	S	REG	34900 N			4.2	34900	10.45024211
Z1-EU32W-419 + Dup	S	REG	86800 N			10.2	86800	11.3713619
Z1-EU32W-421	S	REG	44000 N			10.9	44000	10.89194491
Z1-EU32W-422	S	REG	84700 N			19.8	84700	11.34687068
Z1-EU32W-423	S	REG	110000 N			20	110000	11.60823584
Z1-EU32W-424	S	REG	9980 N			3.6	9980	9.208336369
Z1-EU32W-426	S	REG	48000 N			3.7	48000	10.71441777
Z1-EU32W-427	S	REG	5820 N			3.4	5820	8.616133139
Z1-EU32W-428	S	REG	25700 N			3.8	25700	10.15424087
Z1-EU32W-429	S	REG	18400 N			3.4	18400	9.820105844
Z1-EU32W-430	S	REG	7170 N			3	7170	8.877960824
Z1-EU33W-443	B	REG	85000 N			10.1	85000	11.35040854
Z1-EU33W-444	B	REG	6250 N			3.5	6250	8.740396743
Z1-EU33C-457	C	REG	210000 N			23.9	210000	12.254886281
Z1-EU33W-436	S	REG	1850 N			3.5	1850	7.5283331767
Z1-EU33W-438	S	REG	6520 N			3.6	6520	8.797850849
Z1-EU33W-437	S	REG	26700 N			4	26700	10.19241884
Z1-EU33W-438	S	REG	42800 N			3.8	42800	10.85425336
Z1-EU33W-439	S	REG	13900 N			3.3	13900	9.539944119
Z1-EU33W-440	B	REG	70400 N			10.1	70400	11.15194854
Z1-EU33W-441	S	REG	18000 N			3.2	18000	9.788127007

Number of Samples 57
Number of Detects 57

Minimum 1860
Median 58200
Maximum 254000
Average 79285.965
Standard Deviation 71104.57

PERT-Beta Mean 81443.333

Lognormal Mean 10.719747
Lognormal Standard Deviation 1.2170622

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Ca mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 56

Raw Statistics

Minimum 1860
Maximum 254000
Mean 79296
Median 58200
SD 71105
Coefficient of Variation 0.897
Skewness 0.78

Log-transformed Statistics

Minimum of Log Data 7.528
Maximum of Log Data 12.45
Mean of log Data 10.72
SD of log Data 1.217

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.176
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.118
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 95048
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 95827
95% Modified-t UCL 95210

Assuming Lognormal Distribution

95% H-UCL 185727
95% Chebyshev (MVUE) UCL 174371
97.5% Chebyshev (MVUE) UCL 209654
99% Chebyshev (MVUE) UCL 278960

Gamma Distribution Test

k star (bias corrected) 0.983
Theta Star 80647
nu star 112.1
Approximate Chi Square Value (.05) 88.65
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 88.11

Anderson-Darling Test Statistic 0.814
Anderson-Darling 5% Critical Value 0.779
Kolmogorov-Smirnov Test Statistic 0.121

Kolmogorov-Smirnov 5% Critical Value 0.121

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 94787
95% Jackknife UCL 95048
95% Standard Bootstrap UCL 95140
95% Bootstrap-t UCL 95581
95% Hall's Bootstrap UCL 95808
95% Percentile Bootstrap UCL 95406
95% BCA Bootstrap UCL 94742
95% Chebyshev(Mean, Sd) UCL 120348
97.5% Chebyshev(Mean, Sd) UCL 138112
99% Chebyshev(Mean, Sd) UCL 173004

Assuming Gamma Distribution

95% Approximate Gamma UCL 100262
95% Adjusted Gamma UCL 100876

Potential UCL to Use	Use 97.5% Chebyshev (Mean, Sd) UCL	138112
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Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Redus, 985.483.2715

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12/29/2005 R1.3

Enter input values in yellow shaded cells

Report: OUTPUT UCL-95

			WACFACS WL L SRC INPUT						Calculations				
			STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse		PERT BETA		
SRC			MIN	MED	MAX	E(X)	UCL-95	UCL-95 : EQ	0.99	α_1	α_2	Variance	Max - Min
Calcium (mg/kg)			1860.0000	5.82E+04	2.54E+06	81643.33	162848.39	2.00	162848.39	1.89	4.11	#####	252140.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - MIN)^{\alpha_1} (MAX - 1)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MAX < MIN$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most Likely + MAX}{6}$$

$$V(x) = \frac{(E(x) - MIN)(MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters.

Use the Microsoft Excel 2003 function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Chromium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	117 *		✓	0.18	117	4.762173935
Z1-EU29BW-401	S	REG	19.3 *		✓	0.18	19.3	2.962105296
Z1-EU29BW-402	S	REG	20.7 *		✓	0.18	20.7	3.392297123
Z1-EU29BW-403	S	REG	21.1 *		=	0.18	21.1	3.04927304
Z1-EU29BW-404	S	REG	41.2 *		✓	0.18	41.2	3.718438255
Z1-EU29BW-405 - Dup	S	REG	26 *		✓	0.17	26	3.280396538
Z1-EU29BW-406	S	REG	23.6 *		=	0.16	23.6	3.161246712
Z1-EU29BW-407	S	REG	38.3 *		✓	0.18	38.3	3.846449835
Z1-EU29BW-408	S	REG	24.6 *		✓	0.18	24.6	3.202746443
Z1-EU29BW-409	S	REG	30.5 *		✓	0.17	30.5	3.417726684
Z1-EU30BW-411	B	REG	179 *		✓	0.17	179	5.187385806
Z1-EU30C-444	C	REG	9.7		✓	0.2	9.7	2.272128886
Z1-EU30C-445	C	REG	10.8		✓	0.17	10.8	2.379546134
Z1-EU30C-446	C	REG	11.8		✓	0.21	11.8	2.4786384
Z1-EU30C-447	C	REG	18.9		=	0.21	18.9	2.9427313822
Z1-EU30C-448 - Dup	C	FR	11.3		✓	0.19	11.3	2.424802726
Z1-EU30C-449	C	REG	10.8		✓	0.2	10.8	2.379546134
Z1-EU30C-450	C	REG	12.2		✓	0.2	12.2	2.501435952
Z1-EU30C-451	C	REG	9.9		=	0.2	9.9	2.292534757
Z1-EU30C-452	C	REG	8.9		=	0.2	8.9	2.292534757
Z1-EU30C-453	C	REG	11.5		✓	0.21	11.5	2.442347095
Z1-EU30C-454	C	REG	12.8		✓	0.2	12.8	2.533696814
Z1-EU31BW-415	B	REG	46.6 *		✓	0.18	46.6	3.841800541
Z1-EU31BW-416	B	REG	32.5 *		✓	0.19	32.5	3.481240089
Z1-EU31BW-417	B	REG	2880 *		✓	0.18	2880	7.968248573
Z1-EU31BW-412	S	REG	12.9 *		✓	0.18	12.9	2.557227311
Z1-EU31W-413	S	REG	402 *		=	0.15	402	5.968452080
Z1-EU31W-414	S	REG	35.1 *		✓	0.18	35.1	3.558201113
Z1-EU32BW-431	B	REG	68.5 N *		=	0.17	68.5	4.226833745
Z1-EU32BW-432	B	REG	53.6 N *		✓	0.16	53.6	3.981549004
Z1-EU32BW-433 - Dup	B	FR	22.5 N *		✓	0.18	22.5	3.113515309
Z1-EU32BW-434	B	REG	20.5 *		=	0.16	20.5	3.025424886
Z1-EU32C-455	C	REG	12.1		✓	0.2	12.1	2.493205453
Z1-EU32C-456	C	REG	10		✓	0.21	10	2.302645063
Z1-EU32MW-420	S	REG	33.2		✓	0.17	33.2	3.502549876
Z1-EU32MW-426	S	REG	54.4		✓	0.18	54.4	3.886384154
Z1-EU32W-418	B	REG	21.9		✓	0.21	21.9	3.086466637
Z1-EU32W-419 - Dup	S	REG	85		=	0.17	85	4.442081256
Z1-EU32W-421	S	REG	45.8		✓	0.18	45.8	3.824284091
Z1-EU32W-422	S	REG	91		=	0.18	91	4.510888807
Z1-EU32W-423	S	REG	329		✓	0.17	329	5.786057781
Z1-EU32W-424	S	REG	15.6		✓	0.18	15.6	2.747270814
Z1-EU32W-425	S	REG	36.9		✓	0.18	36.9	3.608211551
Z1-EU32W-427	S	REG	16		=	0.17	16	2.772588722
Z1-EU32W-428	S	REG	19.7		✓	0.19	19.7	2.580618636
Z1-EU32W-429	S	REG	13.7		✓	0.17	13.7	2.617396833
Z1-EU32W-430	S	REG	27.8 N *		✓	0.15	27.8	3.325038021
Z1-EU33BW-443	B	REG	102 *		✓	0.17	102	4.624972813
Z1-EU33BW-444	B	REG	23.2 N *		✓	0.17	23.2	3.144152279
Z1-EU33C-457	C	REG	27.8		✓	0.2	27.8	3.325038021
Z1-EU33W-435	S	REG	19.8 N *		✓	0.18	19.8	2.585681938
Z1-EU33W-436	S	REG	18 N *		✓	0.18	18	2.772588722
Z1-EU33W-437	S	REG	123 N *		✓	0.2	123	4.812184355
Z1-EU33W-438	S	REG	108 N *		✓	0.18	108	4.853436094
Z1-EU33W-439	S	REG	70.4 N *		✓	0.16	70.4	4.254193365
Z1-EU33W-440	S	REG	228 N *		✓	0.17	228	5.429345629
Z1-EU33W-441	S	REG	76.8 N *		✓	0.16	76.8	4.358897077

Number of Samples	57
Number of Detects	57
Minimum	9.7
Median	28
Maximum	2880
Average	102.73509
Standard Deviation	381.87197
PERT-Beta Mean	498.95
Lognormal Mean	3.5200159
Lognormal Standard Deviation	1.108872

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheetLwst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Cr mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 53

Raw Statistics

Minimum 9.7
Maximum 2880
Mean 102.7
Median 26
SD 381.7
Coefficient of Variation 3.715
Skewness 7.136

Log-transformed Statistics

Minimum of Log Data 2.272
Maximum of Log Data 7.966
Mean of log Data 3.52
SD of log Data 1.109

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.404
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.13
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 187.3
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 236.9
95% Modified-t UCL 195.3

Assuming Lognormal Distribution

95% H-UCL 183.2
95% Chebyshev (MVUE) UCL 109.2
97.5% Chebyshev (MVUE) UCL 129.9
99% Chebyshev (MVUE) UCL 170.6

Gamma Distribution Test

k star (bias corrected) 0.543
Theta Star 189.1
nu star 61.94
Approximate Chi Square Value (.05) 44.84
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 44.46

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Anderson-Darling Test Statistic 6.481
Anderson-Darling 5% Critical Value 0.81
Kolmogorov-Smirnov Test Statistic 0.242
Kolmogorov-Smirnov 5% Critical Value 0.124

Data not Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 185.9
95% Jackknife UCL 187.3
95% Standard Bootstrap UCL 184.8
95% Bootstrap-t UCL 530.4
95% Halfs Bootstrap UCL 454.9
95% Percentile Bootstrap UCL 202.7
95% BCA Bootstrap UCL 263.2
95% Chebyshev(Mean, Sd) UCL 323.1
97.5% Chebyshev(Mean, Sd) UCL 418.4
99% Chebyshev(Mean, Sd) UCL 605.7

Assuming Gamma Distribution

95% Approximate Gamma UCL 141.9
95% Adjusted Gamma UCL 143.1

Potential UCL to Use	Use 97.5% Chebyshev (Mean, Sd) UCL	418.4
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Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Redus, 866.483.2716

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12/29/2005 R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

		WACFACS WL L SRC INPUT			Calculations							
		STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
	SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Chromium (mg/kg)		0.7000	26	2880	488.95	1319.61	2.64	1319.61	1.02	4.98	200813.4679	2870.3

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) \times MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < \text{Most Likely} < MAX$$

$$F(x) = \frac{B_1(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times \text{Most Likely} + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel 95/98 Function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Chromium mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU29BW-410		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU29W-401		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU29W-402		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU29W-403		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU29W-404		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU29W-405 + Dup		FR	7.3 B		=	4.6	0.0073	-4.919880931
Z1-EU29W-406		REG	6.8 B		=	4.6	0.0068	-4.890832667
Z1-EU29W-407		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU29W-408		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU29W-409		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU30BW-411		REG	4.9 B		=	4.6	0.0049	-5.318520074
Z1-EU31BW-415		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU31BW-416		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU31BW-417		REG	6.8		=	4.6	0.006	-5.11599581
Z1-EU31W-412		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU31W-413		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU31W-414		REG	7.7 B		=	4.6	0.0077	-4.88653496
Z1-EU32BW-431		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32BW-432		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32BW-433 + Dup		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32BW-434		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU32MW-420		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32MW-426		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32W-418		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32W-419 + Dup		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32W-421		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32W-422		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32W-423		REG	12.3 B		=	12	0.0123	-4.388158017
Z1-EU32W-424		REG	30.1 B		=	12	0.0301	-3.503230107
Z1-EU32W-425		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32W-427		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32W-428		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32W-429		REG	12 U		U	12	0.006	-5.11599581
Z1-EU32W-430		REG	12 U		U	12	0.006	-5.11599581
Z1-EU33BW-443		REG	4.6 U		U	4.6	0.0023	-6.074846156
Z1-EU33BW-444		REG	12 U		U	12	0.006	-5.11599581
Z1-EU33W-435		REG	12 U		U	12	0.006	-5.11599581
Z1-EU33W-436		REG	12 U		U	12	0.006	-5.11599581
Z1-EU33W-437		REG	12 U		U	12	0.006	-5.11599581
Z1-EU33W-438		REG	12 U		U	12	0.006	-5.11599581
Z1-EU33W-439		REG	12 U		U	12	0.006	-5.11599581
Z1-EU33W-440		REG	12 U		U	12	0.006	-5.11599581
Z1-EU33W-441		REG	12 U		U	12	0.006	-5.11599581

Number of Samples 43
Number of Detects 7

Minimum 0.0023
Median 0.006
Maximum 0.0301
Average 0.0055651
Standard Deviation 0.0043928

PERT-Beta Mean 0.0094

Lognormal Mean -5.365416
Lognormal Standard Deviation 0.5663194

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wsl

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Cr mg/L

General Statistics

Number of Valid Observations 43 Number of Distinct Observations 8

Raw Statistics

Minimum 0.0023
Maximum 0.0301
Mean 0.00557
Median 0.006
SD 0.00439
Coefficient of Variation 0.789
Skewness 4.303

Log-transformed Statistics

Minimum of Log Data -6.075
Maximum of Log Data -3.503
Mean of log Data -5.365
SD of log Data 0.566

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.526
Shapiro Wilk Critical Value 0.943

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.763
Shapiro Wilk Critical Value 0.943

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 0.00669
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 0.00714
95% Modified-t UCL 0.00677

Assuming Lognormal Distribution

95% H-UCL 0.0065
95% Chebyshev (MVUE) UCL 0.00765
97.5% Chebyshev (MVUE) UCL 0.00859
99% Chebyshev (MVUE) UCL 0.0105

Gamma Distribution Test

k star (bias corrected) 2.831
Theta Star 0.00197
nu star 243.5

Approximate Chi Square Value (.05) 208.4

Adjusted Level of Significance 0.0444

Adjusted Chi Square Value 207.2

Anderson-Darling Test Statistic 4.425

Anderson-Darling 5% Critical Value 0.755

Kolmogorov-Smirnov Test Statistic 0.278

Kolmogorov-Smirnov 5% Critical Value 0.136

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 0.00667
95% Jackknife UCL 0.00669
95% Standard Bootstrap UCL 0.00665
95% Bootstrap-t UCL 0.00767
95% Hall's Bootstrap UCL 0.0118
95% Percentile Bootstrap UCL 0.00672
95% BCA Bootstrap UCL 0.00727
95% Chebyshev(Mean, Sd) UCL 0.00849
97.5% Chebyshev(Mean, Sd) UCL 0.00975
99% Chebyshev(Mean, Sd) UCL 0.0122

Assuming Gamma Distribution

95% Approximate Gamma UCL 0.0065
95% Adjusted Gamma UCL 0.00654

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Radius, 865.489.2715

WACFACS V3.00.001

12/25/2005 Pt.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

WACFACS V3.00.001 SRC INPUT				Calculations							
SRC	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : EQ5	0.95	α_1	α_2	Variance	Max - Min
Chromium (mg/L)	0.0023	0.006	0.0301	0.01	0.02	1.99	0.02	1.53	4.47	0.0000	0.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) \times (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < Mostlikely < MAX$$

$$F(x) = \frac{B_1(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Mostlikely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel 2003 function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Cobalt mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU290W-410	B	REG	15.4	=	=	0.18	15.4	2.734367809
Z1-EU290W-401	S	REG	5.3	✓	✓	0.16	5.3	1.667706821
Z1-EU290W-402	S	REG	9.1	=	=	0.19	9.1	2.208274414
Z1-EU290W-403	S	REG	5.7	=	=	0.16	5.7	1.740466175
Z1-EU290W-404	S	REG	9.5	=	=	0.18	9.5	2.251291799
Z1-EU290W-405 + Dup	S	REG	7.2	=	=	0.17	7.2	1.974081025
Z1-EU290W-406	S	REG	4.4	✓	✓	0.16	4.4	1.481601541
Z1-EU290W-407	S	REG	14.9	=	=	0.19	14.9	2.701361213
Z1-EU290W-408	S	REG	4.5	✓	✓	0.18	4.5	1.504077397
Z1-EU290W-409	S	REG	9.6	=	=	0.17	9.6	2.251291799
Z1-EU300W-411	B	REG	11.3	✓	✓	0.17	11.3	2.424006725
Z1-EU300C-444	C	REG	3.1	=	=	0.2	3.1	1.131402111
Z1-EU300C-445	C	REG	1.5	=	=	0.17	1.5	0.405465108
Z1-EU300C-446	C	REG	5.2	=	=	0.21	5.2	1.648558626
Z1-EU300C-447	C	REG	2.5	=	=	0.21	2.5	0.916290732
Z1-EU300C-448 + Dup	C	FR	3.7	✓	✓	0.19	3.7	1.30833282
Z1-EU300C-449	C	REG	3.9	✓	✓	0.2	3.9	1.360976653
Z1-EU300C-450	C	REG	2.2	✓	✓	0.2	2.2	0.78945736
Z1-EU300C-451	C	REG	3.5	✓	✓	0.2	3.5	1.252762966
Z1-EU300C-452	C	REG	2.2	=	=	0.2	2.2	0.78945736
Z1-EU300C-453	C	REG	2.8	=	=	0.21	2.8	1.029618417
Z1-EU300C-454	C	REG	2.5	=	=	0.2	2.5	0.955511445
Z1-EU310W-415	B	REG	9.1	✓	✓	0.19	9.1	2.208274414
Z1-EU310W-416	B	REG	7.7	=	=	0.19	7.7	2.041228329
Z1-EU310W-417	B	REG	11.7	✓	✓	0.18	11.7	2.459688842
Z1-EU310W-412	S	REG	3.9	=	=	0.18	3.9	1.360976553
Z1-EU310W-413	S	REG	15.2	=	=	0.15	15.2	2.721295428
Z1-EU310W-414	S	REG	9.7	=	=	0.18	9.7	2.272125896
Z1-EU320W-431	B	REG	12.5	=	=	0.17	12.5	2.525721844
Z1-EU320W-432	B	REG	10.4	=	=	0.16	10.4	2.341805908
Z1-EU320W-433 + Dup	B	REG	14.7	=	=	0.17	14.7	2.687847494
Z1-EU320W-434	B	REG	5.8	✓	✓	0.18	5.8	1.757857918
Z1-EU320C-485	C	REG	2.2	✓	✓	0.2	2.2	0.78945736
Z1-EU320C-456	C	REG	2	✓	✓	0.21	2	0.593147181
Z1-EU320W-420	S	REG	9.5	=	=	0.17	9.5	2.140969163
Z1-EU320W-426	S	REG	9.3	✓	✓	0.18	9.3	2.2300144
Z1-EU320W-418	S	REG	4	✓	✓	0.21	4	1.386294361
Z1-EU320W-419 + Dup	S	FR	11.3	=	=	0.17	11.3	2.424002725
Z1-EU320W-421	S	REG	10.1	✓	✓	0.18	10.1	2.312505424
Z1-EU320W-422	S	REG	9.1	=	=	0.18	9.1	2.208274414
Z1-EU320W-423	S	REG	9.1	✓	✓	0.17	9.1	2.208274414
Z1-EU320W-424	S	REG	10.2	=	=	0.18	10.2	2.32236772
Z1-EU320W-425	S	REG	6.7	✓	✓	0.18	6.7	1.902107526
Z1-EU320W-427	S	REG	13.6	=	=	0.17	13.6	2.610069793
Z1-EU320W-429	S	REG	5.9	=	=	0.19	5.9	1.774952351
Z1-EU320W-429	S	REG	8.5	=	=	0.17	8.5	2.140066163
Z1-EU320W-430	S	REG	9	=	=	0.15	9	2.197224577
Z1-EU330W-443	B	REG	20.9	=	=	0.17	20.9	3.035749159
Z1-EU330W-444	B	REG	9.2	✓	✓	0.17	9.2	2.219203484
Z1-EU330C-457	C	REG	3.3	✓	✓	0.2	3.3	1.193922468
Z1-EU330W-435	S	REG	11.2	✓	✓	0.18	11.2	2.415913778
Z1-EU330W-436	S	REG	8	✓	✓	0.18	8	2.079441542
Z1-EU330W-437	S	REG	16.6	✓	✓	0.2	16.6	2.809402695
Z1-EU330W-438	S	REG	41.9	=	=	0.18	41.9	3.755285827
Z1-EU330W-439	S	REG	12.1	✓	✓	0.16	12.1	2.480206453
Z1-EU330W-440	S	REG	30.3	=	=	0.17	30.3	3.411147713
Z1-EU330W-441	S	REG	11.8	✓	✓	0.16	11.8	2.468099531

Number of Samples 57
Number of Detects 57

Minimum 1.5
Median 9
Maximum 41.9
Average 9.0438598
Standard Deviation 6.6882504

PERT-Beta Mean 13.233333

Lognormal Mean 1.9567724
Lognormal Standard Deviation 0.7054203

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheetLwst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Ca mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 48

Raw Statistics

Minimum 1.5
Maximum 41.9
Mean 9.044
Median 9
SD 6.868
Coefficient of Variation 0.759
Skewness 2.525

Log-transformed Statistics

Minimum of Log Data 0.405
Maximum of Log Data 3.735
Mean of log Data 1.967
SD of log Data 0.705

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.153
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.141
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 10.57
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 10.87
95% Modified-t UCL 10.62

Assuming Lognormal Distribution

95% H-UCL 11.09
95% Chebyshev (MVUE) UCL 13.2
97.5% Chebyshev (MVUE) UCL 14.96
99% Chebyshev (MVUE) UCL 18.43

Gamma Distribution Test

k star (bias corrected) 2.169
Theta Star 4.169
nu star 247.3

Approximate Chi Square Value (.05) 211.9

Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 211.1

Anderson-Darling Test Statistic 0.641

Anderson-Darling 5% Critical Value 0.761

Kolmogorov-Smirnov Test Statistic 0.096

Kolmogorov-Smirnov 5% Critical Value 0.119

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 10.54
95% Jackknife UCL 10.57
95% Standard Bootstrap UCL 10.53
95% Bootstrap-t UCL 11.08
95% Hall's Bootstrap UCL 11.71
95% Percentile Bootstrap UCL 10.52
95% BCA Bootstrap UCL 10.86
95% Chebyshev(Mean, Sd) UCL 13.01
97.5% Chebyshev(Mean, Sd) UCL 14.73
99% Chebyshev(Mean, Sd) UCL 18.1

Assuming Gamma Distribution

95% Approximate Gamma UCL 10.56
95% Adjusted Gamma UCL 10.6

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Radus, 866.483.2715

www.radus-will.com

12/29/2006

R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

		WACFACS W.L. SRC INPUT			Calculations							
		STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse		PERT BETA		
	SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 ± E(X)	0.85	α_1	α_2	Variance	Max - Min
Cobalt (mg/kg)		1.5000	9	41.9	13.23	28.16	1.96	26.16	1.74	4.28	67.7161	40.4

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < Most\ Likely < MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_x(\alpha_1, \alpha_2)$ is the Incomplete Beta Function.
 α_1 and α_2 are calculated parameters.

Use the Microsoft Excel® 95M function: BETA.INV(0.95, α, β, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is:

Statistical Summary for Copper mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	B	REG	135	N *	=	0.18	135	4.905274778
Z1-EU29W-401	S	REG	270	N *	J	0.16	270	5.598421959
Z1-EU29W-402	S	REG	73.8	N *	=	0.19	73.8	4.301358732
Z1-EU29W-403	S	REG	35.7	N *	=	0.16	35.7	3.602778786
Z1-EU29W-404	S	REG	218	N *	=	0.17	218	5.384495063
Z1-EU29W-405 + Dup	S	FR	155	N *	=	0.16	155	5.043426117
Z1-EU29W-406	S	REG	19.9	N *	=	0.16	19.9	2.990719732
Z1-EU29W-407	S	REG	313	N *	=	0.18	313	5.745203191
Z1-EU29W-408	S	REG	13.7	N *	=	0.18	13.7	2.617395830
Z1-EU29W-409	S	REG	162	N *	=	0.17	162	5.087895305
Z1-EU30BW-411	B	REG	222	N *	=	0.17	222	5.402577382
Z1-EU30C-444	C	REG	14.2		=	0.2	14.2	2.643241955
Z1-EU30C-445	C	REG	3.5		=	0.17	3.5	1.282782988
Z1-EU30C-446	C	REG	5		=	0.21	5	1.609437912
Z1-EU30C-447	C	REG	5.6		=	0.21	5.6	1.722765698
Z1-EU30C-448 + Dup	C	REG	14.3		=	0.19	14.3	2.701361213
Z1-EU30C-449	C	REG	20.2		=	0.2	20.2	3.008842604
Z1-EU30C-450	C	REG	5.3		=	0.2	5.3	1.657705821
Z1-EU30C-451	C	REG	16.8		=	0.2	16.8	2.809402695
Z1-EU30C-452	C	REG	8.3		=	0.2	8.3	2.115255515
Z1-EU30C-453	C	REG	14.5		=	0.21	14.5	2.679148649
Z1-EU30C-454	C	REG	6		=	0.2	6	1.791758460
Z1-EU31BW-415	B	REG	98.5	N *	=	0.18	98.5	4.570878741
Z1-EU31BW-416	B	REG	172	N *	=	0.19	172	5.147484477
Z1-EU31BW-417	B	REG	189	N *	=	0.18	189	5.241747016
Z1-EU31W-412	S	REG	87.8	N *	=	0.18	87.8	4.475061501
Z1-EU31W-413	B	REG	381	N *	=	0.15	381	6.542758375
Z1-EU31W-414	S	REG	97.1	N *	=	0.18	97.1	4.575741375
Z1-EU32BW-431	B	REG	584	N *	=	0.17	584	6.369600583
Z1-EU32BW-432	B	REG	385	N *	=	0.18	385	5.959887354
Z1-EU32BW-433 + Dup	B	REG	110	N *	=	0.17	110	4.700480380
Z1-EU32BW-434	B	REG	23.2	N *	=	0.16	23.2	3.144152279
Z1-EU32C-455	C	REG	5		=	0.2	5	1.609437912
Z1-EU32C-456	C	REG	4.4		=	0.21	4.4	1.481504641
Z1-EU32MW-420	S	REG	78.7	N *	=	0.17	78.7	4.365843155
Z1-EU32MW-426	S	REG	83	N *	=	0.18	83	4.418840603
Z1-EU32W-418	S	REG	36.1	N *	J	0.21	36.1	3.586222265
Z1-EU32W-419 + Dup	S	FR	270	N *	=	0.17	270	5.598421959
Z1-EU32W-421	S	REG	4780	N *	=	0.18	4780	8.472195625
Z1-EU32W-422	S	REG	150	N *	=	0.16	150	5.016836294
Z1-EU32W-423	S	REG	284	N *	=	0.17	284	5.689579787
Z1-EU32W-424	S	REG	38.7	N *	=	0.18	38.7	3.6658396
Z1-EU32W-425	S	REG	1260	N *	=	0.18	1260	7.138887
Z1-EU32W-427	S	REG	19.7	N *	=	0.17	19.7	2.980618836
Z1-EU32W-428	S	REG	36.9	N *	=	0.19	36.9	3.604211581
Z1-EU32W-429	S	REG	29.5	N *	=	0.17	29.5	3.384380363
Z1-EU32W-430	S	REG	29.3	N *	=	0.15	29.3	3.377587518
Z1-EU33BW-443	B	REG	837	N *	=	0.17	837	6.942683282
Z1-EU33BW-444	B	REG	106	N *	=	0.17	106	4.663439384
Z1-EU33C-467	C	REG	11		=	0.2	11	2.397895273
Z1-EU33W-435	S	REG	16.7	N *	=	0.18	16.7	2.815408719
Z1-EU33W-436	S	REG	30	N *	=	0.18	30	3.401197382
Z1-EU33W-437	S	REG	1250	N *	=	0.2	1250	7.13068863
Z1-EU33W-438	S	REG	1970	N *	=	0.18	1970	7.585789822
Z1-EU33W-439	S	REG	352	N *	=	0.18	352	5.863631175
Z1-EU33W-440	S	REG	455	N *	=	0.17	455	6.120207418
Z1-EU33W-441	S	REG	136	N *	=	0.18	136	4.912664885

Number of Samples 57
Number of Detects 57

Minimum 3.5
Median 83
Maximum 4780
Average 284.52456
Standard Deviation 704.2813

PERT-Beta Mean 852.58333

Lognormal Mean 4.2255927
Lognormal Standard Deviation 1.7218562

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Cu mg/kg

General Statistics

Number of Valid Observations 57

Number of Distinct Observations 55

Raw Statistics

Minimum 3.5

Maximum 4780

Mean 284.5

Median 83

SD 704.3

Coefficient of Variation 2.475

Skewness 5.15

Log-transformed Statistics

Minimum of Log Data 1.253

Maximum of Log Data 8.472

Mean of log Data 4.226

SD of log Data 1.722

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.345

Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.0858

Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 440.5

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 506

95% Modified-t UCL 451.1

Assuming Lognormal Distribution

95% H-UCL 592.5

95% Chebyshev (MVUE) UCL 680.6

97.5% Chebyshev (MVUE) UCL 852.4

99% Chebyshev (MVUE) UCL 1190

Gamma Distribution Test

k star (bias corrected) 0.441

Theta Star 645.9

nu star 50.22

Approximate Chi Square Value (.05) 34.95

Adjusted Level of Significance 0.0458

Adjusted Chi Square Value 34.62

Anderson-Darling Test Statistic 2.057

Anderson-Darling 5% Critical Value 0.827

Kolmogorov-Smirnov Test Statistic 0.142

Kolmogorov-Smirnov 5% Critical Value 0.125

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 438

95% Jackknife UCL 440.5

95% Standard Bootstrap UCL 438.1

95% Bootstrap-t UCL 633.5

95% Hall's Bootstrap UCL 1014

95% Percentile Bootstrap UCL 447.6

95% BCA Bootstrap UCL 546.4

95% Chebyshev(Mean, Sd) UCL 691.1

97.5% Chebyshev(Mean, Sd) UCL 867.1

99% Chebyshev(Mean, Sd) UCL 1213

Assuming Gamma Distribution

95% Approximate Gamma UCL 408.9

95% Adjusted Gamma UCL 412.8

Potential UCL to Use	Use 95% H-UCL
	592.5

Statistical Summary for Iron mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	30700 N *		✓	10.8	30700	10.33201793
Z1-EU29W-401	S	REG	22000 N *		✓	9.4	22000	9.998797732
Z1-EU29W-402	S	REG	35600 N *		✓	11.5	35600	10.48010092
Z1-EU29W-403	S	REG	26400 N *		✓	9.6	26400	10.26414442
Z1-EU29W-404	S	REG	30800 N *		✓	10.8	30800	10.33528997
Z1-EU29W-405 + Dup	S	REG	18900 N *		✓	10.2	18900	9.846917201
Z1-EU29W-406	S	REG	31800 N *		✓	9.5	31800	10.36722187
Z1-EU29W-407	S	REG	40800 N *		✓	11	40800	10.81543736
Z1-EU29W-408	S	REG	31000 N *		✓	10.5	31000	10.34174248
Z1-EU29W-409	S	REG	35800 N *		✓	10.3	35800	10.49570317
Z1-EU30BW-411	B	REG	25400 N *		✓	10.4	25400	10.18111929
Z1-EU30C-444	C	REG	7980 N		✓	4.4	7980	8.985946039
Z1-EU30C-445	C	REG	5310 N		✓	3.9	5310	6.577347114
Z1-EU30C-446	C	REG	6690 N		✓	4.6	6690	8.646465527
Z1-EU30C-447	C	REG	8090 N		✓	4.7	8090	8.99838401
Z1-EU30C-448 + Dup	C	FR	10100 N		✓	6.3	10100	9.220200703
Z1-EU30C-449	C	REG	9930 N		✓	4.6	9930	9.203315757
Z1-EU30C-450	C	REG	5950 N		✓	4.5	5950	8.691148499
Z1-EU30C-451	C	REG	9710 N		✓	4.8	9710	9.182911551
Z1-EU30C-452	C	REG	4630 N		✓	4.5	4630	8.440312147
Z1-EU30C-453	C	REG	7630 N		✓	4.8	7630	8.939643124
Z1-EU30C-454	C	REG	8290 N		✓	4.6	8290	9.023005248
Z1-EU31BW-415	B	REG	42800 N *		✓	10.8	42800	10.86800953
Z1-EU31BW-416	B	REG	38300 N *		✓	11.2	38300	10.47183624
Z1-EU31BW-417	B	REG	48400 N *		✓	9.7	48400	10.8077057
Z1-EU31W-412	S	REG	17800 N *		✓	10.7	17800	9.786953736
Z1-EU31W-413	S	REG	25700 N *		✓	9.3	25700	10.18424827
Z1-EU31W-414	S	REG	34300 N *		✓	11	34300	10.44290063
Z1-EU32BW-431	B	REG	35100 N		✓	9.8	35100	10.49595041
Z1-EU32BW-432	B	REG	48600 N		✓	10.6	48600	10.79137894
Z1-EU32BW-433 + Dup	B	REG	28900 N		✓	9.9	28900	10.16988157
Z1-EU32BW-434	B	REG	20100 N *		✓	8.8	20100	9.908475084
Z1-EU32C-456	C	REG	7780 N		✓	4.6	7780	8.969311617
Z1-EU32C-456	C	REG	8210 N		✓	4.8	8210	8.733916175
Z1-EU32MW-420	S	REG	18800 N		✓	3.4	18800	9.841812149
Z1-EU32MW-420	S	REG	80800 N		✓	10.8	80800	11.01896845
Z1-EU32W-418	S	REG	18400 N		✓	4.2	18400	9.820105944
Z1-EU32W-419 + Dup	S	REG	51200 N		✓	10.2	51200	10.84348481
Z1-EU32W-421	S	REG	49100 N		✓	10.9	49100	10.80181431
Z1-EU32W-422	B	REG	41100 N		✓	3.3	41100	10.6237834
Z1-EU32W-423	S	REG	27600 N		✓	3.3	27600	10.22557106
Z1-EU32W-424	S	REG	18500 N		✓	3.6	18500	9.825528911
Z1-EU32W-425	S	REG	34100 N		✓	3.7	34100	10.43705288
Z1-EU32W-427	S	REG	18390 N		✓	3.4	18390	9.807960375
Z1-EU32W-428	S	REG	24700 N		✓	3.9	24700	10.11455882
Z1-EU32W-429	S	REG	18790 N		✓	3.4	18790	9.836278809
Z1-EU32W-430	S	REG	15500 N		✓	3.4	15500	9.648565303
Z1-EU33BW-443	B	REG	48100 N *		✓	10.1	48100	10.80181431
Z1-EU33BW-444	B	REG	20400 N		✓	3.9	20400	9.82328018
Z1-EU33C-457	C	REG	8120 N		✓	4.4	8120	9.002085433
Z1-EU33W-435	S	REG	20900 N		✓	4	20900	9.842704266
Z1-EU33W-436	S	REG	17600 N		✓	4	17600	9.778854181
Z1-EU33W-437	S	REG	30000 N		✓	4.5	30000	10.30895268
Z1-EU33W-438	S	REG	68800 N		✓	11.8	68800	11.13604781
Z1-EU33W-439	S	REG	22500 N		✓	3.7	22500	10.02127059
Z1-EU33W-440	S	REG	15600 N		✓	22.8	156000	11.9541804
Z1-EU33W-441	S	REG	28900 N		✓	9.8	28900	10.27159687

Number of Samples	57
Number of Detects	57
Minimum	4630
Median	24700
Maximum	155000
Average	27793.508
Standard Deviation	22787.249
PERT-Beta Mean	43071.887
Lognormal Mean	9.9748357
Lognormal Standard Deviation	0.7420704

General UCL Statistics for Full Data Sets

User Selected Options

From File: WorkSheet.wst
Full Precision: OFF
Confidence Coefficient: 95%
Number of Bootstrap Operations: 2000

Fe mg/kg

General Statistics

Number of Valid Observations: 57 Number of Distinct Observations: 56

Raw Statistics

Minimum: 4630
Maximum: 155000
Mean: 27794
Median: 24700
SD: 22797
Coefficient of Variation: 0.82
Skewness: 3.273

Log-transformed Statistics

Minimum of Log Data: 8.44
Maximum of Log Data: 11.95
Mean of log Data: 9.975
SD of log Data: 0.742

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic: 0.17
Lilliefors Critical Value: 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic: 0.131
Lilliefors Critical Value: 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL: 32844
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL: 34159
95% Modified-t UCL: 33062

Assuming Lognormal Distribution

95% H-UCL: 34656
95% Chebyshev (MVUE) UCL: 41459
97.5% Chebyshev (MVUE) UCL: 47232
99% Chebyshev (MVUE) UCL: 58573

Gamma Distribution Test

k star (bias corrected): 1.993
Theta Star: 13945
nu star: 227.2

Approximate Chi Square Value (.05): 193.3
Adjusted Level of Significance: 0.0458
Adjusted Chi Square Value: 192.5

Anderson-Darling Test Statistic: 0.612
Anderson-Darling 5% Critical Value: 0.762
Kolmogorov-Smirnov Test Statistic: 0.091
Kolmogorov-Smirnov 5% Critical Value: 0.119

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL: 32760
95% Jackknife UCL: 32844
95% Standard Bootstrap UCL: 32642
95% Bootstrap-t UCL: 35204
95% Hall's Bootstrap UCL: 53949
95% Percentile Bootstrap UCL: 33051
95% BCA Bootstrap UCL: 34674
95% Chebyshev(Mean, Sd) UCL: 40956
97.5% Chebyshev(Mean, Sd) UCL: 46651
99% Chebyshev(Mean, Sd) UCL: 57838

Assuming Gamma Distribution

95% Approximate Gamma UCL: 32666
95% Adjusted Gamma UCL: 32803

Potential UCL to Use

Use 95% Approximate Gamma UCL 32666

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

© Radus and Associates, 2001 - 2005

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klradus@ra.net

12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

	SRC	WACFACS VUL SRC INPUT			OUTPUT		Calculations				
		STEP 10	STEP 11	STEP 12			Beta PDF Inverse	PERT BETA			
		MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance
Iron (mg/kg)		4830.0000	24700	195000	43071.67	90299.55	2.10	90299.55	1.53	4.47	150370.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MIN(x) < MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times MED + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN)(MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B(\alpha_1, \alpha_2)$ is the incomplete Beta Function.
 α_1 and α_2 are calculated parameters.

Use the Microsoft Excel BETA.INV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Lead mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	54.2 *	-	-	0.27	54.2	3.992580308
Z1-EU29BW-401	S	REG	50.2 *	-	-	0.23	50.2	3.918016827
Z1-EU29W-402	S	REG	52.2 *	-	-	0.29	52.2	3.955082495
Z1-EU29W-400	S	REG	22.7 *	-	-	0.24	22.7	3.122064824
Z1-EU29W-404	S	REG	148 *	-	-	0.27	148	4.097212274
Z1-EU29W-405 + Dup	S	REG	54.2 *	-	-	0.26	54.2	3.992580308
Z1-EU29W-408	S	REG	17.8 *	-	-	0.24	17.8	2.879189487
Z1-EU29W-407	S	REG	151 *	-	-	0.27	151	5.081404365
Z1-EU29W-409	B	REG	14.1 *	-	-	0.20	14.1	2.648174797
Z1-EU29W-409	S	REG	38.8 *	-	-	0.26	38.8	3.60004824
Z1-EU30BW-411	B	REG	84 *	-	-	0.20	84	4.430815799
Z1-EU30C-444	C	REG	3.5	-	-	0.3	3.5	1.252782968
Z1-EU30C-445	C	REG	3	-	-	0.26	3	1.098612889
Z1-EU30C-446	C	REG	8.2	-	-	0.31	8.2	2.104134154
Z1-EU30C-447	C	REG	3.6	-	-	0.31	3.6	1.252782968
Z1-EU30C-448 + Dup	C	PM	3.2	-	-	0.28	3.2	1.16316881
Z1-EU30C-449	C	REG	3.8	-	-	0.3	3.8	1.335001667
Z1-EU30C-450	C	REG	5.3	-	-	0.3	5.3	1.607708821
Z1-EU30C-451	C	REG	3.2	-	-	0.3	3.2	1.16316881
Z1-EU30C-452	C	REG	5.3	-	-	0.3	5.3	1.607708821
Z1-EU30C-453	C	REG	9.4	-	-	0.32	9.4	2.240709689
Z1-EU30C-454	C	REG	4	-	-	0.3	4	1.386294381
Z1-EU31BW-416	B	REG	27.8 *	-	-	0.27	27.8	3.314186005
Z1-EU31BW-416	B	REG	30.7 *	-	-	0.28	30.7	3.424262655
Z1-EU31BW-417	B	REG	30.4 *	-	-	0.24	30.4	3.414442608
Z1-EU31W-412	S	REG	17.8 *	-	-	0.27	17.8	2.879189487
Z1-EU31W-413	S	REG	76.9 *	-	-	0.23	76.9	4.342505877
Z1-EU31W-414	S	REG	23.7 *	-	-	0.27	23.7	3.155475049
Z1-EU32BW-431	B	REG	733 *	-	-	0.28	733	6.587145702
Z1-EU32BW-432	B	REG	78.4 *	-	-	0.23	78.4	4.361829827
Z1-EU32BW-433 + Dup	B	REG	49.5 *	-	-	0.26	49.5	3.90197267
Z1-EU32BW-434	B	REG	18.8 *	-	-	0.24	18.8	2.922115159
Z1-EU32C-455	C	REG	5.8	-	-	0.31	5.8	1.722788938
Z1-EU32C-456	C	REG	2.9	-	-	0.32	2.9	1.084710737
Z1-EU32W-420	S	REG	84.3	-	-	0.25	84.3	4.434381885
Z1-EU32W-425	S	REG	58.4	-	-	0.27	58.4	4.084294228
Z1-EU32W-418	S	REG	41.8	-	-	0.32	41.8	3.73288834
Z1-EU32W-419 + Dup	S	REG	137	-	-	0.28	137	4.918080926
Z1-EU32W-421	S	REG	98.3	-	-	0.27	98.3	4.598148571
Z1-EU32W-422	S	REG	98	-	-	0.25	98	4.584967479
Z1-EU32W-423	S	REG	57.6	-	-	0.25	57.6	4.053522868
Z1-EU32W-424	S	REG	23.1	-	-	0.27	23.1	3.139832618
Z1-EU32W-425	S	REG	82.9	-	-	0.28	82.9	4.141546164
Z1-EU32W-427	S	REG	31.6	-	-	0.25	31.6	3.453157121
Z1-EU32W-428	S	REG	25.1	-	-	0.29	25.1	3.201836314
Z1-EU32W-429	S	REG	58	-	-	0.25	58	4.050443011
Z1-EU32W-430	S	REG	40.8 *	-	J	0.23	40.8	3.703769067
Z1-EU33BW-443	B	REG	178 *	-	-	0.25	175	5.164765974
Z1-EU33BW-444	B	REG	29.5 *	-	-	0.28	29.5	3.384390253
Z1-EU33C-457	C	REG	11.3	-	-	0.29	11.3	2.424802728
Z1-EU33W-435	S	REG	24.3 *	-	-	0.27	24.3	3.19047595
Z1-EU33W-436	S	REG	37.7 *	-	-	0.27	37.7	3.629880084
Z1-EU33W-437	S	REG	88.8 *	-	-	0.3	88.8	4.484131858
Z1-EU33W-438	S	REG	187 *	-	-	0.28	187	5.231108697
Z1-EU33W-439	S	REG	44.5 *	-	-	0.25	44.5	3.795489189
Z1-EU33W-440	S	REG	93.4 *	-	-	0.25	93.4	4.538991345
Z1-EU33W-441	S	REG	101 *	-	-	0.24	101	4.615120517

Number of Samples

57

Number of Detects

57

Minimum

2.9

Median

36.6

Maximum

733

Average

60.603509

Standard Deviation

101.54888

PERT-Bias Mean

147.05

Lognormal Mean

3.3804044

Lognormal Standard Deviation

1.2792784

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wsl

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Pb mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 52

Raw Statistics

Minimum 2.9
Maximum 733
Mean 60.6
Median 36.6
SD 101.5
Coefficient of Variation 1.676
Skewness 5.421

Log-transformed Statistics

Minimum of Log Data 1.065
Maximum of Log Data 6.597
Mean of log Data 3.38
SD of log Data 1.279

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.285
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.104
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 83.1
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 93.05
95% Modified-t UCL 84.71

Assuming Lognormal Distribution

95% H-UCL 97.11
95% Chebyshev (MVUE) UCL 125.9
97.5% Chebyshev (MVUE) UCL 152.2
99% Chebyshev (MVUE) UCL 204

Gamma Distribution Test

k star (bias corrected) 0.788
Theta Star 77.09
nu star 89.62

Approximate Chi Square Value (.05) 68.79
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 68.32

Anderson-Darling Test Statistic 0.684
Anderson-Darling 5% Critical Value 0.789
Kolmogorov-Smirnov Test Statistic 0.0887
Kolmogorov-Smirnov 5% Critical Value 0.122

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 82.73
95% Jackknife UCL 83.1
95% Standard Bootstrap UCL 82.3
95% Bootstrap-t UCL 106.9
95% Hall's Bootstrap UCL 172.7
95% Percentile Bootstrap UCL 84.54
95% BCA Bootstrap UCL 85.98
95% Chebyshev(Mean, Sd) UCL 119.2
97.5% Chebyshev(Mean, Sd) UCL 144.6
99% Chebyshev(Mean, Sd) UCL 194.4

Assuming Gamma Distribution

95% Approximate Gamma UCL 78.95
95% Adjusted Gamma UCL 79.5

Potential UCL to Use	Use 95% Approximate Gamma UCL	78.95
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Statistical Summary for Lead mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU29BW-410		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU29W-401		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU29W-402		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU29W-403		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU29W-404		REG	66.2	=		34.8	0.0662	-2.715074816
Z1-EU29W-405 + Dup		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU29W-406		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU29W-407		REG	83.4	=		34.8	0.0834	-2.484106897
Z1-EU29W-408		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU29W-409		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU30BW-411		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU31BW-415		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU31BW-416		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU31BW-417		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU31W-412		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU31W-413		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU31W-414		REG	37.7	=		34.8	0.0377	-3.278095185
Z1-EU32BW-431		REG	599	=		18	0.599	-0.512493881
Z1-EU32BW-432		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32BW-433 + Dup		REG	249	=		18	0.249	-1.390302383
Z1-EU32BW-434		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU32MW-420		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32MW-426		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32W-418		REG	56.5 B	=		18	0.0565	-2.873514641
Z1-EU32W-419 + Dup		FR	26.1 B	=		18	0.0261	-3.845819865
Z1-EU32W-421		REG	273	=		18	0.273	-1.298283484
Z1-EU32W-422		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32W-423		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32W-424		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32W-425		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32W-427		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32W-428		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32W-429		REG	18 U	U		18	0.009	-4.710530702
Z1-EU32W-430		REG	18 U	U		18	0.009	-4.710530702
Z1-EU33BW-443		REG	34.2 B	=		18	0.0342	-3.375529635
Z1-EU33BW-444		REG	34.8 U	U		34.8	0.0174	-4.051285073
Z1-EU33W-435		REG	18 U	U		18	0.009	-4.710530702
Z1-EU33W-436		REG	21.2 B	=		18	0.0212	-3.853754087
Z1-EU33W-437		REG	18 U	U		18	0.009	-4.710530702
Z1-EU33W-438		REG	18 U	U		18	0.009	-4.710530702
Z1-EU33W-439		REG	18 U	U		18	0.009	-4.710530702
Z1-EU33W-440		REG	18 U	U		18	0.009	-4.710530702
Z1-EU33W-441		REG	18 U	U		18	0.009	-4.710530702
			21.7 B	=		18	0.0217	-3.858482239

Number of Samples

43

Number of Detects

11

Minimum

0.009

Median

0.0174

Maximum

0.599

Average

0.0439488

Standard Deviation

0.102017

PERT-Beta Mean

0.1129333

Lognormal Mean

-3.941268

Lognormal Standard Deviation

0.982463

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheetLwst
Full Precision OFF
Confidence Coefficient 95%
Number of Bootstrap Operations 2000

Pb mg/L

General Statistics

Number of Valid Observations 43 Number of Distinct Observations 13

Raw Statistics

Minimum 0.009
Maximum 0.599
Mean 0.0439
Median 0.0174
SD 0.102
Coefficient of Variation 2.321
Skewness 4.485

Log-transformed Statistics

Minimum of Log Data -4.711
Maximum of Log Data -0.512
Mean of log Data -3.941
SD of log Data 0.982

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.378
Shapiro Wilk Critical Value 0.943

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.731
Shapiro Wilk Critical Value 0.943

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 0.0701
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 0.0809
95% Modified-t UCL 0.0719

Assuming Lognormal Distribution

95% H-UCL 0.0448
95% Chebyshev (MVUE) UCL 0.0545
97.5% Chebyshev (MVUE) UCL 0.0647
99% Chebyshev (MVUE) UCL 0.0847

Gamma Distribution Test

k star (bias corrected) 0.699
Theta Star 0.0628
nu star 60.14
Approximate Chi Square Value (.05) 43.31
Adjusted Level of Significance 0.0444
Adjusted Chi Square Value 42.81

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Anderson-Darling Test Statistic 6.851
Anderson-Darling 5% Critical Value 0.791
Kolmogorov-Smirnov Test Statistic 0.353
Kolmogorov-Smirnov 5% Critical Value 0.14

Nonparametric Statistics

95% CLT UCL 0.0695
95% Jackknife UCL 0.0701
95% Standard Bootstrap UCL 0.0687
95% Bootstrap-t UCL 0.107
95% Hall's Bootstrap UCL 0.0832
95% Percentile Bootstrap UCL 0.0728
95% BCA Bootstrap UCL 0.0844
95% Chebyshev(Mean, Sd) UCL 0.112
97.5% Chebyshev(Mean, Sd) UCL 0.141
99% Chebyshev(Mean, Sd) UCL 0.199

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL 0.061
95% Adjusted Gamma UCL 0.0617

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 0.112

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

WACFACS WL L SRC INPUT			Calculations								
STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse		PERT BETA			
	MIN	MED	MAX	E(X)	UCL-95	UCL-95: E(X)	0.95	α_1	α_2	Variance	Max - Min
Lead (mg/L)	0.0090	0.0174	0.599	0.11	0.28	2.51	0.28	1.06	4.84	0.0088	0.6

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < Most\ Likely < MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2 + 1)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B(\alpha_1, \alpha_2)$ is the incomplete Beta Function.

α_1 and α_2 are calculated parameters.

Use the Microsoft Excel 2003 function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Lithium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-400	B	REG	8.1 E N	-	-	0.04	8.1	2.091864062
Z1-EU29W-401	S	REG	15.5 E N	J	-	0.03	15.5	2.749844024
Z1-EU29W-402	S	REG	12.1 E N	-	-	0.04	12.1	2.493205483
Z1-EU29W-403	S	REG	12 E N	-	-	0.03	12	2.48490665
Z1-EU29W-404	S	REG	13.6 E N	-	-	0.04	13.6	2.510089783
Z1-EU29W-405 + Dup	S	FA	45.7 E N	-	-	0.03	45.7	3.822038295
Z1-EU29W-406	S	REG	9.2 E N	-	-	0.03	9.2	2.219293484
Z1-EU29W-407	S	REG	13.8 E N	-	-	0.04	13.8	2.624668592
Z1-EU29W-408	S	REG	9.4 E N	-	-	0.04	9.4	2.240709883
Z1-EU29W-409	S	REG	13.3 E N	-	-	0.03	13.3	2.587764035
Z1-EU30BW-411	B	REG	35.1 E N	-	-	0.03	35.1	3.65820113
Z1-EU30C-444	C	REG	10.7 E N	J	-	0.04	10.7	2.370243741
Z1-EU30C-446	C	REG	5.3 E N	-	-	0.03	5.3	1.857706821
Z1-EU30C-446	C	REG	11.5 E N	-	-	0.04	11.5	2.442347035
Z1-EU30C-447	C	REG	6.2 E N	-	-	0.04	6.2	2.104134154
Z1-EU30C-446 + Dup	C	FA	13.2 E N	-	-	0.04	13.2	2.580216883
Z1-EU30C-449	C	REG	14.3 E N	-	-	0.04	14.3	2.434802726
Z1-EU30C-450	C	REG	8.5 E N	-	-	0.04	8.5	2.140068163
Z1-EU30C-461	C	REG	12.3 E N	-	-	0.04	12.3	2.509698262
Z1-EU30C-452	C	REG	13.9 E N	-	-	0.04	13.9	2.624668592
Z1-EU30C-483	C	REG	18.4 E N	-	-	0.04	18.4	2.734367509
Z1-EU30C-454	C	REG	8.1 E N	-	-	0.04	8.1	2.091864062
Z1-EU31BW-415	B	REG	10.4 E N	-	-	0.04	10.4	2.341806806
Z1-EU31BW-416	B	REG	11.3 E N	-	-	0.04	11.3	2.424804728
Z1-EU31BW-417	B	REG	11.8 E N	-	-	0.03	11.8	2.442347035
Z1-EU31W-412	S	REG	19.8 E N	-	-	0.04	19.8	2.685681938
Z1-EU31W-413	S	REG	11.1 E N	-	-	0.03	11.1	2.406945108
Z1-EU31W-414	B	REG	10.2 E N	-	-	0.04	10.2	2.32238772
Z1-EU32BW-431	B	REG	17.5	-	-	0.03	17.5	2.852200881
Z1-EU32BW-432	B	REG	14	-	-	0.03	14	2.63908733
Z1-EU32BW-433 + Dup	B	REG	18.4	-	-	0.03	18.4	2.912306985
Z1-EU32BW-404	B	REG	12.3 E N	-	-	0.03	12.3	2.509698262
Z1-EU32C-455	C	REG	7 E N	-	-	0.04	7	1.940810149
Z1-EU32C-456	C	REG	7.1 E N	-	-	0.04	7.1	1.960094784
Z1-EU32MW-420	S	REG	22.4 E *	-	-	0.03	22.4	3.109060888
Z1-EU32MW-426	S	REG	11.4 E *	-	-	0.04	11.4	2.433613355
Z1-EU32W-418	S	REG	15.4 E *	J	-	0.04	15.4	2.734367609
Z1-EU32W-419 + Dup	S	REG	23.4 E *	-	-	0.03	23.4	3.152738022
Z1-EU32W-421	S	REG	16 E *	-	-	0.04	16	2.772688722
Z1-EU32W-422	S	REG	19.6 E *	-	-	0.03	19.6	2.975623666
Z1-EU32W-423	S	REG	68 E *	-	-	0.03	68	4.218507706
Z1-EU32W-424	S	REG	7.7 E *	-	-	0.04	7.7	2.041280329
Z1-EU32W-425	S	REG	15.5 E *	-	-	0.04	15.5	2.749844024
Z1-EU32W-427	S	REG	10.8 E *	-	-	0.03	10.8	2.360864001
Z1-EU32W-428	S	REG	10.3 E *	-	-	0.04	10.3	2.332143888
Z1-EU32W-428	S	REG	11 E *	-	-	0.03	11	2.397885273
Z1-EU32W-430	S	REG	8.1	-	-	0.03	8.1	2.091864062
Z1-EU33BW-443	B	REG	13 E N	-	-	0.03	13	2.564949057
Z1-EU33BW-444	B	REG	9.6	-	-	0.03	9.6	2.281783098
Z1-EU33C-457	C	REG	14.7 E N	-	-	0.04	14.7	2.687847494
Z1-EU33W-435	S	REG	16.4	-	-	0.04	16.4	2.797281336
Z1-EU33W-436	S	REG	10.4	-	-	0.04	10.4	2.341806806
Z1-EU33W-437	S	REG	14.3	-	-	0.04	14.3	2.660259537
Z1-EU33W-438	S	REG	23.7	-	-	0.04	23.7	3.185475048
Z1-EU33W-439	S	REG	13.7	-	-	0.03	13.7	2.617365833
Z1-EU33W-440	S	REG	11.2	-	-	0.03	11.2	2.415813778
Z1-EU33W-441	S	REG	14.1	-	-	0.03	14.1	2.645174797

Number of Samples 57
Number of Detects 57

Minimum 5.3
Median 12.3
Maximum 68
Average 14.687719
Standard Deviation 9.7310635

PERT-Beta Mean 20.416657

Lognormal Mean 2.5680845
Lognormal Standard Deviation 0.439288

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Li mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	48
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Raw Statistics

Minimum	5.3
Maximum	68
Mean	14.69
Median	12.3
SD	9.731
Coefficient of Variation	0.663
Skewness	3.762

Log-transformed Statistics

Minimum of Log Data	1.668
Maximum of Log Data	4.22
Mean of log Data	2.569
SD of log Data	0.439

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic	0.256
Lilliefors Critical Value	0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic	0.137
Lilliefors Critical Value	0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	16.84
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	17.49
95% Modified-t UCL	16.95

Assuming Lognormal Distribution

95% H-UCL	16.01
95% Chebyshev (MVUE) UCL	18.14
97.5% Chebyshev (MVUE) UCL	19.77
99% Chebyshev (MVUE) UCL	22.99

Gamma Distribution Test

k star (bias corrected)	4.18
Theta Star	3.514
nu star	476.5
Approximate Chi Square Value (.05)	426.9
Adjusted Level of Significance	0.0458
Adjusted Chi Square Value	425.7

Anderson-Darling Test Statistic	2.611
Anderson-Darling 5% Critical Value	0.754
Kolmogorov-Smirnov Test Statistic	0.182
Kolmogorov-Smirnov 5% Critical Value	0.118

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	16.81
95% Jackknife UCL	16.84
95% Standard Bootstrap UCL	16.85
95% Bootstrap-t UCL	16.41
95% Half's Bootstrap UCL	26.36
95% Percentile Bootstrap UCL	16.91
95% BCA Bootstrap UCL	17.58
95% Chebyshev(Mean, Sd) UCL	20.31
97.5% Chebyshev(Mean, Sd) UCL	22.74
99% Chebyshev(Mean, Sd) UCL	27.51

Assuming Gamma Distribution

95% Approximate Gamma UCL	16.39
95% Adjusted Gamma UCL	16.44

Potential UCL to Use

Use 95% Student's-t UCL 16.84

or 95% Modified-t UCL 16.95

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

SRC	WACFACS W/L SRC INPUT			Calculations			
	STEP 10	STEP 11	STEP 12	OUTPUT		Beta PDF Inverse	PERT BETA
	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	α_1 α_2 Variance Max - Min
Lithium (mg/kg)	6.3000	12.3	88	20.42	38.90	1.05	39.90 1.45 4.56 195.4021 82.7

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - \text{MIN})^{\alpha_1 - 1} (\text{MAX} - 1)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (\text{MAX} - \text{MIN})^{\alpha_1 + \alpha_2 - 1}} \quad \text{MIN} < \text{Most Likely} < \text{MAX}$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{\text{MIN} + 4 \times \text{Most Likely} + \text{MAX}}{6}$$

$$\text{Var}(x) = \frac{(E(x) - \text{MIN}) \times (\text{MAX} - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - \text{MIN}}{\text{MAX} - \text{MIN}} \right]$$

$$\alpha_2 = 6 \times \left[\frac{\text{MAX} - E(x)}{\text{MAX} - \text{MIN}} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel (BIM) function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Magnesium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-400	B	REG	2340		✓	10	2340	7.757908208
Z1-EU29W-401	S	REG	13100		✓	8.7	13100	9.480387609
Z1-EU29W-402	S	REG	3280		=	10.8	3250	8.086410875
Z1-EU29W-403	S	REG	4970		✓	8.8	4970	8.511175119
Z1-EU29W-404	S	REG	3290		=	10	3290	8.090842844
Z1-EU29W-405 + Dup	S	FR	25200		×	9.1	25200	10.13459927
Z1-EU29W-406	S	REG	2810		=	8.7	2810	7.940699763
Z1-EU29W-407	S	REG	3770		=	10.1	3770	8.23483028
Z1-EU29W-408	S	REG	1060		<	9.7	1060	6.966024187
Z1-EU29W-409	S	REG	8250		=	9.5	8250	8.740336748
Z1-EU30W-411	B	REG	35300		✓	9.8	35300	10.47183824
Z1-EU30C-444	C	REG	6350 N *		J	21.8	6050	8.756210092
Z1-EU30C-446	C	REG	55200 N *			19.2	86200	10.91871823
Z1-EU30C-446	C	REG	68000 N *		Δ	22.7	68000	10.08359637
Z1-EU30C-447	C	REG	27600 N *		✓	23.1	27600	10.22657106
Z1-EU30C-448 + Dup	C	FR	6310 N *			21	6310	8.748800666
Z1-EU30C-449	C	REG	5440 N *		✓	22.1	5440	8.60163434
Z1-EU30C-450	C	REG	51000 N *		=	22.2	51000	10.83958091
Z1-EU30C-451	C	REG	5880 N *		✓	22	5880	8.679312041
Z1-EU30C-452	C	REG	8850 N *		Δ	22.3	5850	8.948496039
Z1-EU30C-453	C	REG	7020 N *		✓	23.6	7020	8.856618497
Z1-EU30C-454	C	REG	42900 N *		×	22.5	42900	10.6696271
Z1-EU31BW-416	B	REG	1790		=	10	1790	7.488970699
Z1-EU31BW-416	B	REG	1260		×	10.3	1250	7.13089883
Z1-EU31BW-417	B	REG	1750		<	9	1750	7.467371067
Z1-EU31W-412	S	REG	17800		×	9.8	17800	9.788953736
Z1-EU31W-413	S	REG	7050		×	8.8	7050	8.860782886
Z1-EU31W-414	S	REG	2880		=	10.1	2690	7.897296473
Z1-EU32BW-431	B	REG	39700 *		✓	2.1	39700	10.58910647
Z1-EU32BW-432	B	REG	7400 *		Δ	2	7400	8.008235279
Z1-EU32BW-433 + Dup	B	REG	2750 *		=	2.2	2760	7.918365181
Z1-EU32BW-434	B	REG	12800		×	8.8	12800	9.45720045
Z1-EU32C-456	C	REG	45300 N *		=	22.8	48300	10.72106231
Z1-EU32C-456	C	REG	28000 N *		Δ	23.8	28000	10.23986979
Z1-EU32W-420	S	REG	17300 N *		=	3.2	17300	9.75646176
Z1-EU32W-426	S	REG	5480 N *		=	10	5480	8.60888038
Z1-EU32W-418	S	REG	14000 N *		J	3.9	14000	9.548812609
Z1-EU32W-419 + Dup	S	REG	17600 N *		×	9.4	17800	9.779854181
Z1-EU32W-421	S	REG	9800 N *		=	10	9800	9.190137884
Z1-EU32W-422	S	REG	14900 N *		×	3	14900	9.609118492
Z1-EU32W-423	S	REG	48800 N *		Δ	18.4	48800	10.79548559
Z1-EU32W-424	S	REG	2150 N *		✓	3.3	2150	7.673223121
Z1-EU32W-425	S	REG	10400 N *		Δ	3.4	10400	9.249581083
Z1-EU32W-427	S	REG	1300 N *		✓	3.2	1000	7.170119543
Z1-EU32W-428	S	REG	2780 N *		Δ	3.5	2780	7.930206207
Z1-EU32W-429	S	REG	1980 N *		×	3.1	1880	7.530852124
Z1-EU32W-430	S	REG	2820 *		=	1.9	2820	7.944492164
Z1-EU33BW-443	B	REG	6020		=	9.3	6020	8.702842538
Z1-EU33BW-444	B	REG	1450 *		Δ	2.2	1450	7.279318835
Z1-EU33C-457	C	REG	73800 N *		=	21.7	73800	11.20811481
Z1-EU33W-435	S	REG	1520 *		=	2.2	1520	7.326465614
Z1-EU33W-436	S	REG	1980 *		=	2.2	1980	7.580699752
Z1-EU33W-437	S	REG	9740 *		✓	2.6	9740	9.183996397
Z1-EU33W-438	S	REG	14300 *		Δ	2.2	14300	9.568014818
Z1-EU33W-439	S	REG	3430 *		=	2.1	3430	8.14031554
Z1-EU33W-440	S	REG	8630 *		×	2.1	6530	8.784462222
Z1-EU33W-441	S	REG	5900 *		=	2	5900	8.68270763

Number of Samples 57
Number of Detects 57

Minimum 1060
Median 6350
Maximum 73800
Average 14335.814
Standard Deviation 17414.049

PERT-Beta Mean 16710

Lognormal Mean 8.9178376
Lognormal Standard Deviation 1.1803307

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Mg mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 57

Raw Statistics

Minimum 1060
Maximum 73800
Mean 14336
Median 6350
SD 17414
Coefficient of Variation 1.215
Skewness 1.749

Log-transformed Statistics

Minimum of Log Data 6.966
Maximum of Log Data 11.21
Mean of log Data 8.918
SD of log Data 1.16

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.251
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.0994
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 18183
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 18700
95% Modified-L UCL 18282

Assuming Lognormal Distribution

95% H-UCL 38631
95% Chebyshev (MVUE) UCL 26202
97.5% Chebyshev (MVUE) UCL 31329
99% Chebyshev (MVUE) UCL 41398

Gamma Distribution Test

k star (bias corrected) 0.861
Theta Star 16655
nu star 98.12

Approximate Chi Square Value (.05) 76.27
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 75.77

Anderson-Darling Test Statistic 1.749
Anderson-Darling 5% Critical Value 0.785
Kolmogorov-Smirnov Test Statistic 0.173
Kolmogorov-Smirnov 5% Critical Value 0.122

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 18130
95% Jackknife UCL 18193
95% Standard Bootstrap UCL 18052
95% Bootstrap-t UCL 19186
95% Hall's Bootstrap UCL 18759
95% Percentile Bootstrap UCL 18201
95% BCA Bootstrap UCL 18831
95% Chebyshev(Mean, Sd) UCL 24390
97.5% Chebyshev(Mean, Sd) UCL 28740
99% Chebyshev(Mean, Sd) UCL 37285

Assuming Gamma Distribution

95% Approximate Gamma UCL 18443
95% Adjusted Gamma UCL 18564

Potential UCL to Use

Use 95% H-UCL 38631

Statistical Summary for Manganese mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-400	B	REG	934 N *	=		0.04	934	6.839475438
Z1-EU29W-401	B	REG	303 N *	=		0.03	303	5.713132806
Z1-EU29W-402	S	REG	623 N *	=		0.04	623	6.434546519
Z1-EU29W-403	S	REG	455 N *	=		0.03	455	6.120297419
Z1-EU29W-404	S	REG	559 N *	=		0.04	559	6.326148473
Z1-EU29W-406 + Dup	S	REG	630 N *	=		0.03	630	6.445710819
Z1-EU29W-406	S	REG	360 N *	=		0.03	360	5.857933164
Z1-EU29W-407	S	REG	715 N *	=		0.04	715	6.572282543
Z1-EU29W-408	S	REG	403 N *	=		0.04	403	5.998531662
Z1-EU29W-409	S	REG	857 N *	=		0.03	857	6.753437919
Z1-EU30W-411	B	REG	377 N *	=		0.03	377	5.932246187
Z1-EU30C-444	C	REG	282	=		0.04	282	5.641907071
Z1-EU30C-446	C	REG	118	=		0.03	118	4.770684634
Z1-EU30C-448	C	REG	493	=		0.04	493	6.200509174
Z1-EU30C-447	C	REG	244	=		0.04	244	5.487168225
Z1-EU30C-448 + Dup	C	FR	336	=		0.04	336	5.817111116
Z1-EU30C-449	C	REG	356	=		0.04	356	5.874530731
Z1-EU30C-450	C	REG	160	=		0.04	160	5.075173815
Z1-EU30C-461	C	REG	397	=		0.04	397	5.983936281
Z1-EU30C-452	C	REG	59.2	=		0.04	59.2	4.090211643
Z1-EU30C-463	C	REG	72.5	=		0.04	72.5	4.283586562
Z1-EU30C-454	C	REG	221	=		0.04	221	5.398162702
Z1-EU31BW-415	B	REG	828 N *	=		0.04	828	6.442540166
Z1-EU31BW-416	B	REG	653 N *	=		0.04	653	6.481677129
Z1-EU31BW-417	B	REG	1060 N *	=		0.03	1060	6.964716332
Z1-EU31W-412	S	REG	274 N *	=		0.04	274	5.613128106
Z1-EU31W-413	S	REG	398 N *	=		0.03	398	5.973809812
Z1-EU31W-414	S	REG	586 N *	=		0.04	586	6.308594078
Z1-EU32BW-431	B	REG	590 N	=		0.03	590	6.380122537
Z1-EU32BW-432	B	REG	329 N	=		0.03	329	5.796057751
Z1-EU32BW-433 + Dup	B	REG	1350 N	=		0.03	1350	7.207859871
Z1-EU32BW-434	B	REG	487 N *	=		0.03	487	6.188294123
Z1-EU32C-455	C	REG	246	=		0.04	246	5.505331536
Z1-EU32C-460	C	REG	212	=		0.04	212	5.366586275
Z1-EU32MW-420	S	REG	627 N	=		0.03	627	6.440944641
Z1-EU32MW-426	S	REG	496 N	=		0.04	496	6.206575227
Z1-EU32W-418	S	REG	166 N	=		0.04	166	5.049866007
Z1-EU32W-418 + Dup	S	REG	571	=		0.03	571	6.34738221
Z1-EU32W-421	S	REG	461 N	=		0.04	461	6.11146734
Z1-EU32W-422	S	REG	478 N	=		0.03	478	6.171700507
Z1-EU32W-423	S	REG	500 N	=		0.03	500	6.226536068
Z1-EU32W-424	S	REG	1240 N	=		0.04	1240	7.122868559
Z1-EU32W-425	S	REG	317 N	=		0.04	317	5.758901774
Z1-EU32W-427	S	REG	1870 N	=		0.03	1870	7.53388371
Z1-EU32W-428	S	REG	386 N	=		0.04	386	5.881814211
Z1-EU32W-429	S	REG	769 N	=		0.03	769	6.64509097
Z1-EU32W-430	S	REG	1040 N	=		0.03	1040	6.948975992
Z1-EU33BW-443	B	REG	1290 N *	=		0.03	1290	7.162397497
Z1-EU33BW-444	B	REG	793 N	=		0.03	793	6.675823222
Z1-EU33C-467	C	REG	275	=		0.04	275	5.616771068
Z1-EU33W-435	S	REG	2210 N	=		0.04	2210	7.700747795
Z1-EU33W-436	S	REG	840 N	=		0.04	840	6.733401892
Z1-EU33W-437	S	REG	987 N	=		0.04	987	6.694670039
Z1-EU33W-438	S	REG	819 N	=		0.04	819	6.708084084
Z1-EU33W-439	S	REG	1030 N	=		0.03	1030	6.937314081
Z1-EU33W-440	S	REG	1800 N	=		0.03	1800	7.313220387
Z1-EU33W-441	S	REG	854 N	=		0.03	854	6.749831194

Number of Samples	57
Number of Defects	57
Minimum	59.2
Median	496
Maximum	2210
Average	618.74912
Standard Deviation	431.78493
PERT-Beta Mean	708.86667
Lognormal Mean	6.1916353
Lognormal Standard Deviation	0.7336584

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Mn mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 57

Raw Statistics

Minimum 59.2
Maximum 2210
Mean 618.7
Median 496
SD 431.8
Coefficient of Variation 0.698
Skewness 1.552

Log-transformed Statistics

Minimum of Log Data 4.081
Maximum of Log Data 7.701
Mean of log Data 6.192
SD of log Data 0.734

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.156
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.0573
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 714.4
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 725.4
95% Modified-t UCL 716.4

Assuming Lognormal Distribution

95% H-UCL 781.2
95% Chebyshev (MVUE) UCL 933.5
97.5% Chebyshev (MVUE) UCL 1062
99% Chebyshev (MVUE) UCL 1315

Gamma Distribution Test

k star (bias corrected) 2.163
Theta Star 286.1
nu star 246.6

Approximate Chi Square Value (.05) 211.2

Adjusted Level of Significance 0.0458

Adjusted Chi Square Value 210.4

Anderson-Darling Test Statistic 0.171

Anderson-Darling 5% Critical Value 0.761

Kolmogorov-Smirnov Test Statistic 0.068

Kolmogorov-Smirnov 5% Critical Value 0.119

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 712.8

95% Jackknife UCL 714.4

95% Standard Bootstrap UCL 712.1

95% Bootstrap-t UCL 731.3

95% Hall's Bootstrap UCL 738.3

95% Percentile Bootstrap UCL 713.2

95% BCA Bootstrap UCL 736.4

95% Chebyshev(Mean, Sd) UCL 868

97.5% Chebyshev(Mean, Sd) UCL 975.9

99% Chebyshev(Mean, Sd) UCL 1188

Assuming Gamma Distribution

95% Approximate Gamma UCL 722.3

95% Adjusted Gamma UCL 725.2

Potential UCL to Use

Use 95% Approximate Gamma UCL 722.3

Statistical Summary for Mercury mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	B	REG	0.0 N	*	=	0.009	0.0	-0.810826624
Z1-EU29W-401	S	REG	0.02 N	*	J	0.01	0.02	-0.478035801
Z1-EU29W-402	S	REG	0.26 N	*	=	0.01	0.26	-1.347073648
Z1-EU29W-403	S	REG	0.06 N	*	=	0.009	0.05	-0.182518929
Z1-EU29W-404	S	REG	2.5 N	*	=	0.03	2.5	0.916290732
Z1-EU29W-405 + Dup	S	FR	0.51 N	*	=	0.01	0.51	-0.673344553
Z1-EU29W-406	S	REG	0.16 N	*	=	0.01	0.16	-1.832581464
Z1-EU29W-407	S	REG	1.0 N	*	=	0.01	1.0	0.470003829
Z1-EU29W-408	S	REG	0.11 N	*	=	0.01	0.11	-2.207274813
Z1-EU29W-409	S	REG	1.1 N	*	=	0.01	1.1	0.09631018
Z1-EU30W-411	B	REG	4.4 N	*	=	0.05	4.4	1.481604541
Z1-EU30C-444	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU30C-445	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU30C-446	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU30C-447	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU30C-448 + Dup	C	FR	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU30C-449	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU30C-450	C	REG	0.02 B	=	=	0.01	0.02	-3.912023005
Z1-EU30C-451	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU30C-452	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU30C-453	C	REG	0.00	=	=	0.01	0.00	-2.407945809
Z1-EU30C-454	C	REG	0.02 B	=	=	0.01	0.02	-3.912023005
Z1-EU31BW-415	B	REG	0.33 N	*	=	0.01	0.33	-1.109042425
Z1-EU31BW-416	B	REG	0.45 N	*	=	0.01	0.45	-0.798507696
Z1-EU31BW-417	B	REG	0.06 N	*	=	0.01	0.06	-0.010060338
Z1-EU31W-412	S	REG	0.09 N	*	=	0.009	0.09	-2.407945809
Z1-EU31W-413	S	REG	0.32 N	*	=	0.01	0.32	-1.139434283
Z1-EU31W-414	S	REG	0.37 N	*	=	0.01	0.37	-0.994252273
Z1-EU32BW-431	B	REG	2.5 N	*	=	0.04	2.5	0.916290732
Z1-EU32BW-432	B	REG	2.3 N	*	=	0.03	2.3	0.832909123
Z1-EU32BW-433 + Dup	B	FR	0.29 N	*	=	0.01	0.29	-1.237874356
Z1-EU32BW-434	B	REG	0.06 N	*	=	0.01	0.06	-2.813410717
Z1-EU32C-455	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU32C-456	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU32W-420	S	REG	0.94 N	*	=	0.01	0.94	-0.061875404
Z1-EU32W-426	S	REG	1.6 N	*	=	0.01	1.6	0.470003829
Z1-EU32W-418	S	REG	0.61 N	*	J	0.01	0.61	-0.404208322
Z1-EU32W-419 + Dup	S	FR	2.5 N	*	=	0.03	2.5	0.916290732
Z1-EU32W-421	S	REG	2.1 N	*	=	0.03	2.1	0.741837345
Z1-EU32W-422	S	REG	2 N	*	=	0.02	2	0.693147181
Z1-EU32W-423	S	REG	1.8 N	*	=	0.03	1.8	0.587786665
Z1-EU32W-424	S	REG	0.17 N	*	=	0.01	0.17	-1.771850842
Z1-EU32W-425	S	REG	0.97 N	*	=	0.01	0.97	-0.030458207
Z1-EU32W-427	S	REG	0.2 N	*	=	0.01	0.2	-1.609437912
Z1-EU32W-428	S	REG	0.36 N	*	=	0.01	0.36	-1.021651248
Z1-EU32W-429	S	REG	0.11 N	*	=	0.01	0.11	-2.207274813
Z1-EU32W-430	S	REG	0.35 N	*	J	0.01	0.35	-1.048822124
Z1-EU33BW-443	B	REG	1.2 N	*	=	0.01	1.2	0.182321667
Z1-EU33BW-444	B	REG	0.47 N	*	=	0.01	0.47	-0.755022584
Z1-EU33C-457	C	REG	0.01 U	U	U	0.01	0.005	-5.298317367
Z1-EU33W-436	S	REG	0.17 N	*	=	0.01	0.17	-1.771850842
Z1-EU33W-436	S	REG	0.29 N	*	=	0.01	0.29	-1.237874356
Z1-EU33W-437	S	REG	2.7 N	*	=	0.03	2.7	0.993251775
Z1-EU33W-438	S	REG	4.1 N	*	=	0.05	4.1	1.410985974
Z1-EU33W-439	S	REG	2 N	*	=	0.03	2	0.693147181
Z1-EU33W-440	S	REG	3.1 N	*	=	0.05	3.1	1.131402111
Z1-EU33W-441	S	REG	1.7 N	*	=	0.03	1.7	0.530628281

Number of Samples 57
Number of Detects 46

Minimum 0.005
Median 0.36
Maximum 4.4
Average 0.877807
Standard Deviation 1.0842282

PERT-Beta Mean 0.9741567

Lognormal Mean -1.494449
Lognormal Standard Deviation 2.2314244

Goodness-of-Fit Test Statistics for Data Sets with Non-Detects

User Selected Options

From File P:\Waste Generator Services\EM\WMF Profiles\WL 4.12\March 2009 revision\revised total metals to test.d

Full Precision OFF

Confidence Coefficient 0.9

Hg mg/kg

	Num Obs	Num Miss	Num Valid	Detects	NDs	% NDs
Raw Statistics	57	0	57	46	11	19.30%

	Number	Minimum	Maximum	Mean	Median	SD
Statistics (Non-Detects Only)	11	0.005	0.005	0.005	0.005	9.097E-19
Statistics (Detects Only)	46	0.02	4.4	1.087	0.605	1.11
Statistics (All: NDs treated as DL value)	57	0.005	4.4	0.878	0.36	1.084
Statistics (All: NDs treated as DL/2 value)	57	0.0025	4.4	0.877	0.36	1.085
Statistics (Normal ROS Estimated Data)	57	-2.52	4.4	0.605	0.36	1.426
Statistics (Gamma ROS Estimated Data)	57	1.0000E-9	4.4	0.878	0.36	1.084
Statistics (Lognormal ROS Estimated Data)	57	0.0075	4.4	0.883	0.36	1.08

	K Hat	K Star	Theta Hat	Log Mean	Log Stdev	Log CV
Statistics (Detects Only)	0.878	0.844	1.237	-0.585	1.347	-2.303
Statistics (NDs = DL)	0.47	0.457	1.867	-1.494	2.231	-1.493
Statistics (NDs = DL/2)	0.434	0.423	2.022	-1.628	2.468	-1.516
Statistics (Gamma ROS Estimates)	0.197	0.198	4.465	—	—	—
Statistics (Lognormal ROS Estimates)	--	—	—	-1.16	1.716	-1.479

Normal Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Normal ROE
Correlation Coefficient R	0.918	0.89	0.89	0.983

	Test value	Crit (0.1)	Conclusion with Alpha(0.1)
Shapiro-Wilks (Detects Only)	0.835	0.953	Data Not Normal
Lilliefors (Detects Only)	0.206	0.119	Data Not Normal
Lilliefors (NDs = DL)	0.226	0.107	Data Not Normal
Lilliefors (NDs = DL/2)	0.225	0.107	Data Not Normal
Lilliefors (Normal ROS Estimates)	0.148	0.107	Data Not Normal

Gamma Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Gamma ROE
Correlation Coefficient R	0.982	0.97	0.966	0.903

	Test value	Crit (0.1)	Conclusion with Alpha(0.1)
Anderson-Darling (Detects Only)	0.44	0.656	—
Kolmogorov-Smirnov (Detects Only)	0.0962	0.124	Data Appear Gamma Distributed
Anderson-Darling (NDs = DL)	0.897	0.683	—
Kolmogorov-Smirnov (NDs = DL)	0.123	0.114	Data Not Gamma Distributed
Anderson-Darling (NDs = DL/2)	1.004	0.69	—
Kolmogorov-Smirnov (NDs = DL/2)	0.131	0.115	Data Not Gamma Distributed

Anderson-Darling (Gamma ROS Estimates)	6.466	0.748	
Kolmogorov-Smirnov (Gamma ROS Est.)	0.258	0.119	Data Not Gamma Distributed

Lognormal Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Log ROS
Correlation Coefficient R	0.98	0.94	0.928	0.98

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Shapiro-Wilks (Detects Only)	0.946	0.953	Data Not Lognormal
Lilliefors (Detects Only)	0.109	0.119	Data Appear Lognormal
Lilliefors (NDs = DL)	0.149	0.107	Data Not Lognormal
Lilliefors (NDs = DL/2)	0.159	0.107	Data Not Lognormal
Lilliefors (Lognormal ROS Estimates)	0.0921	0.107	Data Appear Lognormal

Note: Substitution methods such as DL or DL/2 are not recommended.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File P:\Waste Generator Services\EM\WMF Profiles\WL 4.12\March 2009 revision\revised total metals to test.d

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Hg mg/kg

General Statistics

Number of Valid Data	57	Number of Detected Data	48
Number of Distinct Detected Data	37	Number of Non-Detect Data	11
		Percent Non-Detects	19.30%

Raw Statistics

Minimum Detected	0.02
Maximum Detected	4.4
Mean of Detected	1.087
SD of Detected	1.11
Minimum Non-Detect	0.005
Maximum Non-Detect	0.005

Log-transformed Statistics

Minimum Detected	-3.912
Maximum Detected	1.482
Mean of Detected	-0.585
SD of Detected	1.347
Minimum Non-Detect	-5.298
Maximum Non-Detect	-5.298

UCL Statistics

Normal Distribution Test with Detected Values Only

Lilliefors Test Statistic	0.835
5% Lilliefors Critical Value	0.945

Data not Normal at 5% Significance Level

Lognormal Distribution Test with Detected Values Only

Lilliefors Test Statistic	0.946
5% Lilliefors Critical Value	0.945

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method

Mean	0.877
SD	1.085
95% DL/2 (t) UCL	1.118

Assuming Lognormal Distribution

DL/2 Substitution Method

Mean	-1.628
SD	2.468
95% H-Stat (DL/2) UCL	7.798

Maximum Likelihood Estimate(MLE) Method

Mean	0.726
SD	1.263
95% MLE (t) UCL	1.006
95% MLE (Tiku) UCL	1.005

Log ROS Method

Mean in Log Scale	-1.16
SD in Log Scale	1.716
Mean in Original Scale	0.883
SD in Original Scale	1.08
95% Percentile Bootstrap UCL	1.138
95% BCA Bootstrap UCL	1.144

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.835
Theta Star	1.301
nu star	76.85

Data Distribution Test with Detected Values Only

Data appear Gamma Distributed at 5% Significance Level

A-D Test Statistic	0.44
5% A-D Critical Value	0.784
K-S Test Statistic	0.784

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.881

5% K-S Critical Value		0.135	SD	1.072
Data appear Gamma Distributed at 5% Significance Level			SE of Mean	0.144
			95% KM (t) UCL	1.121
			95% KM (z) UCL	1.117
Assuming Gamma Distribution			95% KM (jackknife) UCL	1.12
Gamma ROS Statistics using Extrapolated Data			95% KM (bootstrap t) UCL	1.165
	Minimum	1.0000E-9	95% KM (BCA) UCL	1.14
	Maximum	4.4	95% KM (Percentile Bootstrap) UCL	1.121
	Mean	0.878	95% KM (Chebyshev) UCL	1.507
	Median	0.36	97.5% KM (Chebyshev) UCL	1.778
	SD	1.084	99% KM (Chebyshev) UCL	2.31
	k star	0.198	Potential UCLs to Use	
	Theta star	4.435		
	Nu star	22.57	95% KM (Chebyshev) UCL	1.507
	AppChi2	12.77		
	95% Gamma Approximate UCL	1.552		
	95% Adjusted Gamma UCL	1.576		
Note: DU/2 is not a recommended method.				

Statistical Summary for Mercury mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L) (mg/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU29BW-410		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU29W-401		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU29W-402		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU29W-403		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU29W-404		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU29W-405 + Dup		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU29W-406		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU29W-407		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU29W-408		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU29W-409		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU30BW-411		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU31BW-415		REG	0.17 B		U	0.06	0.00003	-10.41431318
Z1-EU31BW-416		REG	0.07 B		U	0.06	0.00003	-10.41431318
Z1-EU31BW-417		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU31W-412		REG	0.32		U	0.06	0.00003	-10.41431318
Z1-EU31W-413		REG	0.28		U	0.06	0.00003	-10.41431318
Z1-EU31W-414		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32BW-431		REG	0.12 B		=	0.06	0.00012	-9.928018815
Z1-EU32BW-432		REG	0.13 B		=	0.06	0.00013	-8.947978108
Z1-EU32BW-433 + Dup		REG	0.08 B		=	0.06	0.00008	-9.433483923
Z1-EU32BW-434		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32MW-420		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32MW-426		REG	0.07 B		=	0.06	0.00007	-9.567015316
Z1-EU32W-418		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32W-419 + Dup		REG	0.15 B		=	0.06	0.00015	-8.804875264
Z1-EU32W-421		REG	0.06 B		=	0.06	0.00006	-9.721165896
Z1-EU32W-422		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32W-423		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32W-424		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32W-425		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32W-427		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32W-428		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32W-429		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU32W-430		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU33BW-443		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU33BW-444		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU33W-435		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU33W-436		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU33W-437		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU33W-438		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU33W-439		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU33W-440		REG	0.06 U		U	0.06	0.00003	-10.41431318
Z1-EU33W-441		REG	0.06 U		U	0.06	0.00003	-10.41431318

Number of Samples 43
Number of Detects 6

Minimum 0.00003
Median 0.00003
Maximum 0.00015
Average 0.00004
Standard Deviation 2.812E-05

PERT-Beta Mean 0.00005

Lognormal Mean -10.25191
Lognormal Standard Deviation 0.4278551

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Hg mg/L

General Statistics

Number of Valid Observations 43

Number of Distinct Observations 7

Raw Statistics

Minimum 3.0000E-5

Maximum 1.5000E-4

Mean 4.0000E-5

Median 3.0000E-5

SD 2.8115E-5

Coefficient of Variation N/A

Skewness 2.959

Log-transformed Statistics

Minimum of Log Data -10.41

Maximum of Log Data -8.805

Mean of log Data -10.25

SD of log Data 0.428

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.416

Shapiro Wilk Critical Value 0.943

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.433

Shapiro Wilk Critical Value 0.943

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 4.7211E-5

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 4.9120E-5

95% Modified-t UCL 4.7534E-5

Assuming Lognormal Distribution

95% H-UCL 4.3678E-5

95% Chebyshev (MVUE) UCL 4.9954E-5

97.5% Chebyshev (MVUE) UCL 5.4874E-5

99% Chebyshev (MVUE) UCL 6.4538E-5

Gamma Distribution Test

k star (bias corrected) 3.876

Theta Star 1.0319E-5

nu star 333.4

Approximate Chi Square Value (.05) 292.1

Adjusted Level of Significance 0.0444

Adjusted Chi Square Value 290.7

Anderson-Darling Test Statistic 12.11

Anderson-Darling 5% Critical Value 0.753

Kolmogorov-Smirnov Test Statistic 0.513

Kolmogorov-Smirnov 5% Critical Value 0.135

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 4.7052E-5

95% Jackknife UCL 4.7211E-5

95% Standard Bootstrap UCL 4.6761E-5

95% Bootstrap-t UCL 5.1076E-5

95% Hall's Bootstrap UCL 4.7106E-5

95% Percentile Bootstrap UCL 4.7209E-5

95% BCA Bootstrap UCL 5.0000E-5

95% Chebyshev(Mean, Sd) UCL 5.8689E-5

97.5% Chebyshev(Mean, Sd) UCL 6.6776E-5

99% Chebyshev(Mean, Sd) UCL 8.2661E-5

Assuming Gamma Distribution

95% Approximate Gamma UCL 4.5657E-5

95% Adjusted Gamma UCL 4.5867E-5

Potential UCL to Use

Use 95% Student's-t UCL 4.7211E-5

or 95% Modified-t UCL 4.7534E-5

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Radus, 865.483.2715

1080 Up Circle Rd

12/29/2005 R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

WACFACS WL L SRC INPUT				OUTPUT			Calculations				
SRC	STEP 10	STEP 11	STEP 12	E(X)	UCL-95	UCL-95 : E(X)	Beta PDF Inverse		PERT BETA		
	MIN	MED	MAX				0.95		α_1	α_2	Variance
Mercury (mg/L)	3.00E-05	3.00E-06	1.50E-04	5.00E-05	8.41E-05	1.88	0.00		1.00	5.00	0.0000

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MIN \leq x \leq MAX$$

$$F(x) = \frac{B_1(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times MED + MAX}{6}$$

$$Var(x) = \frac{[E(x) - MIN] \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \frac{E(x) - MIN}{MAX - MIN}$$

$$\alpha_2 = 6 \times \frac{MAX - E(x)}{MAX - MIN}$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the incomplete Beta Function.
 α_1 and α_2 are calculated parameters.

Use the Microsoft Excel 2000 function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

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APPENDIX E
WASTE HANDLING PLAN CROSSWALK, SAMPLING APPROACH,
CALCULATION/MEASUREMENT METHODS

APPENDIX E: SELECTION AND TRANSFORMATION OF WASTE LOT 4.12 DATA

Prepared by Marshall Davenport, ETTP D&D/RA Project

This summary documents the sampling and analysis plan crosswalk, and selection/ transformation of radiological and chemical data results for development of the Waste Lot 4.12 Controlled Data Set, waste profile, and statistical summaries. A map depicting sample locations follows this documentation.

General Approach for Development of Controlled Data Set

ETTP D&D/RA Project received an electronic copy of the analytical database from the BJC (Bechtel Jacobs Company LLC) SMO (Sample Management Organization) for 59 intrusive samples (including 4 duplicate samples) collected from soils and concrete from the K-770 Scrap Yard in accordance with BJC/OR-3088, *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee* (the sample and analysis plan, or SAP). The sampling strategy involved the collection of 32 systematic random composite soil samples and 13 biased composite soil samples; and 14 systematic random concrete samples from concrete pads within the K-770 Scrap Yard representative of the final waste form. This ensured that the overall contaminant concentrations could be evaluated on the waste as a whole. A total of 45 systematic random and biased composite soil samples, (including 4 field replicate composite soil samples) were collected from the K-770 soils for individual/Total PCB analysis, Total/TCLP Semi-Volatile Organic Analysis (SVOA), Total/TCLP Metals analysis, and Radiological Parameters analysis. 44 of the 45 systematic random and biased composite soil samples (including 3 field replicate composite soil samples) were collected (with the exception of Sample Z1EU29W-401) for Total Volatile Organic Analysis (VOA). Lastly, a total of 14 systematic random samples and 1 field replicate sample were collected from K-770 Scrap Yard concrete pads for Total Metals analysis, individual/Total PCB (polychlorinated biphenyls) analysis, and Radiological Parameters analysis. Two biased composite soil samples (Z1-EU33BW-442 and Z1-EU33BW-445) were found to exhibit elevated Tc-99 concentrations of 2,710 pCi/g and 40,600 pCi/g, respectively and were excluded from consideration for disposal under Waste Lot 4.12 as anomalous wastes for Tc-99 contamination (see Appendix A). Therefore, these two samples were excluded from the Waste Lot 4.12 Controlled Data Set in Appendix C of this profile.

The resulting Waste Lot 4.12 controlled data set contains a total of 57 samples for radiological constituents, 57 samples for Total Metal constituents, 57 samples for individual/Total PCB constituents, 43 samples for TCLP Metal constituents, 43 samples for Total/TCLP SVOA constituents, and 42 samples for Total VOA constituents. Table E1 lists the total number of samples selected for characterization.

Table E1. Waste Lot 4.12 Characterization Samples (including duplicates)

Items Sampled	Total VOA	Total/TCLP SVOA	Total Metals	TCLP Metals	Radiological Samples	PCB Samples
K-770 systematic random composite soil samples	29	30	30	30	30	30
K-770 biased composite soil samples	13	13	13	13	13	13
K-770 systematic random composite concrete samples			14		14	14

For determining chemical properties, intrusive sampling was utilized. The total number of chemical samples used for Waste Lot 4.12 statistical summaries was: 42 for Total VOA, 43 for Total/TCLP SVOA, and 57 for individual/Total PCBs.

For radiological properties, a combination of intrusive sampling and radiological field screening was utilized. The total number of radiological samples used for Waste Lot 4.12 statistical summaries was 57 for radiological SRCs (site related contaminants).

Samples were collected from a representative population of anticipated K-770 Scrap Yard waste items. Samples were analyzed for radionuclides, PCBs (individual and total), metals (total and TCLP), VOCs (total), and SVOCs (total and TCLP). As evidenced by Table E2, sampling requirements as prescribed in the SAP were met (with the exception of Total VOA), since the number of samples collected for each waste category equaled the minimum number of recommended samples provided in Table A.1 of the SAP.

Table E2. SAP Sampling Requirements Evaluation

Waste Category	Sample Parameter	Recommended Number of Samples	Actual Number of Samples Collected*
K-770 systematic random composite soil samples	Radiological	32	32
	PCBs	32	32
	Total Metals	32	32
	TCLP Metals	32	32
	Total/TCLP SVOA	32	32
	Total VOA	32	31
K-770 biased composite soil samples	Radiological	13	13
	PCBs	13	13
	Total Metals	13	13
	TCLP Metals	13	13
	Total/TCLP SVOA	13	13
	Total VOA	13	13
K-770 systematic random concrete samples	Radiological	14	14
	Total Metals	14	14
	PCBs	14	14

Notes: * - total number of samples includes duplicates

In general, the reported data were usable with the exception of the two biased composite soil samples (Z1-EU33BW-442 and Z1-EU33BW-445) that exhibited elevated Tc-99 pCi/g concentrations. One Np-237 sample result and its field replicate result (for sample Z1-EU32BW-433) was rejected due based on professional judgment since the the field duplicate's Relative Percent Difference (RPD) was out of range, possibly due to uranium interference. In some situations, Total VOA, Total SVOA, and PCB constituents were reported at differing concentrations and detection limits due to variable dilution factors. In all cases, only validated data supplied by the SMO with a "Data Use" flag of "Y" was used in development of the Waste Lot 4.12 Controlled Data Set and Data Quality Assessment. Table E.3 provides the details concerning the type of sample collected, date of sample collection, sample location, sample interval description, required analyses to be performed, and comments/notes associated with the sample collection and/or analysis.

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC

[illegible]

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC

V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/Dups	Comments and Notes
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Exposure Unit
30

D	WAC S Lot 2	Z1-EU30	Z1-EU30BW-411	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total SVOA results rejected based on varying dilution factors
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Exposure Unit
31

D	WAC S Lot 1	Z1-EU31	Z1-EU31W-412	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU31	Z1-EU31W-413	Five point composite 1.0-2.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 1.42-1.75 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU31	Z1-EU31W-414	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 2	Z1-EU31	Z1-EU31BW-415	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 2	Z1-EU31	Z1-EU31BW-416	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 2	Z1-EU31	Z1-EU31BW-417	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC

V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/Dups	Comments and Notes
Exposure Unit 32													
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-418	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Hexachlorocyclopentadiene result rejected
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-419	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1 Duplicate	Extraneous PCB, Total VOA, and Total SVOA results for original sample rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU32	Z1-EU32MW-420	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-421	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total SVOA results rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-422	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-423	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-424	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-425	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32MW-426	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-427	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-428	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-429	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Solis WAC

V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/Dups	Comments and Notes
D	WAC S Lot 2	Z1-EU32	Z1-EU32W-430	Five point composite 0.0-0.833 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU32	Z1-EU32BW-431	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA + Total SVOA results rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU32	Z1-EU32BW-432	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 2	Z1-EU32	Z1-EU32BW-433	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1 Duplicate	Np-237 pCi/g results rejected
D	WAC S Lot 2	Z1-EU32	Z1-EU32BW-434	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		

Exposure Unit 33

D	WAC S Lot 1	Z1-EU33	Z1-EU33W-435	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-436	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-437	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-438	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-439	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-440	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC

V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/Dups	Comments and Notes
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-441	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU33	Z1-EU33BW-442	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA + Total SVOA results rejected due to varying dilution factors. Sample removed from WL 4.12 Controlled Data Set due to anomalous Tc-99 result of 2,710 pCi/g
D	WAC S Lot 2	Z1-EU33	Z1-EU33BW-443	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU33	Z1-EU33BW-444	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU33	Z1-EU33BW-445	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA + Total SVOA results rejected due to varying dilution factors. Sample removed from WL 4.12 Controlled Data Set due to anomalous Tc-99 result of 40,600 pCi/g
	Concrete Samples												
		K-725 building slab											
D	WAC conc	Z1-EU30	Z1-EU30C-444	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-445	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-446	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-447	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-448	0-0.25' concrete sample				1		1	1	1 Duplicate	
D	WAC conc	Z1-EU30	Z1-EU30C-449	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-450	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-451	0-0.25' concrete sample				1		1	1		

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC

V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/Dups	Comments and Notes
		Other concrete slabs EU 30											
D	WAC conc	Z1-EU30	Z1-EU30C-452	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-453	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-454	0-0.25' concrete sample				1		1	1		
		K726 building slab EU 32											
D	WAC conc	Z1-EU32	Z1-EU32C-455	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU32	Z1-EU32C-456	0-0.25' concrete sample				1		1	1		
		Other concrete slabs EU 33											
D	WAC conc	Z1-EU33	Z1-EU33C-457	0-0.25' concrete sample				1		1	1		

Total Samples Collected & Analyzed

44 45 45 59 45 59 59

Total Samples Used in WL 4.12 Controlled Data Set & Statistical Summary

42 43 43 57 43 57 57

In general, Total Metal concentrations were reported in milligrams/kilogram, (mg/kg), TCLP Metal concentrations were reported in micrograms/Liter (ug/L), Total VOA, Total SVOA, and Total PCB concentrations were reported in micrograms/kilogram (ug/kg), TCLP SVOA concentrations were reported in milligrams/Liter (mg/L), and radiological concentrations were reported in pico-Curies per gram, (pCi/g). All data used in the Waste Lot 4.12 Controlled Data Set (Appendix C) and Data Quality Assessment (Appendix G) were derived from analytical data collected in accordance with the SAP.

Treatment of Sample and Duplicate Results

In situations where an intrusive sample was collected in conjunction with a duplicate (field replicate) sample, the following approach was used to create a single data point for inclusion in statistical analysis:

- If the sample and its duplicate were assigned "U" or "UJ" laboratory qualifiers or data validation code, then the maximum detection limit (DL) for either the sample or its duplicate was used to represent the sample result and its duplicate result. Note: Data validation codes supersede laboratory qualifiers.
- If either the sample or its duplicate were assigned a "U" or "UJ" laboratory qualifier or data validation code, and the other result was not assigned a "U" or "UJ" laboratory qualifier or data validation code (e.g., J-flagged or "=" code assigned), then the J-flagged or "=" coded reported result was used to represent the sample result and its duplicate result. Note: Data validation codes supersede laboratory qualifiers.
- If the sample result and its duplicate sample result were not assigned "U" or "UJ" laboratory qualifiers or data validation codes, the maximum reported result for either the sample or its duplicate was used to represent the sample result and its duplicate result. Note: Data validation codes supersede laboratory qualifiers.

Data Conditioning

In order to quantify Total Metal, Total VOA, Total SVOA, Total Pesticide/Herbicide, and Total PCB SRC values for the Waste Lot 4.12 profile and statistical summary, analytical data in micrograms per kilogram (ug/kg) or micrograms per gram (ug/g) were converted to milligrams per kilogram (mg/kg) using the following equations:

$$\text{mg/kg} = \text{ug/kg} * 1 \text{ mg}/1000 \text{ ug}$$

$$\text{mg/kg} = \text{ug/g} * 1\text{mg}/1000 \text{ ug} * 1000 \text{ g/kg}$$

In order to quantify TCLP Metal, and TCLP SVOA SRC values for the Waste Lot 4.12 statistical summary, analytical data in micrograms per liter (ug/L) were converted to milligrams per liter (mg/L) using the following equation:

$$\text{mg/L} = \text{ug/L} * 1 \text{ mg}/1000 \text{ ug}$$

In accordance with Appendix C of DOE/OR/01-1909&D3, *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee*, the following data use strategies were employed during development of Total/TCLP Metal, Total VOA, Total/TCLP SVOA, and individual/Total PCB statistical summaries:

- for analytical data assigned laboratory qualifier or data validation codes other than "U" or "UJ", the reported data value converted to mg/kg or mg/L was used

- for analytical data assigned laboratory qualifier or data validation codes "U" or "UJ", the reported minimum detection value converted to mg/kg or mg/L divided by 2 was used

In accordance with Appendix C of DOE/OR/01-1909&D3, *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee*, the following data use strategies were employed during development of radiological isotope-specific statistical summaries:

- for analytical data assigned laboratory qualifier or data validation codes other than "U" or "UJ", the reported data value expressed in pCi/g was used
- for analytical data assigned laboratory qualifier or data validation codes "U" or "UJ", the reported minimum detection value expressed in pCi/g was used

Specific Applications to Waste Lot 4.12 Profile

Administrative WAC

For Table 1 of the WL 4.12 profile, maximum transuranic isotope-specific concentrations in pico-Curies per gram (pCi/g) were converted to nano-Curies per gram (nCi/g) as follows:

$$\begin{aligned}
 \text{Am-241 nCi/g} &= 2.13\text{E-}02 \text{ pCi/g} * 1 \text{ nCi/g} / 1000 \text{ pCi/g} = 2.13\text{E-}05 \text{ nCi/g} \\
 \text{Np-237 nCi/g} &= 3.20\text{E-}01 \text{ pCi/g} * 1 \text{ nCi/g} / 1000 \text{ pCi/g} = 3.20\text{E-}04 \text{ nCi/g} \\
 \text{Pu-238 nCi/g} &= 1.70\text{E-}03 \text{ pCi/g} * 1 \text{ nCi/g} / 1000 \text{ pCi/g} = 1.70\text{E-}06 \text{ nCi/g} \\
 \text{Pu-239/240 nCi/g} &= 1.11\text{E-}02 \text{ pCi/g} * 1 \text{ nCi/g} / 1000 \text{ pCi/g} = 1.11\text{E-}05 \text{ nCi/g}
 \end{aligned}$$

$$\begin{aligned}
 \text{Total TRU nCi/g} &= && 2.13\text{E-}05 \text{ nCi/g Am-241} \\
 &+ && 3.20\text{E-}04 \text{ nCi/g Np-237} \\
 &+ && 1.70\text{E-}06 \text{ nCi/g Pu-238} \\
 &+ && 1.11\text{E-}05 \text{ nCi/g Pu-239/240} \\
 &----- \\
 &= && 3.54\text{E-}04 \text{ nCi/g TRU}
 \end{aligned}$$

For Section 2.4 (RCRA Compliance) and Table 2 of the Waste Lot 4.12 profile, the following approach was developed to support the RCRA non-hazardous waste determination of the K-770 soil and concrete wastes.

The original K-770 soils/concrete database containing the initial TCLP Metals and TCLP SVOAs data were converted from ug/L to mg/L and the mg/L values were compared to the 40 CFR 261.24 regulatory limit for each of these TCLP constituents. In cases, where constituents were not detected (e.g. TCLP SVOAs), the maximum detection limit (DL) value was used against the 40 CFR 261.24 regulatory limit for the determination.

The comparison for constituents for which only Total concentration analytical results were available was made in a similar manner. The K-770 soils/concrete Total concentration data were converted from ug/kg to mg/kg. The maximum value (or DL if the chemical was not detected), in mg/kg, was then divided by 20 (to implement the "20 times rule"). The resulting value was then compared to the 40 CFR 261.24 regulatory limits for those constituents to support the determination.

An initial assessment of these constituents was performed by the Project upon receipt of data from the laboratories. During this assessment the Project determined that none of the maximum Total VOA or SVOA concentrations exceeded its regulatory limit using the 20 times rule.

Table 2 provides the basis for the RCRA non-hazardous waste determination for the Waste Lot 4.12 in Section 2.4 of the Waste Lot 4.12 profile. The waste determination is supported by process knowledge and the use of visual inspection and sorting/segregation techniques for waste items to be disposed at the EMWMF. Due diligence has been provided based on process knowledge, analytical data review, and continuation/enhancement of best management practice (visual inspection and sorting/segregation of waste items) to ensure successful removal of anomalous wastes for future wastes offered for disposal at EMWMF. The method of comparison described above, the results in Table 2 (profile Section 2.4), and the determination that the waste in this waste lot is not hazardous as defined by RCRA have been reviewed and approved by ETPP D&D/RA Project Environmental Compliance.

For Table 3 of the Waste Lot 4.12 profile, average uranium isotope-specific concentrations in

pico-Curies U-isotope per gram waste ($\text{pCi}^{\text{U-isotope}}/\text{g}_{\text{waste}}$) were converted to microgram U-isotope per gram waste ($\text{ug}^{\text{U-isotope}}/\text{g}_{\text{waste}}$) as follows:

$$\begin{aligned}\text{U-234 ug/g}_{\text{waste}} &= 3.95\text{E}+01 \text{ pCi}^{\text{U-234}}/\text{g}_{\text{waste}} * (1 \text{ g}^{\text{U234}} / 6.2\text{E}+09 \text{ pCi}^{\text{U234}}) * 1.0\text{E}+06 \text{ ug}^{\text{U234}} / \text{g}^{\text{U234}} \\ &= 6.36\text{E}-03 \text{ ug}^{\text{U234}}/\text{g}_{\text{waste}} \\ \text{U-235 ug/g}_{\text{waste}} &= 5.07\text{E}+00 \text{ pCi}^{\text{U-235}}/\text{g}_{\text{waste}} * (1 \text{ g}^{\text{U235}} / 2.2\text{E}+06 \text{ pCi}^{\text{U235}}) * 1.0\text{E}+06 \text{ ug}^{\text{U235}} / \text{g}^{\text{U235}} \\ &= 2.30\text{E}+00 \text{ ug}^{\text{U235}}/\text{g}_{\text{waste}} \\ \text{U-238 ug/g}_{\text{waste}} &= 3.35\text{E}+01 \text{ pCi}^{\text{U-238}}/\text{g}_{\text{waste}} * (1 \text{ g}^{\text{U238}} / 3.4\text{E}+05 \text{ pCi}^{\text{U238}}) * 1.0\text{E}+06 \text{ ug}^{\text{U238}} / \text{g}^{\text{U238}} \\ &= 9.84\text{E}+01 \text{ ug}^{\text{U238}}/\text{g}_{\text{waste}}\end{aligned}$$

$$\begin{aligned}\text{Total U ugU/g}_{\text{waste}} &= 6.36\text{E}-03 \text{ ug}^{\text{U234}}/\text{g}_{\text{waste}} \\ &+ 2.30\text{E}+00 \text{ ug}^{\text{U235}}/\text{g}_{\text{waste}} \\ &+ 9.84\text{E}+01 \text{ ug}^{\text{U238}}/\text{g}_{\text{waste}} \\ &= 1.01\text{E}+02 \text{ ugU/g}_{\text{waste}}\end{aligned}$$

Preparer Marshall Stewart Date 4/14/2009

Reviewer Jay Date 4/15/2009

BJC/OR-3655

**Sampling and Analysis Plan
for K-770 Soils for Waste
Acceptance Criteria Attainment
East Tennessee Technology Park,
Oak Ridge, Tennessee**

This document is approved for public release per review by:

[Signature] 11/20/08
EJC EITP Classification and Information Control Office

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DEPARTMENT OF ENERGY

RECORD COPY

BJC/OR-3088

**Sampling and Analysis Plan for K-770 Soils for
Waste Acceptance Criteria Attainment
East Tennessee Technology Park,
Oak Ridge, Tennessee**

Date Issued—August 2008

Prepared for the
U.S. Department of Energy
Office of Environmental Management
by
BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at
East Tennessee Technology Park,
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for the
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APPROVALS

Sampling and Analysis Plan for K-770 Soils
for Waste Acceptance Criteria Attainment
East Tennessee Technology Park,
Oak Ridge, Tennessee
BJC/OR-3088

August 2008

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ACRONYMS

ACM	asbestos-containing material
BJC	Bechtel Jacobs Company LLC
CDM	CDM Federal Programs
COC	contaminant of concern
DQO	data quality objective
DVS	Dynamic Verification Strategy
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
EU	exposure unit
FIDLER	field instrument for detection of low energy radiation
FY	fiscal year
ORNL	Oak Ridge National Laboratory
PCB	polychlorinated biphenyl
PRG	preliminary remediation goal
QAPP	Quality Assurance Project Plan
Quadrex	Quadrex Corporation
RA	remedial action
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act of 1976
RL	remediation level
SAP	Sampling and Analysis Plan
SOF	sum of fractions
SRS	Savannah River Site
SVOC	semivolatile organic compound
TAL	target analyte list
TCLP	Toxicity Characteristic Leaching Procedure
VOC	volatile organic compound
WAC	waste acceptance criteria

1. INTRODUCTION

This Sampling and Analysis Plan (SAP) describes the sampling and analysis that will be performed to support development of a waste profile for K-770 soils, which will satisfy the data quality objective (DQO) requirements for disposal at the Environmental Management Waste Management Facility (EMWMF). The soil volume addressed by this SAP includes soils contaminated by storage and staging of contaminated metal scrap within the K-770 Exposure Unit (EU) Group on the Powerhouse Peninsula at the East Tennessee Technology Park (ETTP), Oak Ridge Tennessee. The objective of this SAP is to provide data of known quality that is representative of the waste lot for comparison under the waste acceptance criteria (WAC) attainment guidance for disposal at EMWMF. The sampling strategy, methodology, sample locations, and analytical protocols are outlined in this SAP.

2. PROJECT DESCRIPTION

The K-770 remedial action (RA) will be executed in accordance with the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, TN* (DOE 2005) and the *Remedial Action Work Plan for Dynamic Verification Strategy for Zone 1 East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2007) (Zone 1 RAWP). The K-770 soils waste lot is expected to meet EMWMF WAC as a single waste lot, but the volume may be subdivided into two waste lots if the sample data indicates a high sum of fractions (SOF) volume is present that can be segregated during execution of the RA.

3. SITE DESCRIPTION

The K-770 Scrap Metal Yard and Contaminated Debris Site is a storage area located southwest of the main portion of ETTP, outside the security perimeter fence in the Powerhouse Area adjacent to the Clinch River. The site is located upstream from the confluence of the Clinch River with Poplar Creek. The scrap yard is surrounded by a locked fence and scrap metal is stored on the ground in piles and as loose objects in the area. The K-770 Scrap Metal Yard and Contaminated Debris Site occupy an approximately 21-acre tract of land. Building K-726, which was used to store polychlorinated biphenyl (PCB)-contaminated fluids scheduled for incineration, is also located within this area.

The K-770 area was used to store radioactively contaminated or suspected contaminated materials during and previous to the cascade upgrading program. Other known or suspected contaminants include PCBs, mercury, and asbestos incidental to scrap metal operations that were stored at the site prior to initiation of a waste management tracking program in 1977. The waste storage facility began operation in the 1960s and is estimated to at one time contain in excess of 40,000 tons of low-level, radioactively contaminated scrap metal. Also, the scrap metal piles contained approximately 20,000 ft² of asbestos-containing material (ACM), which consisted primarily of metal pipe. Scrap metal was taken to the site when it was found to contain alpha or beta/gamma activity on the surface or if the scrap metal originated from a process building.

Prior to 1984, there was no segregation of the low-level, radioactively contaminated scrap metal brought to the K-770 Scrap Yard. Cleanup of the scrap yard was initiated when Martin Marietta Energy Systems, Inc. contracted Quadrex Corporation (Quadrex) to relocate the material out of the 100-year floodplain, reduce the size of the material in an on-site processing unit, and segregate the material into piles separated by metal type. Quadrex performed the Health Physics activities of the contract and subcontracted the task of material handling to Southern Alloy. All material Quadrex was permitted to handle was removed from the floodplain and segregated into piles. The segregated metal debris was removed from the site as part of the K-770 Scrap Removal RA Project that was completed in fiscal year (FY) 2007 by Bechtel Jacobs Company LLC (BJC). An area of approximately 10 acres is located in EUs 29 and 31 where the scrap was originally located in the 100-year floodplain. In the process of moving the materials around and establishing segregated waste piles above the 100-year floodplain, the footprint of the site was expanded by 10-15 acres in EUs 30 and 32. The area in EUs 29 and 31 that was cleared of metallic debris in the floodplain was sown with grass. The areas in EUs 30 and 32 have some scattered vegetation but are generally open and accessible.

Several material categories established for waste at the K-770 Site during the segregation phase include the following:

- Asbestos-containing material
- Rubbish
- Items with hot spots above acceptable limits
- Segregated metal
- Class 004
- Cooling tower wood

With limited exception, all materials contained in these segregated piles have been removed and disposed of at EMWMF. Soils that underlay the original waste storage area in EUs 29 and 31 as well as soils that

underlay the scrap piles in EUs 30 and 32 show substantially elevated radioactivity. In addition to soils present at the site, the slabs for Bldgs. K-725 and K-726 as well as several small concrete pads will be included in this waste lot. These slabs will be characterized as a separate data set. Characterization of these soils and the concrete slabs for disposal at EMWMF comprise the scope of this SAP. Contaminants present in these soils are directly derived from metallic debris and rubbish handled by the waste storage operations and will include the predominant constituents of concern associated with the metallic waste already disposed of at EMWMF. Contaminants on the surface of Bldgs. K-725 and K-726 slabs are associated with beryllium operations and PCB storage activities, respectively. Further sampling and characterization of residual metallic debris embedded in the soils that underlay the debris piles will not be conducted. The residual metallic debris will meet the same WAC criteria as the primary metallic waste lot profile as defined in Waste Lot Profile 65.1 (BJC 2004a), Waste Lot Profile 65.2 (BJC 2004b), and Waste Lot Profile 65.3 (BJC 2005). This residual metal debris will comprise approximately 5% of the total mass of material that will be generated under this RA.

3.1 PREVIOUS CHARACTERIZATION ACTIVITIES

Two investigative programs have been performed in EUs 29 and 31. An investigation conducted by CDM Federal Programs (CDM) under the Radiological Characterization of Inactive Waste Sites Program was performed in the mid-1990s, and Dynamic Verification Strategy (DVS) characterization of the area was performed in late 2004 and early 2005. Both programs used a combination of radiological walkover surveys and subsequent physical sampling to provide an assessment of this portion of the K-770 Waste Storage Site.

3.1.1 Radiation Walkover Surveys

A full-coverage survey of all open and accessible areas in EUs 29 and 31 and the southwestern portion of EU 33 were performed by CDM in the mid-1990s. This survey used a 2X2 NaI probe with geographic positioning equipment to obtain activity data coverage of the accessible areas. One large area of elevated activity and several smaller anomalies within the site were defined.

In 2004, BJC and Restoration Services Inc. conducted a walkover survey in EU 29 of the large area of elevated activity defined by the CDM survey. The more recent survey used a field instrument for detection of low-energy radiation (FIDLER) and was conducted to confirm the extent of elevated activity could be defined using a different field instrument. The FIDLER survey was successful in defining the same approximate boundary as defined by the CDM survey. The use of these survey instruments was to define areas of anomalous conditions and not to estimate quantitative radioisotopic concentrations.

3.1.2 Soil Sampling

Thirty-four surface soil samples were collected under the 1994 CDM assessment program. These were all biased samples selected to provide laboratory analyses in areas of significantly elevated radioactivity. Also, all of these samples were analyzed by gamma spectroscopy [U.S. Environmental Protection Agency (EPA) Method 901.1]. Concentrations of many of the primary Zone 1 radioisotopic contaminants of concern (COCs) cannot be accurately determined by this method; therefore, the radioisotopic concentrations results are considered unreliable and are not used in the assessment of the proposed waste lot.

Under the DVS Soils Characterization Program, the entire areas of EUs 29 and 31 were classified as Class 1 soil units. Based on the historic radiation walkover survey and historic sampling, there was a high

degree of confidence that soil contamination in portions of the EUs was above Zone 1 maximum remediation levels (RLs) and an RA was required. The sampling plan, as defined in the K-770 DQO Summary Report, defined a base program of 40 sample locations placed on a systematic grid over the two EUs. In addition, 21 biased sampling locations were added to the base program sample set. These additional locations were selected within areas of elevated activity as defined by the radiation walkover surveys and, in some cases, in proximity to the historic sample locations to determine the concentration of radioactive contaminants present and compare to the reported historic sample results.

As prescribed under the DVS characterization DQOs, the sampling methodology is biased to high radioactive contaminant areas and intervals. The sampling approach is designed to provide data to support an action/no-action determination as a program objective and produce a high biased data set. The approach does not provide data appropriate for WAC determinations because the data are not representative of the average contaminant concentrations associated with the waste. The analytical methods are designated in the Zone 1 RAWP (DOE 2007) and are appropriate for all the respective radioisotopes. The data are 100% validated and are considered accurate to meet program DQO requirements.

The predominate radiological contaminants identified by the DVS data set include cesium-137 (maximum result = 27 pCi/g), technetium-99 (maximum result = 695 pCi/g), thorium-232 (maximum result = 60.7 pCi/g), uranium-234 (maximum result = 2090 pCi/g), uranium-235 (maximum result = 110 pCi/g), and uranium-238 (maximum result = 1660 pCi/g). With the exception of technetium-99, all of these isotopes are Zone 1 contaminants of concern. It is noted that neptunium was not detected in any DVS samples and radium-226 was detected at very low concentrations, with a maximum reported result of 3.1 pCi/g. These results are in contrast to very high reported concentrations in the historic data set analyzed by gamma spectroscopy. This substantial discrepancy supports the conclusion that the CDM data set is unreliable.

Other possible contaminants that may be present based on historic information include beryllium associated with the K-725 building slab, PCBs and wrapped pipe that contained asbestos. PCBs were stored in Bldg. K-726 prior to incineration.

A summary of sample results for U-238 from the DVS data set are presented in Table 1. These data represent a high bias set and are not considered representative of average concentrations that will be present in the K-770 soil waste lot.

No samples have been collected from the concrete slabs.

Table 1. Uranium-238 results for physical soil samples within the area of excavation at the K-770 soils site

EU	Location ID	Date	Depth		Sample ID	Result	Val	Lab	Defect	Error	X	Y
			Top	Bottom			Q	Q				
Z1-EU29	EU29B-132	1/20/2005	0.0	0.5	K7700708	1.41	=		0.112	0.256	2437910	580827
Z1-EU31	EU31B-125	1/5/2005	0.5	2.0	K7701172	1.42	=		0.1	0.294	2437677	581260
Z1-EU29	EU29B-121	1/3/2005	1.5	2.0	K7700295	1.43	=		0.0762	0.296	2437848	580509
Z1-EU29	EU29B-122	12/14/2004	0.9	2.0	K7700653	2.74	=		0.0807	0.354	2437731	580567
Z1-EU29	EU29B-125	1/14/2005	0.5	2.0	K7700345	3.5	=		0.0697	0.394	2437809	580686
Z1-EU29	EU29B-130	1/11/2005	0.5	2.0	K7700395	3.54	=		0.0587	0.398	2437724	580896
Z1-EU31	EU31B-123	1/25/2005	0.5	2.0	K7701142	3.78	=		0.0716	0.466	2437750	581055
Z1-EU29	EU29B-131	1/10/2005	0.5	2.0	K7700405	4.51	=		0.0998	0.482	2437845	580909
Z1-EU29	EU29B-126	12/14/2004	0.5	2.0	K7700355	4.79	=		0.116	0.466	2437760	580698
Z1-EU29	EU29B-119	12/20/2004	0.5	2.0	K7700275	5.43	=		0.103	0.581	2437802	580446
Z1-EU31	EU31-101	1/12/2005	0.0	2.0	K7701039	5.95	=		0.0698	0.513	2437837	580953
Z1-EU29	EU29B-129	1/12/2005	0.5	2.0	K7700385	10.9	=		0.0813	0.707	2437731	580825
Z1-EU29	EU29B-129	1/12/2005	0.0	0.5	K7700693	11.3	=		0.0313	0.722	2437731	580825
Z1-EU29	EU29B-128	1/12/2005	0.5	2.0	K7700375	11.8	=		0.0702	0.726	2437852	580815
	K-770				SS8K7701101-							
Z1-EU29	MSY-SS8	11/5/2004	0.0	1.0	RAD	12.5	=		0.03	1.1	2437729	580632
Z1-EU31	EU31-104	1/13/2005	0.0	0.5	K7701052	13.8	=		0.085	0.812	2437886	581036
Z1-EU31	EU31B-126	1/5/2005	0.5	2.0	K7701187	14.4	=		0.0753	0.933	2437815	581314
Z1-EU29	EU29B-125	1/14/2005	0.0	0.5	K7700673	14.6	=		0.0709	0.811	2437809	580686
Z1-EU29	EU29B-130	1/11/2005	0.0	0.5	K7700698	16.4	=		0.116	0.879	2437724	580896
Z1-EU29	EU29B-127	1/20/2005	0.0	0.5	K7700683	18.2	=		0.03	0.896	2437839	580704
Z1-EU29	EU29-111	1/14/2005	0.0	0.5	K7700572	23.4	=		0.0773	1.07	2437837	580785
Z1-EU31	EU31-105	1/21/2005	0.1	0.5	K7701057	24.5	=		0.0766	1.13	2437789	581036
Z1-EU31	EU31B-125	1/5/2005	0.0	0.5	K7701167	26.7	=		0.0802	1.31	2437677	581260
Z1-EU31	EU31B-124	1/7/2005	0.5	2.0	K7701157	27.3	=		0.143	1.28	2437608	581173
Z1-EU29	EU29-118	1/24/2005	1.4	1.9	K7700628	31.4	=		0.0922	1.32	2437886	580869
EU33	EU33-145	12/28/2004	0.0	0.7	K7701586	33.6	=		0.072	1.39	2437789	581538
Z1-EU31	EU31-102	1/21/2005	0.7	1.2	K7701044	40.6	=		0.0843	1.52	2437741	580953
Z1-EU29	EU29B-124	12/14/2004	0.5	0.9	K7700327	42.8	=		0.0319	1.42	2437764	580600
Z1-EU29	EU29-109	12/10/2004	0.2	0.5	K7700554	43.2	=		0.0472	1.73	2437644	580785
Z1-EU29	EU29B-127	1/20/2005	0.5	0.9	K7700365	43.2	=		0.0316	1.42	2437839	580704
Z1-EU31	EU31-106	12/16/2004	0.1	0.5	K7701061	45.3	=		0.0749	1.65	2437692	581036
Z1-EU31	EU31B-126	1/5/2005	0.0	0.5	K7701182	53.4	=		0.0795	1.85	2437815	581314
	EU29M-											
Z1-EU29	110	12/15/2004	0.7	1.0	K7700564	55.3	=		0.113	2.06	2437741	580785
Z1-EU29	EU29-103	12/15/2004	0.1	0.5	K7700504	56.6	=		0.125	1.9	2437837	580451
Z1-EU29	EU29B-123	12/14/2004	1.7	2.0	K7700315	61.3	=		0.119	1.72	2437693	580619
Z1-EU29	EU29B-131	1/10/2005	0.0	0.5	K7700703	71	=		0.102	1.93	2437845	580909

Table 1. Uranium-238 results for physical soil samples within the area of excavation at the K-770 soils site (cont.)

EU	Location ID	Date	Depth		Sample ID	Result	Val	Lab	Detect	Error	X	Y
			Top	Bottom			Q	Q				
Z1-EU29	EU29B-126	12/14/2004	0.0	0.4	K7700678	84.7	=		0.0924	2.23	2437760	580698
Z1-EU31	EU31B-128	1/10/2005	0.5	2.0	K7701217	90.5	=		0.135	2.34	2437893	581058
Z1-EU29	EU29-114	12/10/2004	0.0	0.3	K7700598	92.1	=		0.128	2.82	2437692	580702
Z1-EU31	EU31-103	12/16/2004	0.2	0.6	K7701048	117	=		0.0753	3.6	2437644	580953
Z1-EU29	EU29B-119	12/20/2004	0.0	0.5	K7700638	124	=		0.11	3.32	2437802	580446
Z1-EU29	EU29B-128	1/12/2005	0.0	0.5	K7700688	131	=		0.0609	3.43	2437852	580815
Z1-EU29	EU29-107	12/13/2004	0.0	0.3	K7700542	134	=		0.164	3.85	2437741	580618
Z1-EU29	EU29-113	12/13/2004	0.0	0.3	K7700590	147	=		0.0775	4.1	2437789	580702
Z1-EU31	EU31B-123	1/25/2005	0.1	0.5	K7701137	179	=		0.224	4.7	2437750	581055
Z1-EU29	EU29B-122	12/14/2004	0.0	0.3	K7700305	180	=		0.137	4.33	2437731	580567
Z1-EU31	EU31B-124	1/7/2005	0.0	0.5	K7701152	209	=		0.24	5.49	2437608	581173
Z1-EU29	EU29B-124	12/14/2004	0.0	0.3	K7700665	342	J		0.104	7.23	2437764	580600
Z1-EU29	EU29B-121	1/3/2005	0.0	0.5	K7700648	935	=		1.07	23.7	2437848	580509
Z1-EU29	EU29B-123	12/14/2004	0.4	0.6	K7700658	1660	J		1.06	36.1	2437693	580619
Z1-EU31	EU31B-128	1/10/2005	0.0	0.5	K7701212	15900	J		5.79	368	2437893	581058
	All result	Min	1.41	Data set less 15900 result	Min	1.41						
		Max	15900.00		Max	1660.00						
		Mean	415.05		Mean	105.35						
		Standard deviation	2227.21		Standard deviation	265.09						

EU = exposure unit
ID = identification

Max = maximum
Min = minimum

4. PROJECT DQOS

The DQO process is a systematic approach to defining sample program requirements. The following sections provide the K-770 WAC program DQO logic.

The RA to be taken at the K-770 Site will involve a surface excavation within the areas (approximately 10.1 acres) defined by the radiological walkover survey. Soils will be removed over the area to a depth of approximately 1 ft below the existing surface grade. The resultant waste lot will be comprised of 95% soils and approximately 5% metallic debris imbedded in the soil that underlay the scrap waste piles in the area.

4.1 STATE THE PROBLEM

The types and concentrations of PCBs and semivolatile organic, radioactive, and inorganic (metallic) contaminants in the soils and concrete slabs waste lot must be determined to transport and dispose of the contaminated materials from the K-770 Site.

4.2 PRINCIPLE STUDY QUESTION

The principle study question is to determine the average contaminant concentrations for PCBs, semivolatile organic, and radioactive and inorganic (metallic) constituents to a 95% confidence level for the K-770 soil and concrete waste lot, and ascertain if the waste can be disposed of in the EMWMF.

4.3 INFORMATION INPUTS

The following is needed to identify information inputs:

- EMWMF WAC requirements
- Historical information, including facility and site operations
- Analytical data associated with the metallic debris formally stored at the site and the presumed source of the soil contamination.
- Radiological walkover survey data
- DVS program laboratory sample data
- Newly acquired laboratory sample data

Waste acceptance will be determined using EMWMF evaluation criteria as defined in the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2001).

4.4 PROCESS KNOWLEDGE

Beginning in 1944-45, this area was the site of a tank farm designated F-22 and used for storing Bunker C oil (No. 3 grade fuel oil). This oil was stored in 13 tanks, each with a 470,000-gal capacity adjacent to the Clinch River. Each tank was individually isolated by an earthen dike and a secondary dike around each

group of three tanks. Fuel oil usage at the Powerhouse extended from 1944 through the end of 1953 and the tanks remained in place until 1954.

Scrap metal storage in this area began in the 1960s and waste management tracking operations began in 1977. From 1984 to 1986, the metals were segregated under a contract to Quadrex. The waste materials were separated by metal type and reduced in volume by shearing. Categories of metals were ACM, rubbish, items with radiological hot spots, and Class 004 (too large to shear). A Resource Conservation and Recovery Act of 1976 (RCRA) assessment was performed on this site in FY 1994 and all readily identified and accessible RCRA-regulated materials were removed.

The majority of metal at the K-770 Scrap Yard was generated during the Cascade Improvement Program/Cascade Upgrade Program. Most of the scrap metal passed through the K-1420 decontamination facility, where it was vacuumed and washed using water with dilute nitric acid or an alkaline detergent. This decontamination process removed transferable uranium prior to outside storage. In the 1980s, much of the scrap metal was segregated and size reduced. The metal was segregated into groupings of ferrous metals, non-ferrous metals, and other metals with potential recycle value. In addition to material from the ETTP Site (formerly known as the K-25 Site), materials from the Y-12 Site, Savannah River Site (SRS), and Oak Ridge National Laboratory (ORNL) were received at this scrap yard. Material from the Y-12 and K-25 Sites was contaminated with uranium, the SRS material contained scrap metal released as part of a recycling program, and the ORNL waste included four heat exchangers. The total non-uranium based waste (i.e., non-K-25 Site or Y-12 Site waste) was <0.5% of the total waste. The scrap yard material consisted of five primary waste piles of scrap metal that comprised approximately 40% of the waste by weight and were disposed of at EMWMF. All building structures within the area of the site have been demolished to the building slabs, which remain in place. All scrap metal that was not embedded in the surface soils has been removed and disposed of at EMWMF. All physical samples collected by the Zone 1 DVS Soils Characterization Program were analyzed for the presence of PCBs and metals. Results of these analyses indicated the metal concentrations in some samples could exceed the land disposal regulations. No volatile organic compounds (VOCs) were reported in any DVS samples above the industrial use preliminary remediation goals (PRGs), and only two DVS samples reported semivolatile organic compounds (SVOCs) present above the industrial use PRGs. Two samples were reported with PCBs above the Zone 1 average RLs.

4.4.1 K-725 Building

In 1944-1945, the K-725 building was originally used as a machine shop to support activities at the Fercleve S-50 Thermal Diffusion Plant. In the late 1940s and early 1950s, the building was used for beryllium machining and experimentation. Building surveys during the late 1950s identified considerable beryllium contamination and some minor radiological contamination on equipment and building structures (air vents and floor tiles). At least two unsuccessful attempts were made to decontaminate the building. The building was closed to work activities in the 1970s. The structure has been demolished and only the floor slab (approximately 160 x 85 ft (estimated 250 yd of concrete)) remains.

4.4.2 K-726 Building

The K-726 building was originally built as a boiler house to burn bunker C oil to support the Fercleve Thermal Diffusion experiments. Operations at this building were discontinued in 1945. Beginning in 1978, the building was used to store PCB-containing liquids and solids. The structure has been demolished and only the floor slab remains.

4.5 BOUNDARIES OF THE STUDY

The proposed excavation boundaries shown as a green line on Fig. 1 have been defined based on radiological walkover surveys. The area is approximately 10.1 acres in extent and is comprised of three large contiguous areas over 1 acre that is presumed to have contamination generally above Zone 1 average RLs. Several smaller areas of substantially elevated radioactivity are defined within the large contiguous boundaries and at isolated locations of limited areal extent in the surrounding areas of the site. Concrete slabs represent approximately 400 yd of material.

4.6 ANALYTIC APPROACH AND FINAL DECISION STATEMENTS

Contamination at the K-770 Site is present on the ground surface over most of the area to be remediated. Within the larger contiguous areas, there is some acreage that does not appear to have surface contamination. The surface contamination area is identifiable using radiation field-detecting instruments that clearly define anomalous conditions and can be used to establish the initial excavation area boundary. The radiation walkover survey data set, in conjunction with the surface release conceptual model, is supported by institutional knowledge. The high bias data set that was collected by the DVS Characterization Program provided a general depiction of the nature and extent of contamination at the site. The data confirm results of the radiological walkover survey, which indicates there are three large contiguous areas that exhibit slightly to moderately elevated radioactivity (U-238 results, which are the predominant contaminant at the site, are presented in Table 1). Samples located within the areas of elevated radioactivity where contaminated metallic debris was stored generally reported concentrations for at least one radioisotope above Zone 1 average RLs. DVS data indicates the contamination is contained in very thin layers of surface-contaminated soils that are generally no more than a few inches thick. The contaminants remain in the upper foot of soil where contamination has been covered by site activities. Laboratory data indicates the contaminants in excess of Zone 1 average RLs are distributed in surface soils over the broader contiguous areas. Isolated smaller spots of substantially elevated contamination (at or above Zone 1 maximum RLs) are contained within the limits of the broader lower activity surface areas and as isolated smaller areas distributed around the primary area of contamination to the north and east. The proposed RA will define the excavation area boundary using the radiation walkover survey data to define the extent of anomalous activity above approximately 2X background (approximately 8000 cpm using a 2X2 NaI detector, and 3000 cpm for the FIDLER instrument), which generally corresponds to the average RL for Uranium-238. Since more than one radioisotope may be present, the field instrumentation is not considered quantitative. Remedial action will entail scraping approximately 1 ft of surface soil from the area inside the defined boundaries. Certain isolated areas that have high activity (50,000+ cpm) may be segregated from the large soil waste lot as a high SOF waste lot (see decision rule 2 below).

Decision rule no.	If	Then	Otherwise
1	The average concentration of soil COCs in the K-770 waste lot meets WAC for disposal at EMWMF	Dispose of the K-770 soils at EMWMF	Identify and segregate high SOF soils, handle as a separate waste lot, and re-evaluate the remainder against the EMWMF WAC; repeat until a waste lot is acceptable for disposal at the EMWMF
2	The concentration of soil COCs in the high SOF waste lot meets WAC for disposal at EMWMF	Dispose of the high SOF K-770 soils waste lot at EMWMF	Dispose of at an off-site facility

Fig. 1. K-770 planned sample locations overlain on the radiological walkover survey map.

4.7 PERFORMANCE OR ACCEPTANCE CRITERIA

The acceptability of the soils for disposal at EMWMF will be based on samples collected under this SAP and will not include results from previously acquired soil samples. Laboratory detection levels, analytical methods, and reporting requirements shall follow the Zone 1 RAWP Quality Assurance Project Plan (QAPP) (DOE 2007). Waste acceptance will be determined using EMWMF evaluation criteria that are defined in the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2001)

4.8 PLAN FOR OBTAINING DATA

Based on the description above, data collected within the proposed excavation area in EUs 29 and 31 were used to support a determination of the number of samples required to characterize the large contiguous areas of contamination. The DVS data set includes all laboratory sample results from all sample boring locations located within the proposed excavation area boundary. Results from all depths from 0-10-ft BGS are included in the complete data set. Thirty-four sample locations in the DVS program are located within the area of excavation. Of these 34 locations, 16 were placed using VSP™ software on a systematic triangular offset grid with a random start location. One sample was collected from each of the systematic grid locations in the 0-2 ft interval (16 samples). The other 18 sample locations were targeted biased locations associated with areas of substantially elevated radioactivity (greater than 2X background) as defined by the CDM radiological walkover survey of the area. There are two samples from each of these locations in the 0-2.0 ft interval (0-0.5 and 0.5-2.0ft), of these 18 locations one had only a surface sample collected (35 samples). The total number of soil samples collected in the 0-2.0 ft interval within the area to be excavated in EUs 29 and 31 identified 51 total sample results for U-238.

Using the DVS data set laboratory results for U-238, the statistical characteristics of the data were determined and are presented in Fig. 2. Note that the entire data set includes 51 results for U-238, however, the highest result associated with one sample was more than an order of magnitude higher than the next highest value. It is known that there are small isolated areas within the site that have substantial contamination but low volumes. For this reason, the highest value was dropped from the data set. The small isolated areas exhibiting activity > 50,000 cpm will be sampled as a biased set of samples, which may represent a low volume, high sum of fractions waste lot. The sample design is predicated upon collecting two separate data sets. The N value calculated for the large areas of the relatively low-level contamination (large volume low sum-of fractions) waste lot is based on the data set that does not include this single high result. The remaining data set is representative of the broad areas of low contamination and this set of data is used to determine the number of samples needed to characterize the large areas of contaminated soil. A second set of samples biased to the highly contaminated localized soils areas are proposed to provide a representative set of samples for what may be a high SOF small volume waste lot.

Using these data sets and VSP™ software ($\alpha = 0.05$, $\beta = 0.20$, $\delta = 130$, action level = 50, and standard deviation of the U-238 data set = 265), α and β are selected to provide a 95% confidence level on the mean and δ is selected based on the clean-up criteria and risk protocol, which results in removing contaminated soil areas to levels that will not result in an average RL exceedance over the area of an EU. The action level of 50 corresponds to the average remediation level for U-238 as defined by the Zone 1 ROD. Using these parameters the number (N) of samples required to adequately characterize the proposed excavation was determined to be 32 samples. Individual isolated areas to the north and east, and hot spots contained within the large areas of surface contamination that exhibit radioactivity above 50,000 cpm on FIDLER surveys, will be sampled as a separate biased data set. Approximately 13 samples will comprise this separate data set (see Appendix A).

Fig. 2. Summary for K-770 excavation area (0-2.0 ft Interval U-238 results).

Sample locations shown on Fig. 1 are generated in VSP on a triangular offset grid with a random start location, and are approximately 113 ft apart over the excavation areas. The proposed excavation boundary does not include portions of the EU outside the proposed excavation boundary. The three large areas of low-level contamination were treated in VSP as a single polygonal feature. The 32 locations are distributed in relationship to the total large low-contamination proposed excavation area. All samples will be five-point surface composite samples comprised of five equal aliquots of soil collected from the surface to a depth of 1 ft below existing grade. The five aliquots of soil will be spaced 10 ft from the location center point oriented in the cardinal directions. The ground location coordinates are assigned to the sample location center point and are included on the Sample Summary Table (Appendix A).

The five aliquots of soil will be thoroughly mixed according to the sampling procedure identified in the Zone 1 RAWP. All sampling activities will follow the Zone 1 RAWP DVS requirements (DOE 2007). Laboratory results will be validated and verified according to Zone 1 RAWP DVS requirements. Proposed center-point sample locations for the two proposed sample sets are shown on Fig. 1.

The analytical suite for all samples will include VOC, SVOC, target analyte list (TAL) metals, PCBs, Toxicity Characteristic Leaching Procedure (TCLP) SVOC, TCLP metals, and a full suite of radioisotopic analyses as defined in the Zone 1 QAPP, Appendix A, Table A.9 (DOE 2007). Details of the analytical requirements are included in the Zone 1 RAWP, Appendix A, Table A.9, that was developed following the EPA QAPP SAP checklist requirements.

4.9 CONCRETE SAMPLES

A total of 14 concrete samples will be collected (eight from the K-725 slab, two from the K-726 slab, and one from each of the small concrete pads within the K-770 Site). The number of samples represents a 25-ft-radius hot spot generated by VSP software on a systematic grid with a random start location for the K-725 and K-726 buildings. The hot spot radius selected for concrete samples was selected at half of the Zone 1 DVS hot spot size to provide a minimum number of samples. Concrete samples will be collected according to Zone 1 RAWP concrete sampling protocol, which allows roto-hammer drill cutting to be used for all analytes other than VOCs, or chipping to collect PCBs if required. Analyses of the concrete samples will be for radiological constituents, PCBs, and TAL metals, plus beryllium and mercury. Locations of the concrete samples relative to the slab surfaces are shown on Fig. 3. Ground location coordinates and required analyses are provided in the Sample Summary Table (Appendix A).

Fig. 3. K-770 concrete slab sample location map.

5. REFERENCES

- BJC 2004a. *Waste Profile for the Disposal of the Scrap Removal Project Waste Lot 65.1*, BJC/OR-1857, Rev. 1, Bechtel Jacobs Company LLC, July.
- BJC 2004b. *Waste Profile for Disposal of the Scrap Removal Project Waste Lot 65.2, East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1859, Rev. 1, Bechtel Jacobs Company LLC, August.
- BJC 2005. *Waste Profile for Disposal of the Scrap Removal Project Waste Lot 65.3 - East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1859, Rev. 4, Bechtel Jacobs Company LLC, May.
- DOE 2001. *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1909&D3, Bechtel Jacobs Company LLC, Oak Ridge, TN, October.
- DOE 1993. *Radiation Protection of the Public and the Environment*, DOE Order 5400.5, Change 2, U.S. Department of Energy, Washington, D.C.
- DOE 2002. *Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-1997&D2, Bechtel Jacobs Company LLC, Oak Ridge, TN.
- DOE 2005. *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, TN*, DOE/OR/01-1997&D2, Bechtel Jacobs Company LLC, Oak Ridge, Tennessee.
- DOE 2007. *Remedial Action Work Plan for Dynamic Verification Strategy for Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-2182&D4, Bechtel Jacobs Company LLC, Oak Ridge, TN.

APPENDIX A.
SAMPLE SUMMARY TABLE

A-3

Exposure node	Location ID	Location		Sample Interval	Off-site laboratory								Spill/leak	Comments and notes
		North	East		VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCE	Full RAB			
Exposure Unit 29														
Z1-EU29	Z1-EU29W-401	580602	2437682	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-402	580602	2437709	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-403	580708	2437636	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-404	580708	2437712	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-405	580750	2437683	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-406	580756	2437769	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-407	580756	2437636	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-408	580806	2437636	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-409	580836	2437712	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-410	580836	2437618	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Exposure Unit 30														
Z1-EU30	Z1-EU30W-411	580924	2437954	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Exposure Unit 31														
Z1-EU31	Z1-EU31W-412	580994	2437682	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31W-413	580994	2437769	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31W-414	580994	2437656	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31W-415	581139	2437618	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31W-416	581236	2437698	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31W-417	581321	2437902	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Exposure Unit 32														
Z1-EU32	Z1-EU32W-418	581066	2438169	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-419	581066	2438273	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-420	581066	2438387	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-421	581104	2438104	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-422	581104	2438217	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-423	581104	2438338	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-424	581104	2438443	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-425	581362	1,038,128	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1		

Table A-1. Sample summary table for Zone 1 K-779 soil WAC (cont.)

Exposure unit	Location ID	Location		Sample Interval	Off-site laboratory							Split of core	Comments and notes
		North	East		VOC	SVOC	TCLP SVOC	Metals - 8 Hr	TCLP Metals	PCB	PbB		
Z1-EU33	Z1-EU32W-434	581362	2438235	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU32	Z1-EU32W-427	581362	2438387	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU35	Z1-EU32W-428	581360	2438217	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU32	Z1-EU32W-429	581360	2438330	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU32	Z1-EU32W-438	581360	2438445	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU32	Z1-EU32W-431	581040	2438586	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU32	Z1-EU32W-422	581050	2438171	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-433	581221	2438337	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-434	581043	2437889	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Exposure Unit 33													
Z1-EU33	Z1-EU32W-435	581358	2438273	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-436	581358	2438387	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-437	5814298	2438329	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-438	581685	2438389	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-439	581222	2438339	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-440	581722	2438455	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-441	581839	2438387	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-442	581633	2437689	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-443	581564	2437760	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-444	2438138	581365	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Z1-EU33	Z1-EU32W-445	2438144	581458	Five point composite 0-10 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0-5-0.7 ft	1	1	1	1	1	1	1	1	
Concrete samples													
K-135 building slab													
Z1-EU39	Z1-EU39C-444	588609	2438272	Concrete sample									
Z1-EU39	Z1-EU39C-443	588609	2438294	Concrete sample									
Z1-EU39	Z1-EU39C-416	588633	2438208	Concrete sample									
Z1-EU39	Z1-EU39C-417	588633	2438236	Concrete sample									
Z1-EU39	Z1-EU39C-448	588633	2438264	Concrete sample									
Z1-EU39	Z1-EU39C-449	588633	2438294	Concrete sample									
Z1-EU39	Z1-EU39C-450	588633	2438322	Concrete sample									
Z1-EU39	Z1-EU39C-451	588633	2438350	Concrete sample									
K-726 building slab													
Z1-EU39	Z1-EU39C-452	588633	2438375	Concrete sample									
Z1-EU39	Z1-EU39C-453	588633	2438404	Concrete sample									
Other concrete slabs EU 39													
Z1-EU39	Z1-EU39C-454	588633	2437979	Concrete sample									
Other concrete slabs EU 39													
Z1-EU39	Z1-EU39C-455	588633	2438087	Concrete sample									
Z1-EU39	Z1-EU39C-456	588633	2437988	Concrete sample									

Table A-1. Sample summary table (for Zone 1 K-776 wells WAC (cont.)

ID = identifier
PCB = polychlorinated biphenyl
RAD = radiological
SBOC = nonvolatile organic compounds
TCLP = Toxicity Characteristic Leaching Procedure
VOC = volatile organic compounds
WAC = water acceptance criteria

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Core Team Agreement Log #: 228
Areas: Zone 1 Powerhouse 770 Area (EUs Z1-28-33)
FCN-ETTP-Zone 1-092

Core Team Concurrence

In accordance with the Dynamic Verification Strategy, the following revisions are proposed for the Zone 1 Powerhouse 770 Area (EUs Z1-28-33)

Area: Zone 1 770 Area — approve the 770 Area Waste Acceptance Criteria (WAC) Sampling and Analysis Plan (SAP).

Change(s): The proposed change is to approve the attached 770 Area WAC SAP.

This action will be documented in the Zone 1 Powerhouse 770 Area Technical Memoranda, which will be an appendix in future Phased Construction Completion Reports.

Concurrence:

M. A. Trappolini
U.S. Department of Energy

8/21/08
Date

Thomas A. Gilbert
Tennessee Department of Environment and Conservation

8/20/08
Date

Christine Allison Jones
U.S. Environmental Protection Agency

8/17/08
Date

SOW: BKET02533

Revision: 5

Date: 02/17/2009

SOW Group: STANDARD

OAK RIDGE SAMPLE MANAGEMENT OFFICE ANALYTICAL STATEMENT OF WORK

Project Description: Characterization studies for the ETPP Site Zone 1 Areas. Multiple sampling events will determine need for analysis to determine risk for identified exposure units. This SOW is a continuation of the FY08 Zone 1 lab SOW and will include regular sampling events.

Project No: ETPP Zone 1 Work Release No:	Project Manager: Richard Lee Telephone: (865)576-6596 Fax: (865)241-8850 Address: MS 6410, Bldg 6556U PO Box 2008 Bethel Valley Road Oak Ridge, TN 37831-6410
Project Control Engineer: Diana Boshears Telephone: (865)576-6481 Fax: (865)241-5142 Alternate:	Charge Number: KKHIDVS1 ADS: B & R No.: Funding Source:
Sample Start Date: 09/29/2008 Sample Completion Date: 09/30/2009 Sampling Events: One event at present; additional sampling requirements to be added as needed. Containers: Lab WILL supply containers.	
Sample Quantity:	
Sample Disposal: LAB DISPOSAL Comments:	Required Archival: 3 Month(s)
Suspected Hazards:	TSCA Regulated: No (PCBs > 50 ppm)
Isotopes of Concern: Alpha emitters Estimated Level of Radioactivity: Comments:	
Shipping: The Project Manager is to fax the Chain of Custody and any supporting documentation (RFA, Total Activity Report, etc.) to the OR SMO prior to each shipment.	

SOW: BKET02533

REVISION: 5

(NOTE: All turnaround and holding times are in calendar days. An 'NC' in the Hold Time column indicates that the holding time will not be -

calculated for these analyses. CAS Numbers with the prefix of 'N' are non-standard identifiers assigned by the Oak Ridge Environmental Information System. The provided standard and non-standard CAS numbers must be used to report the listed analytes in electronic data.)

Qty	Matrix Type	Proponent/Method	Analyte	Cas No.	Req Report Limit	Turn Time	Hold Time
10	WATER	RAD-GAMMA SPECTROSCOPY	Cesium-137	10045-97-3	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	Cobalt-60	10198-40-0	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	Potassium-40	13968-00-2	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	Thorium-234	15065-10-8	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	Uranium-235	15117-96-1	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	zz All other gamma isos >MDA		PER METHOD	30	180
10	WATER	RAD-GROSS ALPHA/BETA	Gross Alpha	12587-48-1	PER METHOD	30	180
10	WATER	RAD-GROSS ALPHA/BETA	Gross Beta	12587-47-2	PER METHOD	30	180
10	WATER	RAD-NP-237 BY ALPHA	NP-237	13894-20-2	PER METHOD	30	180
10	WATER	RAD-TC-99 BY BETA LSC	TC-99	14133-76-7	PER METHOD	30	180
10	WATER	RAD-TH ISO BY ALPHA	Thorium-228	14274-82-9	PER METHOD	30	180
10	WATER	RAD-TH ISO BY ALPHA	Thorium-230	14268-63-7	PER METHOD	30	180
10	WATER	RAD-TH ISO BY ALPHA	Thorium-232	N2608	PER METHOD	30	180
10	WATER	RAD-U ISO BY ALPHA	U-233/234	NS832	PER METHOD	30	180
10	WATER	RAD-U ISO BY ALPHA	U-235/236	N1047	PER METHOD	30	180
10	WATER	RAD-U ISO BY ALPHA	U-238	24678-82-8	PER METHOD	30	180
88	WATER	SW846-6010B	Aluminum	7429-90-5	PER METHOD	30	180
88	WATER	SW846-6010B	Arsenic	7440-38-2	PER METHOD	30	180
88	WATER	SW846-6010B	Barium	7440-39-3	PER METHOD	30	180
88	WATER	SW846-6010B	Beryllium	7440-41-7	PER METHOD	30	180
88	WATER	SW846-6010B	Boron	7440-42-8	PER METHOD	30	180
88	WATER	SW846-6010B	Calcium	7440-70-2	PER METHOD	30	180
88	WATER	SW846-6010B	Chromium	7440-47-3	PER METHOD	30	180
88	WATER	SW846-6010B	Cobalt	7440-48-4	PER METHOD	30	180
88	WATER	SW846-6010B	Copper	7440-50-8	PER METHOD	30	180
88	WATER	SW846-6010B	Iron	7439-89-6	PER METHOD	30	180
88	WATER	SW846-6010B	Lead	7439-92-1	PER METHOD	30	180
88	WATER	SW846-6010B	Lithium	7438-93-2	PER METHOD	30	180
88	WATER	SW846-6010B	Magnesium	7439-95-4	PER METHOD	30	180
88	WATER	SW846-6010B	Manganese	7439-96-5	PER METHOD	30	180
88	WATER	SW846-6010B	Molybdenum	7438-96-7	PER METHOD	30	180
88	WATER	SW846-6010B	Nickel	7440-02-0	PER METHOD	30	180
88	WATER	SW846-6010B	Potassium	7440-09-7	PER METHOD	30	180
88	WATER	SW846-6010B	Selenium	7782-49-2	PER METHOD	30	180
88	WATER	SW846-6010B	Silver	7440-22-4	PER METHOD	30	180
88	WATER	SW846-6010B	Sodium	7440-23-5	PER METHOD	30	180
88	WATER	SW846-6010B	Vanadium	7440-62-2	PER METHOD	30	180
88	WATER	SW846-6010B	Zinc	7440-66-6	PER METHOD	30	180
88	WATER	SW846-6020A	Antimony	7440-36-0	PER METHOD	30	180
88	WATER	SW846-6020A	Cadmium	7440-43-9	PER METHOD	30	180
88	WATER	SW846-6020A	Thallium	7440-28-0	PER METHOD	30	180
88	WATER	SW846-6020A	Uranium	7440-61-1	PER METHOD	30	180
88	WATER	SW846-7470A	Mercury	7439-97-6	PER METHOD	30	28
10	WATER	SW846-8082	Aroclor 1016	12674-11-2	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1221	11104-28-2	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1232	11141-16-5	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1242	58489-21-9	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1248	12672-29-8	PER METHOD	30	7

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Qty	Matrix Type	Proponent/Method	Analyte	Case No.	Req Report Limit	Turn Time	Hold Time
10	WATER	SW846-8082	Aroclor 1254	11087-69-1	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1260	11096-82-5	PER METHOD	30	7
10	WATER	SW846-8082TPCB	Total PCB	TOTAL PCB	PER METHOD	30	7
30	WATER	SW846-8260B	ALL ANALYTES		PER METHOD	30	14
10	WATER	SW846-8270C	ALL ANALYTES		PER METHOD	30	7
26	SOIL	RAD-GAMMA SPECTROSCOPY	Cesium-137	10045-97-3	1.0 PC/G	30	180
26	SOIL	RAD-GAMMA SPECTROSCOPY	Cobalt-60	10198-40-0	1.0 PC/G	30	180
26	SOIL	RAD-GAMMA SPECTROSCOPY	Potassium-40	13966-00-2	10.0 PC/G	30	180
26	SOIL	RAD-GAMMA SPECTROSCOPY	Thorium-234	15085-10-8	1.0 PC/G	30	180
26	SOIL	RAD-GAMMA SPECTROSCOPY	Uranium-235	15117-98-1	PER ATTACHMENT	30	180
26	SOIL	RAD-GROSS ALPHA/BETA	Gross Alpha	12587-48-1	5.0 PC/G	30	180
26	SOIL	RAD-GROSS ALPHA/BETA	Gross Beta	12587-47-2	5.0 PC/G	30	180
26	SOIL	RAD-NP-237 BY ALPHA	NP-237	13894-20-2	1.0 PC/G	30	180
26	SOIL	RAD-TC 99 BY BETA LSC	TC 99	14133-76-7	10.0 PC/G	30	180
26	SOIL	RAD-TH ISO BY ALPHA	Thorium-228	14274-82-9	1.0 PC/G	30	180
26	SOIL	RAD-TH ISO BY ALPHA	Thorium-230	14269-83-7	1.0 PC/G	30	180
26	SOIL	RAD-TH ISO BY ALPHA	Thorium-232	N2808	1.0 PC/G	30	180
26	SOIL	RAD-U ISO BY ALPHA	U-233/234	NS632	1.0 PC/G	30	180
26	SOIL	RAD-U ISO BY ALPHA	U-238	24678-82-8	1.0 PC/G	30	180
26	SOIL	RAD-U ISO BY ALPHA	Uranium-235/236	N1047	1.0 PC/G	30	180
112	SOIL	SW846-6010B	Aluminum	7429-90-5	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Arsenic	7440-38-2	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Barium	7440-39-3	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Beryllium	7440-41-7	0.1 MG/KG	30	180
112	SOIL	SW846-6010B	Boron	7440-42-8	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Calcium	7440-70-2	5.0 MG/KG	30	180
112	SOIL	SW846-6010B	Chromium	7440-47-3	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Cobalt	7440-48-4	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Copper	7440-50-8	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Iron	7439-89-6	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Lead	7439-92-1	0.3 MG/KG	30	180
112	SOIL	SW846-6010B	Lithium	7439-93-2	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Magnesium	7439-95-4	5.0 MG/KG	30	180
112	SOIL	SW846-6010B	Manganese	7439-98-5	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Molybdenum	7439-98-7	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Nickel	7440-02-0	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Potassium	7440-09-7	5.0 MG/KG	30	180
112	SOIL	SW846-6010B	Selenium	7782-49-2	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Silver	7440-22-4	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Zinc	7440-66-8	0.5 MG/KG	30	180
112	SOIL	SW846-6020A	Antimony	7440-36-0	0.5 MG/KG	30	180
112	SOIL	SW846-6020A	Cadmium	7440-43-9	0.1 MG/KG	30	180
112	SOIL	SW846-6020A	Thallium	7440-28-0	0.2 MG/KG	30	180
112	SOIL	SW846-6020A	Uranium	7440-61-1	0.002 MG/KG	30	180
112	SOIL	SW846-7471A	Mercury	7439-97-6	0.1 MG/KG	30	28
112	SOIL	SW846-8082	Aroclor 1016	12674-11-2	33 UG/KG	30	14
112	SOIL	SW846-8082	Aroclor 1221	11104-28-2	67 UG/KG	30	14
112	SOIL	SW846-8082	Aroclor 1232	11141-16-5	35 UG/KG	30	14

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Qty	Matrix Type	Proponent/Method	Analyte	Case No.	Req Report Limit	Turn Time	Hold Time
112	SOIL	SW846-8082	Aroclor 1242	53469-21-9	33 UG/KG	30	14

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METHODOLOGY	QC REQUIREMENTS	DATA DELIVERABLE
METALS	PER APPROPRIATE AMS	FORMS PLUS RAW DATA
PEST,PCB,HERB	PER APPROPRIATE AMS	FORMS PLUS RAW DATA

RADIOLOGICAL VOA & SVOA	PER APPROPRIATE AMS PER APPROPRIATE AMS	FORMS PLUS RAW DATA FORMS PLUS RAW DATA

QC COMMENTS: Per ICPT AMS and Specified Methodology

Results will be reported as dry weight unless otherwise specified in the following comment field or as an attachment.

DATA DELIVERABLE COMMENTS: Orgnl/CD to Ann Masvidal; CD to SMO; AMS/EDD to PEMS

TICS: For GC/MS methods, lab must report TICs: YES

(For AMS/EDD files, lab must submit .tic file when TICs are required.)

ANALYTICAL BATCH REQUIREMENTS: PROJECT SPECIFIC

REPORTING REQUIREMENTS: (Report results formally to:)

Original:

Ann Masvidal
Bechtel Jacobs Company, LLC
P.O. Box 4699
Highway 58 and Blair Road
Bldg. 1580, Mail Stop 7120
Oak Ridge, TN 37831

Copy:

Attention: Mr. Ben Dettorre
Bechtel Jacobs Company, LLC
ETTP Central Receiving
2010 Highway 58
Building CT97500, Room No. 25, MS 6400
Oak Ridge, TN 37830

ATTACHMENTS: Attachments provide the project analyte list with reporting levels for soil matrices.

OTHER COMMENTS & REVISION HISTORY: Quick TAT may be requested. Quick TAT= complete data package. Sample receipt verification within 24 hrs of receipt of samples. TAT is calculated based on calendar days only.

Richard Lee
Project Manager

Approving Manager

Jim Chambers
SMO Representative

4/14/09

Date
4/14/09

Date
4/14/09

Date

SAMPLE RECEIPT CONFIRMATION: The laboratory is to fax a copy of the signed Chain of Custody, Sample Receipt Report, and other supporting documentation to the OR SMO and the Project Manager with each shipment received.

Thu, April 09, 2009 11:46:38

(SOW Main Menu)

**Analytical methods and estimated quantitation levels
for VOCs analyzed at the off-site laboratory**

VOC	Analytical method	Quantitation level in soils*
1,1,1-Trichloroethane	SW846-8260B	5 µg/kg
1,1,2,2-Tetrachloroethane	SW846-8260B	5 µg/kg
1,1,2-Trichloroethane	SW846-8260B	5 µg/kg
1,1-Dichloroethane	SW846-8260B	5 µg/kg
1,1-Dichloroethene	SW846-8260B	5 µg/kg
1,2-Dichloroethane	SW846-8260B	5 µg/kg
1,2-Dichloropropane	SW846-8260B	5 µg/kg
2-Butanone	SW846-8260B	10 µg/kg
2-Hexanone	SW846-8260B	10 µg/kg
4-Methyl-2-pentanone	SW846-8260B	10 µg/kg
Acetone	SW846-8260B	10 µg/kg
Benzene	SW846-8260B	5 µg/kg
Bromodichloromethane	SW846-8260B	5 µg/kg
Bromomethane	SW846-8260B	10 µg/kg
Carbon disulfide	SW846-8260B	5 µg/kg
Carbon tetrachloride	SW846-8260B	5 µg/kg
Chlorobenzene	SW846-8260B	5 µg/kg
Chloroethane	SW846-8260B	10 µg/kg
Chloroform	SW846-8260B	5 µg/kg
Chloromethane	SW846-8260B	10 µg/kg
<i>cis</i> -1,3-Dichloropropene	SW846-8260B	5 µg/kg
<i>cis</i> -1,2-Dichloroethene	SW846-8260B	5 µg/kg
Dibromochloromethane	SW846-8260B	5 µg/kg
Ethylbenzene	SW846-8260B	5 µg/kg
Methylene chloride	SW846-8260B	5 µg/kg
Styrene	SW846-8260B	5 µg/kg
Tetrachloroethene	SW846-8260B	5 µg/kg
Toluene	SW846-8260B	2 µg/kg
<i>trans</i> -1,3-Dichloropropene	SW846-8260B	5 µg/kg
<i>trans</i> -1,2-Dichloroethene	SW846-8260B	5 µg/kg
Tribromomethane	SW846-8260B	5 µg/kg
Trichloroethene	SW846-8260B	5 µg/kg
Vinyl chloride	SW846-8260B	2 µg/kg
Xylenes (total)	SW846-8260B	5 µg/kg

*Report results on dry weight basis.
Mg/kg = milligrams per kilogram

**Analytical Method and estimated quantitation levels for SVOCs
analyzed at the off-site laboratory**

SVOC	Analytical method	Quantitation level in soils
Acenaphthene	SW846-8270C	330 µg/kg
Acenaphthylene	SW846-8270C	330 µg/kg
Aniline	SW846-8270C	830 µg/kg
Anthracene	SW846-8270C	330 µg/kg
Benz(a)anthracene	SW846-8270C	330 µg/kg
Benzo(b)fluoranthene	SW846-8270C	330 µg/kg
Benzo(k)fluoranthene	SW846-8270C	330 µg/kg
Benzoic acid	SW846-8270C	1700 µg/kg
Benzo(g,h,i)perylene	SW846-8270C	330 µg/kg
Benzo(a)pyrene	SW846-8270C	330 µg/kg
Benzyl alcohol	SW846-8270C	330 µg/kg
Bis(2-chloroethoxy)methane	SW846-8270C	330 µg/kg
Bis(2-chloroethyl) ether	SW846-8270C	330 µg/kg
Bis(2-chloroisopropyl) ether	SW846-8270C	330 µg/kg
4-Bromophenyl phenyl ether	SW846-8270C	330 µg/kg
Butyl benzyl phthalate	SW846-8270C	330 µg/kg
4-Chloroaniline	SW846-8270C	830 µg/kg
4-Chloro-3-methylphenol	SW846-8270C	330 µg/kg
2-Chloronaphthalene	SW846-8270C	330 µg/kg
2-Chlorophenol	SW846-8270C	330 µg/kg
4-Chlorophenyl phenyl ether	SW846-8270C	330 µg/kg
Carbazole	SW846-8270C	330 µg/kg
Chrysene	SW846-8270C	330 µg/kg
Dibenz(a,h)anthracene	SW846-8270C	330 µg/kg
Dibenzofuran	SW846-8270C	330 µg/kg
1, 2-Dichlorobenzene	SW846-8270C	330 µg/kg
1, 3-Dichlorobenzene	SW846-8270C	330 µg/kg
1, 4-Dichlorobenzene	SW846-8270C	330 µg/kg
3, 3'-Dichlorobenzidine	SW846-8270C	1700 µg/kg
2, 4-Dichlorophenol	SW846-8270C	330 µg/kg
Diethyl phthalate	SW846-8270C	330 µg/kg
2, 4-Dimethylphenol	SW846-8270C	330 µg/kg
Dimethyl phthalate	SW846-8270C	330 µg/kg
4, 6-Dinitro-2-methylphenol	SW846-8270C	1700 µg/kg
2, 4-Dinitrophenol	SW846-8270C	1700 µg/kg
2, 4-Dinitrotoluene	SW846-8270C	330 µg/kg
2, 6-Dinitrotoluene	SW846-8270C	330 µg/kg
Di-n-octyl phthalate	SW846-8270C	330 µg/kg
Bis(2-ethylhexyl) phthalate	SW846-8270C	330 µg/kg
Fluoranthene	SW846-8270C	330 µg/kg
Fluorene	SW846-8270C	330 µg/kg
Hexachlorobenzene	SW846-8270C	330 µg/kg
Hexachlorobutadiene	SW846-8270C	330 µg/kg
Hexachlorocyclopentadiene	SW846-8270C	330 µg/kg
Hexachloroethane	SW846-8270C	330 µg/kg
Indeno(1,2,3-cd)pyrene	SW846-8270C	330 µg/kg
Isophorone	SW846-8270C	330 µg/kg
2-Methylnaphthalene	SW846-8270C	330 µg/kg
2-Methylphenol	SW846-8270C	330 µg/kg
4-Methylphenol	SW846-8270C	330 µg/kg
Naphthalene	SW846-8270C	330 µg/kg
2-Nitroaniline	SW846-8270C	1700 µg/kg

SVOC	Analytical method	Quantitation level in soils
3-Nitroaniline	SW846-8270C	1700 µg/kg
4-Nitroaniline	SW846-8270C	1700 µg/kg
Nitrobenzene	SW846-8270C	330 µg/kg
2-Nitrophenol	SW846-8270C	330 µg/kg
4-Nitrophenol	SW846-8270C	1700 µg/kg
N-Nitrodiphenylamine	SW846-8270C	330 µg/kg
N-Nitroso-di-n-propylamine	SW846-8270C	330 µg/kg
N-Nitrosodiphenylamine	SW846-8270C	330 µg/kg
Pentachlorophenol	SW846-8270C	1700 µg/kg
Phenanthrene	SW846-8270C	330 µg/kg
Phenol	SW846-8270C	330 µg/kg
Pyrene	SW846-8270C	330 µg/kg
Pyridine	SW846-8270C	330 µg/kg
1,2,4-Trichlorobenzene	SW846-8270C	330 µg/kg
2,3,4,6-Tetrachlorophenol	SW846-8270C	1700 µg/kg
2,4,5-Trichlorophenol	SW846-8270C	330 µg/kg
2,4,6-Trichlorophenol	SW846-8270C	330 µg/kg

µg/kg = micrograms per kilogram
ND = not determined

APPENDIX F
DATA QUALITY OBJECTIVES CHECKLIST

APPENDIX F: DATA QUALITY OBJECTIVES

Waste acceptance criteria used to develop decision rules for the EMWMF are provided in the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria* DOE/OR/01-1909&D3 and the *Waste Acceptance Criteria Attainment Team Project Execution Plan* BJC/OR-1091, Revision 4. The null hypothesis or baseline condition generally applied to the EMWMF decision rules is stated in terms that the waste does not exceed waste acceptance criteria and is acceptable for disposal. The Action Level and the Type I ($\alpha = 0.05$) and Type II ($\beta = 0.20$) decision errors associated with the null hypothesis are thoroughly evaluated for each applicable waste acceptance criteria and are then used to create a statistical-based sample design. The sample design is outlined in detail in *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-3088. The hypothesis test is completed in the Data Quality Assessment phase of the project to verify that the baseline condition remains valid. The following table documents the Data Quality Objectives process used to characterize the waste in this waste lot. Appendix G documents the assessment of the quality of the characterization data.

Table F.1. Waste Lot 4.12 Data Quality Objectives Checklist

1. State the Problem and the Decision (DQO Steps 1 and 2)	
What is the description of the waste?	The waste lot consists of soil, concrete, incidental scrap metal, wood, vegetation, and personal protective equipment generated during soil/concrete sampling events and soil removal action activities at the K-770 Scrap Yard. This waste was assigned EMWMF Waste Lot 4.12
Who needs information about the waste?	The ETPP D&D/RA Project, Environmental Management Waste Management Facility (EMWMF) Waste Acceptance Criteria (WAC) Attainment Team, and EMWMF Operations.
What are the contaminants of interest?	Radiological Parameters, Total/TCLP Metals, Total Volatile Organics, Total/TCLP Semi-Volatile Organics, and individual/Total PCBs.
What decisions need to be made regarding the waste?	The waste must be disposed of at an approved disposal facility. The decision to be made is whether or not the waste lot meets the EMWMF disposal criteria contained in the EMWMF WAC and the Project Execution Plan (BJC/OR-1091). If the waste does not meet EMWMF WAC, the data will be evaluated to satisfy off-site disposal facility WAC.
2. Inputs to the Decision (DQO Step 3)	
What historical data exist?	Radiation walkover surveys and intrusive analytical data collected in the mid-1990s and in late 2004/early 2005. Intrusive biased samples of soil for radiological parameters (primarily U-238 pCi/g concentrations) were used to develop the sampling program. Historical data also exist in a K-770 site summary document (BJC/OR-1296) and a K-725 Beryllium Building site summary document (BJC/OR-1298/D1). These samples were not included in the dataset used to characterize this waste lot because the Project concluded that they were not representative of the final waste form. Additionally, alpha and beta-gamma surveys were conducted to determine if K-770 scrap waste items meet free release criteria.
What process knowledge exists?	Process knowledge included in the approved sample and analysis plan (BJC/OR-3088), the approved K-770 Scrap Yard waste handling plans (DOE/OR-01-2162&D2, DOE/OR-01-2263&D2, and DOE/OR-01-2148&D2), the approved EMWMF profile for the K-770 scrap metal (BJC/OR-1857) as well as other documents used to assemble Appendix B of this profile were used to identify analytes of concern and to determine the number and type of intrusive samples to be collected to support the waste determination.
What additional data must be collected?	Intrusive samples have been collected and analyzed in accordance with the SAP. Analytical data collected in accordance with the SAP are sufficient to adequately characterize the radiological and chemical characteristics for compliance with EMWMF WAC. Dose rate surveys will be collected to support decisions on size reduction, packaging, and transportation. No additional sampling is required.

Table F.1. Waste Lot 4.12 Data Quality Objectives Checklist (cont.)

3. Physical Boundaries to be Considered (DQO Step 4)	
What is the potential contamination?	Radiological, chemical (organics and inorganics).
What consideration affects the number of samples?	Section 4.8 of the SAP provides the basis for sample size determination. Historical U-238 pCi/g data from the late-2004/early-2005 Dynamic Verification Sampling campaign were used to determine number of intrusive radiological and chemical samples, respectively.
Are there any sampling problems?	<p>All samples prescribed in the SAP have been collected and analyzed, with the exception of 1 random composite soil samples that was to be collected for Total VOA analysis. Total VOA data indicate 100% non-detect rate for all VOA constituents, except for 2-Butanone (MEK), Acetone, and Chloroform. Maximum detected results for these VOA constituents is less than 1 mg/kg. Therefore, not collecting the 1 omitted sample has no impact to EMWMP Analytical, Hazard Index, or Administrative WAC.</p> <p>Two samples excluded from Waste Lot 4.12 Controlled Data Set and Data Quality Assessment due to elevated To-99 results. Soils in areas related to these samples have been identified as anomalous waste for Waste Lot 4.12.</p> <p>Np-237 results for one sample and duplicate were rejected due to Relative Percent Difference out of range, possibly due to uranium interference.</p> <p>Select Total VOA, Total SVOA, and PCB samples exhibited multiple results and detection limits due to varying sample dilution factors. Only validated data from Sample Management Organization with appropriate data use flag was used to construct the Waste Lot 4.12 Controlled Data Set and Data Quality Assessment.</p>
Are there other sampling constraints, such as temporal, schedule, or seasonal concerns, regulatory requirements, etc.?	No.

Table F.1. Waste Lot 4.12 Data Quality Objectives Checklist (cont.)

4. Decision Statement and Uncertainty (DQO Steps 5 and 6)	
What are the allowable decision errors	Alpha = 0.05 and beta = 0.20
What are the steps to be taken after the analytical results are received?	The Project Environmental Measurements System database will be used as a repository for sample results. Data generated from this sampling will not be exported to the Oak Ridge Environmental Information System. A turnaround time of 30 days will be requested for analytical results from the laboratories unless accelerated turn-around is approved by the Project Manager. Contract compliance verification and a hardcopy to electronic deliverable comparison will be performed on each data package received from the laboratories. Level 3 validation (quality control summary validation) will be performed on 10% of the data generated from the characterization. [100% of the data were validated.] In addition, BJC project personnel will conduct a limited data assessment on each data package to determine the usability of the results. Waste Management personnel will use the data to construct waste profiles in accordance with the <i>Waste Management Plan for ETP Closure and ETP D&D Projects</i> (BJC 2004a).
5. Develop the Data Sampling Design (DQO Step 7)	
State the type of data to be obtained.	Analytical Support Level 3 data for radiological parameters and organic/inorganic parameters. Level 3 validation (quality control summary validation) will be performed on 10% of the data generated from the characterization. In addition, BJC project personnel will conduct a limited data assessment on each data package to determine the usability of the results
State the approach to sample selection.	Sample design was included in Section 4.8 of the SAP. Visual Sample Plan software was used to determine the sample size based on U-238 data. Systematic random and biased composite soil and concrete samples have been collected for radiological and chemical analyses in accordance with Section Table A.1 of the SAP.
<p>BJC = Bechtel Jacobs Company D&D/RA = Decontamination and Decommissioning/Remedial Action EMWMF = Environmental Management Waste Management Facility ETTP = East Tennessee Technology Park TCLP = Toxicity Characteristic Leachate Procedure WAC = waste acceptance criteria</p>	

APPENDIX G
DATA QUALITY ASSESSMENT

APPENDIX G: DATA QUALITY ASSESSMENT

DQA Summary

Waste Lot 4.12 (titled K-770 Scrap Yard Soils) includes the soils, concrete, and residual metallic/other miscellaneous debris, and secondary generated during the remediation of the K-770 Scrap Yard at the East Tennessee Technology Park. This waste lot profile describes and characterizes this waste for disposal in the Environmental Management Waste Management Facility (EMWMF). The total volume of all waste in Waste Lot 4.12 is approximately 17,000 yd³. This appendix assesses the quality of the data used to characterize the waste in this profile.

Radiation walkdown surveys, process knowledge for debris origin, and historical analytical data were used to establish the baseline for identifying and quantifying the radiological contamination expected to be present in the soil, concrete, and on the miscellaneous debris originating at the K-770 Scrap Yard. The types of radiological contaminants that could be present in K-770 Scrap Yard waste items are Co-60, Cs-137, K-40, Tc-99, Th-228, Th-232, U-234, U-235, and U-238.

Analytical data used to evaluate acceptability of K-770 Scrap Yard Soils profile (Waste Lot 4.12) waste for disposal in the EMWMF are in the controlled data set. To obtain the radiological data, a total of 32 systematic random composite and 13 biased composite samples were collected from K-770 soils that make up Waste Lot 4.12. In addition, 14 systematic random samples were collected from K-770 concrete pads distributed throughout the K-770 Scrap Yard. These analytical data were sufficient for use in establishing the expected pCi/g activity for each radionuclide detected and the values were supported by radiation walkdown surveys and historical Dynamic Verification Sampling data, which established the baseline for characterization activities. Radiological data for two biased composite soil samples (Z1-EU33BW-442 and Z1-EU33BW-445) were excluded from the Controlled Data Set in Appendix C due to elevated Tc-99 pCi/g results that were found to exceed 10 times the EMWMF Carcinogenic waste acceptance criteria (WAC) limit of 172 pCi/g for Tc-99. Soils within these areas have been identified as anomalous waste (see Appendix A of this profile). Therefore, a total of 57 radiological samples are included in the controlled data set and were used in this Data Quality Assessment (DQA).

It is noted that all samples prescribed in the SAP have been collected and analyzed, with the exception of 1 random composite soil sample (Z1-EU29W-401) that was to be collected for Total VOA analysis. Total VOA data indicate 100% non-detect rate for all VOA constituents, except for 2-Butanone (MEK), Acetone, and Chloroform. Maximum detected results for these VOA constituents is less than 1 mg/kg. Therefore, not collecting the 1 omitted sample has no impact to EMWMF Analytical, Hazard Index, or Administrative WAC.

To quantify the chemical (inorganic and organic) contaminants that are associated with Waste Lot 4.12, process knowledge (e.g., Material Safety Data Sheets, historical document reviews, previously approved EMWMF profiles, visual inspections, etc.) and analytical data were used. In general, 32 systematic random composite and 13 biased composite soil samples were submitted for Total/TCLP SVOA analysis, Total/TCLP Metals analysis, and individual/Total PCB analysis. 31 systematic random composite and 13 biased composite soil samples were submitted for Total VOA analysis. In addition, 14 systematic random concrete samples were collected for Total Metals analysis, and individual/Total PCB analysis. Appendix C contains the analytical results from chemical analyses and Appendix B contains the process knowledge used to quantify the chemical contaminants present.

Soil samples collected to characterize this waste lot were not analyzed for the metals strontium and tin. Historical data indicate that these metals may be present in the waste lot soils at very low concentrations. However, for the reasons cited in Appendix B, historical data are not considered reliable and were not

used to quantitatively characterize this waste lot. To characterize these two metals in the soils in this waste lot, the EMWMF Waste Lot 65.1 profile (BJC 2004) was reviewed (see Appendix B). Samples of metallic debris in the scrap yard were analyzed for strontium and tin in the EMWMF Waste Lot 65.1 profile. Strontium was not detected. Based on these results, the Project concluded that strontium was not present in the waste lot soils. Tin was detected in the EMWMF Waste Lot 65.1 profile. Based on these results, the Project concluded that tin was present in the waste lot soils. Tin was quantitatively characterized for this waste lot by incorporating the input values for tin in the Waste Lot 65.1 Waste Acceptance Criteria Forecasting Analysis Capability Systems (WACFACS) in the WACFACS input for this waste lot.

The purpose of the DQA is to identify Site Related Contaminants (SRC), evaluate the usability of the data for the intended purpose, and determine the representative average concentration of each SRC and the associated uncertainties. This information is used to provide inputs to WACFACS so that a Sum of Fractions (SOF) and a Volume Weighted Sum of Fractions (VWSF) for the period FY09-FY11 can be calculated.

The technical approach used to perform the DQA followed guidance provided in the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2001a) and *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (EPA 2000). Where applicable, ProUCL V.4.00.02 Software, and "Upper 95th Confidence Interval Calculations for a PERT Beta PDF" (Redus & Associates) were used for all statistical analyses.

The technical approach of this DQA and the results and conclusions of the evaluation for EMWMF waste acceptance are summarized below.

Technical Approach

The approach used to perform the DQA and to calculate the SOF for Waste Lot 4.12 includes the following:

- Confirm that project SRC data meet data validation/verification requirements and Data Quality Objectives (DQOs)
 - Obtain sample data sets
 - Review the SRC data and confirm all data is verified and properly validated
 - Eliminate reported short-lived (half-life < 2 months) radionuclides, plus those radionuclides not detected from further statistical evaluation.
 - Confirm the SRC data meet the DQOs.
- Conduct a preliminary SRC review
 - Examine statistical parameters (means, variances, coefficients of variation, etc.) and graphical behavior of SRC data to identify suspected anomalies and/or multiple populations based upon either operational interpretation (e.g., nuclide relationships, SRC impacts to the analytic WAC based on activity values, and expected mean based on statistical distribution outcome) or statistical interpretation (e.g., SRC sample result is many times larger than median of all observations).
- Select appropriate statistical tests

- Apply suitable transformations of data (e.g., use detection limit as proxy value for all negative values if statistical analysis is performed on natural logarithms of SRC data)
 - Perform Goodness-of-Fit (GOF) tests using the Shapiro-Wilk test statistic (or other appropriate statistical test) to identify the underlying probability density function that describes the mean concentration of each SRC (BJC 2001)
 - Perform statistical analysis techniques, as required, to identify SRCs that exhibit marked outliers or unusual variation.
- Verify assumptions
 - Examine data to confirm sampling requirements/DQOs followed (DOE 2001)
 - Confirm random samples were obtained.
 - Draw conclusions
 - Determine GOF for SRCs
 - Complete WACFACS inputs.

Summary of Results

Radiological and organic/inorganic chemical data associated with the waste are presented in Sections 3 and 4 of the profile, including all other SRCs (as discussed in DOE 2001a), that were eliminated by Process Knowledge.

Waste Lot 4.12 K-770 Scrap Yard Soils – Appendix G, Site Related Contaminant (SRC) Elimination Listing		
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Chemical Name	Units	SRC Elimination Justification
1,1,1-Trichloroethane	ug/kg	100% Non-detect rate
1,1,2,2-Tetrachloroethane	ug/kg	100% Non-detect rate
1,1,2-Trichloroethane	ug/kg	100% Non-detect rate
1,1-Dichloroethane	ug/kg	100% Non-detect rate
1,1-Dichloroethene	ug/kg	100% Non-detect rate
1,2,4-Trichlorobenzene	ug/kg	100% Non-detect rate
1,2-Dichlorobenzene	ug/kg	100% Non-detect rate
1,2-Dichloroethane	ug/kg	100% Non-detect rate
1,2-Dichloroethene	ug/kg	100% Non-detect rate
1,2-Dichloropropane	ug/kg	100% Non-detect rate
1,3-Dichlorobenzene	ug/kg	100% Non-detect rate
1,4-Dichlorobenzene	ug/kg, mg/L	100% Non-detect rate
2,3,4,6-Tetrachlorophenol	ug/kg	100% Non-detect rate
2,4,5-T		Process Knowledge
2,4,5-Trichlorophenol	ug/kg, mg/L	100% Non-detect rate
2,4,6-Trichlorophenol	ug/kg, mg/L	100% Non-detect rate
2,4-D		Process knowledge
2,4-Dichlorophenol	ug/kg	100% Non-detect rate
2,4-Dimethylphenol	ug/kg	<5% detects and < 2x DL
2,4-Dinitrophenol	ug/kg	100% Non-detect rate
2,4-Dinitrotoluene	ug/kg, mg/L	100% Non-detect rate

**Waste Lot 4.12 K-770 Scrap Yard Soils – Appendix G, Site Related
Contaminant (SRC) Elimination Listing**

Chemical Name	Units	SRC Elimination Justification
2,6-Dinitrotoluene	ug/kg	100% Non-detect rate
2-Chloronaphthalene	ug/kg	100% Non-detect rate
2-Chlorophenol	ug/kg	100% Non-detect rate
2-Hexanone	ug/kg	<20% J-flagged
2-Methyl-4,6-dinitrophenol	ug/kg	100% Non-detect rate
2-Methylphenol	mg/L	100% Non-detect rate
2-Methylphenol	ug/kg	<20% J-flagged
2-Nitrobenzenamine	ug/kg	100% Non-detect rate
2-Nitrophenol	ug/kg	100% Non-detect rate
3,3'-Dichlorobenzidine	ug/kg	100% Non-detect rate
3-Nitrobenzenamine	ug/kg	100% Non-detect rate
3 & 4-Methylphenol	mg/L	100% Non-detect rate
4-Bromophenyl phenyl ether	ug/kg	100% Non-detect rate
4-chlorobenzamine	ug/kg	100% Non-detect rate
4-chloro-3-methylphenol	ug/kg	100% Non-detect rate
4-Chlorophenyl phenyl ether	ug/kg	100% Non-detect rate
4-Methyl-2-pentanone (Methyl Isobutyl Ketone)	ug/kg	100% Non-detect rate
4-Nitrobenzamine	ug/kg	100% Non-detect rate
4-Nitrophenol	ug/kg	100% Non-detect rate
Ac-228	pCi/g	Th-232 Decay Series Daughter
Aldrin		Process Knowledge
Alpha activity	pCi/g	Total Alpha activity reference only
alpha-BHC		Process Knowledge
Aniline	ug/kg	100% Non-detect rate
Antimony	ug/L	Not in Admin/Analytic/ASA WAC
Arsenic	ug/L	100% Non-detect rate
Benzene	ug/kg	<20% J-flagged
Benzenemethanol	ug/kg	100% Non-detect rate
Beta activity	pCi/g	Total Beta Activity reference only
beta-BHC		Process Knowledge
Bi-214	pCi/g	U-238 Decay Series Daughter
Bis(2-chloroethoxy)methane	ug/kg	100% Non-detect rate
Bis(2-chloroethyl) ether	ug/kg	100% Non-detect rate
Bis(2-chloroisopropyl) ether	ug/kg	100% Non-detect rate
Bromodichloromethane	ug/kg	100% Non-detect rate
Bromoform	ug/kg	100% Non-detect rate
Bromomethane	ug/kg	100% Non-detect rate
Carbon disulfide	ug/kg	100% Non-detect rate
Carbon tetrachloride	ug/kg	100% Non-detect rate
Chlordane		Process Knowledge
Chlorobenzene	ug/kg	100% Non-detect rate
Chloroethane (Ethylchloride)	ug/kg	100% Non-detect rate
Chloroform	ug/kg	<20% J-flagged
Chloromethane	ug/kg	100% Non-detect rate
cis-1,2-Dichloroethene	ug/kg	100% Non-detect rate

**Waste Lot 4.12 K-770 Scrap Yard Soils – Appendix G, Site Related
Contaminant (SRC) Elimination Listing**

Chemical Name	Units	SRC Elimination Justification
cis-1,3-Dichloropropene	ug/kg	100% Non-detect rate
Cyanide		Process Knowledge
DDD		Process Knowledge
DDE		Process Knowledge
delta-BHC		Process Knowledge
Dibromochloromethane	ug/kg	100% Non-detect rate
Dieldrin		Process Knowledge
Diethyl phthalate	ug/kg	100% Non-detect rate
Dimethyl phthalate	ug/kg	<20% J-flagged
Endrin		Process Knowledge
Endrin Aldehyde		Process Knowledge
Endrin Ketone		Process Knowledge
Endosulfan and Metabolites		Process Knowledge
Ethylbenzene	ug/kg	<20% J-flagged
Heptachlor		Process Knowledge
Heptachlor Epoxide		Process Knowledge
Hexachlorobenzene	mg/L	100% Non-detect rate
Hexachlorobenzene	ug/kg	<20% J-flagged
Hexachlorobutadiene	ug/kg, mg/L	100% Non-detect rate
Hexachlorocyclopentadiene	ug/kg	100% Non-detect rate
Hexachloroethane	ug/kg, mg/L	100% Non-detect rate
Isophorone	ug/kg	100% Non-detect rate
Lindane		Process Knowledge
Lead-212	pCi/g	Th-232 Decay Series Daughter
Lead-214	pCi/g	U-238 Decay Series Daughter
Methylene chloride	ug/kg	Laboratory Contaminant, 100% Non-detect rate
Np-237	pCi/g	<20% J-flagged
Nitrobenzene	ug/kg, mg/L	100% Non-detect rate
N-Nitroso-di-n-propylamine	ug/kg	100% Non-detect rate
N-Nitrosodiphenylamine	ug/kg	100% Non-detect rate
PCB-1016	ug/kg	100% Non-detect rate
PCB-1221	ug/kg	100% Non-detect rate
PCB-1232	ug/kg	100% Non-detect rate
PCB-1242	ug/kg	100% Non-detect rate
Pentachlorophenol	ug/kg, mg/L	100% Non-detect rate
Pa-234m	pCi/g	U-238 Decay Series Daughter
Pyridine	ug/kg, mg/L	100% Non-detect rate
Ra-226	pCi/g	U-238 Decay Series Daughter
Selenium	ug/L	100% Non-detect rate
Silver	ug/L	<5% detects and < 2x DL
Strontium		Process Knowledge- non-detect in Waste Lot 65.1 profile
Styrene	ug/kg	100% Non-detect rate
Tetrachloroethene	ug/kg	<20% J-flagged
Thallium	mg/kg	<5% detects and < 2x DL

**Waste Lot 4.12 K-770 Scrap Yard Soils – Appendix G, Site Related
Contaminant (SRC) Elimination Listing**

Chemical Name	Units	SRC Elimination Justification
Tl-208	pCi/g	Th-232 Decay Series Daughter
Th-230	pCi/g	U-238/U-234 Decay Series Daughter Th-232 + Daughter Reference
Th-232 Corrected	pCi/g	Information Only
Th-234	pCi/g	U-238 Decay Series Daughter
Toluene	ug/kg	<20% I-flagged
Total Xylene	ug/kg	<20% I-flagged
trans-1,2-Dichloroethene	ug/kg	100% Non-detect rate
trans-1,3-Dichloropropene	ug/kg	100% Non-detect rate
Trichloroethene	ug/kg	100% Non-detect rate
Vinyl chloride	ug/kg	100% Non-detect rate

The WACFACS Input Sheet, SRC Summary Statistic Spreadsheet, computer generated output sheets, and the individual SRC mean calculation spreadsheets, included in this appendix, plus Sections 3 and 4 of the profile package provide summary statistics for the Analytic WAC and the Auditable Safety Analysis SRCs. The expected concentration and the UCL₉₅ for the expected concentration of the SRCs are calculated based on the results of the GOF tests. The results are summarized in the WACFACS Input Sheet (Appendix H), SRC Summary Statistic Spreadsheet (Appendix G), Table 6 (Section 3.0) and Tables 7 and 8 in Section 4.1 and 4.2, respectively, of the profile package.

Sum of Fractions For Waste Lot 4.12

The following information is provided for Waste Lot 4.12, K-770 Scrap Yard Soils profile for the 3-year window FY09 – FY11 as calculated by WACFACS, Version 1.0, Q1 FY08 Rev 08-05.

Waste Lot 4.12 Carcinogenic SOF
E (Waste Lot 4.12 Carcinogenic SOF) = 0.668

Waste Lot 4.12 HI SOF
E (Waste Lot 4.12 HI SOF) = 0.172

The information contained in the WACFACS Input Sheet will be provided in this profile for the UCL₉₅ (WL 4.12 Carcinogenic SOF) and UCL₉₅ (Waste Lot 4.12 HI SOF) to be calculated by WACFACS, Version 1.0, Q1 FY08 Rev 08-05. The output information will be included in Appendix H for reference.

Volume Weighted Sum of Fractions For Waste Lot 4.12

The information contained in the WACFACS Input Sheet will be provided for Waste Lot 4.12, K-770 Scrap Yard Soils Profile in order for the 3-year window FY09 – FY11 to be calculated by WACFACS, Version 1.0, Q1 FY08 Rev 08-05. The output information will be included in Appendix H for reference.

REFERENCES

- BJC (Bechtel Jacobs Company LLC) 2004. *Waste Profile for: Disposal of the Scrap Metal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1857, Rev. 1, Bechtel Jacobs Company LLC, Oak Ridge, TN, July.
- BJC 2001. Implementation Plan and User's Guide for the Waste Acceptance Criteria Forecasting and Analysis Capability System (WACFACS) Version 1.0, BJC/OR-1089.
- DOE (US Department of Energy) 2001. Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee, DOE/OR/01-1909&D3.
- EPA (US Environmental Protection Agency) 2000. Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, EPA/600/R-96/084 (QA00 Update), July 2000.

**WL 4.12 K-77 Scrap Yard Soils
EMWMF SRC Summary Statistics**

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	E(X)	UCL95	HI SOF	CA SOF
Cs-137	pCi/g	57	33	0.030	0.190	28.600	0.79	B			4.90	13.07		
Co-60	pCi/g	57	5	0.030	0.080	1.870	0.13	LN	-2.426	0.748	0.12	0.14		
K-40	pCi/g	57	57	1.380	10.200	16.800	9.77	B			9.83	14.45		
Tc-99	pCi/g	57	37	1.290	4.310	629.000	20.26	B			107.92	287.20		0.627
Th-228	pCi/g	57	57	0.240	1.090	3.530	1.09	N		0.666	1.09	1.24		
Th-232	pCi/g	57	57	0.200	0.990	3.330	1.00	N		0.574	1.00	1.13		
U-233/234	pCi/g	57	56	0.110	10.200	1360.000	39.45	LN	2.061	1.626	29.50	54.43	0.000	0.017
U-235	pCi/g	57	44	0.050	1.080	185.000	5.07	LN	-0.120	1.647	3.44	8.45	0.000	0.002
U-238	pCi/g	57	57	0.430	7.650	1150.000	33.45	LN	1.841	1.659	25.00	47.09	0.017	0.021
Aluminum	mg/kg	57	57	4400.000	12300.000	21400.000	12261.05	B			12500.00	17657.28		
Antimony	mg/kg	57	35	0.115	0.500	65.100	2.01	B			11.20	29.79	0.070	
Arsenic	mg/kg	57	57	2.900	6.600	18.400	7.27	LN	1.889	0.437	7.28	8.10		
Barium	mg/kg	57	57	31.300	71.500	395.000	80.37	B			118.72	231.67	0.001	
Barium	mg/L	43	43	0.223	0.531	1.770	0.64	LN	-0.597	0.548	0.64	0.75		
Beryllium	mg/kg	57	57	0.140	0.400	1.800	0.43	B			0.59	1.12		
Boron	mg/kg	57	57	1.900	5.900	39.100	7.43	LN	1.798	0.825	7.34	8.64	0.000	
Cadmium	mg/kg	57	54	0.020	0.750	14.200	1.52	LN	-0.525	1.562	2.01	3.56		
Cadmium	mg/L	43	25	0.002	0.008	0.096	0.015	B			0.020	0.05		
Calcium	mg/kg	57	57	1860	58200	254000	79296	B			81443.33	162846.39		
Chromium	mg/kg	57	57	9.700	26.000	2880.000	102.74	B			498.95	1319.51	0.004	
Chromium	mg/L	43	7	0.002	0.006	0.030	0.01	B			0.01	0.02		
Cobalt	mg/kg	57	57	1.500	9.000	41.900	9.04	B			13.23	26.16		
Copper	mg/kg	57	57	3.500	83.000	4780.000	284.53	LN	4.226	1.722	301.00	592.50		
Iron	mg/kg	57	57	4630.000	24700.000	155000.000	27793.51	B			43071.87	90299.55		
Lead	mg/kg	57	57	2.900	36.600	733.000	60.60	LN	3.380	1.279	66.50	97.11	0.044	
Lead	mg/L	43	11	0.009	0.017	0.599	0.04	B			0.11	0.28		
Lithium	mg/kg	57	57	5.300	12.300	68.000	14.89	B			20.42	39.90		
Magnesium	mg/kg	57	57	1060.000	6350.000	73800.000	14335.61	LN	8.918	1.160	14600.00	38631.00		
Manganese	mg/kg	57	57	59.200	496.000	2210.000	618.75	LN	6.192	0.734	640.00	781.20	0.002	
Mercury	mg/kg	57	46	0.0050	0.360	4.400	0.88	LN	-1.628	2.468	4.13	7.80		
Mercury	mg/L	43	6	3.000E-05	3.000E-05	1.500E-04	4.000E-05	B			5.000E-05	8.410E-05		
Molybdenum	mg/kg	57	57	0.690	2.700	69.200	5.56	B			13.45	33.51	0.003	
Nickel	mg/kg	57	57	4.200	48.900	1700.000	127.18	LN	3.814	1.478	135.00	220.10		
Potassium	mg/kg	57	57	482.000	838.000	1940.000	880.44	B			962.330	1434.51		
Selenium	mg/kg	57	12	0.230	0.275	25.700	0.82	B			4.51	11.75	0.003	
Silver	mg/kg	57	25	0.040	0.050	1.400	0.24	B			0.27	0.66		
Sodium	mg/kg	57	50	0.750	75.400	481.000	124.410	LN	3.933	1.960	349.000	418.700		
Tin	mg/kg	42	14	15.500	23.200	232.000	37.400	B			56.700	120.000	0.026	
Vanadium	mg/kg	57	57	8.000	21.800	52.900	22.29	N		9.428	22.29	24.38	0.001	
Zinc	mg/kg	57	57	9.300	110.000	1040.000	186.21	LN	4.667	1.139	203.00	571.60		
PCB-1248	mg/kg	57	6	0.008	0.110	13.000	1.77	B			2.24	5.96		

**WL 4.12 K-77C Scrap Yard Soils
EMWMF SRC Summary Statistics**

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	E(X)	UCL95	HI SOF	CA SOF
PCB-1254	mg/kg	57	46	0.008	0.39	7.30	1.35	B			1.48	3.66		
PCB-1260	mg/kg	57	43	0.006	0.20	2.80	0.49	B			0.60	1.45		
Total PCBs	mg/kg	57	46	0.024	0.590	23.000	3.58	B			4.23	10.90		
2-Butanone	mg/kg	42	14	0.000	0.006	0.045	0.01	B			0.01	0.02		
2-Methylnaphthalene	mg/kg	43	30	0.020	0.071	0.300	0.10	B			0.10	0.19	0.000	
3 & 4 Methylphenol	mg/kg	43	4	0.019	0.190	0.580	0.19	B			0.23	0.41	0.001	
Acenaphthene	mg/kg	43	14	0.019	0.185	1.200	0.17	B			0.33	0.70	0.000	
Acenaphthylene	mg/kg	43	5	0.019	0.190	0.205	0.17	B			0.16	0.20	0.000	
Acetone	mg/kg	42	31	0.004	0.026	0.260	0.06	B			0.06	0.14	0.000	
Anthracene	mg/kg	43	25	0.019	0.110	3.200	0.19	B			0.61	1.54		
Benzo(a)anthracene	mg/kg	43	37	0.024	0.160	10.000	0.37	B			1.78	4.65		
Benzo(a)pyrene	mg/kg	43	39	0.021	0.150	8.200	0.33	B			1.47	3.83		
Benzo(b)fluoranthene	mg/kg	43	39	0.024	0.140	7.400	0.31	B			1.33	3.46		
Benzo(ghi)perylene	mg/kg	43	39	0.035	0.140	5.500	0.26	B			1.02	2.60		
Benzo(k)fluoranthene	mg/kg	43	38	0.025	0.150	8.000	0.32	B			1.44	3.74		
Benzoic Acid	mg/kg	43	17	0.022	0.185	0.290	0.15	B			0.18	0.25	0.000	
Bis(2-ethylhexyl)phthalate	mg/kg	43	11	0.180	0.200	140.000	3.65	B			23.50	63.20		
Butyl benzyl phthalate	mg/kg	43	5	0.026	0.190	14.000	0.50	B			2.46	6.49		
Carbazole	mg/kg	43	16	0.021	0.190	1.100	0.16	B			0.31	0.66		0.000
Chrysene	mg/kg	43	39	0.020	0.160	9.700	0.38	B			1.73	4.52		
Dibenz(a,h)anthracene	mg/kg	43	27	0.019	0.080	2.200	0.16	B			0.42	1.06		
Dibenzofuran	mg/kg	43	17	0.021	0.185	0.520	0.14	B			0.21	0.38		
Di-n-octylphthalate	mg/kg	43	3	0.027	0.190	0.590	0.19	B			0.23	0.41		
Fluoranthene	mg/kg	43	39	0.025	0.180	26.000	0.83	B			4.46	11.90		
Fluorene	mg/kg	43	10	0.021	0.190	1.200	0.19	B			0.33	0.70		
Indeno(1,2,3-cd)pyrene	mg/kg	43	38	0.024	0.120	5.000	0.23	B			0.92	2.36		
Naphthalene	mg/kg	43	21	0.019	0.180	0.205	0.12	B			0.16	0.20	0.000	
Phenanthrene	mg/kg	43	38	0.029	0.170	11.000	0.45	B			1.95	5.11		
Phenol	mg/kg	43	7	0.023	0.190	1.100	0.19	B			0.31	0.66	0.000	
Pyrene	mg/kg	43	39	0.021	0.195	16.000	0.61	B			2.80	7.39		

Notes:

SRC = Site Related Contaminant

PDF = Probability Density Function

LN = Lognormal, N = Normal, B = PERT Beta

Standard Deviation = Standard deviation from arithmetic mean for Normal distributions and standard deviation from log transformed mean for Lognormal distributions.

N = Number of Samples

pCi/g = picoCurie/gram

mg/kg = milligram/kilogram

E(X) = Expected Concentration in Waste Lot

UCL95 = 95% Upper Confidence Limit on the Mean

0.172 0.688

Statistical Summary for Cs-137 pCv/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU299W-410	B	REG	0.09 U		U	0.18	0.18	-1.832581484
Z1-EU299W-401	S	REG	0.22		=	0.04	0.22	-1.814127733
Z1-EU299W-402	S	REG	0.08 J		U	0.09	0.09	-2.407945609
Z1-EU299W-403	S	REG	3.48		=	0.08	3.48	1.347032254
Z1-EU299W-404	S	REG	0.39		=	0.06	0.39	0.94160854
Z1-EU299W-406 + Dup	S	REG	0.1 J		J	0.05	0.1	-2.302585093
Z1-EU299W-406	S	REG	0.02 U		U	0.09	0.09	-2.407945609
Z1-EU299W-407	S	REG	0.22		=	0.08	0.22	-1.814127733
Z1-EU299W-408	S	REG	0.09 U		U	0.1	0.1	-2.302585093
Z1-EU299W-409	S	REG	0.11 J		J	0.06	0.11	-2.207274913
Z1-EU300W-411	B	REG	2.05		=	0.05	2.05	0.717836793
Z1-EU300C-444	C	REG	0 U		U	0.04	0.04	-3.218875825
Z1-EU300C-446	C	REG	-0.01 U L		U	0.03	0.03	-3.80657897
Z1-EU300C-446	C	REG	-0.02 U L		U	0.04	0.04	-3.218875825
Z1-EU300C-447	C	REG	0.01 U		U	0.04	0.04	-3.218875825
Z1-EU300C-448 + Dup	C	REG	0.15		=	0.03	0.15	-1.897119985
Z1-EU300C-449	C	REG	0.04 J		U	0.04	0.04	-3.218875825
Z1-EU300C-450	C	REG	-0.01 U L		U	0.04	0.04	-3.218875825
Z1-EU300C-451	C	REG	0 U		U	0.03	0.03	-3.80657897
Z1-EU300C-452	C	REG	0 U		U	0.04	0.04	-3.218875825
Z1-EU300C-453	C	REG	0.02 U		U	0.04	0.04	-3.218875825
Z1-EU300C-454	C	REG	0.03 U		U	0.03	0.03	-3.506557897
Z1-EU310W-416	B	REG	0.14 J		J	0.17	0.14	-1.895112255
Z1-EU310W-416	B	REG	0.09 U		U	0.26	0.26	-1.347073648
Z1-EU310W-417	B	REG	0.42		=	0.1	0.42	-0.867500568
Z1-EU310W-412	S	REG	0.28		=	0.12	0.28	-1.272985676
Z1-EU310W-413	S	REG	0.06 J		J	0.08	0.08	-2.826728544
Z1-EU310W-414	S	REG	0.07 J		U	0.07	0.07	-2.559260037
Z1-EU320W-431	B	REG	0.74		=	0.28	0.74	-0.301105053
Z1-EU320W-432	B	REG	0.32		=	0.09	0.32	-1.139434283
Z1-EU320W-433 + Dup	B	REG	0.74 J		U	0.55	0.74	-0.301105053
Z1-EU320W-434	B	REG	0.12		=	0.05	0.12	-2.120268598
Z1-EU320C-455	C	REG	0.01 U		U	0.04	0.04	-3.218875825
Z1-EU320C-456	C	REG	-0.01 U L		U	0.04	0.04	-3.218875825
Z1-EU320W-420	S	REG	0.18 J		J	0.14	0.18	-1.714798438
Z1-EU320W-425	S	REG	0.29		=	0.09	0.29	-1.237874356
Z1-EU320W-416	S	REG	0.24		J	0.12	0.24	-1.427118366
Z1-EU320W-419 + Dup	S	FR	0.38		J	0.08	0.38	-0.967584028
Z1-EU320W-421	S	REG	0.64		=	0.1	0.64	-0.446287103
Z1-EU320W-422	S	REG	0.28		=	0.08	0.28	-1.272985676
Z1-EU320W-423	S	REG	28.6		=	0.13	28.6	3.353406718
Z1-EU320W-424	S	REG	0.08 U		U	0.23	0.23	-1.45867597
Z1-EU320W-426	S	REG	0.15 J		J	0.09	0.15	-1.4077119885
Z1-EU320W-427	S	REG	0.02 U		U	0.14	0.14	-1.966112856
Z1-EU320W-428	S	REG	0.08 U		U	0.21	0.21	-1.850847748
Z1-EU320W-429	S	REG	0.21		=	0.09	0.21	-1.560647748
Z1-EU320W-430	S	REG	0.24		=	0.08	0.24	-1.427118366
Z1-EU330W-443	B	REG	0.11 J		J	0.1	0.11	-2.207274913
Z1-EU330W-444	B	REG	0.04 U		U	0.19	0.19	-1.660731207
Z1-EU330C-457	C	REG	0.01 U		U	0.03	0.03	-3.506557897
Z1-EU330W-435	S	REG	-0.01 U L		U	0.19	0.19	-1.660731207
Z1-EU330W-436	S	REG	0.2		=	0.07	0.2	-1.609437912
Z1-EU330W-437	S	REG	0.2		=	0.08	0.2	-1.609437912
Z1-EU330W-438	S	REG	0.33		=	0.15	0.33	-1.108862626
Z1-EU330W-439	S	REG	0.27		=	0.09	0.27	-1.30803382
Z1-EU330W-440	S	REG	0.28		=	0.06	0.28	-1.347073648
Z1-EU330W-441	S	REG	0.85		=	0.06	0.85	-0.162518929

Number of Samples 57
Number of Defects 33

Minimum- 0.03
Median 0.19
Maximum 28.6
Average 0.7929825
Standard Deviation 3.7856453

PERT-Beta Mean 4.8983333

Lognormal Mean -1.774201
Lognormal Standard Deviation 1.263908

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Cs-137 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	33
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Raw Statistics

Minimum	0.03
Maximum	28.6
Mean	0.793
Median	0.19
SD	3.786
Coefficient of Variation	4.774
Skewness	7.337

Log-transformed Statistics

Minimum of Log Data	-3.507
Maximum of Log Data	3.353
Mean of log Data	-1.774
SD of log Data	1.264

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic	0.441
Lilliefors Critical Value	0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic	0.125
Lilliefors Critical Value	0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	1.632
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	2.138
95% Modified-t UCL	1.713

Assuming Lognormal Distribution

95% H-UCL	0.556
95% Chebyshev (MVUE) UCL	0.708
97.5% Chebyshev (MVUE) UCL	0.855
99% Chebyshev (MVUE) UCL	1.143

Gamma Distribution Test

k star (bias corrected)	0.412
Theta Star	1.923
nu star	47

Approximate Chi Square Value (.05)	32.27
Adjusted Level of Significance	0.0458
Adjusted Chi Square Value	31.95

Anderson-Darling Test Statistic	7.842
Anderson-Darling 5% Critical Value	0.834
Kolmogorov-Smirnov Test Statistic	0.315
Kolmogorov-Smirnov 5% Critical Value	0.126

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	1.618
95% Jackknife UCL	1.632
95% Standard Bootstrap UCL	1.586
95% Bootstrap-t UCL	9.632
95% Hall's Bootstrap UCL	5.097
95% Percentile Bootstrap UCL	1.765
95% BCA Bootstrap UCL	2.413
95% Chebyshev(Mean, Sd) UCL	2.979
97.5% Chebyshev(Mean, Sd) UCL	3.924
99% Chebyshev(Mean, Sd) UCL	5.782

Assuming Gamma Distribution

95% Approximate Gamma UCL	1.155
95% Adjusted Gamma UCL	1.166

Potential UCL to Use	Use 97.5% Chebyshev (Mean, Sd) UCL	3.924
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Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Radus, 865.483.2715

www.radus.com

12/29/2006

R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

WACFACS WLL SRC INPUT					Calculations							
		STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
	SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Cs-137 (pCi/g)		0.0300	0.1900	28.8000	4.90	13.07	2.67	13.07	1.02	4.99	19.8699	28.8

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - \text{MIN})^{\alpha_1 - 1} (\text{MAX} - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (\text{MAX} - \text{MIN})^{\alpha_1 + \alpha_2 - 1}} \quad \text{MIN} < \text{Mostlikely} < \text{MAX}$$

$$F(x) = \frac{B_1(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{\text{MIN} + 4 \times \text{Most Likely} + \text{MAX}}{6}$$

$$\text{Var}(x) = \frac{(E(x) - \text{MIN}) \times (\text{MAX} - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - \text{MIN}}{\text{MAX} - \text{MIN}} \right]$$

$$\alpha_2 = 6 \times \left[\frac{\text{MAX} - E(x)}{\text{MAX} - \text{MIN}} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function.
 α_1 and α_2 are calculated parameters.

Use the Microsoft Excel 2003 function **BETAINV(0.95, α_1 , α_2 , MIN, MAX)** to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Co-60 pCi/g

Location ID	Sample		Result		Validation	Detection		Proxy Value	LN Proxy Value
	Lot	Type	Result	Qualifier		Limit	Proxy Value		
Z1-EU29W-410	B	REG	-0.04	U L	U	0.13	0.13	-2.040220429	
Z1-EU29W-401	S	REG	0	U	U	0.05	0.05	-2.698732374	
Z1-EU29W-402	S	REG	0.01	U	U	0.07	0.07	-2.859260037	
Z1-EU29W-403	S	REG	-0.03	U L	U	0.06	0.06	-2.813410717	
Z1-EU29W-404	S	REG	0.03	U	U	0.06	0.06	-2.813410717	
Z1-EU29W-405 + Dup	S	FR	0.03	U	U	0.06	0.06	-2.813410717	
Z1-EU29W-406	S	REG	0	U	U	0.09	0.09	-2.407946609	
Z1-EU29W-407	S	REG	-0.01	U L	U	0.07	0.07	-2.859260037	
Z1-EU29W-408	S	REG	-0.01	U L	U	0.09	0.09	-2.407946609	
Z1-EU29W-409	S	REG	0.01	U	U	0.06	0.06	-2.813410717	
Z1-EU30BW-411	B	REG	0.01	U	U	0.06	0.06	-2.813410717	
Z1-EU30C-444	C	REG	0.01	U	U	0.04	0.04	-3.218875825	
Z1-EU30C-445	C	REG	-0.01	U L	U	0.03	0.03	-3.508557897	
Z1-EU30C-446	C	REG	-0.01	U L	U	0.04	0.04	-3.218875825	
Z1-EU30C-447	C	REG	-0.01	U L	U	0.04	0.04	-3.218875825	
Z1-EU30C-448 + Dup	C	REG	0.01	U	U	0.04	0.04	-3.218875825	
Z1-EU30C-449	C	REG	-0.02	U L	U	0.04	0.04	-3.218875825	
Z1-EU30C-450	C	REG	0.01	U	U	0.04	0.04	-3.218875825	
Z1-EU30C-451	C	REG	0	U	U	0.04	0.04	-3.218875825	
Z1-EU30C-452	C	REG	0.02	U L	U	0.09	0.09	-2.508557897	
Z1-EU30C-453	C	REG	0	U	U	0.04	0.04	-3.218875825	
Z1-EU30C-454	C	REG	0.02	U	U	0.04	0.04	-3.218875825	
Z1-EU31BW-415	B	REG	-0.02	U L	U	0.13	0.13	-2.040220429	
Z1-EU31W-416	B	REG	-0.1	U L	U	0.19	0.19	-1.660731207	
Z1-EU31W-417	B	REG	0	U	U	0.11	0.11	-2.207274913	
Z1-EU31W-418	S	REG	-0.01	U L	U	0.18	0.18	-1.714798428	
Z1-EU31W-419	S	REG	-0.06	U L	U	0.07	0.07	-2.659260037	
Z1-EU31W-414	S	REG	-0.02	U L	U	0.06	0.06	-2.813410717	
Z1-EU32BW-431	B	REG	1.87		=	0.16	1.87	0.625938431	
Z1-EU32BW-432	B	REG	0.31		=	0.19	0.31	-1.171182982	
Z1-EU32BW-433 + Dup	B	REG	-0.05	U L	U	0.3	0.3	-1.203972604	
Z1-EU32BW-434	B	REG	0.02	U	U	0.07	0.07	-2.659260037	
Z1-EU32C-456	C	REG	-0.01	U L	U	0.04	0.04	-3.218875825	
Z1-EU32C-456	C	REG	0.03	U	U	0.04	0.04	-3.218875825	
Z1-EU32W-420	S	REG	0.05	U	U	0.18	0.18	-1.714798428	
Z1-EU32W-426	S	REG	0.02	U	U	0.1	0.1	-2.302585093	
Z1-EU32W-418	S	REG	0.03	U	U	0.12	0.12	-2.120263536	
Z1-EU32W-419 + Dup	S	FR	0.2		J	0.09	0.2	-1.609437912	
Z1-EU32W-421	S	REG	0.04	U	U	0.13	0.13	-2.040220429	
Z1-EU32W-422	S	REG	0.17		=	0.09	0.17	-1.771956942	
Z1-EU32W-423	S	REG	0.09	J	U	0.14	0.14	-1.964112856	
Z1-EU32W-424	S	REG	0.09	U	U	0.23	0.23	-1.48967597	
Z1-EU32W-425	S	REG	-0.04	U L	U	0.1	0.1	-2.302585093	
Z1-EU32W-427	S	REG	0.12	J	U	0.18	0.16	-1.897113986	
Z1-EU32W-428	S	REG	0.03	U	U	0.2	0.2	-1.609437912	
Z1-EU32W-429	S	REG	0	U	U	0.09	0.09	-2.407946609	
Z1-EU32W-430	S	REG	-0.01	U L	U	0.08	0.08	-2.525729844	
Z1-EU33BW-449	B	REG	0.01	U	U	0.08	0.08	-2.625729844	
Z1-EU33W-444	B	REG	0.24	J	J	0.19	0.24	-1.427118366	
Z1-EU33C-467	C	REG	0	U	U	0.03	0.03	-3.508557897	
Z1-EU33W-436	S	REG	-0.01	U L	U	0.19	0.16	-1.714798428	
Z1-EU33W-438	S	REG	0.04	U	U	0.1	0.1	-2.302585093	
Z1-EU33W-437	S	REG	-0.01	U L	U	0.09	0.09	-2.625729844	
Z1-EU33W-436	S	REG	-0.08	U L	U	0.12	0.12	-2.120263536	
Z1-EU33W-439	S	REG	0.06	J	U	0.1	0.1	-2.302585093	
Z1-EU33W-440	S	REG	0.01	U	U	0.07	0.07	-2.659260037	
Z1-EU33W-441	S	REG	0.01	U	U	0.1	0.1	-2.302585093	

Number of Samples	57
Number of Detects	5
Minimum	0.03
Median	0.09
Maximum	1.87
Average	0.1329825
Standard Deviation	0.2436258
PERT-Beta Mean	0.37
Lognormal Mean	-2.426085
Lognormal Standard Deviation	0.7482546

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheetWst1

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Co-60 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	22
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Raw Statistics

Minimum	0.03
Maximum	1.87
Mean	0.133
Median	0.08
SD	0.244
Coefficient of Variation	1.832
Skewness	6.703

Log-transformed Statistics

Minimum of Log Data	-3.507
Maximum of Log Data	0.826
Mean of log Data	-2.426
SD of log Data	0.748

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic	0.336
Lilliefors Critical Value	0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic	0.101
Lilliefors Critical Value	0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.187
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	0.217
95% Modified-t UCL	0.192

Assuming Lognormal Distribution

95% H-UCL	0.144
95% Chebyshev (MVUE) UCL	0.172
97.5% Chebyshev (MVUE) UCL	0.196
99% Chebyshev (MVUE) UCL	0.243

Gamma Distribution Test

k star (bias corrected)	1.306
Theta Star	0.102
nu star	148.9
Approximate Chi Square Value (.05)	121.7
Adjusted Level of Significance	0.0458
Adjusted Chi Square Value	121.1

Data Distribution

Data appear Lognormal at 5% Significance Level

Anderson-Darling Test Statistic	2.866
Anderson-Darling 5% Critical Value	0.771
Kolmogorov-Smirnov Test Statistic	0.159
Kolmogorov-Smirnov 5% Critical Value	0.12

Data not Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	0.186
95% Jackknife UCL	0.187
95% Standard Bootstrap UCL	0.185
95% Bootstrap-t UCL	0.299
95% Hall's Bootstrap UCL	0.387
95% Percentile Bootstrap UCL	0.196
95% BCA Bootstrap UCL	0.234
95% Chebyshev(Mean, Sd) UCL	0.274
97.5% Chebyshev(Mean, Sd) UCL	0.335
99% Chebyshev(Mean, Sd) UCL	0.454

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.163
95% Adjusted Gamma UCL	0.164

Statistical Summary for K-40 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	B	REG	11.5	-	-	1.18	11.5	2.442947035
Z1-EU29W-401	S	REG	8.63	-	-	0.31	8.63	2.143589062
Z1-EU29W-402	S	REG	11.7	-	-	0.44	11.7	2.459508842
Z1-EU29W-403	S	REG	13.9	-	-	0.44	13.9	2.63188884
Z1-EU29W-404	S	REG	13	-	-	0.43	13	2.564949357
Z1-EU29W-405 + Dup	S	FR	9.2	-	J	0.5	9.2	2.219203484
Z1-EU29W-406	S	REG	16.3	-	-	0.63	16.3	2.791165108
Z1-EU29W-407	S	REG	12.3	-	-	0.50	12.3	2.505593262
Z1-EU29W-408	S	REG	13.8	-	-	0.78	13.8	2.602688886
Z1-EU29W-409	S	REG	10.1	-	-	0.36	10.1	2.312535424
Z1-EU30BW-411	B	REG	9.31	-	-	0.39	9.31	2.231089091
Z1-EU30C-444	C	REG	6.54	-	-	0.30	6.54	1.873339456
Z1-EU30C-445	C	REG	2.18	-	-	0.28	2.18	0.779324677
Z1-EU30C-446	C	REG	1.72	-	-	0.41	1.72	0.542324281
Z1-EU30C-447	C	REG	1.69	-	-	0.39	1.69	0.504728529
Z1-EU30C-448 + Dup	C	REG	7.44	-	-	0.36	7.44	2.004970842
Z1-EU30C-449	C	REG	6.25	-	-	0.28	6.25	1.832561484
Z1-EU30C-450	C	REG	1.73	-	-	0.36	1.73	0.548121409
Z1-EU30C-451	C	REG	7.11	-	-	0.27	7.11	1.961502244
Z1-EU30C-452	C	REG	1.89	-	-	0.28	1.89	0.636676629
Z1-EU30C-453	C	REG	1.38	-	-	0.28	1.38	0.322063489
Z1-EU30C-454	C	REG	2.84	-	-	0.3	2.84	0.932184081
Z1-EU31BW-415	B	REG	13.1	-	-	0.90	13.1	2.57261223
Z1-EU31BW-416	B	REG	9.41	-	-	1.66	9.41	2.241772954
Z1-EU31BW-417	B	REG	12.4	-	-	0.9	12.4	2.517596473
Z1-EU31W-412	S	REG	10.3	-	-	1.14	10.3	2.332143695
Z1-EU31W-413	S	REG	10.2	-	-	0.56	10.2	2.30238772
Z1-EU31W-414	S	REG	14.9	-	-	0.51	14.9	2.701361213
Z1-EU32BW-431	B	REG	10.8	-	-	1.27	10.8	2.351975257
Z1-EU32BW-432	B	REG	12.5	-	-	0.73	12.5	2.525728644
Z1-EU32BW-433 + Dup	B	FR	16.8	-	-	2.07	16.8	2.821378885
Z1-EU32BW-434	B	REG	11.9	-	-	0.6	11.9	2.4765384
Z1-EU32C-455	C	REG	1.98	-	-	0.36	1.98	0.683098648
Z1-EU32C-456	C	REG	1.96	-	-	0.3	1.96	0.444685821
Z1-EU32MW-420	S	REG	7.1	-	-	1.33	7.1	1.800094784
Z1-EU32MW-428	S	REG	15	-	-	0.67	15	2.708050801
Z1-EU32W-418	S	REG	15.3	-	-	0.91	15.3	2.727852828
Z1-EU32W-418 + Dup	S	FR	10.2	-	-	0.64	10.2	2.32238772
Z1-EU32W-421	S	REG	13.2	-	-	0.91	13.2	2.580214983
Z1-EU32W-422	S	REG	12.5	-	-	0.46	12.5	2.525728644
Z1-EU32W-423	S	REG	9.72	-	-	0.78	9.72	2.274189618
Z1-EU32W-424	S	REG	14	-	-	1.69	14	2.63905733
Z1-EU32W-425	S	REG	16.3	-	-	0.73	16.3	2.727852828
Z1-EU32W-427	S	REG	14.4	-	-	1.09	14.4	2.667208207
Z1-EU32W-428	S	REG	10.2	-	-	1.91	10.2	2.32238772
Z1-EU32W-429	S	REG	13.2	-	-	0.73	13.2	2.58021683
Z1-EU32W-430	S	REG	8.73	-	-	0.84	8.73	2.16878537
Z1-EU33BW-443	B	REG	9.41	-	-	0.63	9.41	2.241772954
Z1-EU33BW-444	B	REG	8.31	-	-	1.62	8.31	2.117489609
Z1-EU33C-467	C	REG	4.65	-	J	0.23	4.65	1.53686722
Z1-EU33W-435	S	REG	14.8	-	-	1.43	14.8	2.694627181
Z1-EU33W-436	S	REG	11.2	-	-	0.72	11.2	2.415013778
Z1-EU33W-437	S	REG	10.5	-	-	0.67	10.5	2.361375287
Z1-EU33W-438	S	REG	9.32	-	-	1.14	9.32	2.232182629
Z1-EU33W-439	S	REG	13.5	-	-	0.5	13.5	2.802689886
Z1-EU33W-440	S	REG	9.97	-	-	0.55	9.97	2.299580584
Z1-EU33W-441	S	REG	10.8	-	-	0.73	10.8	2.378546134

Number of Samples 57
Number of Detects 57

Minimum 1.38
Median 10.2
Maximum 16.8
Average 9.785614
Standard Deviation 4.3216548

PERT-Beta Mean 9.83

Lognormal Mean 2.1040888
Lognormal Standard Deviation 0.7084048

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

K-40 pCl/g

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 49

Raw Statistics

Minimum 1.38
Maximum 16.8
Mean 9.768
Median 10.2
SD 4.322
Coefficient of Variation 0.443
Skewness -0.636

Log-transformed Statistics

Minimum of Log Data 0.322
Maximum of Log Data 2.821
Mean of log Data 2.104
SD of log Data 0.706

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.132
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.249
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 10.72
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 10.66
95% Modified-t UCL 10.71

Assuming Lognormal Distribution

95% H-UCL 12.73
95% Chebyshev (MVUE) UCL 15.16
97.5% Chebyshev (MVUE) UCL 17.18
99% Chebyshev (MVUE) UCL 21.17

Gamma Distribution Test

k star (bias corrected) 2.87
Theta Star 3.403
nu star 327.2

Approximate Chi Square Value (.05) 286.3

Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 285.3

Anderson-Darling Test Statistic 4.018
Anderson-Darling 5% Critical Value 0.758
Kolmogorov-Smirnov Test Statistic 0.221
Kolmogorov-Smirnov 5% Critical Value 0.119

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 10.71
95% Jackknife UCL 10.72
95% Standard Bootstrap UCL 10.69
95% Bootstrap-t UCL 10.66
95% Hall's Bootstrap UCL 10.65
95% Percentile Bootstrap UCL 10.71
95% BCA Bootstrap UCL 10.64
95% Chebyshev (Mean, Sd) UCL 12.26
97.5% Chebyshev (Mean, Sd) UCL 13.34
99% Chebyshev (Mean, Sd) UCL 15.46

Assuming Gamma Distribution

95% Approximate Gamma UCL 11.16
95% Adjusted Gamma UCL 11.2

Potential UCL to Use	Use 95% Chebyshev (Mean, Sd) UCL	12.26
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Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

		WACFACS WLL SRC INPUT			Calculations							
		STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
	SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	z-95	α_1	α_2	Variance	Max - Min
K-49 (PCBs)		1.3800	10.2000	16.6000	9.63	14.45	1.47	14.45	3.29	2.71	18.6141	15.4

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - \text{MIN})^{\alpha_1 - 1} (\text{MAX} - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (\text{MAX} - \text{MIN})^{\alpha_1 + \alpha_2 - 1}} \quad \text{MIN} < \text{Max Value} < \text{MAX}$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{\text{MIN} + 4 \times \text{Most Likely} + \text{MAX}}{6}$$

$$\text{Var}(x) = \frac{(E(x) - \text{MIN}) \times (\text{MAX} - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - \text{MIN}}{\text{MAX} - \text{MIN}} \right]$$

$$\alpha_2 = 6 \times \left[\frac{\text{MAX} - E(x)}{\text{MAX} - \text{MIN}} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_x(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters.

Use the Microsoft Excel (MIN function BETA.INV(0.95, α_1 , α_2 , MIN, MAX)) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Tc-99 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-400	B	REG	8.28	J	J	1.52	8.28	2.113842888
Z1-EU29W-401	S	REG	1.94 J	J	J	1.51	1.94	0.682887973
Z1-EU29W-402	S	REG	4.25	J	J	1.47	4.25	1.448918983
Z1-EU29W-403	S	REG	8.38	J	J	1.53	8.38	2.125847914
Z1-EU29W-404	S	REG	23.8	J	J	1.61	23.8	3.163688581
Z1-EU29W-405 + Dup	S	REG	5.33	J	J	1.51	5.33	1.673351238
Z1-EU29W-406	B	REG	2.82	U	U	1.38	1.38	0.329303747
Z1-EU29W-407	S	REG	8.74	J	J	1.43	8.74	2.167810119
Z1-EU29W-408	S	REG	3.34	U	U	1.37	1.37	0.31481074
Z1-EU29W-409	S	REG	4.35	J	J	1.5	4.35	1.470175845
Z1-EU30W-411	B	REG	16.2	J	J	1.48	16.2	2.785011242
Z1-EU30C-444	C	REG	-0.52 U	U	U	1.62	1.62	0.482420149
Z1-EU30C-445	C	REG	-0.49 U	U	U	1.53	1.53	0.425267735
Z1-EU30C-446	C	REG	0 U	U	U	1.6	1.6	0.470003623
Z1-EU30C-447	C	REG	0 U	U	U	1.54	1.54	0.431782416
Z1-EU30C-448 + Dup	C	REG	-0.48 U	U	U	1.49	1.49	0.38877812
Z1-EU30C-449	C	REG	-0.94 U	U	U	1.47	1.47	0.385262401
Z1-EU30C-450	C	REG	0.61 U	U	U	1.58	1.58	0.457424847
Z1-EU30C-451	C	REG	0 U	U	U	1.47	1.47	0.385262401
Z1-EU30C-452	C	REG	0 U	U	U	1.49	1.49	0.38877812
Z1-EU30C-453	C	REG	-0.98 U	U	U	1.54	1.54	0.431782416
Z1-EU30C-454	C	REG	0.51 U	U	U	1.58	1.58	0.457424847
Z1-EU31W-416	B	REG	3.63	U	U	1.3	1.3	0.252384264
Z1-EU31W-416	B	REG	9.4	U	U	1.38	9.4	2.240709889
Z1-EU31W-417	B	REG	7.94	U	U	1.42	7.94	2.077913276
Z1-EU31W-418	S	REG	2.34	U	U	1.34	1.34	0.282888914
Z1-EU31W-419	S	REG	31.8	U	U	1.36	31.8	3.45946628
Z1-EU31W-414	S	REG	8.42	J	J	1.53	8.42	1.890068816
Z1-EU32W-431	B	REG	87	J	J	1.47	87	4.465908119
Z1-EU32W-432	B	REG	13.7	U	U	1.48	13.7	2.617388433
Z1-EU32W-433 + Dup	B	REG	829	J	J	1.45	829	6.444131257
Z1-EU32W-434	B	REG	3.44	U	U	1.4	1.4	0.336472237
Z1-EU32C-455	C	REG	-0.52 U	U	U	1.61	1.61	0.478234179
Z1-EU32C-456	C	REG	-0.48 U	U	U	1.49	1.49	0.38877812
Z1-EU32W-420	B	REG	6.7	J	J	1.45	6.7	1.740486175
Z1-EU32W-426	S	REG	5.43	J	J	1.51	5.43	1.691939134
Z1-EU32W-418	B	REG	4.11	J	J	1.39	4.11	1.413423029
Z1-EU32W-419 + Dup	S	FR	15.5	J	J	1.43	15.5	2.740840024
Z1-EU32W-421	B	REG	20	J	J	1.38	20	2.995732274
Z1-EU32W-422	S	REG	20.4	J	J	1.38	20.4	3.015534801
Z1-EU32W-423	S	REG	40.1	J	J	1.48	40.1	3.691376334
Z1-EU32W-424	B	REG	2.38	J	J	1.45	2.38	0.887160488
Z1-EU32W-425	S	REG	7.24	J	J	1.47	7.24	1.979821206
Z1-EU32W-427	B	REG	9.23	J	J	1.48	9.23	2.22459049
Z1-EU32W-428	S	REG	13.6	J	J	1.48	13.6	2.610089793
Z1-EU32W-429	S	REG	2.34	J	J	1.43	2.34	0.868168829
Z1-EU32W-430	S	REG	1.9 J	J	J	1.45	1.9	0.641853885
Z1-EU33W-443	B	REG	17.8	U	U	1.27	17.8	2.879198467
Z1-EU33W-444	B	REG	60.1	U	U	1.68	60.1	4.098009842
Z1-EU33C-457	C	REG	1.25 J	U	U	1.29	1.25	0.254842218
Z1-EU33W-435	B	REG	0.86 J	U	U	1.43	1.43	0.357874444
Z1-EU33W-436	S	REG	1.49 J	J	J	1.48	1.49	0.38877812
Z1-EU33W-437	B	REG	4.14	U	U	1.55	4.14	1.420685788
Z1-EU33W-438	S	REG	12.4	U	U	1.49	12.4	2.517898473
Z1-EU33W-439	S	REG	4.31	U	U	1.43	4.31	1.468377904
Z1-EU33W-440	S	REG	6.71	U	U	1.54	6.71	1.903658951
Z1-EU33W-441	S	REG	4.74	U	U	1.58	4.74	1.865037138

Number of Samples 57
Number of Detects 37

Minimum 1.29
Median 4.31
Maximum 829
Average 20.257544
Standard Deviation 83.412099

PERT-Beta Mean 107.92187

Lognormal Mean 1.5972831
Lognormal Standard Deviation 1.3080875

General UCL Statistics for Full Data Sets

User Selected Options

From File: WorkSheet.wst

Full Precision: OFF

Confidence Coefficient: 95%

Number of Bootstrap Operations: 2000

Tc-99 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	51
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Raw Statistics

Minimum	1.29
Maximum	629
Mean	20.26
Median	4.31
SD	83.41
Coefficient of Variation	4.118
Skewness	7.198

Log-transformed Statistics

Minimum of Log Data	0.255
Maximum of Log Data	6.444
Mean of log Data	1.597
SD of log Data	1.306

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic	0.41
Lilliefors Critical Value	0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic	0.172
Lilliefors Critical Value	0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	38.74
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	49.69
95% Modified-t UCL	40.49

Assuming Lognormal Distribution

95% H-UCL	16.67
95% Chebyshev (MVUE) UCL	22.17
97.5% Chebyshev (MVUE) UCL	26.88
99% Chebyshev (MVUE) UCL	36.13

Gamma Distribution Test

k star (bias corrected)	0.444
Theta Star	45.6
nu star	50.64

Approximate Chi Square Value (.05)	35.3
Adjusted Level of Significance	0.0458
Adjusted Chi Square Value	34.97

Anderson-Darling Test Statistic	6.244
Anderson-Darling 5% Critical Value	0.826
Kolmogorov-Smirnov Test Statistic	0.233
Kolmogorov-Smirnov 5% Critical Value	0.125

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	29.06
95% Adjusted Gamma UCL	29.34

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	38.43
95% Jackknife UCL	38.74
95% Standard Bootstrap UCL	38.56
95% Bootstrap-t UCL	128.6
95% Hall's Bootstrap UCL	100
95% Percentile Bootstrap UCL	42.48
95% BCA Bootstrap UCL	54.35
95% Chebyshev(Mean, Sd) UCL	68.42
97.5% Chebyshev(Mean, Sd) UCL	89.25
99% Chebyshev(Mean, Sd) UCL	130.2

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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kredus@rcr.net

12/29/2006 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

	SRC	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
		STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
		MIN	MED	MAX					α_1	α_2	Variance	Max - Min
To-89 pChg		1.2900	4.3100	629.0000	E(X)	UCL-95	UCL-95 : E(X)	0.95	1.02	4.96	9561.9662	627.7

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - \text{MIN})^{\alpha_1 - 1} (\text{MAX} - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (\text{MAX} - \text{MIN})^{\alpha_1 + \alpha_2 - 1}} \quad \text{MIN} < \text{Most Likely} < \text{MAX}$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{\text{MIN} + 4 \times \text{Most Likely} + \text{MAX}}{6}$$

$$\text{Var}(x) = \frac{(E(x) - \text{MIN}) \times (\text{MAX} - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - \text{MIN}}{\text{MAX} - \text{MIN}} \right]$$

$$\alpha_2 = 6 \times \left[\frac{\text{MAX} - E(x)}{\text{MAX} - \text{MIN}} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel 2003 function **BETA.INV(0.95, α_1 , α_2 , MIN, MAX)** to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Th-232 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-400	S	REG	1.54	-	-	0.12	1.54	0.434898242
Z1-EU29W-401	S	REG	0.52	-	-	0.1	0.52	-0.663926467
Z1-EU29W-402	S	REG	1.67	-	-	0.23	1.67	0.512823826
Z1-EU29W-403	S	REG	1.5	-	-	0.12	1.5	0.406486108
Z1-EU29W-404	S	REG	1.23	-	-	0.15	1.23	0.207014168
Z1-EU29W-405 + Dup	S	FR	3.53	J	-	0.13	3.53	1.261297871
Z1-EU29W-406	S	REG	1.45	-	-	0.1	1.45	0.371563556
Z1-EU29W-407	S	REG	1.77	-	-	0.34	1.77	0.570979647
Z1-EU29W-408	S	REG	1.46	-	-	0.11	1.46	0.378436438
Z1-EU29W-409	S	REG	1.53	-	-	0.04	1.53	0.425267735
Z1-EU30BW-411	B	REG	0.88	-	-	0.15	0.86	-0.16082288
Z1-EU30C-444	C	REG	0.52	-	-	0.14	0.52	-0.659886487
Z1-EU30C-445	C	REG	0.24	-	-	0.09	0.24	-1.427116356
Z1-EU30C-446	C	REG	0.32	-	-	0.15	0.32	-1.139434283
Z1-EU30C-447	C	REG	0.29	-	-	0.14	0.29	-1.237874366
Z1-EU30C-448 + Dup	C	REG	0.39	-	-	0.14	0.39	-0.94160854
Z1-EU30C-449	C	REG	0.37	-	-	0.09	0.37	-0.994262273
Z1-EU30C-480	C	REG	0.27	-	-	0.12	0.27	-1.30933332
Z1-EU30C-451	C	REG	0.48	-	-	0.11	0.48	-0.733969176
Z1-EU30C-452	C	REG	0.4	-	-	0.12	0.4	-0.916290732
Z1-EU30C-453	C	REG	0.29	-	-	0.11	0.29	-1.237874366
Z1-EU30C-484	C	REG	0.34	-	-	0.1	0.34	-1.078809661
Z1-EU31BW-415	B	REG	1.11	-	-	0.17	1.11	0.104360015
Z1-EU31BW-416	B	REG	1.45	-	-	0.1	1.45	0.371563556
Z1-EU31BW-417	B	REG	1.62	-	-	0.07	1.62	0.482429149
Z1-EU31W-412	S	REG	0.68	-	-	0.11	0.68	-0.385862461
Z1-EU31W-413	S	REG	0.71	-	-	0.12	0.71	-0.342490309
Z1-EU31W-414	S	REG	2.15	-	-	0.15	2.15	0.765467842
Z1-EU32BW-431	B	REG	0.89	-	-	0.05	0.89	-0.116833816
Z1-EU32BW-432	B	REG	0.47	-	-	0.1	0.47	-0.758022584
Z1-EU32BW-433 + Dup	B	FR	2.88	-	-	0.23	2.88	1.066273387
Z1-EU32BW-434	B	REG	0.84	-	-	0.12	0.84	-0.174353387
Z1-EU32C-455	C	REG	0.38	-	-	0.09	0.35	-1.048612124
Z1-EU32C-456	C	REG	0.34	-	-	0.1	0.24	-1.427116356
Z1-EU32MW-420	S	REG	0.93	-	-	0.13	0.93	-0.072670693
Z1-EU32MW-426	S	REG	1.5	-	-	0.16	1.5	0.405488108
Z1-EU32W-418	S	REG	1.28	-	-	0.12	1.28	0.248460079
Z1-EU32W-419 + Dup	S	FR	1.65	-	-	0.13	1.66	0.500776288
Z1-EU32W-421	S	REG	1.2	-	-	0.24	1.2	0.182321567
Z1-EU32W-422	S	REG	1.1	-	-	0.2	1.1	-0.09501018
Z1-EU32W-423	S	REG	1.01	-	-	0.21	1.01	0.008850331
Z1-EU32W-424	S	REG	1.7	-	-	0.12	1.7	0.530538261
Z1-EU32W-425	S	REG	1.13	-	-	0.13	1.13	0.122217633
Z1-EU32W-427	S	REG	2.18	-	-	0.14	2.18	0.779324877
Z1-EU32W-428	S	REG	1.62	-	-	0.16	1.62	0.558838501
Z1-EU32W-429	S	REG	1.29	-	-	0.1	1.29	0.254642216
Z1-EU32W-430	S	REG	1.09	-	-	0.09	1.09	0.088177686
Z1-EU33BW-443	B	REG	0.85	-	-	0.12	0.85	-0.162518223
Z1-EU33BW-444	B	REG	0.68	-	-	0.12	0.68	-0.020202707
Z1-EU33C-457	C	REG	0.27	J	J	0.16	0.27	-1.30933332
Z1-EU33W-435	S	REG	1.08	-	-	0.09	1.06	0.078861041
Z1-EU33W-436	S	REG	1.15	-	-	0.07	1.15	0.139761942
Z1-EU33W-437	S	REG	1.16	-	-	0.05	1.15	0.148429006
Z1-EU33W-438	S	REG	1.09	-	-	0.15	1.09	0.086177686
Z1-EU33W-439	S	REG	0.9	-	-	0.11	0.9	-0.105380516
Z1-EU33W-440	S	REG	0.97	-	-	0.06	0.97	-0.030468207
Z1-EU33W-441	S	REG	1.25	-	-	0.16	1.25	0.223143551

Number of Samples 57
Number of Detects 57

Minimum 0.24
Median 1.09
Maximum 3.53
Average 1.0903509
Standard Deviation 0.6658747

PERT-Beta Mean 1.355

Lognormal Mean -0.113814
Lognormal Standard Deviation 0.6769985

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Th-228 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	50
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Raw Statistics

Minimum	0.24
Maximum	3.53
Mean	1.09
Median	1.09
SD	0.666
Coefficient of Variation	0.611
Skewness	1.2

Log-transformed Statistics

Minimum of Log Data	-1.427
Maximum of Log Data	1.261
Mean of log Data	-0.114
SD of log Data	0.677

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic	0.101
Lilliefors Critical Value	0.117

Data appear Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic	0.149
Lilliefors Critical Value	0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	1.238
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	1.25
95% Modified-t UCL	1.24

Assuming Lognormal Distribution

95% H-UCL	1.344
95% Chebyshev (MVUE) UCL	1.593
97.5% Chebyshev (MVUE) UCL	1.799
99% Chebyshev (MVUE) UCL	2.204

Gamma Distribution Test

k star (bias corrected)	2.522
Theta Star	0.432
nu star	287.5

Approximate Chi Square Value (.05) 249.2

Adjusted Level of Significance 0.0458

Adjusted Chi Square Value 248.3

Anderson-Darling Test Statistic 0.878

Anderson-Darling 5% Critical Value 0.76

Kolmogorov-Smirnov Test Statistic 0.106

Kolmogorov-Smirnov 5% Critical Value 0.119

Follow Appr. Gamma Distribution at 5% Significance Level

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	1.235
95% Jackknife UCL	1.238
95% Standard Bootstrap UCL	1.231
95% Bootstrap-t UCL	1.252
95% Hall's Bootstrap UCL	1.27
95% Percentile Bootstrap UCL	1.228
95% BCA Bootstrap UCL	1.239
95% Chebyshev(Mean, Sd) UCL	1.475
97.5% Chebyshev(Mean, Sd) UCL	1.641
99% Chebyshev(Mean, Sd) UCL	1.968

Assuming Gamme Distribution

95% Approximate Gamma UCL 1.258

95% Adjusted Gamma UCL 1.262

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Statistical Summary for Molybdenum mg/kg

Location ID	Sample Lot	Sample Type	Result	Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-400	B	REG	17.2		✓	0.27	17.2	2.844909384
Z1-EU29W-401	S	REG	2.7		✓	0.23	2.7	0.993261773
Z1-EU29W-402	S	REG	3.1		✓	0.29	3.1	1.131402111
Z1-EU29W-403	S	REG	1.6		✓	0.24	1.6	0.406485106
Z1-EU29W-404	S	REG	6.6		✓	0.27	6.6	1.887060849
Z1-EU29W-405 + Dup	S	REG	3.1		✓	0.26	3.1	1.131402111
Z1-EU29W-406	S	REG	1.7		✓	0.24	1.7	0.530828251
Z1-EU29W-407	S	REG	6.3		✓	0.27	6.3	1.840543633
Z1-EU29W-408	S	REG	1.4		✓	0.26	1.4	0.398472237
Z1-EU29W-409	S	REG	4.9		✓	0.26	4.9	1.589235205
Z1-EU30BW-411	B	REG	9.3		✓	0.26	9.3	2.2300144
Z1-EU30C-444	C	REG	0.69 B		✓	0.3	0.69	-0.371063681
Z1-EU30C-445	C	REG	1.2		✓	0.26	1.2	0.182321657
Z1-EU30C-446	C	REG	1.1		✓	0.31	1.1	0.096310118
Z1-EU30C-447	C	REG	1.2		✓	0.37	1.2	0.182321657
Z1-EU30C-448 + Dup	C	FR	0.71 B		✓	0.28	0.71	-0.343490309
Z1-EU30C-449	C	REG	0.98 B		✓	0.3	0.98	-0.020202707
Z1-EU30C-450	C	REG	1.5		✓	0.3	1.5	0.406485106
Z1-EU30C-451	C	REG	0.79 B		✓	0.3	0.79	-0.236722334
Z1-EU30C-452	C	REG	0.79 B		✓	0.3	0.79	-0.236722334
Z1-EU30C-453	C	REG	1.3		✓	0.32	1.3	0.262364284
Z1-EU30C-454	C	REG	1.9		✓	0.3	1.9	0.641853886
Z1-EU31BW-416	B	REG	3.4		✓	0.27	3.4	1.223775432
Z1-EU31BW-418	B	REG	2.1		✓	0.28	3.1	1.131402111
Z1-EU31BW-417	B	REG	18		✓	0.24	18	2.890371758
Z1-EU31W-412	S	REG	1.8		✓	0.27	1.8	0.587786665
Z1-EU31W-413	S	REG	11.0		✓	0.23	11.0	2.451005038
Z1-EU31W-414	S	REG	3.6		✓	0.27	3.6	1.280939845
Z1-EU32BW-431	B	REG	4.7		✓	0.28	4.7	1.547842509
Z1-EU32BW-432	B	REG	7.3		✓	0.28	7.3	2.066862759
Z1-EU32BW-433 + Dup	B	FR	2		✓	0.26	2	0.693147181
Z1-EU32BW-434	B	REG	1.3		✓	0.24	1.3	0.262364284
Z1-EU32C-455	C	REG	0.99 B		✓	0.31	0.99	-0.072570893
Z1-EU32C-456	C	REG	0.97 B		✓	0.32	0.97	-0.030459207
Z1-EU32MW-429	S	REG	2.8		✓	0.26	2.8	1.029819417
Z1-EU32MW-428	S	REG	6.4		✓	0.27	6.4	1.85628738
Z1-EU32W-418	S	REG	1.5		✓	0.32	1.5	0.406485106
Z1-EU32W-419 + Dup	S	FR	7.3		✓	0.26	7.3	1.987874348
Z1-EU32W-421	S	REG	5.4		✓	0.27	5.4	1.686398364
Z1-EU32W-422	S	REG	6.1		✓	0.28	6.1	1.808288771
Z1-EU32W-423	S	REG	7.6		✓	0.25	7.6	2.028148247
Z1-EU32W-424	S	REG	1.4		✓	0.27	1.4	0.336472237
Z1-EU32W-425	S	REG	4.2		✓	0.28	4.2	1.435084528
Z1-EU32W-427	S	REG	1.9		✓	0.26	1.9	0.641853886
Z1-EU32W-428	S	REG	1.7		✓	0.28	1.7	0.530628251
Z1-EU32W-429	S	REG	1.4		✓	0.26	1.4	0.336472237
Z1-EU32W-430	S	REG	1.6		✓	0.23	1.6	0.470003629
Z1-EU33BW-443	B	REG	15.0		✓	0.25	15.6	2.747270814
Z1-EU33BW-444	B	REG	2.2		✓	0.26	2.2	0.78845736
Z1-EU33C-467	C	REG	4.1		✓	0.28	4.1	1.410986974
Z1-EU33W-435	S	REG	1.4		✓	0.27	1.4	0.336472237
Z1-EU33W-436	S	REG	1.3		✓	0.27	1.3	0.262364284
Z1-EU33W-437	S	REG	7.2		✓	0.3	7.2	1.974081026
Z1-EU33W-438	S	REG	28.3		✓	0.26	28.3	3.342861805
Z1-EU33W-439	S	REG	3		✓	0.25	3	1.098612299
Z1-EU33W-440	S	REG	69.2		✓	0.25	69.2	4.237000663
Z1-EU33W-441	S	REG	6.1		✓	0.24	6.1	1.808288771

Number of Samples 57
Number of Detects 57

Minimum 0.69
Median 2.7
Maximum 69.2
Average 5.5607018
Standard Deviation 9.9810218

PERT-Beta Mean 13.448333

Lognormal Mean 1.089053
Lognormal Standard Deviation 1.0033012

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Mo mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 43

Raw Statistics

Minimum 0.69
Maximum 69.2
Mean 5.561
Median 2.7
SD 9.981
Coefficient of Variation 1.795
Skewness 5.064

Log-transformed Statistics

Minimum of Log Data -0.371
Maximum of Log Data 4.237
Mean of log Data 1.089
SD of log Data 1.003

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.313
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.128
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 7.772
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 8.683
95% Modified-t UCL 7.92

Assuming Lognormal Distribution

95% H-UCL 11.79
95% Chebyshev (MVUE) UCL 8.176
97.5% Chebyshev (MVUE) UCL 9.614
99% Chebyshev (MVUE) UCL 12.44

Gamma Distribution Test

k star (bias corrected) 0.892
Theta Star 6.234
nu star 101.7

Approximate Chi Square Value (.05) 79.42
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 78.91

Anderson-Darling Test Statistic 2.758
Anderson-Darling 5% Critical Value 0.783
Kolmogorov-Smirnov Test Statistic 0.157
Kolmogorov-Smirnov 5% Critical Value 0.122

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 7.735
95% Jackknife UCL 7.772
95% Standard Bootstrap UCL 7.763
95% Bootstrap-t UCL 10.51
95% Hall's Bootstrap UCL 16.85
95% Percentile Bootstrap UCL 7.961
95% BCA Bootstrap UCL 8.85
95% Chebyshev(Mean, Sd) UCL 11.32
97.5% Chebyshev(Mean, Sd) UCL 13.82
99% Chebyshev(Mean, Sd) UCL 18.71

Assuming Gamma Distribution

95% Approximate Gamma UCL 7.12
95% Adjusted Gamma UCL 7.166

Potential UCL to Use

Use 97.5% Chebyshev (Mean, Sd) UCL

13.82

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2006 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

	WACFACS WILL SRC INPUT			Calculations							
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Molybdenum (mg/kg)	0.6900	2.7	68.2	13.45	33.51	2.49	33.51	1.12	4.88	124.8676	68.5

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - \text{MIN})^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - \text{MIN})^{\alpha_1 + \alpha_2 - 1}} \quad \text{MIN} < \text{Min(Med)} < \text{MAX}$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{\text{MIN} + 4 \times \text{Med(Like)} + \text{MAX}}{6}$$

$$\text{Var}(x) = \frac{(E(x) - \text{MIN})(MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - \text{MIN}}{\text{MAX} - \text{MIN}} \right]$$

$$\alpha_2 = 6 \times \left[\frac{\text{MAX} - E(x)}{\text{MAX} - \text{MIN}} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_x(\alpha_1, \alpha_2)$ is the incomplete Beta Function that α_1 and α_2 are calculated parameters.

Use the Microsoft Excel 2003 function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Nickel mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	289 N *	-	-	0.18	289	5.668496686
Z1-EU29W-401	S	REG	87.5 N *	-	-	0.16	87.5	4.212127458
Z1-EU29W-402	S	REG	144 N *	-	-	0.16	144	4.9698133
Z1-EU29W-403	S	REG	50.3 N *	-	-	0.16	50.3	3.918005777
Z1-EU29W-404	S	REG	57.8 N *	-	-	0.18	57.8	4.053542164
Z1-EU29W-405 + Dup	S	REG	93.8 N *	-	-	0.17	93.8	4.541184855
Z1-EU29W-406	S	REG	12 N *	-	-	0.18	12	2.48490665
Z1-EU29W-407	S	REG	95.2 N *	-	-	0.18	95.2	4.556429359
Z1-EU29W-408	S	REG	8.3 N *	-	-	0.18	8.3	2.118255819
Z1-EU29W-409	S	REG	203 N *	-	-	0.17	203	5.313205978
Z1-EU30BW-411	B	REG	297 N *	-	-	0.17	297	5.693732139
Z1-EU30C-444	C	REG	6.1	-	-	0.2	6.1	1.808288771
Z1-EU30C-445	C	REG	4.2	-	-	0.17	4.2	1.435084525
Z1-EU30C-446	C	REG	8.7	-	-	0.21	8.7	2.16332026
Z1-EU30C-447	C	REG	9	-	-	0.21	9	2.197274577
Z1-EU30C-448 + Dup	C	REG	7.5	-	-	0.19	7.5	2.014803021
Z1-EU30C-449	C	REG	5.9	-	-	0.2	5.9	1.891521412
Z1-EU30C-450	C	REG	8.2	-	-	0.2	8.2	2.104134154
Z1-EU30C-451	C	REG	7	-	-	0.2	7	1.94910149
Z1-EU30C-452	C	REG	5.9	-	-	0.2	5.9	1.774002351
Z1-EU30C-453	C	REG	8.7	-	-	0.21	8.7	2.163323026
Z1-EU30C-454	C	REG	17.5	-	-	0.2	17.5	2.862200881
Z1-EU31BW-415	B	REG	575 N *	-	-	0.18	575	6.354370041
Z1-EU31BW-416	B	REG	184 N *	-	-	0.18	184	5.214935758
Z1-EU31BW-417	B	REG	1700 N *	-	-	0.16	1700	7.438788353
Z1-EU31W-412	S	REG	23.9 N *	-	-	0.18	23.9	3.173878458
Z1-EU31W-413	S	REG	296 N *	-	-	0.15	296	5.690359454
Z1-EU31W-414	S	REG	84.1 N *	-	-	0.18	84.1	4.432009567
Z1-EU32BW-421	B	REG	86	-	-	0.17	86	4.17431727
Z1-EU32BW-432	B	REG	181	-	-	0.18	181	4.799530201
Z1-EU32BW-433 + Dup	B	REG	207	-	-	0.17	207	5.332718793
Z1-EU32BW-434	B	REG	24.5 N *	-	-	0.16	24.5	3.198673118
Z1-EU32C-455	C	REG	5.2	-	-	0.2	5.2	1.824849282
Z1-EU32C-456	C	REG	5.4	-	-	0.21	5.4	1.686398054
Z1-EU32W-420	S	REG	35.8 *	-	-	0.17	35.8	3.577947693
Z1-EU32W-426	S	REG	22.1 *	-	-	0.18	22.1	3.398169709
Z1-EU32W-418	S	REG	30.6 *	-	-	0.21	30.6	3.421000009
Z1-EU32W-419 + Dup	S	REG	153 *	-	-	0.17	153	5.030437521
Z1-EU32W-421	S	REG	172 *	-	-	0.18	172	5.147494477
Z1-EU32W-422	S	REG	99.4 *	-	-	0.19	99.4	4.599152114
Z1-EU32W-423	S	REG	278 *	-	-	0.17	275	5.616771098
Z1-EU32W-424	S	REG	48.9 *	-	-	0.18	48.9	3.889777384
Z1-EU32W-425	S	REG	70.5 *	-	-	0.18	70.5	4.25561271
Z1-EU32W-427	S	REG	15.8 *	-	-	0.17	15.8	2.76000954
Z1-EU32W-428	S	REG	19.2 *	-	-	0.18	19.2	2.954910279
Z1-EU32W-429	S	REG	13.8 *	-	-	0.17	13.8	2.624558592
Z1-EU32W-430	S	REG	19.1 *	-	-	0.18	19.1	2.949688135
Z1-EU33BW-443	B	REG	325 N *	-	-	0.17	326	5.78887381
Z1-EU33BW-444	B	REG	34.2 *	-	-	0.17	34.2	3.532225644
Z1-EU33C-457	C	REG	11.7	-	-	0.2	11.7	2.469588842
Z1-EU33W-425	S	REG	10.2 *	-	-	0.18	10.2	2.705011242
Z1-EU33W-426	S	REG	18.8 *	-	-	0.18	18.8	2.93395687
Z1-EU33W-437	S	REG	84.4 *	-	-	0.2	84.4	4.435587402
Z1-EU33W-438	S	REG	478 *	-	-	0.18	478	6.168610732
Z1-EU33W-439	S	REG	33.4 *	-	-	0.16	33.4	3.5085559
Z1-EU33W-440	S	REG	251 *	-	-	0.17	251	5.525452939
Z1-EU33W-441	S	REG	131 *	-	-	0.18	131	4.875107323

Number of Samples 57
Number of Defects 57

Minimum 4.2
Median 48.9
Maximum 1700
Average 127.1807
Standard Deviation 245.46609

PERT-Beta Mean 316.83333

Lognormal Mean 3.8141086
Lognormal Standard Deviation 1.477612

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wsl

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Ni mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 56

Raw Statistics

Minimum 4.2
Maximum 1700
Mean 127.2
Median 48.9
SD 245.5
Coefficient of Variation 1.93
Skewness 5.018

Log-transformed Statistics

Minimum of Log Data 1.435
Maximum of Log Data 7.438
Mean of log Data 3.814
SD of log Data 1.478

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.308
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.106
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 181.6
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 203.7
95% Modified-t UCL 185.2

Assuming Lognormal Distribution

95% H-UCL 220.1
95% Chebyshev (MVUE) UCL 278
97.5% Chebyshev (MVUE) UCL 342
99% Chebyshev (MVUE) UCL 467.7

Gamma Distribution Test

k star (bias corrected) 0.579
Theta Star 219.5
nu star 66.04

Approximate Chi Square Value (.05) 48.34
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 47.95

Anderson-Darling Test Statistic 1.486
Anderson-Darling 5% Critical Value 0.806
Kolmogorov-Smirnov Test Statistic 0.129
Kolmogorov-Smirnov 5% Critical Value 0.124

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 180.7
95% Jackknife UCL 181.6
95% Standard Bootstrap UCL 181.2
95% Bootstrap-t UCL 235.1
95% Hall's Bootstrap UCL 402.5
95% Percentile Bootstrap UCL 185.1
95% BCA Bootstrap UCL 217.6

95% Chebyshev(Mean, Sd) UCL 268.9
97.5% Chebyshev(Mean, Sd) UCL 330.2
99% Chebyshev(Mean, Sd) UCL 450.7

Assuming Gamma Distribution

95% Approximate Gamma UCL 173.7
95% Adjusted Gamma UCL 175.2

Potential UCL to Use

Use 95% H-UCL 220.1

Statistical Summary for Potassium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	B	REG	786		=	44.4	786	6.66966792
Z1-EU29W-401	S	REG	691		=	38.5	691	6.538139624
Z1-EU29W-402	S	REG	813		=	47.1	813	6.700731111
Z1-EU29W-403	S	REG	838		=	39.3	838	6.7310181
Z1-EU29W-404	S	REG	991		=	44.4	991	6.898714534
Z1-EU29W-406 + Dup	S	FR	1940		=	40.4	1940	7.570443252
Z1-EU29W-406	S	REG	855		=	38.9	855	6.751101469
Z1-EU29W-407	S	REG	1060		=	45	1060	6.96471632
Z1-EU29W-408	S	REG	818		=	43.2	818	6.706882337
Z1-EU29W-409	S	REG	911		=	42.4	911	6.814542697
Z1-EU30W-411	B	REG	680		=	42.6	680	6.522092788
Z1-EU30C-444	C	REG	847 E		J	3.9	847	6.741700696
Z1-EU30C-448	C	REG	914 E		=	3.5	914	6.817830571
Z1-EU30C-446	C	REG	1240 E		=	4.1	1240	7.122866559
Z1-EU30C-447	C	REG	567 E		=	4.2	567	6.32256524
Z1-EU30C-448 + Dup	C	FR	1240 E		=	3.8	1240	7.122866559
Z1-EU30C-449	C	REG	1220 E		=	4	1220	7.106806136
Z1-EU30C-450	C	REG	789 E		=	4	789	6.64509037
Z1-EU30C-451	C	REG	1200 E		=	4	1200	7.090074836
Z1-EU30C-452	C	REG	1500 E		=	4	1500	7.313220387
Z1-EU30C-453	C	REG	1180 E		=	4.3	1180	7.073268717
Z1-EU30C-454	C	REG	918 E		=	4.1	918	6.820015385
Z1-EU31W-416	B	REG	747		=	44.3	747	6.618085185
Z1-EU31W-416	B	REG	778		=	48	778	6.658726524
Z1-EU31W-417	B	REG	883		=	40	883	6.541028899
Z1-EU31W-412	S	REG	857		=	43.8	857	6.785038977
Z1-EU31W-413	S	REG	535		=	38.1	535	6.282266747
Z1-EU31W-414	S	REG	880		=	45.1	880	6.779821907
Z1-EU32W-431	B	REG	879		=	3.4	879	6.778784898
Z1-EU32W-432	B	REG	823		=	3.1	823	6.712956201
Z1-EU32W-433 + Dup	B	REG	1090		=	3.5	1090	6.939332975
Z1-EU32W-434	B	REG	1130		=	3.9	1130	7.029972912
Z1-EU32C-455	C	REG	886 E		=	4.1	886	6.786716951
Z1-EU32C-456	C	REG	732 E		=	4.3	732	6.595780514
Z1-EU32WW-420	S	REG	589		=	42.3	589	6.378426184
Z1-EU32WW-426	S	REG	897		=	44.8	897	6.799056882
Z1-EU32W-418	S	REG	890		=	52.1	890	6.781221463
Z1-EU32W-419 + Dup	S	REG	848		=	42	848	6.74051836
Z1-EU32W-421	S	REG	778		=	44.6	778	6.656728524
Z1-EU32W-422	S	REG	777		=	40.6	777	6.65344035
Z1-EU32W-423	S	REG	951		=	41	951	6.857514063
Z1-EU32W-424	S	REG	588		=	44.8	588	6.338894078
Z1-EU32W-425	S	REG	841		=	45.2	841	6.73459186
Z1-EU32W-427	S	REG	685		=	42.3	685	6.629418638
Z1-EU32W-428	S	REG	889		=	46.5	889	6.790097236
Z1-EU32W-429	S	REG	778		=	42	778	6.66415252
Z1-EU32W-430	S	REG	482		=	3	482	6.177944114
Z1-EU33W-443	B	REG	732		=	41.6	732	6.586780614
Z1-EU33W-444	B	REG	628		=	3.5	628	6.442540166
Z1-EU33C-457	C	REG	1570 E		=	3.9	1570	7.358830686
Z1-EU33W-436	S	REG	906		=	3.5	906	6.807934044
Z1-EU33W-436	S	REG	637		=	3.6	637	6.458789685
Z1-EU33W-437	S	REG	813		=	4	813	6.700731111
Z1-EU33W-438	S	REG	802		=	3.5	802	6.687108608
Z1-EU33W-439	S	REG	832		=	3.3	832	6.723832441
Z1-EU33W-440	S	REG	510		=	10.1	510	6.234410728
Z1-EU33W-441	S	REG	783		=	3.2	783	6.637258031

Number of Samples 57
Number of Detects 57

Minimum 482
Median 838
Maximum 1940
Average 880.4366
Standard Deviation 282.62289

PERT-Beta Mean 982.33333

Lognormal Mean 6.7429741
Lognormal Standard Deviation 0.2690248

General UCL Statistics for Full Data Sets

User Selected Options

From File Worksheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

K mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 53

Raw Statistics

Minimum 482
Maximum 1940
Mean 880.4
Median 838
SD 262.6
Coefficient of Variation 0.298
Skewness 1.694

Log-transformed Statistics

Minimum of Log Data 6.178
Maximum of Log Data 7.57
Mean of log Data 6.743
SD of log Data 0.269

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.218
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.169
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 938.6
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 946
95% Modified-t UCL 939.9

Assuming Lognormal Distribution

95% H-UCL 935.8
95% Chebyshev (MVUE) UCL 1017
97.5% Chebyshev (MVUE) UCL 1077
99% Chebyshev (MVUE) UCL 1195

Gamma Distribution Test

k star (bias corrected) 12.82
Theta Star 68.89
nu star 1461

Approximate Chi Square Value (.05) 1373
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 1371

Anderson-Darling Test Statistic 1.24
Anderson-Darling 5% Critical Value 0.75
Kolmogorov-Smirnov Test Statistic 0.178
Kolmogorov-Smirnov 5% Critical Value 0.118

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 937.7
95% Jackknife UCL 938.6
95% Standard Bootstrap UCL 937.9
95% Bootstrap-t UCL 951.2
95% Hall's Bootstrap UCL 959.4
95% Percentile Bootstrap UCL 940.2
95% BCA Bootstrap UCL 949.5

95% Chebyshev(Mean, Sd) UCL 1032
97.5% Chebyshev(Mean, Sd) UCL 1098
99% Chebyshev(Mean, Sd) UCL 1227

Assuming Gamma Distribution

95% Approximate Gamma UCL 936.7
95% Adjusted Gamma UCL 938.2

Potential UCL to Use

Use 95% Student's-t UCL 938.6

or 95% Modified-t UCL 939.9

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2005 R1.3

Enter input values in yellow shaded cells:

Report OUTPUT UCL-95

	SRC	WACFACS WLL SRC INPUT			OUTPUT			Calculations				
		STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
		MIN	MED	MAX				0.95	α_1	α_2	Variance	Max - Min
Potassium (mg/kg)		482.0000	838	1940	982.33	1434.51	1.49	1434.51	1.98	4.02	100046.5714	1458.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MINIMILE < MAX$$

$$F(x) = \frac{B(x - MIN, \alpha_1)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times MED + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN)(MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_x(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters.

Use the Microsoft Excel 60TH Function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Selenium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-400	B	REG	0.64 B		-	0.54	0.64	0.4462817100
Z1-EU29W-401	B	REG	0.47 U		U	0.47	0.235	1.448169785
Z1-EU29W-402	S	REG	0.57 U		U	0.57	0.285	-1.255266099
Z1-EU29W-403	S	REG	0.48 U		U	0.48	0.24	-1.427116358
Z1-EU29W-404	S	REG	0.54 U		U	0.54	0.27	-1.309030332
Z1-EU29W-405 + Dup	S	REG	0.51 U		U	0.51	0.255	1.366491734
Z1-EU29W-406	S	REG	0.47 U		U	0.47	0.235	1.448169785
Z1-EU29W-407	S	REG	1 B		-	0.65	1	0
Z1-EU29W-408	S	REG	0.53 U		U	0.53	0.265	1.328025453
Z1-EU29W-409	S	REG	0.52 U		U	0.52	0.26	1.347073648
Z1-EU30W-411	B	REG	0.52 U		U	0.52	0.26	1.347073648
Z1-EU30C-444	C	REG	0.59 U/N		U/N	0.59	0.295	1.220779823
Z1-EU30C-448	C	REG	0.62 U/N		U	0.52	0.26	1.347073648
Z1-EU30C-446	C	REG	0.62 U/N		U	0.62	0.31	-1.171162962
Z1-EU30C-447	C	REG	0.63 U/N		U	0.63	0.315	-1.15518264
Z1-EU30C-448 + Dup	C	FR	0.57 U/N		U	0.57	0.285	-1.255266099
Z1-EU30C-449	C	REG	0.6 U/N		U	0.6	0.3	-1.203972804
Z1-EU30C-450	C	REG	0.6 U/N		U	0.6	0.3	-1.203972804
Z1-EU30C-451	C	REG	0.6 U/N		U	0.6	0.3	-1.203972804
Z1-EU30C-452	C	REG	0.61 U/N		U	0.61	0.305	1.187443802
Z1-EU30C-453	C	REG	0.64 B/N		-	0.64	0.64	-0.4462817100
Z1-EU30C-454	C	REG	0.61 U/N		U	0.61	0.305	1.187443802
Z1-EU31BW-415	B	REG	0.64 U		U	0.64	0.27	-1.309030332
Z1-EU31BW-416	B	REG	0.56 U		U	0.56	0.26	-1.272966675
Z1-EU31BW-417	B	REG	1.1 B		-	0.49	1.1	0.08531018
Z1-EU31W-412	S	REG	0.62 B		-	0.53	0.62	0.478006801
Z1-EU31W-413	S	REG	0.48 U		U	0.46	0.23	1.46967597
Z1-EU31W-414	S	REG	0.55 U		U	0.55	0.275	1.290984181
Z1-EU32BW-431	B	REG	0.61 U		U	0.51	0.255	-1.366491734
Z1-EU32BW-432	B	REG	0.47 U		U	0.47	0.235	-1.448169785
Z1-EU32BW-433 + Dup	B	FR	0.53 U		U	0.53	0.265	1.328025453
Z1-EU32BW-434	B	REG	0.47 U		U	0.48	0.24	1.427116358
Z1-EU32C-446	C	REG	0.61 U/N		U	0.61	0.305	1.187443802
Z1-EU32C-456	C	REG	0.64 U/N		U	0.64	0.32	1.138434283
Z1-EU32MW-420	S	REG	0.61 U		U	0.51	0.255	-1.366491734
Z1-EU32MW-426	S	REG	0.64 U		U	0.54	0.27	-1.309030332
Z1-EU32W-418	S	REG	0.63 U		U	0.63	0.315	-1.15518264
Z1-EU32W-419 + Dup	S	REG	25.7		-	0.51	25.7	3.246490962
Z1-EU32W-421	S	REG	0.54 U		U	0.54	0.27	-1.309030332
Z1-EU32W-422	S	REG	0.6 U		U	0.5	0.25	1.366491734
Z1-EU32W-423	S	REG	0.5 U		U	0.5	0.25	1.366491734
Z1-EU32W-424	S	REG	0.54 U		U	0.54	0.27	-1.309030332
Z1-EU32W-425	S	REG	0.55 U		U	0.55	0.275	1.290984181
Z1-EU32W-427	S	REG	0.61 U		U	0.61	0.265	-1.366491734
Z1-EU32W-428	S	REG	0.57 U		U	0.57	0.285	-1.255266099
Z1-EU32W-429	S	REG	0.61 U		U	0.61	0.265	-1.366491734
Z1-EU32W-430	S	REG	0.46 U		U	0.46	0.23	-1.46967597
Z1-EU33BW-443	B	REG	0.61 U		U	0.61	0.265	-1.366491734
Z1-EU33BW-444	B	REG	0.72 B		-	0.52	0.72	0.328504067
Z1-EU33C-457	C	REG	0.69 U/N		U	0.59	0.295	1.220779823
Z1-EU33W-435	S	REG	0.63 U		U	0.53	0.265	1.328025453
Z1-EU33W-436	S	REG	0.64 B		-	0.53	0.64	0.4462817100
Z1-EU33W-437	S	REG	1.2 B		-	0.5	1.2	0.182321557
Z1-EU33W-438	S	REG	0.61 B		-	0.63	0.61	0.210721031
Z1-EU33W-439	S	REG	0.94 B		-	0.49	0.94	-0.061875404
Z1-EU33W-440	S	REG	0.51 U		U	0.51	0.255	-1.366491734
Z1-EU33W-441	S	REG	0.69 B		-	0.48	0.69	-0.371060681

Number of Samples 57
Number of Detects 12

Minimum 0.23
Median 0.275
Maximum 25.7
Average 0.6228847
Standard Deviation 3.3621521

PERT-Beta Mean 4.505

Lognormal Mean -1.020536
Lognormal Standard Deviation 0.7297484

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheetLwst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Se mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 27

Raw Statistics

Minimum 0.23
Maximum 25.7
Mean 0.823
Median 0.275
SD 3.362
Coefficient of Variation 4.086
Skewness 7.493

Log-transformed Statistics

Minimum of Log Data -1.47
Maximum of Log Data 3.246
Mean of log Data -1.021
SD of log Data 0.73

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.438
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.354
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 1.568
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 2.028
95% Modified-t UCL 1.641

Assuming Lognormal Distribution

95% H-UCL 0.574
95% Chebyshev (MVUE) UCL 0.685
97.5% Chebyshev (MVUE) UCL 0.779
99% Chebyshev (MVUE) UCL 0.964

Gamma Distribution Test

k star (bias corrected) 0.701
Theta Star 1.173
nu star 79.96

Approximate Chi Square Value (.05) 60.36
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 59.92

Anderson-Darling Test Statistic 13.43
Anderson-Darling 5% Critical Value 0.794
Kolmogorov-Smirnov Test Statistic 0.401
Kolmogorov-Smirnov 5% Critical Value 0.123

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 1.555
95% Jackknife UCL 1.568
95% Standard Bootstrap UCL 1.552
95% Bootstrap-t UCL 9.097
95% Hall's Bootstrap UCL 4.628
95% Percentile Bootstrap UCL 1.709
95% BCA Bootstrap UCL 2.176
95% Chebyshev(Mean, Sd) UCL 2.764
97.5% Chebyshev(Mean, Sd) UCL 3.604
99% Chebyshev(Mean, Sd) UCL 5.254

Assuming Gamma Distribution

95% Approximate Gamma UCL 1.09
95% Adjusted Gamma UCL 1.098

Potential UCL to Use

Use 95% Chebyshev (Mean Sd) UCL

2.764

Statistical Summary for Silver mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	0.15 B	-	-	0.09	0.15	-1.897119985
Z1-EU29W-401	S	REG	0.12 B	-	-	0.08	0.12	-2.120283538
Z1-EU29W-402	S	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU29W-403	S	REG	1.2	-	-	0.08	1.2	0.182321887
Z1-EU29W-404	S	REG	0.43 B	-	-	0.09	0.43	-0.84397007
Z1-EU29W-405 + Dup	S	REG	0.09 U	U	U	0.09	0.045	-3.101092789
Z1-EU29W-406	S	REG	0.08 U	U	U	0.08	0.04	-3.218875825
Z1-EU29W-407	S	REG	0.39 B	-	-	0.09	0.39	-0.94160854
Z1-EU29W-408	S	REG	0.09 U	U	U	0.09	0.048	-3.101092789
Z1-EU29W-409	S	REG	0.09 U	U	U	0.09	0.045	-3.101092789
Z1-EU30BW-411	B	REG	0.57	-	-	0.09	0.57	-0.582118918
Z1-EU30C-444	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU30C-445	C	REG	0.09 U	U	U	0.09	0.048	-3.101092789
Z1-EU30C-446	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU30C-447	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU30C-448 + Dup	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU30C-449	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU30C-450	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU30C-451	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU30C-452	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU30C-453	C	REG	0.11 U	U	U	0.11	0.055	-2.900422094
Z1-EU30C-454	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU31BW-415	B	REG	0.91	-	-	0.09	0.91	-0.094310679
Z1-EU31BW-416	B	REG	0.21 B	-	-	0.09	0.21	-1.590847748
Z1-EU31BW-417	B	REG	0.08 U	U	U	0.08	0.04	-3.218875825
Z1-EU31W-412	S	REG	0.09 U	U	U	0.09	0.048	-3.101092789
Z1-EU31W-413	S	REG	0.17 B	-	-	0.08	0.17	-1.771956842
Z1-EU31W-414	S	REG	0.09 U	U	U	0.09	0.045	-3.101092789
Z1-EU32BW-431	B	REG	0.57	-	-	0.09	0.57	-0.582118918
Z1-EU32W-432	B	REG	0.67	-	-	0.08	0.67	-0.400477557
Z1-EU32W-433 + Dup	B	FR	0.09 U	U	U	0.09	0.045	-3.101092789
Z1-EU32W-434	B	REG	0.08 U	U	U	0.08	0.04	-3.218875825
Z1-EU32C-455	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU32C-456	C	REG	0.11 U	U	U	0.11	0.055	-2.900422094
Z1-EU32W-420	S	REG	0.09 B +	-	-	0.09	0.09	-2.407946609
Z1-EU32W-426	S	REG	0.32 B +	-	-	0.09	0.32	-1.139434283
Z1-EU32W-418	S	REG	0.11 U +	U	U	0.11	0.055	-2.900422094
Z1-EU32W-419 + Dup	S	REG	0.73 +	-	-	0.09	0.73	-0.314710745
Z1-EU32W-421	S	REG	0.54 +	-	-	0.08	0.54	-0.519185139
Z1-EU32W-422	S	REG	0.49 +	-	-	0.08	0.49	-0.713345888
Z1-EU32W-423	S	REG	1.1 +	-	-	0.08	1.1	0.09531018
Z1-EU32W-424	S	REG	0.09 U +	U	U	0.09	0.045	-3.101092789
Z1-EU32W-425	S	REG	0.18 B +	-	-	0.09	0.18	-1.714788426
Z1-EU32W-427	S	REG	0.09 U +	U	U	0.09	0.045	-3.101092789
Z1-EU32W-428	S	REG	0.09 U +	U	U	0.09	0.045	-3.101092789
Z1-EU32W-429	S	REG	0.09 U +	U	U	0.09	0.045	-3.101092789
Z1-EU32W-430	S	REG	0.08 U	U	U	0.08	0.04	-3.218875825
Z1-EU33BW-443	B	REG	0.77	-	-	0.08	0.77	-0.251364784
Z1-EU33BW-444	B	REG	0.08 U	U	U	0.08	0.048	-3.101092789
Z1-EU33C-457	C	REG	0.1 U	U	U	0.1	0.05	-2.995732274
Z1-EU33W-436	S	REG	0.08 U	U	U	0.08	0.045	-3.101092789
Z1-EU33W-436	S	REG	0.09 U	U	U	0.09	0.045	-3.101092789
Z1-EU33W-437	S	REG	0.15 B	-	-	0.1	0.15	-1.897119985
Z1-EU33W-438	S	REG	0.76	-	-	0.09	0.76	-0.274436848
Z1-EU33W-439	S	REG	0.24 B	-	-	0.08	0.24	-1.427116356
Z1-EU33W-440	S	REG	1.4	-	-	0.08	1.4	0.338472237
Z1-EU33W-441	S	REG	0.12 B	-	-	0.08	0.12	-2.120283538

Number of Samples	57
Number of Detects	25
Minimum	0.04
Median	0.05
Maximum	1.4
Average	0.2427193
Standard Deviation	0.3319855
PERT Beta Mean	0.2733333
Lognormal Mean	-2.174878
Lognormal Standard Deviation	1.1719812

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Ag mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 25

Raw Statistics

Minimum 0.04
Maximum 1.4
Mean 0.243
Median 0.05
SD 0.332
Coefficient of Variation 1.368
Skewness 1.87

Log-transformed Statistics

Minimum of Log Data -3.219
Maximum of Log Data 0.336
Mean of log Data -2.175
SD of log Data 1.172

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.293
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.311
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 0.316

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 0.327
95% Modified-t UCL 0.318

Assuming Lognormal Distribution

95% H-UCL 0.57

95% Chebyshev (MVUE) UCL 0.407
97.5% Chebyshev (MVUE) UCL 0.487
99% Chebyshev (MVUE) UCL 0.644

Gamma Distribution Test

k star (bias corrected) 0.754
Theta Star 0.322
nu star 86.01

Approximate Chi Square Value (.05) 65.63

Adjusted Level of Significance 0.0458

Adjusted Chi Square Value 65.17

Anderson-Darling Test Statistic 6.033

Anderson-Darling 5% Critical Value 0.791

Kolmogorov-Smirnov Test Statistic 0.321

Kolmogorov-Smirnov 5% Critical Value 0.122

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 0.315

95% Jackknife UCL 0.316

95% Standard Bootstrap UCL 0.314

95% Bootstrap-t UCL 0.336

95% Hall's Bootstrap UCL 0.321

95% Percentile Bootstrap UCL 0.316

95% BCA Bootstrap UCL 0.322

95% Chebyshev(Mean, Sd) UCL 0.434

97.5% Chebyshev(Mean, Sd) UCL 0.517

99% Chebyshev(Mean, Sd) UCL 0.68

Assuming Gamma Distribution

95% Approximate Gamma UCL 0.318

95% Adjusted Gamma UCL 0.32

Potential UCL to Use

Use 97.5% Chebyshev (Mean, Sd) UCL

0.517

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

		WACFACS WL 1 SRC INPUT			OUTPUT			Calculations				
		STEP 10	STEP 11	STEP 12				Beta PDF Inverse		PERT BETA		
		MIN	MED	MAX	E(X)	UCL-95	UCL-95 - E(X)	0.95		α_1	α_2	Variance
Silver (mg/kg)	SRC	0.0400	0.05	1.4	0.27	0.66	2.43	0.88		1.03	4.97	0.0453
												Max - Min
												1.4

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MostLikely < MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times MostLikely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function.
 α_1 and α_2 are calculated parameters.

Use the Microsoft Excel 2004 function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Sodium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	21.9 E	-	-	1.8	21.9	3.085488837
Z1-EU29W-401	S	REG	113 E	J	-	1.8	113	4.727367619
Z1-EU29W-402	S	REG	34.3 E	-	-	1.8	34.3	3.535145354
Z1-EU29W-403	S	REG	51.5 E	-	-	1.8	51.5	3.941581806
Z1-EU29W-404	S	REG	30.5 E	-	-	1.8	30.5	3.421000009
Z1-EU29W-405 + Dup	S	FR	262 E	-	-	1.8	262	5.628428088
Z1-EU29W-406	S	REG	49.9 E	-	-	1.8	49.9	3.910021003
Z1-EU29W-407	S	REG	50.3 E	-	-	1.8	50.3	3.918005077
Z1-EU29W-408	S	REG	41.7 E	-	-	1.8	41.7	3.730501129
Z1-EU29W-409	S	REG	78.6 E	-	-	1.7	78.6	4.364371599
Z1-EU30BW-411	B	REG	113 E	-	-	1.7	113	4.727367619
Z1-EU30C-444	C	REG	257 E	J	-	2	257	5.549075095
Z1-EU30C-445	C	REG	311 E	-	-	1.7	311	5.739792912
Z1-EU30C-446	C	REG	417 E	-	-	2.1	417	6.033086222
Z1-EU30C-447	C	REG	166 E	-	-	2.1	166	5.111867788
Z1-EU30C-448 + Dup	C	FR	378 E	-	-	1.9	378	5.934894195
Z1-EU30C-449	C	REG	481 E	-	-	2	481	6.17885727
Z1-EU30C-450	C	REG	359 E	-	-	2	359	5.893322388
Z1-EU30C-451	C	REG	356 E	-	-	2	356	5.874930731
Z1-EU30C-452	C	REG	287 E	-	-	2	287	5.659482218
Z1-EU30C-453	C	REG	257 E	-	-	2.1	257	5.549075095
Z1-EU30C-454	C	REG	302 E	-	-	2	302	5.710427017
Z1-EU31BW-415	B	REG	34.5 E	-	-	1.8	34.5	3.540869334
Z1-EU31BW-416	B	REG	45.7 E	-	-	1.9	45.7	3.822088209
Z1-EU31BW-417	B	REG	38.3 E	-	-	1.8	38.3	3.671224819
Z1-EU31W-412	S	REG	70.3 E	-	-	1.8	70.3	4.252771799
Z1-EU31W-413	S	REG	51.9 E	-	-	1.5	51.9	3.94801879
Z1-EU31W-414	S	REG	31.7 E	-	-	1.8	31.7	3.456315691
Z1-EU32BW-431	B	REG	181 *	-	-	1.7	181	5.017279637
Z1-EU32BW-432	B	REG	112 *	-	-	1.8	112	4.718499871
Z1-EU32BW-433 + Dup	B	REG	38.9 *	-	-	1.7	38.9	3.660894261
Z1-EU32BW-434	B	REG	83.9 E	-	-	1.5	83.9	4.429625613
Z1-EU32C-455	C	REG	214 E	-	-	2	214	5.365978016
Z1-EU32C-456	C	REG	166 E	-	-	2.1	166	5.111867788
Z1-EU32MW-420	S	REG	63.1 *	-	-	1.7	63.1	4.14472077
Z1-EU32MW-425	S	REG	73.9 *	-	-	1.8	73.9	4.302712826
Z1-EU32W-418	S	REG	88.8 *	J	-	2.1	88.8	4.48638665
Z1-EU32W-419 + Dup	S	REG	96.5 *	-	-	1.7	96.5	4.889543308
Z1-EU32W-421	S	REG	80.5 *	-	-	1.8	80.5	4.388257184
Z1-EU32W-422	S	REG	87.2 *	-	-	1.8	87.2	4.488204331
Z1-EU32W-423	S	REG	95.9 *	-	-	1.7	95.9	4.557029911
Z1-EU32W-424	S	REG	46.7 *	-	-	1.8	0.9	-0.105380515
Z1-EU32W-426	S	REG	57.5 *	-	-	1.8	0.9	-0.105380515
Z1-EU32W-427	S	REG	49.7 *	-	-	1.7	0.85	-0.182518929
Z1-EU32W-428	S	REG	49.1 *	-	-	1.9	0.95	-0.051293294
Z1-EU32W-429	S	REG	89.6 *	-	-	1.7	89.6	4.49635532
Z1-EU32W-430	S	REG	27.1 *	-	-	1.5	0.75	-0.287842073
Z1-EU32W-443	B	REG	58 E	-	-	1.7	58	4.219507795
Z1-EU32W-444	B	REG	36 *	-	-	1.7	0.85	-0.182518929
Z1-EU33C-457	C	REG	449 E	-	-	2	449	6.107028888
Z1-EU33W-436	S	REG	70.5 *	-	-	1.8	70.5	4.25861271
Z1-EU33W-439	S	REG	32.3 *	-	-	1.8	0.9	-0.105380515
Z1-EU33W-437	S	REG	75.4 *	-	-	2	75.4	4.322807275
Z1-EU33W-438	S	REG	104 *	-	-	1.8	104	4.644392992
Z1-EU33W-439	S	REG	41.9 *	-	-	1.5	41.9	3.735385827
Z1-EU33W-440	S	REG	74.3 *	-	-	5.1	74.3	4.308110952
Z1-EU33W-441	S	REG	48.7 *	-	-	1.5	48.7	3.88987933

Number of Samples 57
Number of Detects 50

Minimum 0.75
Median 75.4
Maximum 481
Average 123.95814
Standard Deviation 125.2382

PERT-Beta Mean 130.55833

Lognormal Mean 4.0179096
Lognormal Standard Deviation 1.7522032

Goodness-of-Fit Test Statistics for Data Sets with Non-Detects

User Selected Options

From File P:\Waste Generator Services\EMWME Profiles\WL 4.12\March 2009 revision\revised total metals to test

Full Precision OFF

Confidence Coefficient 0.9

Na mg/kg

	Num Obs	Num Miss	Num Valid	Detects	NDs	% NDs
Raw Statistics	57	0	57	50	7	12.28%

	Number	Minimum	Maximum	Mean	Median	SD
Statistics (Non-Detects Only)	7	0.75	0.95	0.871	0.9	0.0636
Statistics (Detects Only)	50	21.9	481	141.1	85.55	125.5
Statistics (All: NDs treated as DL value)	57	0.75	481	123.9	75.4	126.2
Statistics (All: NDs treated as DL/2 value)	57	0.375	481	123.8	75.4	126.3
Statistics (Normal ROS Estimated Data)	57	-170.6	481	108.4	75.4	147.1
Statistics (Gamma ROS Estimated Data)	57	1.0000E-9	481	123.7	75.4	126.3
Statistics (Lognormal ROS Estimated Data)	57	11.22	481	125.7	75.4	124.5
	K Hat	K Star	Theta Hat	Log Mean	Log Stdv	Log CV
Statistics (Detects Only)	1.578	1.506	89.42	4.6	0.832	0.181
Statistics (NDs = DL)	0.748	0.72	165.7	4.018	1.752	0.436
Statistics (NDs = DL/2)	0.684	0.66	180.9	3.933	1.96	0.498
Statistics (Gamma ROS Estimates)	0.218	0.218	587.3	--	--	--
Statistics (Lognormal ROS Estimates)	--	--	--	4.371	0.996	0.228

Normal Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Normal ROS
Correlation Coefficient R	0.896	0.903	0.903	0.958

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Shapiro-Wilks (Detects Only)	0.79	0.955	Data Not Normal
Lilliefors (Detects Only)	0.269	0.114	Data Not Normal
Lilliefors (NDs = DL)	0.254	0.107	Data Not Normal
Lilliefors (NDs = DL/2)	0.253	0.107	Data Not Normal
Lilliefors (Normal ROS Estimates)	0.207	0.107	Data Not Normal

Gamma Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Gamma ROS
Correlation Coefficient R	0.972	0.971	0.968	0.891

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Anderson-Darling (Detects Only)	1.783	0.642	
Kolmogorov-Smirnov (Detects Only)	0.179	0.117	Data Not Gamma Distributed
Anderson-Darling (NDs = DL)	1.484	0.661	
Kolmogorov-Smirnov (NDs = DL)	0.145	0.112	Data Not Gamma Distributed
Anderson-Darling (NDs = DL/2)	1.853	0.666	
Kolmogorov-Smirnov (NDs = DL/2)	0.166	0.113	Data Not Gamma Distributed

Anderson-Darling (Gamma ROS Estimates)	12.54	0.74	
Kolmogorov-Smirnov (Gamma ROS Est.)	0.433	0.119	Data Not Gamma Distributed

Lognormal Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Log ROS
Correlation Coefficient R	0.977	0.896	0.873	0.988

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Shapiro-Wilks (Detects Only)	0.936	0.955	Data Not Lognormal
Lilliefors (Detects Only)	0.119	0.114	Data Not Lognormal
Lilliefors (NDs = DL)	0.226	0.107	Data Not Lognormal
Lilliefors (NDs = DL/2)	0.257	0.107	Data Not Lognormal
Lilliefors (Lognormal ROS Estimates)	0.0882	0.107	Data Appear Lognormal

Note: Substitution methods such as DL or DL/2 are not recommended.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File P:\Waste Generator Services\EMWME Profiles\WL 4.12\March 2009 revision\revised total metals to test
 Full Precision OFF
 Confidence Coefficient 95%
 Number of Bootstrap Operations 2000

Na mg/kg

General Statistics

Number of Valid Data	57	Number of Detected Data	50
Number of Distinct Detected Data	47	Number of Non-Detect Data	7
		Percent Non-Detects	12.28%

Raw Statistics

Minimum Detected	21.9
Maximum Detected	481
Mean of Detected	141.1
SD of Detected	125.5
Minimum Non-Detect	0.75
Maximum Non-Detect	0.95

Log-transformed Statistics

Minimum Detected	3.086
Maximum Detected	6.176
Mean of Detected	4.6
SD of Detected	0.832
Minimum Non-Detect	-0.288
Maximum Non-Detect	-0.0513

Note: Data have multiple DLs - Use of KM Method is recommended

For all methods (except KM, DL/2, and ROS Methods),

Observations < Largest ND are treated as NDs

Number treated as Non-Detect 7

Number treated as Detected 50

Single DL Non-Detect Percentage 12.28%

UCL Statistics

Normal Distribution Test with Detected Values Only

Lilliefors Test Statistic	0.79
5% Lilliefors Critical Value	0.947

Data not Normal at 5% Significance Level

Lognormal Distribution Test with Detected Values Only

Lilliefors Test Statistic	0.936
5% Lilliefors Critical Value	0.947

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

DL/2 Substitution Method

Mean	123.8
SD	125.3
95% DL/2 (t) UCL	151.8

Maximum Likelihood Estimate(MLE) Method

Mean	114.3
SD	138.5
95% MLE (t) UCL	145
95% MLE (Tiku) UCL	144.4

Assuming Lognormal Distribution

DL/2 Substitution Method

Mean	3.933
SD	1.96
95% H-Stat (DL/2) UCL	418.7

Log ROS Method

Mean in Log Scale	4.371
SD in Log Scale	0.996
Mean in Original Scale	125.7
SD in Original Scale	124.5
95% Percentile Bootstrap UCL	153.8
95% BCA Bootstrap UCL	157.2

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.496
Theta Star	94.28
nu star	149.6

Data Distribution Test with Detected Values Only

Data do not follow a Discernable Distribution (0.05)

A-D Test Statistic	1.783
5% A-D Critical Value	0.767
K-S Test Statistic	0.767
5% K-S Critical Value	0.127

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1.0000E-9
Maximum	481
Mean	123.7
Median	75.4
SD	126.3
k star	0.218
Theta star	566.8
Nu star	24.89
AppChi2	14.53
95% Gamma Approximate UCL	212
95% Adjusted Gamma UCL	215.1

Nonparametric Statistics

Kaplan-Meier (KM) Method

Mean	126.4
SD	122.8
SE of Mean	16.42
95% KM (t) UCL	153.9
95% KM (z) UCL	153.5
95% KM (jackknife) UCL	153.1
95% KM (bootstrap t) UCL	157.2
95% KM (BCA) UCL	154.4
95% KM (Percentile Bootstrap) UCL	156.6
95% KM (Chebyshev) UCL	198
97.5% KM (Chebyshev) UCL	229
99% KM (Chebyshev) UCL	289.9

Potential UCLs to Use

95% KM (Chebyshev) UCL	198
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Note: DL/2 is not a recommended method.

Statistical Summary for Vanadium mg/kg

Location ID	Sample		Result	Qualifier	Validation	Detection		
	Lot	Type				Limit	Proxy Value	LN Proxy Value
Z1-EU29W-410	B	REG	35.7 *		✓	0.13	35.7	3.575150682
Z1-EU29W-401	S	REG	8.6 *		✓	0.11	8.6	2.251291799
Z1-EU29W-402	S	REG	37.4 *		✓	0.13	37.4	3.631670704
Z1-EU29W-403	S	REG	29.9 *		✓	0.11	29.9	3.39785848
Z1-EU29W-404	S	REG	30.3 *		✓	0.13	30.3	3.411147713
Z1-EU29W-405 + Dup	S	REG	15.5 *		✓	0.12	15.5	2.740840024
Z1-EU29W-406	S	REG	31.8 *		✓	0.11	31.8	3.459186329
Z1-EU29W-407	S	REG	37.3 *		✓	0.13	37.3	3.618981327
Z1-EU29W-408	S	REG	38.5 *		✓	0.12	38.5	3.597312251
Z1-EU29W-409	S	REG	29.6 *		✓	0.12	29.6	3.397774361
Z1-EU30W-411	B	REG	14.8 *		✓	0.12	14.8	2.694627181
Z1-EU30C-444	C	REG	8		✓	0.14	8	2.079441542
Z1-EU30C-445	C	REG	10.6		✓	0.12	10.6	2.350854001
Z1-EU30C-446	C	REG	12		✓	0.14	12	2.48490885
Z1-EU30C-447	C	REG	13.3		✓	0.15	13.3	2.587764005
Z1-EU30C-448 + Dup	C	FR	10.4		✓	0.13	10.4	2.341906805
Z1-EU30C-449	C	REG	9.7		✓	0.14	9.7	2.272125895
Z1-EU30C-450	C	REG	11.9		✓	0.14	11.9	2.4786384
Z1-EU30C-451	C	REG	8.9		✓	0.14	8.9	2.186051277
Z1-EU30C-452	C	REG	13		✓	0.14	13	2.564949367
Z1-EU30C-453	C	REG	15.7		✓	0.15	15.7	2.753660712
Z1-EU30C-454	C	REG	16.8		✓	0.16	16.8	2.821378885
Z1-EU31W-415	B	REG	31.5 *		✓	0.13	31.5	3.448987545
Z1-EU31W-416	B	REG	38.1 *		✓	0.13	38.1	3.640214282
Z1-EU31W-417	B	REG	52.9 *		✓	0.11	52.9	3.968403339
Z1-EU31W-412	S	REG	17.1 *		✓	0.12	17.1	2.839078454
Z1-EU31W-413	S	REG	18.8 *		✓	0.11	18.8	2.93385867
Z1-EU31W-414	S	REG	38.2 *		✓	0.13	38.2	3.642835515
Z1-EU32W-431	B	REG	17.3		✓	0.12	17.3	2.850706502
Z1-EU32W-432	B	REG	17.3		✓	0.11	17.3	2.850706502
Z1-EU32W-433 + Dup	B	FR	27.8		✓	0.12	27.8	3.925038321
Z1-EU32W-434	B	REG	14.9 *		✓	0.11	14.9	2.701361213
Z1-EU32C-455	C	REG	14.6		✓	0.14	14.6	2.691021529
Z1-EU32C-456	C	REG	10.9		✓	0.15	10.9	2.388762789
Z1-EU32W-420	S	REG	22.5		✓	0.12	22.5	3.113515309
Z1-EU32W-425	S	REG	20		✓	0.13	20	2.995732274
Z1-EU32W-418	S	REG	21.1		✓	0.15	21.1	3.04927304
Z1-EU32W-419 + Dup	S	FR	23.5		✓	0.12	23.5	3.157000421
Z1-EU32W-421	S	REG	18.4		✓	0.13	18.4	2.912350605
Z1-EU32W-422	S	REG	16.6		✓	0.12	16.6	2.809402655
Z1-EU32W-423	S	REG	18.1		✓	0.12	18.1	2.895911506
Z1-EU32W-424	S	REG	23.3		✓	0.13	23.3	3.148453351
Z1-EU32W-426	S	REG	18.3		✓	0.13	18.3	2.901421694
Z1-EU32W-427	S	REG	26.8		✓	0.12	26.8	3.288401888
Z1-EU32W-428	S	REG	22.1		✓	0.13	22.1	3.086577809
Z1-EU32W-429	S	REG	22.9		✓	0.12	22.9	3.131136811
Z1-EU32W-430	S	REG	22.1		✓	0.11	22.1	3.095577609
Z1-EU33W-443	B	REG	28 *		✓	0.12	28	3.258046538
Z1-EU33W-444	B	REG	21.8		✓	0.12	21.8	3.08190997
Z1-EU33C-457	C	REG	34.8		✓	0.14	34.8	3.549817347
Z1-EU33W-435	S	REG	32.8		✓	0.12	32.8	3.490428515
Z1-EU33W-436	S	REG	23.2		✓	0.12	23.2	3.144152279
Z1-EU33W-437	S	REG	23.7		✓	0.14	23.7	3.165475048
Z1-EU33W-438	S	REG	25.4		✓	0.12	25.4	3.234748174
Z1-EU33W-439	S	REG	26.3		✓	0.12	26.3	3.269568939
Z1-EU33W-440	S	REG	17.9		✓	0.12	17.9	2.884800713
Z1-EU33W-441	S	REG	25.1		✓	0.11	25.1	3.222867845

Number of Samples 57
Number of Detects 1 57

Minimum 8
Median 21.8
Maximum 52.9
Average 22.291228
Standard Deviation 8.4280789
PERT-Beta Mean 24.883333

Lognormal Mean 3.0149649
Lognormal Standard Deviation 0.43374

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

V mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 55

Raw Statistics

Minimum 8
Maximum 52.9
Mean 22.29
Median 21.8
SD 9.428
Coefficient of Variation 0.423
Skewness 0.76

Log-transformed Statistics

Minimum of Log Data 2.079
Maximum of Log Data 3.968
Mean of log Data 3.015
SD of log Data 0.434

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.101
Lilliefors Critical Value 0.117

Data appear Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.0701
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 24.38
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 24.48
95% Modified-t UCL 24.4

Assuming Lognormal Distribution

95% H-UCL 24.9
95% Chebyshev (MVUE) UCL 28.18
97.5% Chebyshev (MVUE) UCL 30.7
99% Chebyshev (MVUE) UCL 35.64

Gamma Distribution Test

k star (bias corrected) 5.473
Theta Star 4.073
nu star 624

Approximate Chi Square Value (.05) 587
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 565.6

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 24.35
95% Jackknife UCL 24.38
95% Standard Bootstrap UCL 24.29
95% Bootstrap-t UCL 24.49
95% Hall's Bootstrap UCL 24.45
95% Percentile Bootstrap UCL 24.39
95% BCA Bootstrap UCL 24.33
95% Chebyshev(Mean, Sd) UCL 27.73
97.5% Chebyshev(Mean, Sd) UCL 30.09
99% Chebyshev(Mean, Sd) UCL 34.72

Assuming Gamma Distribution

95% Approximate Gamma UCL 24.53
95% Adjusted Gamma UCL 24.59

to appear Gamma Distributed at 5% Significance Level

Potential UCL to Use

Use 95% Student's-t UCL 24.38

Statistical Summary for Zinc mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29W-400	B	REG	181 N	-	-	0.54	181	5.198497031
Z1-EU29W-401	S	REG	225 N	-	-	0.47	225	5.418100402
Z1-EU29W-402	S	REG	161 N	-	-	0.57	161	5.081404365
Z1-EU29W-403	B	REG	84.9 N	-	-	0.48	84.9	4.441474093
Z1-EU29W-404	S	REG	233 N	-	-	0.54	233	5.451938454
Z1-EU29W-408 + Dup	B	REG	303 N	-	-	0.51	303	5.713732605
Z1-EU29W-406	S	REG	40 N	-	-	0.47	40	3.688879464
Z1-EU29W-407	B	REG	372 N	-	-	0.55	372	5.918893854
Z1-EU29W-408	S	REG	34 N	-	-	0.63	34	3.828580628
Z1-EU29W-409	S	REG	174 N	-	-	0.52	174	5.159055299
Z1-EU30BW-411	B	REG	458 N	-	-	0.52	458	6.128889184
Z1-EU30C-444	C	REG	52 N	J	-	0.59	52	3.951243719
Z1-EU30C-445	C	REG	9.3 N	-	-	0.52	9.3	2.2300144
Z1-EU30C-446	C	REG	26.1 N	-	-	0.82	26.1	3.261935314
Z1-EU30C-447	C	REG	20.4 N	-	-	0.63	20.4	3.015534901
Z1-EU30C-448 = Dup	C	FA	28.1 N	-	-	0.57	28.1	4.042146884
Z1-EU30C-449	C	REG	68.5 N	-	-	0.6	68.5	4.286833745
Z1-EU30C-450	C	REG	13.6 N	-	-	0.6	13.6	2.602680666
Z1-EU30C-451	C	REG	51.7 N	-	-	0.6	51.7	3.945457782
Z1-EU30C-452	C	REG	22.7 N	-	-	0.81	22.7	3.122344924
Z1-EU30C-453	C	REG	41.3 N	-	-	0.64	41.3	3.72068825
Z1-EU30C-454	C	REG	17.3 N	-	-	0.61	17.3	2.850708602
Z1-EU31BW-415	B	REG	95.9 N	-	-	0.54	95.9	4.563305982
Z1-EU31BW-416	B	REG	138 N	-	-	0.56	138	4.927253685
Z1-EU31BW-417	B	REG	218 N	-	-	0.49	218	5.384486063
Z1-EU31W-412	S	REG	80.7 N	-	-	0.53	80.7	4.380738575
Z1-EU31W-413	S	REG	234 N	-	-	0.46	234	5.455321115
Z1-EU31W-414	S	REG	110 N	-	-	0.55	110	4.700480386
Z1-EU32BW-431	B	REG	286 N	-	-	0.51	286	5.658991811
Z1-EU32BW-432	B	REG	318 N	-	-	0.47	318	5.762051383
Z1-EU32BW-433 + Dup	B	REG	170 N	-	-	0.52	170	5.135798437
Z1-EU32BW-434	B	REG	73.7 N	-	-	0.48	73.7	4.300002799
Z1-EU32C-455	C	REG	15.4 N	-	-	0.61	15.4	2.734387809
Z1-EU32C-456	C	REG	13.1 N	-	-	0.64	13.1	2.57261223
Z1-EU32MW-420	S	REG	137 N	-	-	0.51	137	4.919880926
Z1-EU32MW-426	S	REG	231 N	-	-	0.54	231	5.442417711
Z1-EU32W-418	S	REG	66.4 N	J	-	0.63	66.4	4.48318896
Z1-EU32W-419 + Dup	S	REG	350 N	-	-	0.51	350	5.857993154
Z1-EU32W-421	S	REG	346 N	-	-	0.54	346	5.843644417
Z1-EU32W-422	S	REG	315 N	-	-	0.5	315	5.752572639
Z1-EU32W-423	S	REG	348 N	-	-	0.6	348	6.35220248
Z1-EU32W-424	S	REG	41.1 N	-	-	0.54	41.1	3.716008122
Z1-EU32W-425	S	REG	168 N	-	-	0.66	168	5.123963979
Z1-EU32W-427	S	REG	46.2 N	-	-	0.51	46.2	3.832979796
Z1-EU32W-428	S	REG	60.6 N	-	-	0.67	60.6	4.104294893
Z1-EU32W-429	S	REG	80.2 N	-	-	0.51	80.2	4.384523515
Z1-EU32W-430	S	REG	57.6 N	J	-	0.46	57.6	4.053622588
Z1-EU32W-443	B	REG	902 N	-	-	1.5	902	6.80461452
Z1-EU33BW-444	B	REG	125 N	-	-	0.62	125	4.828313737
Z1-EU33C-457	C	REG	26.4 N	-	-	0.59	26.4	3.27336401
Z1-EU33W-436	S	REG	66.9 N	-	-	0.63	66.9	4.203193967
Z1-EU33W-436	S	REG	63.3 N	-	-	0.53	63.3	4.147885329
Z1-EU33W-437	S	REG	530 N	-	-	0.6	530	6.272877007
Z1-EU33W-438	S	REG	1040 N	-	-	1.6	1040	6.946978332
Z1-EU33W-439	S	REG	344 N	-	-	0.49	344	5.840641657
Z1-EU33W-440	S	REG	514 N	-	-	0.61	514	6.242223266
Z1-EU33W-441	S	REG	334 N	-	-	0.48	334	5.811140993

Number of Samples 57
Number of Detects 97

Minimum 9.3
Median 110
Maximum 1040
Average 186.20526
Standard Deviation 204.1501

PERT-Beta Mean 248.21667

Lognormal Mean 4.6673
Lognormal Standard Deviation 1.1368204

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Zn mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 57

Raw Statistics

Minimum 9.3
Maximum 1040
Mean 186.2
Median 110
SD 204.2
Coefficient of Variation 1.096
Skewness 2.255

Log-transformed Statistics

Minimum of Log Data 2.23
Maximum of Log Data 6.947
Mean of log Data 4.667
SD of log Data 1.139

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.193
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.0865
Lilliefors Critical Value 0.117

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 231.4
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 239.3
95% Modified-t UCL 232.8

Assuming Lognormal Distribution

95% H-UCL 571.6
95% Chebyshev (MVUE) UCL 360.8
97.5% Chebyshev (MVUE) UCL 430.5
99% Chebyshev (MVUE) UCL 567.3

Gamma Distribution Test

k star (bias corrected) 0.986
Theta Star 188.9
nu star 112.4

Approximate Chi Square Value (.05) 88.91
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 88.37

Anderson-Darling Test Statistic 0.526
Anderson-Darling 5% Critical Value 0.779
Kolmogorov-Smirnov Test Statistic 0.0997

Kolmogorov-Smirnov 5% Critical Value 0.121

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL 230.7
95% Jackknife UCL 231.4
95% Standard Bootstrap UCL 231
95% Bootstrap-t UCL 245
95% Hall's Bootstrap UCL 250.9
95% Percentile Bootstrap UCL 233.4
95% BCA Bootstrap UCL 241.9

95% Chebyshev(Mean, Sd) UCL 304.1
97.5% Chebyshev(Mean, Sd) UCL 355.1
99% Chebyshev(Mean, Sd) UCL 455.3

Assuming Gamma Distribution

95% Approximate Gamma UCL 235.4
95% Adjusted Gamma UCL 236.8

Potential UCL to Use

Use 95% Approximate Gamma UCL 235.4

Statistical Summary for PCB-1248 mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
Z1-EU28W-410	S	REG	310 U		U	320	0.16	-1.832581454
Z1-EU29W-401	S	REG	110		U	58	0.11	-2.207274913
Z1-EU29W-402	S	REG	80 U		U	90	0.04	-3.218675925
Z1-EU29W-403	S	REG	85		U	90	0.085	-2.453407983
Z1-EU29W-404	S	REG	2000		U	160	1	0.693147181
Z1-EU29W-408 + Dup	S	FR	890		J	74	0.98	-0.020202707
Z1-EU29W-406	S	REG	16 U		U	15	0.008	-4.828313737
Z1-EU29W-407	S	REG	700		U	84	0.7	-0.358674944
Z1-EU29W-408	S	REG	16 U		U	15	0.008	-4.828313737
Z1-EU29W-409	S	REG	150 U		U	150	0.075	-2.590267168
Z1-EU30W-411	S	REG	2300		J	760	2.3	0.832909123
Z1-EU30C-444	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU30C-445	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU30C-446	C	REG	150 U		U	150	0.078	-2.580367186
Z1-EU30C-447	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU30C-448 + Dup	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU30C-449	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU30C-450	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU30C-451	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU30C-452	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU30C-453	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU30C-454	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU31W-415	S	REG	210		U	32	0.21	-1.540447748
Z1-EU31W-416	S	REG	510		J	80	0.51	-0.484286322
Z1-EU31W-417	S	REG	600		U	81	0.6	-0.510826624
Z1-EU31W-412	S	REG	15 U		U	15	0.008	-4.828313737
Z1-EU31W-413	S	REG	32 U		U	32	0.016	-4.135165557
Z1-EU31W-414	S	REG	15 U		U	18	0.008	-4.828313737
Z1-EU32W-431	S	REG	9900		U	810	9.9	2.292534757
Z1-EU32W-432	S	REG	3600		U	370	3.6	1.290933845
Z1-EU32W-433 + Dup	S	REG	390 U		U	380	0.195	-1.63476872
Z1-EU32W-434	S	REG	16 U		U	15	0.0075	-4.889262258
Z1-EU32C-466	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU32C-468	C	REG	180 U		U	150	0.075	-2.590267168
Z1-EU32MW-420	S	REG	2500		U	150	2.5	0.916290732
Z1-EU32MW-426	S	REG	3700		U	300	3.7	1.30833282
Z1-EU32W-419	S	REG	2900		U	180	2.9	1.020019417
Z1-EU32W-419 + Dup	S	PR	8500		U	1400	8.5	2.140006153
Z1-EU32W-421	S	REG	13000		U	1200	13	2.864343857
Z1-EU32W-422	S	REG	7100		U	720	7.1	1.950094784
Z1-EU32W-423	S	REG	7800		U	1400	7.8	2.054123734
Z1-EU32W-424	S	REG	87		U	15	0.087	-2.441847116
Z1-EU32W-425	S	REG	2000		U	300	2	0.693147181
Z1-EU32W-427	S	REG	60		U	15	0.06	-2.813410717
Z1-EU32W-428	S	REG	84		U	15	0.084	-2.918771232
Z1-EU32W-429	S	REG	30		U	15	0.08	-3.506567897
Z1-EU32W-430	S	REG	480		U	73	0.46	-0.775528799
Z1-EU33W-443	S	REG	7500		J	620	7.5	2.028148247
Z1-EU33W-444	S	REG	2500		U	300	2.5	0.918293732
Z1-EU33C-457	C	REG	140 U		U	140	0.07	-2.659260037
Z1-EU33W-435	S	REG	78		U	18	0.078	-2.551048452
Z1-EU33W-436	S	REG	800		U	90	0.2	-1.6084037912
Z1-EU33W-437	S	REG	2500		U	410	3.5	1.252762986
Z1-EU33W-438	S	REG	8100		U	570	8.1	1.82924084
Z1-EU33W-439	S	REG	3900		U	380	3.9	1.360976553
Z1-EU33W-440	S	REG	4700		U	580	4.7	1.547542506
Z1-EU33W-441	S	REG	2400		U	300	2.4	0.875468737
Number of Samples			57					
Number of Detects			32					
Minimum			0.0075					
Median			0.11					
Maximum			13					
Average			1.7663246					
Standard Deviation			2.9114791					
PERT-Beta Mean			2.24125					
Lognormal Mean			-1.255329					
Lognormal Standard Deviation			2.194857					

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wsl

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

PCB-1248 mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 39

Raw Statistics

Minimum 0.0075
Maximum 13
Mean 1.766
Median 0.11
SD 2.911
Coefficient of Variation 1.648
Skewness 2.067

Log-transformed Statistics

Minimum of Log Data -4.893
Maximum of Log Data 2.565
Mean of log Data -1.255
SD of log Data 2.195

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.292
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.197
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 2.411
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 2.513
95% Modified-t UCL 2.429

Assuming Lognormal Distribution

95% H-UCL 8.857
95% Chebyshev (MVUE) UCL 8.187
97.5% Chebyshev (MVUE) UCL 10.53
99% Chebyshev (MVUE) UCL 15.12

Gamma Distribution Test

k star (bias corrected) 0.358
Theta Star 4.929
nu star 40.86

Approximate Chi Square Value (.05) 27.21
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 26.92

Anderson-Darling Test Statistic 3.111
Anderson-Darling 5% Critical Value 0.847
Kolmogorov-Smirnov Test Statistic 0.234

Kolmogorov-Smirnov 5% Critical Value 0.127

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 2.401
95% Jackknife UCL 2.411
95% Standard Bootstrap UCL 2.386
95% Bootstrap-t UCL 2.533
95% Halfs Bootstrap UCL 2.531
95% Percentile Bootstrap UCL 2.433
95% BCA Bootstrap UCL 2.562
95% Chebyshev(Mean, Sd) UCL 3.447
97.5% Chebyshev(Mean, Sd) UCL 4.175
99% Chebyshev(Mean, Sd) UCL 5.603

Assuming Gamma Distribution

95% Approximate Gamma UCL 2.852
95% Adjusted Gamma UCL 2.681

Potential UCL to Use

Use 99% Chebyshev (Mean, Sd) UCL

5.603

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

© Redus and Associates, 2001 - 2005

Information: Ken Redus, 865.483.2715

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12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

SRC	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
	MIN	MED	MAX					α_1	α_2	Variance	Max - Min
PCB-1248 (mg/kg)	7.50E-03	1.10E-01	1.30E+01	2.24E+00	5.96E+00	2.86	5.96	1.03	4.97	4.1460	13.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - \frac{MIN}{MAX})^{\alpha_1 - 1} (\frac{MAX - 1}{MAX - MIN})^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MIN \leq x \leq MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times MED + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the incomplete Beta Function.
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel 98™ function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for PCB-1254 mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
Z1-EU29W-400	S	REG	2100	J		320	2.1	0.741937345
Z1-EU29W-401	S	REG	440	-		58	0.44	-0.820960662
Z1-EU29W-402	S	REG	880	-		60	0.88	-0.127333372
Z1-EU29W-403	S	REG	280	-		30	0.28	-1.272965676
Z1-EU29W-404	S	REG	1800	-		160	1.8	0.587786663
Z1-EU29W-405 + Dup	S	FR	820	J		74	0.82	-0.198480935
Z1-EU29W-406	S	REG	25	-		16	0.025	-3.849658741
Z1-EU29W-407	S	REG	1000	-		64	1	0
Z1-EU29W-408	S	REG	16 U	U		16	0.006	-4.326313737
Z1-EU29W-409	S	REG	810	-		160	0.81	-0.210721031
Z1-EU30W-411	B	REG	4600	J		780	4.6	1.828056309
Z1-EU30C-444	C	REG	140 U	U		140	0.07	-2.8159260037
Z1-EU30C-445	C	REG	140 U	U		140	0.07	-2.8592160037
Z1-EU30C-446	C	REG	150 U	U		160	0.075	-2.390287166
Z1-EU30C-447	C	REG	140 U	U		140	0.07	-2.858280037
Z1-EU30C-448 + Dup	C	FR	45 J	J		140	0.045	-3.015934881
Z1-EU30C-449	C	REG	140 U	U		140	0.07	-2.669280037
Z1-EU30C-450	C	REG	140 U	U		140	0.07	-2.659280037
Z1-EU30C-451	C	REG	140 U	U		140	0.07	-2.640280037
Z1-EU30C-452	C	REG	43 J	J		140	0.043	-3.140551163
Z1-EU30C-453	C	REG	110 J	J		140	0.11	-2.207274519
Z1-EU30C-454	C	REG	140 U	U		140	0.07	-2.669280037
Z1-EU31W-415	B	REG	170	-		32	0.17	-1.771956042
Z1-EU31W-416	B	REG	940	J		60	0.94	-0.061875454
Z1-EU31W-417	B	REG	540	-		51	0.54	-0.516186139
Z1-EU31W-412	S	REG	40	-		15	0.04	-3.218875825
Z1-EU31W-413	S	REG	360	-		32	0.36	-0.94160654
Z1-EU31W-414	S	REG	130	-		15	0.13	-2.040220629
Z1-EU32W-431	B	REG	7300	-		610	7.3	1.987874349
Z1-EU32W-432	B	REG	2800	-		370	2.8	1.029619417
Z1-EU32W-433 + Dup	B	FR	550	J		380	0.55	-0.587857001
Z1-EU32W-434	B	REG	21	-		16	0.021	-3.863233841
Z1-EU32C-455	C	REG	180	-		140	0.18	-1.850731207
Z1-EU32C-456	C	REG	180 U	U		150	0.075	-2.580267155
Z1-EU32W-420	S	REG	1600	-		150	1.6	0.405465106
Z1-EU32W-426	S	REG	3700	-		300	3.7	1.30833282
Z1-EU32W-418	S	REG	1400	-		160	1.4	0.338472217
Z1-EU32W-419 + Dup	S	FR	5300	-		1400	5.3	1.667706621
Z1-EU32W-421	S	REG	6900	-		1200	6.6	1.887099649
Z1-EU32W-422	S	REG	6900	-		720	6.9	1.689236206
Z1-EU32W-423	S	REG	6000	-		1400	6	1.791759489
Z1-EU32W-424	S	REG	45	-		15	0.045	-3.101699789
Z1-EU32W-425	S	REG	990	-		300	0.99	-0.010050036
Z1-EU32W-427	S	REG	58	-		15	0.058	-2.830217835
Z1-EU32W-428	S	REG	84	-		16	0.054	-2.364480457
Z1-EU32W-429	S	REG	18	-		15	0.018	-4.017383521
Z1-EU32W-430	S	REG	270	-		73	0.27	-1.309333362
Z1-EU33W-443	B	REG	2200	J		620	2.2	0.78845735
Z1-EU33W-444	B	REG	2200	-		300	2.2	0.78845735
Z1-EU33C-457	C	REG	140 U	U		140	0.07	-2.869280037
Z1-EU33W-435	S	REG	88	-		15	0.088	-2.490418465
Z1-EU33W-436	S	REG	130	-		30	0.13	-2.040220629
Z1-EU33W-437	S	REG	3400	-		410	3.4	1.223775432
Z1-EU33W-438	S	REG	3000	-		610	3	1.096612289
Z1-EU33W-439	S	REG	1800	-		380	1.8	0.587786663
Z1-EU33W-440	S	REG	4200	-		590	4.2	1.435084525
Z1-EU33W-441	S	REG	2100	-		200	2.1	0.741937345

Number of Samples 57
Number of Detects 46

Minimum 0.008
Median 0.39
Maximum 7.3
Average 1.3483333
Standard Deviation 1.8801573

PERT-Beta Mean 1.478

Lognormal Mean -1.00501
Lognormal Standard Deviation 1.8547127

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

PCB-1254 mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 45

Raw Statistics

Minimum 0.008
Maximum 7.3
Mean 1.346
Median 0.39
SD 1.88
Coefficient of Variation 1.397
Skewness 1.652

Log-transformed Statistics

Minimum of Log Data -4.828
Maximum of Log Data 1.988
Mean of log Data -1.005
SD of log Data 1.855

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.24
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.137
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 1.763
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 1.814
95% Modified-t UCL 1.772

Assuming Lognormal Distribution

95% H-UCL 4.416
95% Chebyshev (MVUE) UCL 4.83
97.5% Chebyshev (MVUE) UCL 6.101
99% Chebyshev (MVUE) UCL 8.596

Gamma Distribution Test

k star (bias corrected) 0.475
Theta Star 2.833
nu star 54.18

Approximate Chi Square Value (.05) 38.27
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 37.92

Anderson-Darling Test Statistic 1.767
Anderson-Darling 5% Critical Value 0.818
Kolmogorov-Smirnov Test Statistic 0.171
Kolmogorov-Smirnov 5% Critical Value 0.125

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 1.756
95% Jackknife UCL 1.763
95% Standard Bootstrap UCL 1.745
95% Bootstrap-t UCL 1.854
95% Hall's Bootstrap UCL 1.792
95% Percentile Bootstrap UCL 1.771
95% BCA Bootstrap UCL 1.841

95% Chebyshev(Mean, Sd) UCL 2.432
97.5% Chebyshev(Mean, Sd) UCL 2.902
99% Chebyshev(Mean, Sd) UCL 3.824

Assuming Gamma Distribution

95% Approximate Gamma UCL 1.906
95% Adjusted Gamma UCL 1.924

Potential UCL to Use

Use 97.5% Chebyshev (Mean, Sd) UCL 2.902

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Redus, 865.483.2715

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12/29/2006 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

SRC	WACFACS WL SRC INPUT			Calculations							
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
PCB-1254 (mg/kg)	8.00E-03	3.90E-01	7.30E+00	1.48E+00	3.66E+00	2.47	3.66	1.21	4.79	1.5313	7.3

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MostLikely < MAX$$

$$F(x) = \frac{B_1(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times MostLikely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN)(MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel @TM function BETA.INV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for PCB-1260 mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
Z1-EU28W-410	B	REG	880		J	320	0.88	-0.415513444
Z1-EU28W-401	S	REG	890		J	58	0.48	-0.713343888
Z1-EU28W-402	S	REG	340		A	80	0.34	-1.078809861
Z1-EU28W-403	S	REG	110		=	30	0.11	-2.307274913
Z1-EU28W-404	S	REG	550		=	160	0.55	-0.587837001
Z1-EU28W-405 + Dup	S	FR	440		J	74	0.44	-0.820360492
Z1-EU28W-406	S	REG	7.7 J	J	J	16	0.0077	-4.86853486
Z1-EU28W-407	S	REG	370		=	64	0.37	-0.994252873
Z1-EU28W-408	S	REG	16 U		U	16	0.008	-4.828313737
Z1-EU28W-408	S	REG	350		=	150	0.35	-1.048822124
Z1-EU30W-411	B	REG	1800		J	780	1.8	0.641803888
Z1-EU30C-444	C	REG	140 U		U	140	0.07	-2.859280037
Z1-EU30C-445	C	REG	140 U		U	140	0.07	-2.859280037
Z1-EU30C-446	C	REG	150 U		U	150	0.075	-2.590267165
Z1-EU30C-447	C	REG	140 U		U	140	0.07	-2.859280037
Z1-EU30C-448 + Dup	C	FR	70 J	J	J	140	0.07	-2.859280037
Z1-EU30C-449	C	REG	140 U		U	140	0.07	-2.859280037
Z1-EU30C-450	C	REG	140 U		U	140	0.07	-2.859280037
Z1-EU30C-451	C	REG	140 U		U	140	0.07	-2.859280037
Z1-EU30C-452	C	REG	140 U		U	140	0.07	-2.859280037
Z1-EU30C-453	C	REG	47 J	J	J	140	0.047	-3.057800877
Z1-EU30C-454	C	REG	140 U		U	140	0.07	-2.859280037
Z1-EU318W-415	B	REG	77		=	32	0.077	-2.563949887
Z1-EU318W-416	B	REG	360		J	80	0.36	-1.021651248
Z1-EU318W-417	B	REG	360		=	81	0.36	-1.021651248
Z1-EU31W-418	S	REG	28		=	18	0.028	-3.576560769
Z1-EU31W-419	S	REG	200		=	32	0.2	-1.809437912
Z1-EU31W-414	S	REG	120		=	18	0.12	-2.120263536
Z1-EU328W-431	B	REG	2100		=	810	2.1	0.741957348
Z1-EU328W-432	B	REG	830		=	370	0.83	-0.186329578
Z1-EU328W-433 + Dup	B	REG	390 U		U	390	0.195	-1.834735572
Z1-EU328W-434	B	REG	14 J	J	J	15	0.014	-4.268487949
Z1-EU32C-455	C	REG	340		A	140	0.34	-1.078809861
Z1-EU32C-456	C	REG	150 U		U	150	0.075	-2.590267165
Z1-EU32W-420	S	REG	680		A	150	0.68	-0.415515444
Z1-EU32W-425	S	REG	1600		=	300	1.6	0.470003629
Z1-EU32W-418	S	REG	650		=	160	0.65	-0.415515444
Z1-EU32W-419 + Dup	S	FR	1500		=	1400	1.5	0.405445108
Z1-EU32W-421	S	REG	2400		=	1200	2.4	1.028819477
Z1-EU32W-422	S	REG	1300		=	720	1.3	0.262364864
Z1-EU32W-423	S	REG	2000		A	1400	2	0.680147181
Z1-EU32W-424	S	REG	20		A	15	0.02	-3.512032005
Z1-EU32W-425	S	REG	520		=	300	0.62	-0.6538926467
Z1-EU32W-427	S	REG	49		=	15	0.049	-3.015934861
Z1-EU32W-428	S	REG	41		=	15	0.041	-3.194188212
Z1-EU32W-429	S	REG	6.4 J	J	J	16	0.0064	-5.054457288
Z1-EU32W-430	S	REG	61 J	J	UJ	73	0.0365	-3.370443018
Z1-EU32W-443	B	REG	1000		J	620	1	0
Z1-EU308W-444	B	REG	790		=	300	0.79	-0.235722334
Z1-EU33C-457	C	REG	140 U		U	140	0.07	-2.859280037
Z1-EU33W-436	S	REG	37		A	16	0.037	-3.286837346
Z1-EU33W-438	S	REG	45		A	30	0.045	-3.101082789
Z1-EU33W-437	S	REG	620		=	410	0.62	-0.082381800
Z1-EU33W-438	S	REG	870		=	610	0.87	-0.138282067
Z1-EU33W-439	S	REG	390		A	380	0.39	-0.94160884
Z1-EU33W-440	S	REG	690		=	690	0.97	-0.030465207
Z1-EU33W-441	S	REG	770		=	300	0.77	-0.261264784

Number of Samples 57
Number of Detects 43

Minimum 0.0064
Median 0.2
Maximum 2.6
Average 0.4885193
Standard Deviation 0.8227348

PERT-Beta Mean 0.6010667

Lognormal Mean -1.67191
Lognormal Standard Deviation 1.5694963

General UCL Statistics for Fud Data Sets

User Selected Options

From File Worksheet.wsl

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

PCB-1260 mg/kg

General Statistics

Number of Valid Observations 57

Number of Distinct Observations 43

Raw Statistics

Minimum 0.0064

Maximum 2.8

Mean 0.487

Median 0.2

SD 0.623

Coefficient of Variation 1.28

Skewness 1.845

Log-transformed Statistics

Minimum of Log Data -5.051

Maximum of Log Data 1.03

Mean of log Data -1.672

SD of log Data 1.569

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.22

Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.154

Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 0.624

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 0.644

95% Modified-t UCL 0.628

Assuming Lognormal Distribution

95% H-UCL 1.148

95% Chebyshev (MVUE) UCL 1.375

97.5% Chebyshev (MVUE) UCL 1.703

99% Chebyshev (MVUE) UCL 2.349

Gamma Distribution Test

k star (bias corrected) 0.621

Theta Star 0.784

nu star 70.77

Approximate Chi Square Value (.05) 52.4

Adjusted Level of Significance 0.0458

Adjusted Chi Square Value 51.99

Anderson-Darling Test Statistic 1.214

Anderson-Darling 5% Critical Value 0.802

Kolmogorov-Smirnov Test Statistic 0.193

Kolmogorov-Smirnov 5% Critical Value 0.123

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 0.622

95% Jackknife UCL 0.624

95% Standard Bootstrap UCL 0.62

95% Bootstrap-t UCL 0.656

95% Halfs Bootstrap UCL 0.651

95% Percentile Bootstrap UCL 0.627

95% BCA Bootstrap UCL 0.651

95% Chebyshev(Mean, Sd) UCL 0.846

97.5% Chebyshev(Mean, Sd) UCL 1.002

99% Chebyshev(Mean, Sd) UCL 1.307

Assuming Gamma Distribution

95% Approximate Gamma UCL 0.657

95% Adjusted Gamma UCL 0.662

Potential UCL to Use

Use 97.5% Chebyshev (Mean, Sd) UCL

1.002

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Radius, 865.483.2715

WACFACS 3.0 User Manual

12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

WACFACS W.L. SRC INPUT				Calculations							
				OUTPUT			Beta PDF Inverse		PERT BETA		
STEP 10 STEP 11 STEP 12				E(X)	UCL-95	UCL-95: E(X)	0.95		0 ₁	0 ₂	Variance
MIN	MED	MAX									Max - Min
PCB-1290 (mg/kg)	8.40E-03	2.00E-01	2.80E+00	6.01E-01	1.45E+00	2.41	1.45	1.26	4.72	0.2373	2.8

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval (0, 1). The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - MIN)^{0.5} (MAX - (1 - MIN)^{0.5})}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < MAX \text{ and } MIN < x < MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times MAX \text{ Likelihood} + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
 α_1 and α_2 are calculated parameters.

Use the Microsoft Excel 2003 function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Total PCBs mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LM Proxy Value
Z1-EU29BW-400	B	REG	2800		J	860	2.8	1.029818417
Z1-EU29W-401	S	REG	1000		J	170	1	0
Z1-EU29W-402	S	REG	1200		=	240	1.2	0.182321557
Z1-EU29W-403	S	REG	490		=	91	0.49	-0.713349888
Z1-EU29W-404	S	REG	4400		=	470	4.4	1.481904541
Z1-EU29W-406 + Dup	S	FR	2200		J	220	2.2	0.788467735
Z1-EU29W-406	S	REG	30 J		J	48	0.033	-3.411247718
Z1-EU29W-407	S	REG	2100		=	190	2.1	0.741937345
Z1-EU29W-408	S	REG	48 U		U	48	0.034	-3.729701449
Z1-EU29W-409	S	REG	1200		=	450	1.2	0.182321557
Z1-EU30BW-411	B	REG	8700		J	2300	8.7	2.153323026
Z1-EU30C-444	C	REG	430 U		U	430	0.218	-1.537117251
Z1-EU30C-445	C	REG	420 U		U	420	0.21	-1.560647748
Z1-EU30C-446	C	REG	440 U		U	440	0.22	-1.514127753
Z1-EU30C-447	C	REG	430 U		U	430	0.215	-1.637117251
Z1-EU30C-448 + Dup	C	FR	120 J		J	420	0.12	-2.120263536
Z1-EU30C-449	C	REG	420 U		U	420	0.21	-1.560647748
Z1-EU30C-450	C	REG	430 U		U	430	0.215	-1.537117251
Z1-EU30C-451	C	REG	410 U		U	410	0.205	-1.5947493
Z1-EU30C-452	C	REG	43 J		J	430	0.043	-3.146551453
Z1-EU30C-453	C	REG	160 J		J	430	0.16	-1.632581464
Z1-EU30C-454	C	REG	430 U		U	430	0.215	-1.537117251
Z1-EU31BW-415	B	REG	450		=	95	0.45	-0.798507698
Z1-EU31BW-416	B	REG	1900		J	240	1.9	0.641853888
Z1-EU31BW-417	B	REG	1500		=	240	1.5	0.405466108
Z1-EU31W-412	S	REG	48		=	47	0.048	-2.588247874
Z1-EU31W-413	S	REG	590		=	96	0.59	-0.837532742
Z1-EU31W-414	S	REG	250		=	48	0.25	-1.386254351
Z1-EU32BW-431	B	REG	19000		=	2400	19	2.944438979
Z1-EU32BW-432	B	REG	7200		=	1100	7.2	1.974081026
Z1-EU32BW-433 + Dup	B	FR	550 J		J	1200	0.55	-0.867337001
Z1-EU32BW-434	B	REG	35 J		J	45	0.035	-3.352407217
Z1-EU32C-455	C	REG	530		=	430	0.53	-0.634878272
Z1-EU32C-456	C	REG	460 U		U	460	0.23	-1.48957057
Z1-EU32W-420	S	REG	4600		=	450	4.6	1.528056303
Z1-EU32W-426	S	REG	8800		=	910	8.9	2.186051277
Z1-EU32W-418	S	REG	4300		=	490	4.3	1.588235205
Z1-EU32W-419 + Dup	S	FR	18000		=	4300	15	2.708080201
Z1-EU32W-421	S	REG	23000		=	3600	23	3.135184216
Z1-EU32W-422	S	REG	13000		=	2200	13	2.564343367
Z1-EU32W-423	S	REG	16000		=	4300	16	2.772588722
Z1-EU32W-424	S	REG	150		=	48	0.15	-1.857119985
Z1-EU32W-425	S	REG	3500		=	900	3.5	1.252762068
Z1-EU32W-427	S	REG	170		=	45	0.17	-1.771964842
Z1-EU32W-428	S	REG	180		=	48	0.18	-1.680731207
Z1-EU32W-429	S	REG	54		J	48	0.054	-2.918771232
Z1-EU32W-430	S	REG	900		=	220	0.9	-0.223143551
Z1-EU33BW-443	B	REG	11000		J	1900	11	2.397185273
Z1-EU33BW-444	B	REG	5500		=	890	5.5	1.704744022
Z1-EU33C-487	C	REG	420 U		U	420	0.21	-1.580647748
Z1-EU33W-435	S	REG	200		=	47	0.2	-1.609437912
Z1-EU33W-436	S	REG	390		=	85	0.39	-0.967584026
Z1-EU33W-437	S	REG	7900		=	1200	7.9	2.098862758
Z1-EU33W-438	S	REG	8000		=	1800	8	2.187224577
Z1-EU33W-439	S	REG	5100		=	1100	5.1	2.808285771
Z1-EU33W-440	S	REG	9800		=	1800	9.8	2.282382348
Z1-EU33W-441	S	REG	5300		=	910	5.3	1.657708827

Number of Samples 57
Number of Detects 46

Minimum 0.024
Median 0.59
Maximum 23
Average 3.5812632
Standard Deviation 5.3066198

PERT-Beta Mean 4.2306667

Lognormal Mean -0.122658
Lognormal Standard Deviation 1.9102028

Statistical Summary for Total PCBs mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection		
						Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
EU28W-406	B	REG	2800		J	950	2.8	1.029619417
EU29W-401	S	REG	1000		J	170	1	0
EU29W-402	S	REG	1200		-	240	1.2	0.182321557
EU29W-403	S	REG	490		-	91	0.49	-0.713340888
EU29W-404	S	REG	4400		-	470	4.4	1.481004541
EU29W-406 + Dup	S	FR	2200		J	220	2.2	0.78845738
EU29W-408	S	REG	33 J		J	48	0.033	-3.411247718
EU29W-407	S	REG	2100		-	190	2.1	0.741937345
EU29W-408	S	REG	48 U		U	48	0.024	-3.728701449
EU29W-409	S	REG	1200		-	450	1.2	0.182321557
EU30BW-411	B	REG	8700		J	2300	8.7	2.163323026
EU30C-444	C	REG	430 U		U	430	0.215	-1.537117251
EU30C-445	C	REG	420 U		U	420	0.21	-1.560647748
EU30C-446	C	REG	440 U		U	440	0.22	-1.514127733
EU30C-447	C	REG	430 U		U	430	0.215	1.537117251
EU30C-448 + Dup	C	FR	120 J		J	420	0.12	-2.120265336
EU30C-449	C	REG	420 U		U	420	0.21	-1.560647748
EU30C-450	C	REG	430 U		U	430	0.218	-1.537117251
EU30C-451	C	REG	410 U		U	410	0.206	-1.5847483
EU30C-452	C	REG	43 J		J	430	0.043	-3.148855163
EU30C-453	C	REG	100 J		J	430	0.16	-1.822581464
EU30C-454	C	REG	430 U		U	430	0.215	-1.537117251
EU31BW-415	B	REG	450		-	85	0.45	-0.798507696
EU31BW-416	B	REG	1900		J	290	1.9	0.641863886
EU31BW-417	B	REG	1500		-	240	1.5	0.405455108
EU31W-412	S	REG	58		=	47	0.058	-2.688247574
EU31W-413	S	REG	590		=	95	0.59	-0.527632742
EU31W-414	S	REG	280		-	48	0.25	-1.386294361
EU32BW-431	B	REG	19000		-	2400	19	2.944408979
EU32BW-432	B	REG	7200		-	1100	7.2	1.974061020
EU32BW-433 + Dup	B	FR	550 J		J	1200	0.55	-0.597837001
EU32BW-434	B	REG	35 J		J	45	0.035	-3.352407217
EU32C-455	C	REG	530		-	430	0.53	-0.634878272
EU32C-456	C	REG	490 U		U	490	0.23	-1.489627507
EU32MW-420	S	REG	4800		-	430	4.8	1.569368300
EU32MW-426	S	REG	8900		-	510	8.9	2.180051277
EU32W-418	S	REG	4900		-	490	4.9	1.689238206
EU32W-419 + Dup	S	FR	15000		-	4300	15	2.708350201
EU32W-421	S	REG	29000		-	3500	23	3.135494216
EU32W-422	S	REG	13000		-	2200	13	2.564949357
EU32W-423	S	REG	18000		-	4300	18	2.772568722
EU32W-424	S	REG	180		-	46	0.15	-1.897119085
EU32W-425	S	REG	3500		-	900	3.5	1.252762988
EU32W-427	S	REG	170		=	45	0.17	-1.771556842
EU32W-428	S	REG	190		=	45	0.19	-1.895731207
EU32W-429	S	REG	54		J	46	0.054	-2.814771232
EU32W-430	S	REG	600		-	220	0.6	-0.223142851
EU33BW-440	B	REG	11000		J	1900	11	2.397896273
EU33BW-444	B	REG	5900		=	890	5.5	1.704748092
EU33C-457	C	REG	420 U		U	430	0.21	-1.560647748
EU33W-435	S	REG	200		-	47	0.2	-1.609437812
EU33W-436	S	REG	390		-	89	0.39	-0.967894026
EU33W-437	S	REG	7900		=	1200	7.9	2.068862759
EU33W-438	S	REG	9000		-	1800	9	2.197224577
EU33W-439	S	REG	9100		-	7100	9.1	1.808266771
EU33W-440	S	REG	9800		-	1800	9.8	2.282362396
EU33W-441	S	REG	5000		-	510	5.3	1.657706821

Number of Samples 57
Number of Detects 46

Minimum 0.024
Median 0.59
Maximum 23
Average 3.5812632
Standard Deviation 5.3088136

PERT-Beta Mean 4.2306667

Lognormal Mean -0.122658
Lognormal Standard Deviation 1.9100208

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

Total PCBs mg/kg

General Statistics

Number of Valid Observations 57 Number of Distinct Observations 51

Raw Statistics

Minimum 0.024
Maximum 23
Mean 3.581
Median 0.59
SD 5.309
Coefficient of Variation 1.482
Skewness 1.892

Log-transformed Statistics

Minimum of Log Data -3.73
Maximum of Log Data 3.135
Mean of log Data -0.123
SD of log Data 1.91

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic 0.252
Lilliefors Critical Value 0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic 0.149
Lilliefors Critical Value 0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 4.757
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 4.926
95% Modified-t UCL 4.787

Assuming Lognormal Distribution

95% H-UCL 12.34
95% Chebyshev (MVUE) UCL 13.18
97.5% Chebyshev (MVUE) UCL 16.7
99% Chebyshev (MVUE) UCL 23.61

Gamma Distribution Test

k star (bias corrected) 0.448
Theta Star 8
nu star 51.03

Approximate Chi Square Value (.05) 35.63
Adjusted Level of Significance 0.0458
Adjusted Chi Square Value 35.29

Anderson-Darling Test Statistic 1.914
Anderson-Darling 5% Critical Value 0.825
Kolmogorov-Smirnov Test Statistic 0.174
Kolmogorov-Smirnov 5% Critical Value 0.125

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 4.738
95% Jackknife UCL 4.757
95% Standard Bootstrap UCL 4.73
95% Bootstrap-t UCL 5.021
95% Hall's Bootstrap UCL 4.97
95% Percentile Bootstrap UCL 4.774
95% BCA Bootstrap UCL 4.97
95% Chebyshev(Mean, Sd) UCL 6.646
97.5% Chebyshev(Mean, Sd) UCL 7.972
99% Chebyshev(Mean, Sd) UCL 10.58

Assuming Gamma Distribution

95% Approximate Gamma UCL 5.13
95% Adjusted Gamma UCL 5.178

Potential UCL to Use

Use 97.5% Chebyshev (Mean, Sd) UCL

7.972

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Redus, 866.483.2715

kredus@rick.net

12/29/2005 R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

WACFACS WL L SRC INPUT						Calculations							
						OUTPUT		Beta PDF Inverse		PERT BETA			
	SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95		α_1	α_2	Variance	Max - Min
Total PCBs (mg/kg)		2.40E-02	5.90E-01	2.30E+01	4.23E+00	1.69E+01	2.58	10.83		1.10	4.90	18.6075	23.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < Mostlikely < MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Mostlikely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_2(\alpha_1, \alpha_2)$ is the incomplete Beta Function
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel BETA INVERSE ($\alpha_1, \alpha_2, MIN, MAX$) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for 2-Butanone mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection		LN Proxy Value
						Limit (ug/kg)	Proxy Value (mg/kg)	
Z1-EU29BW-410	B	REG	20 U	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-402	S	REG	20 U	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-403	S	REG	2.4 J	J	J	0.85	0.0024	-6.032286542
Z1-EU29W-404	S	REG	20 U	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-405 + Dup	S	REG	20 U	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-406	S	REG	0.86 J	=	=	0.85	0.00086	-6.948577274
Z1-EU29W-407	S	REG	20 U	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-408	S	REG	20 U	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-409	S	REG	20 U	U	U	0.85	0.000425	-7.763421389
Z1-EU30BW-411	B	REG	20 U	U	U	0.85	0.000425	-7.763421389
Z1-EU31BW-415	B	REG	11 U	U	U	11	0.0055	-5.203007187
Z1-EU31BW-416	B	REG	11 U	U	U	11	0.0055	-5.203007187
Z1-EU31BW-417	B	REG	23	J	J	12	0.023	-3.772281063
Z1-EU31W-412	S	REG	10 U	U	U	10	0.005	-5.298317367
Z1-EU31W-413	S	REG	3.8 J	J	J	0.85	0.0039	-5.546778728
Z1-EU31W-414	S	REG	20 U	U	U	0.85	0.000425	-7.763421389
Z1-EU32BW-431	B	REG	9 U	U	U	9	0.0045	-5.403677882
Z1-EU32BW-432	B	REG	10 U	U	U	10	0.005	-5.298317367
Z1-EU32BW-433 + Dup	B	FR	12	=	=	9	0.012	-4.422848629
Z1-EU32BW-434	B	REG	9 U	U	U	9	0.0045	-5.403677882
Z1-EU32MW-420	S	REG	10 U	U	U	10	0.005	-5.298317367
Z1-EU32MW-426	S	REG	9 U	U	U	9	0.0045	-5.403677882
Z1-EU32W-418	S	REG	10 U	U	U	10	0.005	-5.298317367
Z1-EU32W-419 + Dup	S	REG	9 U	U	U	9	0.0045	-5.403677882
Z1-EU32W-421	S	REG	9 U	U	U	9	0.0045	-5.403677882
Z1-EU32W-422	S	REG	17	=	=	10	0.017	-4.074541935
Z1-EU32W-423	S	REG	8 U	U	U	8	0.004	-5.521460918
Z1-EU32W-424	S	REG	27	=	=	10	0.027	-3.611918413
Z1-EU32W-425	S	REG	9 U	U	U	9	0.0045	-5.403677882
Z1-EU32W-427	S	REG	17	=	=	10	0.017	-4.074541935
Z1-EU32W-428	S	REG	9 U	U	U	9	0.0045	-5.403677882
Z1-EU32W-429	S	REG	9 U	U	U	9	0.0045	-5.403677882
Z1-EU32W-430	S	REG	33	=	=	9	0.033	-3.411247718
Z1-EU33BW-443	B	REG	45	J	J	10	0.045	-3.101092789
Z1-EU33BW-444	B	REG	9 U	U	U	9	0.0045	-5.403677882
Z1-EU33W-435	S	REG	10 U	U	U	10	0.005	-5.298317367
Z1-EU33W-436	S	REG	20	J	J	9	0.02	-3.912023005
Z1-EU33W-437	S	REG	27	=	=	10	0.027	-3.611918413
Z1-EU33W-438	S	REG	10 U	U	U	10	0.005	-5.298317367
Z1-EU33W-439	S	REG	14	=	=	9	0.014	-4.268687949
Z1-EU33W-440	S	REG	32	=	=	9	0.032	-3.442018378
Z1-EU33W-441	S	REG	9 U	U	U	9	0.0045	-5.403677882

Number of Samples 42
Number of Defects 14

Minimum 0.000425
Median 0.0045
Maximum 0.045
Average 0.0087639
Standard Deviation 0.0106721

PERT-Beta Mean 0.0105708

Lognormal Mean -5.520374
Lognormal Standard Deviation 1.4203869

General UCL Statistics for Full Data Sets

User Selected Options

From File Worksheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

2-Butanone mg/kg

General Statistics

Number of Valid Observations 42 Number of Distinct Observations 17

Raw Statistics

Minimum 4.2500E-4
Maximum 0.045
Mean 0.00876
Median 0.0045
SD 0.0107
Coefficient of Variation 1.218
Skewness 1.786

Log-transformed Statistics

Minimum of Log Data -7.763
Maximum of Log Data -3.101
Mean of Log Data -5.52
SD of Log Data 1.42

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.709
Shapiro Wilk Critical Value 0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.833
Shapiro Wilk Critical Value 0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 0.0115
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 0.012
95% Modified-t UCL 0.0115

Assuming Lognormal Distribution

95% H-UCL 0.0206
95% Chebyshev (MVUE) UCL 0.0234
97.5% Chebyshev (MVUE) UCL 0.029
99% Chebyshev (MVUE) UCL 0.0399

Gamma Distribution Test

k star (bias corrected) 0.724
Theta Star 0.0121
nu star 60.81

Approximate Chi Square Value (.05) 43.88
Adjusted Level of Significance 0.0443
Adjusted Chi Square Value 43.37

Anderson-Darling Test Statistic 1.848
Anderson-Darling 5% Critical Value 0.789
Kolmogorov-Smirnov Test Statistic 0.23
Kolmogorov-Smirnov 5% Critical Value 0.142

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 0.0115
95% Jackknife UCL 0.0115
95% Standard Bootstrap UCL 0.0114
95% Bootstrap-t UCL 0.0123
95% Hall's Bootstrap UCL 0.0119
95% Percentile Bootstrap UCL 0.0115
95% BCA Bootstrap UCL 0.012
95% Chebyshev(Mean, Sd) UCL 0.0159
97.5% Chebyshev(Mean, Sd) UCL 0.019
99% Chebyshev(Mean, Sd) UCL 0.0251

Assuming Gamma Distribution

95% Approximate Gamma UCL 0.0121
95% Adjusted Gamma UCL 0.0123

Potential UCL to Use

Use 99% Chebyshev (Mean - Sd) UCL 0.0251

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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Information: Ken Radius, 865.483.2719

kradius@radius.net

12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

SRC	WACFACS W.L.L.SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12	E(X)	UCL-95	UCL-95 : E(X)	Beta PDF Inverse		PERT BETA		
	MIN	MED	MAX				0.99		α_1	α_2	Variance
2-Butanone (mg/kg)	4.25E-04	4.50E-03	4.50E-02	1.06E-02	2.43E-02	2.30	0.02		1.37	4.83	0.0001
											Max - Min
											0.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(1 - \text{MIN})^{\alpha_1 - 1} (\text{MAX} - 1)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (\text{MAX} - \text{MIN})^{\alpha_1 + \alpha_2 - 1}} \quad \text{MIN} < \text{Minibet} < \text{MAX}$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{\text{MIN} + 4 \times \text{Minibet} + \text{MAX}}{6}$$

$$\text{Var}(x) = \frac{(E(x) - \text{MIN}) \times (\text{MAX} - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - \text{MIN}}{\text{MAX} - \text{MIN}} \right]$$

$$\alpha_2 = 6 \times \left[\frac{\text{MAX} - E(x)}{\text{MAX} - \text{MIN}} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_1(\alpha_1, \alpha_2)$ is the incomplete Beta Function

α_1 and α_2 are calculated parameters

Use the Microsoft Excel BETA.INV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for 2-Methylnaphthalene mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection		LN Proxy Value
						Limit (ug/kg)	Proxy Value (mg/kg)	
Z1-EU29BW-410	B	REG	38 J	J		400	0.039	-3.244193633
Z1-EU29W-401	S	REG	360 U	U		380	0.18	-1.714786428
Z1-EU29W-402	S	REG	20 J	J		400	0.02	-3.912023005
Z1-EU29W-403	S	REG	380 U	UU		380	0.19	-1.660731207
Z1-EU29W-404	S	REG	380 U	UU		390	0.195	-1.63475572
Z1-EU29W-405 + Dup	S	FR	87 J	J		370	0.087	-2.44184718
Z1-EU29W-406	S	REG	400 U	UU		400	0.2	-1.609437812
Z1-EU29W-407	S	REG	23 J	J		400	0.023	-3.772261063
Z1-EU29W-408	S	REG	20 J	J		400	0.02	-3.912023005
Z1-EU28W-409	S	REG	28 J	J		380	0.028	-3.575550769
Z1-EU30BW-411	B	REG	93 J	J		380	0.093	-2.375155786
Z1-EU31BW-415	B	REG	50 J	J		400	0.05	-2.985732274
Z1-EU31BW-416	B	REG	400 U	UU		400	0.2	-1.609437812
Z1-EU31BW-417	B	REG	40 J	J		410	0.04	-3.218875625
Z1-EU31W-412	S	REG	300 J	J		380	0.3	-1.203872804
Z1-EU31W-413	S	REG	44 J	J		400	0.044	-3.123665645
Z1-EU31W-414	S	REG	82 J	J		400	0.082	-2.780820894
Z1-EU32BW-431	B	REG	87 J	J		410	0.087	-2.44184718
Z1-EU32BW-432	B	REG	43 J	J		370	0.043	-3.146555183
Z1-EU32BW-433 + Dup	B	REG	390 U	U		390	0.195	-1.63475572
Z1-EU32BW-434	B	REG	130 J	J		370	0.13	-2.040220829
Z1-EU32MW-420	S	REG	33 J	J		370	0.033	-3.411247718
Z1-EU32MW-426	S	REG	24 J	J		380	0.024	-3.729701449
Z1-EU32W-418	S	REG	410 U	UU		410	0.205	-1.5847453
Z1-EU32W-419 + Dup	S	FR	150 J	J		360	0.15	-1.897119965
Z1-EU32W-421	S	REG	52 J	J		370	0.052	-2.95881156
Z1-EU32W-422	S	REG	41 J	J		360	0.041	-3.194183212
Z1-EU32W-423	S	REG	380 U	U		360	0.18	-1.714786428
Z1-EU32W-424	S	REG	380 U	U		380	0.19	-1.660731207
Z1-EU32W-425	S	REG	29 J	J		380	0.029	-3.540468449
Z1-EU32W-427	S	REG	21 J	J		380	0.021	-3.883223841
Z1-EU32W-428	S	REG	53 J	J		370	0.053	-2.937483365
Z1-EU32W-429	S	REG	380 U	U		380	0.19	-1.660731207
Z1-EU32W-430	S	REG	380 U	UU		360	0.18	-1.714786428
Z1-EU33BW-443	B	REG	54 J	J		380	0.054	-2.918771232
Z1-EU33BW-444	B	REG	78 J	J		370	0.078	-2.551046452
Z1-EU33W-435	S	REG	390 U	U		390	0.195	-1.63475572
Z1-EU33W-436	S	REG	370 U	U		370	0.185	-1.687999454
Z1-EU33W-437	S	REG	55 J	J		410	0.055	-2.800422094
Z1-EU33W-438	S	REG	45 J	J		380	0.045	-3.101092789
Z1-EU33W-439	S	REG	71 J	J		380	0.071	-2.645075402
Z1-EU33W-440	S	REG	41 J	J		370	0.041	-3.194183212
Z1-EU33W-441	S	REG	120 J	J		380	0.12	-2.120263536

Number of Samples 43
Number of Detects 3

Minimum 0.02
Median 0.071
Maximum 0.3
Average 0.1027442
Standard Deviation 0.0749228

PERT-Beta Mean 0.1006667

Lognormal Mean -2.573653
Lognormal Standard Deviation 0.8137728

General UCL Statistics for Full Data Sets

User Selected Options

From File WorkSheet.wst

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

2_Methylnaphthalene mg/kg

General Statistics

Number of Valid Observations 43 Number of Distinct Observations 33

Raw Statistics

Minimum 0.02
Maximum 0.3
Mean 0.103
Median 0.071
SD 0.0749
Coefficient of Variation 0.729
Skewness 0.643

Log-transformed Statistics

Minimum of Log Data -3.912
Maximum of Log Data -1.204
Mean of log Data -2.574
SD of log Data 0.814

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.851
Shapiro Wilk Critical Value 0.943

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.906
Shapiro Wilk Critical Value 0.943

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 0.122
95% UCLs (Adjusted for Skewness)
95% Adjusted-CLT UCL 0.123
95% Modified-t UCL 0.122

Assuming Lognormal Distribution

95% H-UCL 0.139
95% Chebyshev (MVUE) UCL 0.169
97.5% Chebyshev (MVUE) UCL 0.196
99% Chebyshev (MVUE) UCL 0.25

Gamma Distribution Test

k star (bias corrected) 1.714
Theta Star 0.0599
nu star 147.4

Approximate Chi Square Value (.05) 120.4
Adjusted Level of Significance 0.0444
Adjusted Chi Square Value 119.5

Anderson-Darling Test Statistic 1.658
Anderson-Darling 5% Critical Value 0.762
Kolmogorov-Smirnov Test Statistic 0.184

Kolmogorov-Smirnov 5% Critical Value 0.137

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 0.122
95% Jackknife UCL 0.122
95% Standard Bootstrap UCL 0.121
95% Bootstrap-t UCL 0.123
95% Hall's Bootstrap UCL 0.122
95% Percentile Bootstrap UCL 0.122
95% BCA Bootstrap UCL 0.122
95% Chebyshev(Mean, Sd) UCL 0.153
97.5% Chebyshev(Mean, Sd) UCL 0.174
99% Chebyshev(Mean, Sd) UCL 0.216

Assuming Gamma Distribution

95% Approximate Gamma UCL 0.126
95% Adjusted Gamma UCL 0.127

Potential UCL to Use

Use 95% Chebyshev (Mean Sd) UCL 0.153

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

© Radius and Associates, 2001 - 2005

Information: Ken Radius, 865.483.2715

kradius@cox.net

12/29/2005 R1.3

Enter input values in yellow shaded cells

Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)		α_1	α_2	Variance	Max - Min
2-Methylnaphthalene (mg/kg)	2.00E-02	7.10E-02	3.00E-01	1.01E-01	1.90E-01	1.89	0.19	1.73	4.27	0.0032	0.3

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (MIN, MAX) where MIN < MAX and MIN denotes the minimum value and MAX denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

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The PERT Beta PDF is denoted as $f(x)$ for the random variable, x . The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1} (MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2) (MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < Most\ Likely < MAX$$

$$F(x) = \frac{B(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN} \right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN} \right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_x(\alpha_1, \alpha_2)$ is the incomplete Beta Function
 α_1 and α_2 are calculated parameters

Use the Microsoft Excel @1H function BETAINV(0.95, α_1 , α_2 , MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Davenport, John M (MDN)

From: Redus, Kenneth S (3KR)
Sent: Tuesday, April 14, 2009 10:38 PM
To: Davenport, John M (MDN); Hanahan, Douglas W. (HGG)
Cc: Hampshire, G John (O57); Hopper Jr, James Guy (HPZ)
Subject: WL 4.12 R0 VWSF Transmittal and Att 3

Attachments: WL 4.12 R0 Att 3 2009 04 14.xls

To the WL - please include this in your Profile. To the WL - please include this in your Profile. These results are based on the data received on 04/13/2009 as WL 4.12_Appendix H_WACFACS Input Sheet (041309 Revision).xls from Marshall Davenport under WACFACS Configuration Control as WL 4.12 K-770 Soils 2009 04 14.xls. If there are changes in WACFACS Input Worksheet, the VWSF statistics will need to be recalculated.

WL 4.12 R0 VWSF Transmittal and Att 3

The following information is provided for WL 4.12 K-770 Scrap Yard Soils and Misc. Debris.

The 3-year window is FY09 – FY11 using WACFACS, Q1 FY09 Rev 0.

WGF Volume = 17500 CY (CIVV = VL for 16200 CY of Soil-Like Waste and CIVV = VL for 1300 CY of Debris-Like Waste)

Expected Total Volume = 20271 CY and UCL-95 Total Volume = 25740 CY

WL 4.12 Carcinogenic SOF

E (WL Carcinogenic SOF) = 0.67

UCL-95 (WL Carcinogenic SOF) = 1.71

WL 4.12 HI SOF

E (WL HI SOF) = 0.17

UCL-95 (WL HI SOF) = 0.37

WL 4.12 Carcinogenic VWSF

E (WL 4.12 Carcinogenic VWSF) = 7.20E-03

WL 4.12 HI VWSF

E (WL 4.12 HI VWSF) = 1.84E-03

EMWMF Carcinogenic VWSF

E (EMWMF Carcinogenic VWSF) = 0.7

UCL-90 (EMWMF Carcinogenic VWSF) = 0.8

EMWMF HI VWSF

E (EMWMF HI VWSF) = 0.5

UCL-90 (EMWMF HI VWSF) = 0.6

If you have any questions, please contact me.

K. S. Redus

EMWMF WAC Attainment Team

WL 4.12 R0 Att 3
2009 04 14.xl...

APPENDIX H
WASTE ACCEPTANCE FORECASTING ANALYSIS CAPABILITY
SYSTEMS (WACFACS)

APPENDIX I
APPROVED VARIANCE REQUESTS

ENVIRONMENTAL MANAGEMENT WASTE MANAGEMENT FACILITY

Physical Waste Acceptance Criterion Blanket Variance

Blanket Variance No: EMWMF-BV-07-01

Revision No: 0

Effective Date: 09/23/05

Approval Signature

Blanket Variance Applicable to: Pipe, tubing, and conduit with internal diameter of 6 inches

Physical Waste Acceptance Criterion No

Requirement: Piping shall be segregated from other wastes and shall be placed in haulage containers to avoid bridging or otherwise wedging during unloading. Pipe and tubing less than 6-in. diameter is accepted without further restrictions. Pipes between 6-in. and 12-in. diameter shall be crushed, shredded, or filled to minimize void spaces.

Basis: Analysis in the EMWMF Performance Assessment indicates that pipes with excessive internal void must be filled, crushed or split to meet subsidence requirements.

Variance

Piping, tubing and conduit formed from rigid metal that is 6-inches or less in diameter, which are not placed inside another container for disposal, may be placed in the disposal cell without further treatment.

Justification: The EMWMF Performance Assessment indicates that pipes with internal diameters of 6-inches and less do not substantially affect the long-term performance of the EMWMF and may therefore be disposed without restriction.

3 Conditions of Variance

- a. This variance is for 6-inch internal diameter pipe, metal tubing and metal conduit only.
- b. Pipe, tubing, and conduit shall be cut in lengths appropriate to the haulage container such that pipe may freely fall during dumping without becoming wedged or jammed.

4 Application of Blanket Variance

- a. Certification of full compliance with the conditions of this blanket variance, as stated herein, by the waste generator of a specific, approved waste lot fulfills the requirements of a variance to the physical waste acceptance criterion in accordance with *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1909&D3).

- b. Generator to reference Blanket Variance EMWMP-BV-07-01 in required sections of the Waste Profile and attach a hard copy when submitting the waste profile to the Waste Acceptance Criteria (WAC) Attainment Team.
- c. Generator to attach a hard copy of this blanket variance to Section of the Readiness to Ship Checklist.

5. Revocation of Blanket Variance:

Upon discovery of waste from a specific waste lot that is not in full compliance with the conditions stated herein, this blanket variance may be revoked by written communications to the generator's BJC responsible contact and the waste declared to be anomalous waste.

**ENVIRONMENTAL MANAGEMENT WASTE
MANAGEMENT FACILITY**
Physical Waste Acceptance Criterion Blanket Variance Approval

Blanket Variance No: EMWMF-BV-08-01

Revision No: 2

Effective Date: 08/11/06

Approval Signature

Blanket Variance Applicable to: Non-friable asbestos-containing transite panels only.

1. Physical Waste Acceptance Criterion No.: 8

Requirement: Asbestos-containing materials (ACM) shall be wetted, double-bagged and shipped separately or with adequate volumes of soil to facilitate safe transportation and burial. Bags shall be limited to a maximum weight of 40 lbs.

Basis: General handling/disposal practices associated with building decontamination and demolition work to address asbestos abatement that includes transite panels.

Note 1: Because this blanket variance does not apply to beryllium dust containing waste as stated in the physical waste acceptance criterion, reference to beryllium has been removed from the requirement above.

2. Variance:

Alternate packaging for intact (not broken or crumbled) Category II non-friable ACM transite panels in good condition that is in various sizes to: 1) eliminate need for size reduction and placing ACM in double 40-lb bags and 2) change method of shipment to flatbed trailers, shipped without soil.

Justification: Disposal of whole transite panels is generally more protective of workers health than requiring transite to be cut or broken. Disposal of securely packaged transite panels can also be accomplished with a minimum risk of release if the conditions as stated in Section 3 are followed.

3. Conditions of Variance:

- a. This variance is for intact transite panels that are in good condition only.
- b. Transite panels shall be shipped separately from other waste types and without soil.
- c. Transite panels that are 4-feet wide and up to 12-feet long shall be stacked as follows:
 1. All panels to be stacked shall be of similar length.
 2. Panels shall be stacked in a stable configuration that minimizes void space between panels [e.g., only like panels shall constitute a stack, such as corrugated with corrugated and flat-with flat].

3. Panel stacks shall have a uniform shape and be limited to maximum dimensions of 4-feet in height by 4-feet wide and 12-feet in length.
 4. Panel stacks shall not exceed 24,000 lbs.
 5. Panel stacks shall be banded sufficiently to prevent shifting during transportation and unloading. **[Note: Stacks of 12-foot long transite panels shall also be banded on the long axis in order to prevent draping of material over the forks potentially resulting in breakage during offloading].**
 6. Stacked and banded transite panels shall be wrapped in a single layer of plastic sheeting with a minimum thickness of 6-mil with all flaps folded over and sealed with tape or equivalent, in accordance with 29 CFR 1926.1101(l)(2).
- d. Transite panels with dimensions that are $\leq$ 4-feet wide by 4-feet long shall be stacked as follows:
1. Panels shall be stacked in a stable configuration that minimizes void space between each individual transite panel (e.g., only like panels shall constitute a stack, such as corrugated with corrugated and flat with flat).
 2. Panel stacks shall be limited to a maximum height of 4-feet.
 3. Panel stacks shall not exceed 24,000 lbs.
 4. Panel stacks shall be wrapped in a single layer of plastic with a minimum thickness of 6-mil with all flaps folded over and sealed with tape or equivalent, in accordance with 29 CFR 1926.1101(l)(2).
 5. Panel stacks shall be banded to a pallet to prevent shifting during transportation and unloading.
- e. Smaller length or broken transite panels (i.e., pieces) that are not conducive to orderly stacking shall be packaged as follow:
1. Transite panel pieces shall be placed into double-lined supersacks or sealed bladder bags.
 2. Supersacks or bladder bag packages shall be capable of being placed in a nominal 18 inch lift and being sufficiently compacted following placement.
- f. The transite packages shall be labeled in accordance with 29 CFR 1926.1101(k)(8).
- g. Shipping papers shall include the term "asbestos".
- h. Transite panels shall be shipped as follows:
1. Stacked and banded transite panels greater than 4-feet in length shall be shipped via flatbed truck using bed-mounted dunnage (minimum 4 inch by 4 inch). **[Note: packaging material beneath the stacks shall not obstruct forks during offloading].**
 2. Stacked transite panels less than 4-feet in length that are strapped to a pallet shall be shipped via flatbed truck **[Note: packaging material beneath the stacks shall not obstruct forks during offloading].**
 3. Supersack or bladder bag packages shall be shipped in intermodal containers or via flatbed truck when banded to a wooden pallet **[Note: packaging material beneath the stacks shall not obstruct forks during offloading].**

4. Application of Blanket Variance:

- a. Certification of full compliance with the conditions of this blanket variance, as stated herein, by the waste generator of a specific and approved waste lot fulfills the requirements of a variance to the physical waste acceptance criterion in accordance with *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1909&D3).
- b. Generator to reference Blanket Variance EMWMF-BV-08-01, Revision 2 in required sections of the Waste Profile and attach a hard copy when submitting the waste profile to the Waste Acceptance Criteria (WAC) Attainment Team.
- c. Generator to attach a hard copy of this blanket variance to Section II of the Readiness to Ship Checklist.

5. Revocation of Blanket Variance:

Upon discovery of waste from a specific waste lot that is not in full compliance with the conditions stated herein, the application of this blanket variance may be revoked by written communications to the waste generator's BJC responsible contact and the waste declared to be anomalous waste.

ENVIRONMENTAL MANAGEMENT WASTE MANAGEMENT FACILITY

Physical Waste Acceptance Criterion Blanket Variance Approval

Blanket Variance No: EMWMF-BV-08-02

Revision No: 1

Effective Date: 10/14/05

Approval Signature

Blanket Variance Applicable to: Friable and non-friable asbestos-containing (ACM) including, but not limited to, the following items containing asbestos: insulation, floor tiles, baseboards, roofing materials, miscellaneous building debris, asbestos wrapped pipe (≤ 2 in. diameter); asbestos-core fire doors, and conduit containing asbestos insulated wire.

Note: Does not apply to transite, instead refer to EMWMF-BV-08-01

Physical Waste Acceptance Criterion No.: 8

Requirement: Asbestos-containing materials shall be wetted, double-bagged and shipped separately or with adequate volumes of soil to facilitate safe transportation and burial. Bags shall be limited to a maximum weight of 40 lbs.

Basis: General handling/disposal practices associated with asbestos abatement work.

Note: No distinction made between friable and non-friable ACM.

Note 1: Because this blanket variance does not apply to beryllium dust containing waste as stated in the physical waste acceptance criterion, reference has been removed from the requirement above.

Note 2: This variance is not applicable to items that cause the package to be larger than 24-inches in height (e.g., tanks, structural members), , and items containing proportionally large voids (e.g., fire safe or filing cabinet, boiler, furnace, dryer, autoclave). Items such as these will require individual PWAC variances.

2 Variance

Alternate packaging for friable and non-friable ACM and asbestos items in lined supersacks, sealed bladder bags, wrapped in double layer of plastic exceeding 40 lbs. or placed in double 10-mil ACM bags exceeding 40-lbs per bag and shipped separately in intermodal containers without soil to facilitate direct dumping or on flatbed trucks for offloading.

Justification: Use of the alternate method for packaging and disposal of ACM as provided in this variance is more protective of disposal workers health as it reduces the potential for ripped ACM containing bags and it eliminates direct handling of bags.

3 Conditions of Variance

- a. Soft asbestos insulation with or without occasional hard asbestos contaminated items (e.g., wood, metal, or plastic), hard asbestos containing items (floor tiles, baseboards, roofing materials, miscellaneous building debris), or other ACM:
 - 1. Shall be wetted and packaged in double-lined supersacks or sealed bladder bags;
 - 2. Shall not have sharp points or jagged edges (e.g., no protruding nails, wire or metal) that may puncture or rip the supersack or bladder bag;
 - 3. Supersacks and bladder bags shall be capable of being placed in a nominal 24 inch lift and being sufficiently compacted following placement;
 - 4. Supersacks or bladder bags containing ACM shall be properly labeled in accordance with applicable regulatory requirements;
 - 5. Supersacks and bladder bags shall be shipped in roll-off containers or intermodal containers with other similar packages and without soil or strapped to pallets and shipped on flatbed trailers; or
 - 6. Shall be wetted and packaged in double 10-mil ACM bags and shipped in intermodals without soil for bulk disposal.
- b. Asbestos insulated pipe:
 - 1. Shall be less than 2 inches interior diameter and less than or equal to 8 ft. in length;
 - 2. Shall be wetted and packaged and shipped as follows:
 - For intermodal containers: Individual pipes or bundles of 10 or less pipes strapped firmly together shall be wrapped with double layer of 10-mil plastic and shipped in lined intermodal containers for bulk placement unless a liner variance has been approved.
 - Multiple pipes shall be banded together, wrapped with double layer of 10-mil plastic or packaged in supersacks and strapped to pallets and transported via flatbed truck for offloading.
 - 3. Packages shall be capable of being placed in a nominal 18 inch lift and being sufficiently compacted following placement.

Conduit containing asbestos insulated wire:

- 1. Shall be cut in lengths not to exceed 8 feet;
- 2. Shall have ends of conduit double wrapped with 10-mil plastic or have ends sealed with caulk and wrapped with one of layer or 10-mil plastic;
- 3. Shall be banded securely together, strapped to pallets and transported via flatbed truck for offloading;
- 4. Packages shall be capable of being placed in a nominal 18 inch lift and being sufficiently compacted following placement
- 5. Miscellaneous pieces of conduit shall conform to 3.a above.

- d. Packaged ACM items shall meet the void space WAC requirements
- e. Appropriate labels for ACM shall be visible on all containers and packages and shipping papers accompanying an ACM load shall have the term "asbestos" listed in accordance with applicable regulatory requirements.

4 Application of Blanket Variance

- a. Certification of full compliance with the conditions of this blanket variance, as stated herein, by the waste generator of a specific, approved waste lot fulfills the requirements

of a variance to the physical waste acceptance criterion in accordance with *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1909&D3).

- b. Generator to reference Blanket Variance EMWMF-BV-08-02 in required sections of the Waste Profile and attach a hard copy when submitting the waste profile to the Waste Acceptance Criteria (WAC) Attainment Team.
- c. Generator to attach a hard copy of this blanket variance to Section II of the Readiness to Ship Checklist.

5 Revocation of Blanket Variance:

Upon discovery of waste from a specific waste lot that is not in full compliance with the conditions stated herein, this blanket variance may be revoked by written communications to the generator's BJC responsible contact and the waste declared to be anomalous waste.

**Request for Approval of Variance from Physical Waste Acceptance Criteria (WAC) for the
Environmental Management Waste Management Facility (EMWMF)**

Instructions: The Waste Generator shall:

- (1) Communicate with the EMWMF Waste Generator Services Lead to discuss the proposed variance request prior to the submittal of this form.
- (2) Complete Section 1 and prepare any necessary support information.
- (3) Electronically transmit the completed form and support information to the EMWMF WAC Manager.

BJC EMWMF Operations will coordinate the review of the variance request and transmit the results of the review to the Waste Generator.

Section 1--To be Completed by Waste Generator	
1. Waste Lot No.: 4.12	2. Date: December 29, 2008
3. Waste Lot Name: K-770 Scrap Yard Soils	
4. Name of Project: ETPP D&D/RA	
5. Name of Requestor: Marshall Davenport	6. Telephone No.: 576-8049
7. Alternate contact: Doug Hanahan	8. Telephone No.: 241-9573
9. Company Affiliation: BJC	10. Fax No.: 241-5178
11. Describe the physical WAC parameter(s) for which a variance is being requested: The EMWMF physical WAC states that rebar shall be cut to a maximum 4-ft length and shall be in rolls or bundles that can be placed and graded in an 18-in lift.	
12. Describe the proposed variance The Project is expecting to encounter rebar in the concrete foundation slabs that will be demolished at the K-770 Scrap Yard. It is requesting that a variance be granted to allow rebar to be sheared to lengths of 4-ft or less and commingled with the remainder of the waste lot in dump trucks for bulk disposal at the EMWMF. Rebar will be removed from concrete by crushing the concrete. Most rebar is expected to be free of concrete. However, some may contain incidental, small pieces of concrete. The Project will attempt to distribute the rebar evenly between the loads of waste and commingle with significant amounts of soil.	
13. Describe why the physical WAC parameter(s) cannot be met and provide justification for the proposed variance: Based on the expected configuration of the rebar present in this waste lot (from past experience), it would be difficult (and unsafe) to cut into 4-ft lengths and reconfigure into rolls or bundles. By removing rebar from the concrete, further size-reducing the rebar to 4-ft lengths or less, and commingling with soil in the dump truck, the debris should be suitable for placement and grading into an 18-in lift.	
14. Describe and identify if the variance is requested for the entire waste lot or for a specific portion of the waste lot: This variance request is for the entire waste lot. However, it is estimated that the rebar will comprise less than 1% of the waste lot. An attempt will be made to evenly distribute it in loads of waste (primarily soil) at the time it is generated.	
15. Describe the potential impacts of implementing the variance request and the suggested mitigation actions by the waste generator and EMWMF Operations: None.	

**Request for Approval of Variance from Physical Waste Acceptance Criteria (WAC) for the
Environmental Management Waste Management Facility (EMWMF)**

16. Other support information:

Similar variances for the ETTP D&D/RA Project have been previously approved (see approved variance EMWME-VR-128)

Section 2—To be Completed by EMWMP Operations

17. Was a field walkdown performed to review the waste? Yes ☐ No ☒

If so, state notes from the field walkdown that are pertinent to the variance review:

18. Provide brief justification for concurring with or rejecting the variance request:

Rebar commingled with other waste has been received at EMWWMF without incident.

19. Will the requested variance impact the design basis for EMWMF? Yes ☐ No ☒

If so, describe the potential impact and mitigation measures.

20. Are other reviews (i.e., Procurement, Engineering, RADCON) required?

Yes ☒

No ☐

21. If other reviews are required, do the reviews support approval of the requested variance?

Yes ☒

No ☐

22. State variance request approval conditions:

1. Rebar shall be cut to less than or equal to 4 feet in length.
2. Bent rebar shall be cut at the bends in order to eliminate long pieces of angled lengths of rebar.
3. Rebar protruding from concrete shall be cut as closely to the concrete surface as practicable.
4. Waste shall be transported in dump trucks only.
5. Generator shall contact EMWMF Operations prior to shipping waste with commingled rebar, indicating truck number containing rebar.

Approval / Disapproval by BJC EMWME Operations

23. Approved ☐

Approved with conditions ☒

Disapproved

Printed Name: _____

Steve Kucera

Signature:

[Signature]

Date:

2/19/09

APPENDIX J
CERCLA DOCUMENTATION

I-10513-0005

DOE/OR/01-1997&D2

**Record of Decision for Interim Actions in Zone 1,
East Tennessee Technology Park,
Oak Ridge, Tennessee**

This document has received the appropriate
reviews for release to the public.

PREFACE

This *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1977&D2), was prepared in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986, to present the public with the selected remedy for environmental remediation of contaminated areas within Zone 1. This Record of Decision (ROD) documents the selected remedy agreed on by the U.S. Department of Energy, the Tennessee Department of Environment and Conservation, and the U.S. Environmental Protection Agency. The remedy addresses the inactive units, contaminated soil, and other contaminated material to the extent practicable while minimizing disruption of the continuing mission (environmental cleanup of the former Oak Ridge Gaseous Diffusion Plant) of the East Tennessee Technology Park. This decision is based on the Administrative Record file for this project. Following are the principal documents supporting this ROD:

- (draft) *Remedial Investigation Report for the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 1999a); and
- *Proposed Plan for Interim Remedial Actions for Selected Contaminated Soil, Material, and Blair Quarry within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2001a).

These documents and other information supporting the selected remedial action can be found at the Information Center, 475 Oak Ridge Turnpike, Oak Ridge, TN 37830; (865) 241-4780.

1.1 SITE NAME AND LOCATION

Zone 1 at East Tennessee Technology Park
Oak Ridge Reservation
Oak Ridge, Tennessee
CERCLA Information System ID TN #1890090003

1.2 STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) for interim actions presents the selected remedy for environmental remediation of contaminated areas within Zone 1 of East Tennessee Technology Park (ETTP), formerly the K-25 Site and the Oak Ridge Gaseous Diffusion Plant (ORGD), on the U.S. Department of Energy's (DOE's) Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee. The remedy specifically addresses known areas of contaminated soil, Blair Quarry, and surface features (scrap material and debris in the K-770 Area and the K-710 sludge beds and Imhoff tanks). The scope of the decision also establishes remediation levels for soil and burial areas and a methodology for making action/no-action determinations, based on the reasonably anticipated end use for the surface of Zone 1. Finally, this ROD includes a decision to remediate other Zone 1 contaminated soil or buried waste if the Dynamic Verification Strategy (DVS), discussed later in this section and in Sect. 2.4, shows remediation is required and the selected remedy is cost effective. The scope does not include contaminated groundwater, surface water, or sediment. However, expected activities will address underlying contaminated soils that present a continuing source of groundwater contamination. Because this remedy does not include contaminated groundwater, surface water, sediment, or final land use controls (LUCs), it is an interim remedy.

Environmental remediation occurs primarily through removal of contamination. Land use controls are also selected for the residual contamination. Because this is an interim remedy, interim LUCs are specified as appropriate; however, final LUCs are not within the scope of this decision. This interim decision applies to the 1400-acre area designated as Zone 1 at ETTP. This area includes waste disposal areas, open undeveloped areas, and a previously industrialized area with facilities and scrap remaining.

DOE is currently developing for approval under the Federal Facility Agreement (FFA) for the ORR (DOE 1992) the DVS for conducting final status assessments and associated data gap sampling efforts for the remaining areas of soil in Zone 1. Final status assessments consist of the collection, analysis, and evaluation of medium-specific and screening measurement data for the purpose of determining whether additional remediation is required. The DVS generally follows the guidance outlined in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) [DOE et al. 2000] and follows the U.S. Environmental Protection Agency's (EPA's) "Triad" approach (EPA 2001). MARSSIM provides prescriptive, yet flexible guidance for collecting defensible data as part of the site closeout process. The Triad approach incorporates systematic planning, dynamic techniques, and real-time measurement technologies to streamline sampling, analysis, and data management activities.

This set of remedial actions for Zone 1 was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) [42 *United States Code* Sect. 9601 et seq.], and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 *Code of Federal Regulations (CFR)* 300]. The FFA was developed to provide a legal framework for remediation activities at the ORR and to coordinate remedial activities under CERCLA and the Resource Conservation

and Recovery Act of 1976 (RCRA). The FFA's integrated approach extends to preparation of decision documents under CERCLA and RCRA. In addition, National Environmental Policy Act of 1969 (NEPA) values are incorporated in the documents prepared for this project in accordance with the *Secretarial Policy Statement on the National Environmental Policy Act of 1969* (DOE 1994a). This policy states that DOE will rely on the CERCLA process for review of actions taken under CERCLA and will address and incorporate NEPA values to the extent practicable in CERCLA evaluations.

Remediation measures presented in this ROD are intended to protect human receptors from exposure to hazardous substances in Zone 1. The primary receptor is the industrial worker. Through remediation of known areas of contamination and the application of LUCs for unknown areas and areas where subsurface residual contamination remains, the industrial worker will be protected throughout this action and until the final decision.

The interim LUCs selected in this ROD will continue in effect and remain enforceable as part of the selected CERCLA remedy until such time as they may be changed by a future CERCLA decision. DOE has developed a Land Use Control Assurance Plan (LUCAP) for the ORR to help ensure that land use restrictions are maintained and periodically verified. DOE will develop a specific Land Use Control Implementation Plan (LUCIP) that will further detail the specific measures required for land use restrictions as part of this action. DOE is committed to implementing and maintaining LUCs, including institutional controls, to ensure that the selected remedy remains protective of human health. The implementation and funding of these activities will take place in accordance with the ORR FFA. The public will be informed and involved in a timely manner in the CERCLA decision-making process consistent with requirements of CERCLA, the NCP, the ORR FFA, and the ORR CERCLA public involvement plan. Documents pertaining to the implementation and performance of the remedial actions, including 5-year reviews, will be placed in a post-ROD file, which will be available to the public.

This decision is based on documents contained in the Administrative Record file for Zone 1 of ETTP. Normally, a final remedial investigation (RI) and feasibility study (FS) will exist prior to completing a ROD. However, in this case, only a draft RI (DOE/OR/01-1778/V1-V5&D1) exists. Based on the information contained in the draft RI, contaminated areas warranting remediation were identified. In an effort to expedite remediation of these areas, a proposed plan was developed documenting some of the information normally found in a final RI and FS. This type of streamlining is encouraged by the NCP to allow cleanup to proceed as soon as sufficient information exists to make a decision on an interim remedy. DOE has considered all comments received on the proposed plan in preparing this ROD. DOE, U.S. Environmental Protection Agency (EPA), and Tennessee Department of Environment and Conservation (TDEC) [parties to the FFA] concur with the selected remedy.

1.3 ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health or welfare from actual or threatened releases of hazardous substances into the environment. The potential for an unacceptable risk to an industrial worker exists from soils in Zone 1, from soils and buried material in Blair Quarry, and from surface features (scrap, debris, tanks, and sludge beds).

1.4 DESCRIPTION OF THE SELECTED REMEDY

This remedy addresses Blair Quarry, miscellaneous contaminated soil (including the K-895 Cylinder Destruct Facility Area and the Powerhouse Area), scrap metal and debris in the K-770 Area, and the K-710 sludge beds and Imhoff tanks. Principal actions include (1) soil removal, (2) burial area removal, (3) scrap metal and debris removal, (4) demolition of certain above-ground structures, and (5) imposition of land use controls limiting use of the entire Zone 1 area, including groundwater. This decision also establishes remediation levels based on reasonably anticipated future land use for Zone 1. Known areas of contamination in Zone 1 will be remediated to meet an unrestricted industrial land use. Industrial uses will be allowed without controls to a maximum depth of 10 ft below ground surface (bgs). Use of the subsurface below 10 ft will be restricted. Until sufficient information is collected about the areas not known to be contaminated, use of these areas will also be restricted. The remedial action objective (RAO) for Zone 1 is to "Protect human health under an unrestricted industrial land use to a risk level not to exceed 10^{-4} ." In addition, expected activities may control selected releases from contaminated soil to help minimize further impacts to groundwater.

Following are the major components of the selected remedy:

- Excavation of the Blair Quarry burial area and associated contaminated soil, with subsequent disposal at the Environmental Management Waste Management Facility (EMWMF) or an off-site permitted facility. Unless excavation of contaminated soil is determined to be necessary for groundwater protection, excavation will not go beyond 10 ft bgs. [Note: The EMWMF is the on-site disposal facility selected for the comprehensive management of waste generated from environmental restoration activities on the ORR. The ROD for disposal of ORR CERCLA waste documents the selection of the EMWMF (DOE 1999b)].
- Excavation of miscellaneous contaminated soil in the K-895 Cylinder Destruct Facility area and in the Powerhouse Area (includes K-725 Beryllium Building Slab), with subsequent disposal at the EMWMF or an off-site permitted facility. Unless excavation of contaminated soil is determined to be necessary for groundwater protection, excavation will not go beyond 10 ft bgs.
- Removal of scrap-metal and debris from the K-770 Area and disposal at the EMWMF or an off-site permitted facility.
- Removal of sludge and demolition of the K-710 sludge beds and Imhoff tanks with disposal at the EMWMF or an off-site permitted facility.
- Implementation of LUCs to prevent exposures to contamination known to exist in Zone 1 surface and subsurface areas, including groundwater, and to contamination which may be present in those Zone 1 areas where characterization is incomplete.

Interim LUCs are a necessary part of the selected remedy to ensure its protectiveness. The types and objectives of LUCs being imposed under this remedy include 1) property record restrictions to restrict uses of the property by imposing limitations on its use and to prohibit uses of groundwater; 2) property record notices to provide notice to anyone searching records about the existence and location of contaminated areas and limitations on their use; 3) zoning notices to provide notice to the city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes; 4) an excavation/penetration permit program to provide notice to permit requestors of the extent of contamination and prohibiting or limiting excavation/penetration activity; 5) access controls to control and restrict access to workers and the public in order to prevent unauthorized uses; and 7) surveillance

2.1 SITE NAME, LOCATION, AND DESCRIPTION

Zone 1 at East Tennessee Technology Park
Oak Ridge Reservation
Oak Ridge, Tennessee
CERCLA Information System ID #TN1890090003

The 34,516-acre DOE ORR is located within and adjacent to the corporate limits of the city of Oak Ridge, Tennessee, in Roane and Anderson counties. The ORR is bounded to the east, south, and west by the Clinch River and on the north by the developed portion of the city of Oak Ridge. The ORR hosts three major industrial research and production facilities originally constructed as part of the World War II-era Manhattan Project: ETTP, formerly the K-25 Site and ORGDP; Oak Ridge National Laboratory (ORNL), formerly X-10; and the Y-12 National Security Complex (hereafter Y-12 Complex) [Fig. 2.1].

ETTP is located near the northwest corner of the ORR with more than 5000 acres considered part of ETTP. Potentially impacted areas account for roughly 2200 acres of the 5000 acres. A decision was made by the FFA parties to divide the site into smaller OUs for decision-making. The potentially impacted area of ETTP currently is divided into two areas: outside the main fence (Zone 1 - 1400 acres) and inside the main fence (Zone 2 - 800 acres) [Fig. 2.2]. Historically, Zone 1 was used for light industrial purposes and has some open areas with waste disposal. Zone 2 is the main plant area and has historically had a heavy industrial use.

Zone 1 has been divided into four project areas based on geography and previous land use: the K-901 Area, the Powerhouse Area, the Duct Island Area, and the K-1007 Ponds Area (Fig. 2.3).

The K-901 Area is located in the northwest portion of ETTP and extends around the site to the north. The area had very little industrial activity and tended to be used as a disposal area for construction debris and related materials associated with the construction and operation of the facility. The majority of this area has no evidence of disturbance. Waste disposal areas remain the primary problem today in the K-901 Area.

The Powerhouse Area is located on the Powerhouse Peninsula in the southwestern portion of ETTP. It is bounded by the Clinch River to the north, south, and west, and by Poplar Creek to the east. In the past, the Powerhouse Area has been divided into an industrialized area devoted to power production, storage, and plant infrastructure, and an unindustrialized area that has remained wooded and grassy. Today, the industrialized area is largely shut down, and a number of buildings have been decommissioned and demolished. Scrap material (e.g., 40,000 tons of scrap metal), building rubble and debris, concrete slabs from previously demolished buildings, an inactive sewage treatment facility, a capped fly ash pile, other surface features, contaminated soil, and burial areas remain in the Powerhouse Area.

The Duct Island Area constitutes the land area in the western-central portion of ETTP. Duct Island is bounded on the east, south, and west by Poplar Creek and on the north by the K-901 Area. Currently, Duct Island is covered by grass and woods, and there are no industrial activities occurring. This area was not frequently used in the past, although limited waste disposal occurred.

The K-1007 Ponds Area makes up the southeast portion of ETTP. It is bounded to the north by the main plant, State Highway 58 to the south and east, and Poplar Creek to the west. Today, the area contains large grassy areas, ponds, parking lots, and office buildings. In the past, the area was the site of several vehicle maintenance facilities and gas stations. They have been demolished.

Fig. 2.3. ETP Zone 1 project areas.

2.2.1 PREVIOUS INVESTIGATIONS AND DATA SOURCES

A comprehensive field investigation of the entire ETTP site was conducted from 1997 through 1998. This investigation resulted in a draft site-wide RI report in 1999 (DOE 1999a). This report summarized historical information as well as the results of an additional sampling effort across the site. Key historical sampling events in Zone 1 included a site-wide radiological walkover in 1994 and 1995 (also included surface soil sampling for radionuclides), sampling to support the footprint reduction program at Blair Quarry, and sampling for environmental compliance monitoring (surface water and groundwater). The RI activities included sampling for groundwater, surface soil, subsurface soil, surface water, and sediment. Other sampling summarized in the draft RI report included that associated with early actions. Since the draft RI was prepared, the Reindustrialization Program has sampled approximately 80 locations in the Powerhouse Area, 25 locations in the K-1007 Ponds Area under the Reindustrialization Parcel 3 Project, and 34 locations along the railroad tracks in the K-1007 Area. These soil samples were collected from the surface soil interval (i.e., 0 to 2 ft. bgs).

2.2.2 PREVIOUS CLEANUP DECISIONS

Previous cleanup decisions under CERCLA and other authorities have addressed, or are now addressing, some of the contamination in Zone 1, as follows:

- fish kill and cylinder removal from the K-901-A Holding Pond under an action memorandum (DOE 1997);
- excavation of the K-1070-A Burial Ground under a ROD (DOE 2000);
- demolition of two buildings in the Powerhouse Area under an action memorandum (DOE 1997);
- demolition of the Powerhouse, cooling towers, and associated buildings under categorical exclusions (DOE 1994b, 1994c, and 1994d); and
- removal of drums from the K-1085 area under an action memorandum (DOE 2001b).

2.2.3 LAND USE CONTROLS

By separate Memorandum of Understanding (MOU), EPA, TDEC, and DOE have agreed to implement facility-wide periodic site inspection, certification, and notification procedures set forth in a LUCAP (DOE, EPA, and TDEC 1999). These procedures are designed to ensure DOE maintenance of any waste-unit-specific LUCs set forth in this ROD and deemed necessary for future protection of human health and the environment. A fundamental premise underlying execution of the MOU is that, through DOE's substantial good-faith compliance with the procedures called for in the LUCAP, reasonable assurances would be provided to EPA and TDEC as to the permanency of those remedies that include the use of waste-unit-specific LUCs at the ORR.

The terms and conditions of the LUCAP, or MOU, are not specifically incorporated or made enforceable herein by reference. However, DOE, EPA, and TDEC understand and agree that the contemplated permanence of the remedy reflected herein is dependent in part on DOE's substantial good-faith compliance with the specific LUC maintenance commitments reflected in the LUCAP. Should such compliance not occur, or should the MOU be terminated, it is understood that the protectiveness of the remedy may be reconsidered; consequently, additional measures may be needed to ensure adequate and necessary future protection of human health and the environment.

2.4 SCOPE AND ROLE OF THE ACTION

The scope of the remedial actions in this interim decision is focused on the 1400-acre area designated as Zone 1 in ETPP (Fig. 2.2). This area includes waste disposal areas, open undeveloped areas, and a previously industrialized area with facilities and scrap remaining. As a result of the activities in Zone 1, surrounding media have been contaminated. This action focuses on those known sources of releases and on known areas of soil contamination.

The scope of the selected remedy also includes areas with insufficient data to determine if a release occurred or if the potential for a release is present. DOE is currently developing for approval under the FFA for the ORR (DOE 1992) the DVS for conducting final status assessments and associated data gap sampling efforts for the remaining areas of soil in Zone 1. Final status assessments consist of the collection, analysis, and evaluation of medium-specific and screening measurement data for the purpose of determining whether additional remediation is required. The DVS generally follows the guidance outlined in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (DOE et al. 2000) and follows the U.S. Environmental Protection Agency's (EPA's) "Triad" approach (EPA 2001). MARSSIM provides prescriptive, yet flexible guidance for collecting defensible data as part of the site closeout process. The Triad approach incorporates systematic planning, dynamic techniques, and real-time measurement technologies to streamline sampling, analysis, and data management activities.

DOE and other parties involved in the final status assessments and data gap sampling activities will use the DVS to identify and eliminate data gaps and to interpret and present data ultimately leading to a remedial or No Further Action (NFA) designation (i.e., no further action for industrial use in the top 10 ft of site soils. Additional action may be required for the protection of groundwater, but groundwater-related actions are beyond the scope of this ROD). As a result of this approach, one of three recommendations will be made for each Zone 1 land area: (1) NFA, (2) remediation, or (3) data gap sampling. In all cases the ultimate goal is to release the unit for unrestricted industrial use (i.e., achieve NFA status). These decisions will be made using a combination of historical data and information, flyover maps, gamma walkover survey data, data collected as part of this ongoing effort, and other information compiled from Zone 1 studies.

The final status assessment will determine the levels and extent of residual contamination, if any, in site soils and will describe how to compare contaminant conditions with the Zone 1 soil remediation levels (RLs) presented in this ROD. The guidance found in the MARSSIM and the data quality objective (DQO) process (EPA 1994) will be used to demonstrate compliance with Zone 1 soil remediation RLs. The DVS will include a method for evaluating soil contamination levels for both radiological and non-radiological contaminants of concern (COCs). Also, the DVS will describe the data quality assessment process to be used in the Zone 1 areas. In the event the DVS approach produces recommendations that require additional remedial actions, an Explanation of Significant Differences (ESD) or ROD Amendment will be prepared. Remedial action differences, such as excavated material volume or cost increases, will be documented after implementation with an ESD. Additional remedial actions that require evaluation of alternative remedies or a no further action determination will require a ROD amendment prior to implementation.

The DVS is designed to provide flexibility to make field decisions based on real-time experience or when encountering unanticipated obstacles. Thus, conditions encountered during implementation of the DVS and findings as the survey progresses may trigger modifications to the plan. Modifications to the DVS will be justified and documented, including appropriate project approvals.

A full ecological risk assessment has not been performed for Zone 1. An ecological screening risk assessment to identify at-risk habitats, species, communities, and populations in the areas of remediation

will be conducted during remedial design. A full ecological risk assessment will be completed and any necessary remedial objectives for ecological risk and remedial actions will be included in a future decision document.

The selected remedy includes contamination removal and imposition of LUCs as the overall cleanup strategy for Zone 1. Contaminant sources and contaminated soil will be removed, and LUCs will be imposed over the entire Zone 1 area, including deep soils and groundwater below the surface of Zone 1, in order to protect human health. Although the protection of ecological receptors is not an objective of this interim action, incremental improvements will occur as a result of this action.

In the event that an area of contamination presenting a significant threat to groundwater quality is discovered during soil excavation activity, DOE will take additional response actions to remove or otherwise control such contamination. Where practicable and cost-effective, such contamination will be addressed by excavation of the discovered material. Decisions on how and when to address any newly discovered groundwater contamination sources will be made on a case-by-case basis, in consultation with all parties to the FFA for this site. Groundwater use restrictions will be implemented as part of this decision to protect human health.

In addition to this ROD for interim actions in Zone 1 at the ETTP, two associated RODs are planned. One, the Zone 2 ROD, is planned to address environmental releases at the more central and industrialized portion of the ETTP. A third ROD will be developed and implemented to address site-wide groundwater contamination issues not addressed by the Zone 1 and 2 RODs.

The selected remedy will leave hazardous substances in place above risk-based levels for unrestricted use, which require land use restrictions until a final decision is made. Any future measures, including final long-term LUCs, will be addressed in a future decision document. However, the interim LUCs selected in this ROD will continue in effect and remain enforceable as part of the selected CERCLA remedy until such time as they may be changed by a future CERCLA decision.

Some of the waste areas addressed in this ROD are SWMUs [Blair Quarry-R019; K-725 Beryllium Building Soils-C004; K-770 Scrap Metal Yard-R008; K-710 Sludge Beds and Imhoff Tanks-R076; K-770 Wood Pile - C136] as defined in the RCRA Hazardous and Solid Waste Amendments of 1984 (HSWA) Permit for the ORR (#TN 001). In accordance with FFA Sect. IV (RCRA/CERCLA Coordination), the parties have agreed that for the inactive SWMUs listed in Appendix A-1 (a) of the HSWA Permit, RCRA corrective action that would otherwise be required under that permit will be deferred to the CERCLA response action process as implemented under the focused feasibility study. FFA-listed sites in Zone 1 are presented in Appendix C of this ROD, along with the ways in which that site is being addressed under this remedy.

2.5 SITE CHARACTERISTICS

Data used in characterizing Zone 1 are presented in the draft RI report (DOE 1999a) and are supplemented by Reindustrialization Program data summarized in the proposed plan (DOE 2001a). This section summarizes the data to broadly depict the primary contamination in Zone 1. Additional detailed information is provided in Appendix A.

2.5.1 AREAS OF CONCERN

Based on the data collected to date in Zone 1, only four areas of concern have been identified: Blair Quarry, miscellaneous contaminated soil (including the K-895 Cylinder Destruct Facility Area and the Powerhouse Area), scrap metal and debris in the K-770 Area, and the K-710 sludge beds and Imhoff tanks. The locations of these areas are identified on Fig. 2.4.

Blair Quarry. A remedial site evaluation sampling effort was conducted at the Blair Quarry in 1998. The quarry is a 2-acre site where historical burning and burial of miscellaneous material occurred. The site evaluation effort included constructing trenches in the area and taking 18 samples at varying depths from the content of the trenches. The deepest sample was 12 ft bgs. In addition, three surface soil samples were taken during the radiological survey activities. Samples during the remedial site evaluation were analyzed for radionuclides, polychlorinated biphenyls (PCBs), and dioxin/furans. PCBs were found up to 22 mg/kg (over 20 mg/kg in two locations from 2.5 to 3.5 ft deep) with some dioxins/furans detected in four of the samples. The radionuclides were generally present at levels below site-specific remediation levels. The exceptions were a sample that contained ^{238}U at 94 picocuries per gram (pCi/g) and two samples that contained ^{235}U at 8 to 9 pCi/g. All of these concentrations are above the average remediation levels selected by this remedy, but less than the maximum remediation levels (maximum remediation level is defined in Sect. 2.12.6 of this ROD).

Miscellaneous Soil. This area of concern includes soils from the K-770 Area scrap yard and northern portion of the Powerhouse Area (including the K-725 Beryllium Building Soils) and the soil associated with the formerly demolished K-895 Cylinder Destruct Facility in the K-901 Area.

The draft site-wide RI collected information from five borings drilled to the water table in the scrap yard/northern portion of the Powerhouse Area and analyzed for metals and radionuclides. An additional five surface soil samples were taken for the same analysis. These sample results were added to 63 surface soil samples taken during the earlier radiological walkover studies. Fifteen metals were detected above background levels, as were most radionuclides. The most prevalent radionuclides (detected in over 50% of the locations) were ^{240}Pu , ^{99}Tc , and the uranium isotopes; however, all radionuclides were only detected above background levels in the surface sampling interval. Cesium-137 was detected at a maximum of 193 pCi/g; ^{234}U at 15,200 pCi/g; ^{235}U at 1180 pCi/g; ^{238}U at 14,600 pCi/g; and ^{237}Np at 670 pCi/g. All of these radionuclide activities are considerably higher than the maximum remediation levels selected by this remedy.

During the K-901 Pond removal action, 21 soil samples were collected from around the K-895 Cylinder Destruct Facility area. Twelve of the samples were collected from different depths and analyzed for inorganic elements, radionuclides, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and PCBs. Nine surface soil samples were analyzed for radionuclides. No new samples were collected during the RI due to the extensive coverage provided by these historical samples.

No significant organic contamination was present in the samples around the K-895 Cylinder Destruct Facility area (only toluene detected at low concentrations). Likewise, the inorganic elements were usually present below background levels, and none was present above the selected remediation levels. However, the soil is contaminated with radionuclides in a few locations. Uranium-238 was as high as 7100 pCi/g; ^{235}U was as high as 171 pCi/g; ^{226}Ra was as high as 131 pCi/g, and ^{232}Th was as high as 147 pCi/g. Of the 21 samples taken, only 2 samples had concentrations above the maximum remediation levels, and they were both surface soil samples. However, subsurface soils samples did exceed average remediation levels (4 out of 12 samples taken), indicating unacceptable contamination with depth is likely.

Fig. 2.4. Zone 1 areas of concern.

Scrap Metal and Debris. Early investigations in the K-770 scrap yard indicated that this area may be a source of metals and radionuclides into the environment. Associated storm drain sediment sampling during the RI indicated slightly elevated levels of radionuclides. Most of the metals were near their background levels. The maximum ^{99}Tc activity found was 42 pCi/g, and the maximum ^{235}U activity was 5 pCi/g. Neither of these radionuclide levels is sufficiently elevated to warrant remediation, but they indicate that low levels of radionuclides may be migrating from the scrap yard areas.

Soil immediately under the scrap metal and debris has not been sampled. However, the scrap metal has been scanned in the past and does have elevated levels of radioactivity. RCRA material was separated out of the scrap metal earlier, and remaining scrap metal is assumed to need to be managed as low-level waste (LLW). However, some of the debris may be a RCRA characteristic waste. Soils presently inaccessible for sampling/excavation due to the presence of the scrap metal and debris will be addressed under this ROD. DOE has assumed that these soils will require remediation. The DVS described in this ROD will be used to identify data needs and sampling requirements. Remediation of the soils will be postponed until the scrap metal and debris have been removed. Once the soil becomes accessible, remediation of the postponed contaminated soils will follow the same remedial strategy described for all other contaminated soil addressed under this ROD.

K-710 Sludge Beds and Imhoff Tanks. Based on process knowledge and known compositions of influent wastewater streams from the Powerhouse Area, the residual sludge beds and tanks were thought to be contaminated with metals, radionuclides, and PCBs. Therefore, the sludge was sampled in each bed and one of the tanks during the site-wide RI and analyzed for inorganic elements, radionuclides, and PCBs. The sample from the tank contained elevated levels of radionuclides; maximums of 39 pCi/g of ^{99}Tc and 5 pCi/g of ^{235}U . PCBs have been detected at concentrations of 120 mg/kg in the sediment in the Imhoff tanks.

Conceptual Site Model. The data compiled for the ETTP site-wide draft RI (DOE 1999a) provides information to construct a conceptual site model for the four areas of concern. The data suggest soil contamination is present at all four areas of concern that could provide a direct threat to human health. There is also limited information to suggest that contamination is migrating from the soil to groundwater. However, there is insufficient information to determine the extent of the impact and whether this migration is cause for concern. The current information suggests that impacts to groundwater are limited.

Figure 2.5 (a through c) summarizes the conceptual site models for these areas. The major pathways of concern at the K-901 Area are direct exposure to buried waste and soils. These pathways also exist at the Powerhouse Area in addition to direct exposure to scrap and surface soil under the scrap.

2.6 CURRENT AND POTENTIAL FUTURE LAND USES

In order to focus remedial planning, DOE evaluated and determined current and reasonably anticipated future land use. This allowed DOE to propose and select remedial actions protective of receptors consistent with exposure under these land use scenarios. Because this action does not address surface water or groundwater, resource uses were not evaluated.

Following the shutdown of the ETTP facility, a vision for the future use of the facility and all associated land has been developed. This vision is that ETTP becomes a commercial/industrial park with very limited DOE obligations. To facilitate the transition from a DOE-controlled uranium enrichment facility to a commercial/industrial park, significant activities need to occur. These activities include site remediation under CERCLA to bring the site to a state of protectiveness consistent with its future

I-10038-0284

DOE/OR/01-2148&D2

**Waste Handling Plan, Part II
for the K-770 Soils Within Zone 1,
East Tennessee Technology Park,
Oak Ridge, Tennessee**

RECEIVED AUG 28 2006

This document has been approved for public release per
review by:

DR MIT

8/4/06

BJC ETP Classification & Information Control Office Date

**Waste Handling Plan, Part II
for the ETTP Scrap Removal Project,
East Tennessee Technology Park,
Oak Ridge, Tennessee**

This document has been approved for public release per
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I-10038-0175

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DOE/OR/01-2263&D1

**Waste Handling Plan, Part II
for the K-710 Facilities and the K-725 Concrete Slab
Within Zone 1, East Tennessee Technology Park,
Oak Ridge, Tennessee**

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This document is approved for public release per
Review by:

David D. Holt *8/23/2005*
BJC ETP Classification & Information Office Date

APPENDIX K
EMWMF NUCLEAR CRITICALITY COMPLIANCE DOCUMENTATION

EMWMF Material Screen Calculation Worksheet

Click here to view the EMWMF Material Screen Calculation Worksheet, Rev. 0.

Title: WL 4.12 K-770 Soils and Misc. Debris		Revision No: 0 1 2	
Date: 4/14/2009	Contact: Marshall Davenport	Phone No: 578-8048	
WASTE DESCRIPTION			
DESCRIPTION OF THE WASTE MATERIAL: (include origin of waste, mass of waste, form and composition of waste, quantity of fissionable nuclides, types of containers, FEM calculations, etc. If information is attached, list attachments here.)			
Waste Lot 4.12 consists of a total of approximately 17,500 yd ³ of primarily soil, miscellaneous debris such as embedded residual metal debris, lumber, etc. (less than 5% of waste lot), concrete (approximately 8% of waste lot), and secondary waste such as PPE, signage, plastic, hula hoops, etc. from the K-770 Scrap Yard Soils Removal Action Project. Waste will be transported in dump trucks with an estimated 40,000 lbs per conveyance.			
Radiological summary data attached (Attachment 1)?		☒ YES ☐ NO	
235U FEM calculation attached (Attachment 2) and signed by preparer and reviewer?		☒ YES ☐ NO	
If the shipment does not meet one of the three Exemption Criteria listed below, then an NCS evaluation shall be performed to determine acceptability of the waste at EMWMF.			
NOTE: This form is not required if approved NCS addresses the waste shipment.			
Enrichment Exemption Criteria			
1. Is the uranium enrichment in the shipment less than 0.90 wt% 235U?		☐ YES ☐ NO	
2. Is the total activity of fissionable transuranic nuclides less than 1400 pCi/g waste?		☐ YES ☐ NO	
If the answers to questions 1 and 2 are BOTH YES, then the shipment meets the requirements of Enrichment Exempt material and may be shipped to EMWMF with NCS concurrence noted below. Answers to questions 3 - 7 are not required.			
Mass/Volume Exemption Criteria			
3. Does each waste package contain less than 15 g 235U FEM?		☐ YES ☐ NO	
If the answer to question 3 is YES, then the material meets the requirements of Mass/Volume Exempt materials and may be shipped to EMWMF with NCS concurrence noted below. Answers to question 1, 2 and 4 through 7 are not required.			
Concentration Exemption Criteria			
4. Is the fissile material concentration less than 2 g 235U FEM / kg-waste? The concentration calculation shall use the highest sample value for fissile concentration and shall not include the mass of the waste container.		☒ YES ☐ NO	
5. Does the waste primarily consist of soil and/or building debris?		☒ YES ☐ NO	
6. Is the fissile material uniformly dispersed within the waste with NO concentrated deposits of fissile material?		☒ YES ☐ NO	
7. Are there NO quantities of beryllium or reactor grade graphite in excess of 1% of the mass of waste?		☒ YES ☐ NO	
If the answers to questions 4 through 7 are ALL YES, then the shipment meets the requirements of Concentration Exempt material and may be shipped to EMWMF with NCS concurrence noted below. Answers to questions 1, 2 and 3 are not required.			

I certify all information on this form is accurate and correct to the best of my knowledge.

Responsible Waste Management Lead: Marshall Davenport Signature MARSHALL DAVENPORT Print 4/14/2009 Date

Concurrence that the information on this form meets the specified NCS exemption criterion.

NCS Engineer: Clyde Magin Signature Clyde Magin Print 4-14-09 Date

Concurrence that the Waste Lot specified on this form meets the EMWMF administrative WAC for NCS.

EMWMF Waste Generator Services Lead: Steve Kucera Signature Steve Kucera Print 4/20/09 Date

Concurrence that the Waste Lot specified on this form is acceptable for receipt at the EMWMF.

EMWMF Facility Manager: Jeffrey W. Grindstaff Signature JEFFREY W. GRINDSTAFF Print 4/20/09 Date

EMWMF Material Screen Calculation Worksheet

*A waste package is defined as a container together with its contents of waste in its final form for disposal, one or more of which may constitute a shipment. Examples are (1) a single box; (2) a single drum; (3) the entire contents of a single bulk shipment. For this form, a waste package may not be smaller than 30 gallons in volume.

[Click here](#) to view Technical Information for Delivery of Waste to the Environmental Management Waste Management Facility.

**WL 4.12 K-770 Scrap Yard Soils
EMWMF SRC Summary Statistics**

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	EQ3	UCL95	HI SDF	CA SDF
Ce-137	pCi/g	57	33	0.030	0.190	28.600	0.79	B			4.90	13.07		
Co-60	pCi/g	57	5	0.030	0.080	1.870	0.13	LN	-2.428	0.748	0.12	0.14		
K-40	pCi/g	57	57	1.380	10.200	18.800	9.77	B			9.83	14.45		
Tc-99	pCi/g	57	37	1.290	4.310	829.000	20.26	B			107.92	287.20		0.027
Th-228	pCi/g	57	57	0.240	1.090	3.530	1.09	N		0.866	1.09	1.24		
Th-232	pCi/g	57	57	0.200	0.990	3.330	1.00	N		0.574	1.00	1.13		
U-233/234	pCi/g	57	56	0.110	10.200	1360.000	39.45	LN	2.061	1.028	29.60	54.43	0.000	0.017
U-235	pCi/g	57	44	0.050	1.080	185.000	5.07	LN	-0.120	1.647	3.44	6.45	0.000	0.002
U-238	pCi/g	57	57	0.430	7.850	1150.000	33.45	LN	1.841	1.888	25.00	47.09	0.017	0.021
Aluminum	mg/kg	57	57	4400.000	12300.000	21400.000	12261.05	B			12500.00	17857.28		
Antimony	mg/kg	57	35	0.115	0.500	85.100	2.01	B			11.20	29.79	0.070	
Arsenic	mg/kg	57	57	2.900	8.600	18.400	7.27	LN	1.889	0.437	7.28	8.10		
Barium	mg/kg	57	57	31.300	71.500	395.000	80.37	B			118.72	231.67	0.001	
Barium	mg/L	43	43	0.223	0.631	1.770	0.64	LN	-0.697	0.548	0.64	0.75		
Beryllium	mg/kg	57	57	0.140	0.400	1.800	0.43	B			0.59	1.12		
Boron	mg/kg	57	57	1.900	5.900	39.100	7.43	LN	1.798	0.625	7.34	8.64	0.000	
Cadmium	mg/kg	57	54	0.020	0.750	14.200	1.52	LN	-0.525	1.582	2.01	3.68		
Cadmium	mg/L	43	25	0.002	0.008	0.096	0.015	B			0.020	0.06		
Calcium	mg/kg	57	57	1880	58200	254000	79298	B			81443.33	162846.39		
Chromium	mg/kg	57	57	9.700	26.000	2880.000	102.74	B			498.85	1319.51	0.004	
Chromium	mg/L	43	7	0.002	0.008	0.030	0.01	B			0.01	0.02		
Cobalt	mg/kg	57	57	1.600	9.000	41.000	9.04	B			13.23	26.16		
Copper	mg/kg	57	57	3.600	83.000	4780.000	284.53	LN	4.226	1.722	301.00	592.50		
Iron	mg/kg	57	57	4830.000	24700.000	155000.000	27793.51	B			43071.87	90299.55		
Lead	mg/kg	57	57	2.900	38.800	733.000	60.80	LN	3.380	1.279	68.50	97.11	0.044	
Lead	mg/L	43	11	0.009	0.017	0.589	0.04	B			0.11	0.28		
Lithium	mg/kg	57	57	5.300	12.300	88.000	14.69	B			20.42	39.90		
Magnesium	mg/kg	57	57	1060.000	6350.000	73800.000	14335.61	LN	8.918	1.180	14600.00	38631.00		
Manganese	mg/kg	57	57	69.200	495.000	2210.000	618.75	LN	6.192	0.734	640.00	781.20	0.002	
Mercury	mg/kg	57	46	0.0050	0.360	4.400	0.89	LN	-1.628	2.468	4.13	7.80		
Mercury	mg/L	43	6	3.000E-05	3.000E-05	1.500E-04	4.000E-05	B			5.000E-05	8.410E-05		
Molybdenum	mg/kg	57	57	0.680	2.700	89.200	5.58	B			13.46	33.51	0.003	
Nickel	mg/kg	57	57	4.200	48.900	1700.000	127.18	LN	3.814	1.478	135.00	220.19		
Potassium	mg/kg	57	57	482.000	838.000	1940.000	880.44	B			962.330	1434.51		
Selenium	mg/kg	57	12	0.230	0.275	25.700	0.82	B			4.51	11.75	0.003	
Silver	mg/kg	57	26	0.040	0.050	1.400	0.24	B			0.27	0.66		
Sodium	mg/kg	57	50	0.750	75.400	481.000	124.410	LN	3.933	1.960	349.000	418.700		
Tin	mg/kg	42	14	15.500	23.200	232.000	37.400	B			58.700	120.000	0.026	
Vanadium	mg/kg	57	57	8.000	21.800	52.900	22.29	N		9.428	22.29	24.38	0.001	
Zinc	mg/kg	57	57	9.300	110.000	1040.000	188.21	LN	4.667	1.139	203.00	571.60		
PCB-1248	mg/kg	57	6	0.008	0.110	13.000	1.77	B			2.24	5.98		

**WL 4.12 K-770 Scrap Yard Soils
EMWMF SRC Summary Statistics**

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	E(X)	UCL95
PCB-1254	mg/kg	57	48	0.008	0.38	7.30	1.35	B			1.48	3.66
PCB-1260	mg/kg	57	43	0.006	0.20	2.60	0.49	B			0.60	1.45
Total PCBs	mg/kg	57	46	0.024	0.690	23.000	3.58	B			4.23	10.90
2-Butanone	mg/kg	42	14	0.000	0.005	0.045	0.01	B			0.01	0.02
2-Methylnaphthalene	mg/kg	43	30	0.020	0.071	0.300	0.10	B			0.10	0.19
3 & 4 Methylphenol	mg/kg	43	4	0.019	0.180	0.580	0.19	B			0.23	0.41
Acenaphthene	mg/kg	43	14	0.019	0.185	1.200	0.17	B			0.33	0.70
Acenaphthylene	mg/kg	43	5	0.019	0.190	0.205	0.17	B			0.18	0.20
Acetone	mg/kg	42	31	0.004	0.026	0.280	0.06	B			0.08	0.14
Anthracene	mg/kg	43	26	0.019	0.110	3.290	0.19	B			0.61	1.54
Benz(a)anthracene	mg/kg	43	37	0.024	0.160	10.000	0.37	B			1.78	4.65
Benzo(a)pyrene	mg/kg	43	39	0.021	0.150	8.200	0.33	B			1.47	3.63
Benzo(b)fluoranthene	mg/kg	43	38	0.024	0.140	7.400	0.31	B			1.33	3.46
Benzo(g,h)perylene	mg/kg	43	39	0.035	0.140	5.800	0.26	B			1.02	2.60
Benzo(k)fluoranthene	mg/kg	43	38	0.025	0.160	8.000	0.32	B			1.44	3.74
Benzoic Acid	mg/kg	43	17	0.022	0.185	0.290	0.15	B			0.18	0.25
Bis(2-ethylhexyl)phthalate	mg/kg	43	11	0.180	0.200	140.000	3.85	B			23.50	63.20
Butyl benzyl phthalate	mg/kg	43	5	0.026	0.190	14.000	0.50	B		*	2.46	6.49
Carbazole	mg/kg	43	16	0.021	0.190	1.100	0.16	B			0.31	0.66
Chrysene	mg/kg	43	39	0.020	0.160	8.700	0.38	B			1.73	4.52
Dibenz(a,h)anthracene	mg/kg	43	27	0.019	0.080	2.200	0.16	B			0.42	1.06
Dibenzofuran	mg/kg	43	17	0.021	0.185	0.520	0.14	B			0.21	0.39
Di-n-octylphthalate	mg/kg	43	3	0.027	0.190	0.690	0.19	B			0.23	0.41
Fluoranthene	mg/kg	43	38	0.025	0.180	26.000	0.83	B			4.46	11.90
Fluorene	mg/kg	43	10	0.021	0.190	1.200	0.19	B			0.33	0.70
Indeno(1,2,3-cd)pyrene	mg/kg	43	38	0.024	0.120	5.000	0.23	B			0.92	2.38
Naphthalene	mg/kg	43	21	0.019	0.180	0.205	0.12	B			0.16	0.20
Phenanthrene	mg/kg	43	38	0.029	0.170	11.000	0.45	B			1.95	5.11
Phenol	mg/kg	43	7	0.023	0.190	1.100	0.19	B			0.31	0.66
Pyrene	mg/kg	43	38	0.021	0.195	16.000	0.61	B			2.80	7.38

M
SOF

CA
SOF

0.000
0.001
0.000
0.000
0.000

0.000

0.000

0.172

0.668

Notes:

SRC = Site Related Contaminant

N = Number of Samples

PDF = Probability Density Function

pCi/g = picocurie/gram

LN = Lognormal, N = Normal, B = PERT Beta

mg/kg = milligram/kilogram

Standard Deviation = Standard deviation from arithmetic mean for Normal distributions and standard deviation from log transformed mean for Lognormal distributions.

E(X) = Expected Concentration in Waste Lot

UCL95 = 95% Upper Confidence Limit on the Mean

Waste Lot 4.12 EMWMF Material Screen

Radionuclide	Max Detect (pCi/g)	Rad Error (pCi/g)	2X Rad Error (pCi/g)	Total (pCi/g)
U-234	1380	283	566	1928
U-235	185	117	234	419
U-238	1150	248	492	1842

Enrichment Exemption Criteria (Questions 1 & 2)		wt% ²³⁵ U (GCI)
Uranium enrichment	5.20	
Fissionable Transurane	2.00E-05	

FOUR-PAK CARTRIDGES FOR NUCLEAR WASTE CHARACTERIZATION (CONTINUED)									
Nuclide	Maximum Activity (pCi/g)	T _{1/2} ^{1,2} (years)	Atomic Weight	Specific Activity ³ (d/g)	Total grains per container (g)	Curies (Ci)	Mass (g)	²³⁵ U FEM Magn Factor	²³⁵ U FEM (d)
²³⁸ U	1000	4.468E+09	238	1.24E+08	1.00E-07	1.24E-05	1.00E-07	1.4	1.40E+07
²³⁴ U	1000	2.445E+05	234	4.26E+08	1.00E-07	4.26E-05	1.00E-07	100	100
^{234m} Pa	420	1.16E+01	234	2.10E+09	1.00E-07	2.10E-05	1.00E-07	1	2.10E+03
²³⁰ Th	1000	1.39E+04	230	3.70E+08	1.00E-07	3.70E-05	1.00E-07	100	100
²²⁶ Ra	1000	1.60E+03	226	3.70E+08	1.00E-07	3.70E-05	1.00E-07	100	100
²¹⁴ Pb	1000	2.69E-02	214	1.05E+10	1.00E-07	1.05E-05	1.00E-07	100	100
²¹⁴ Bi	1000	1.99E-03	214	1.05E+10	1.00E-07	1.05E-05	1.00E-07	100	100
²¹⁰ Pb	1000	2.20E+01	210	4.20E+09	1.00E-07	4.20E-05	1.00E-07	100	100
²¹⁰ Bi	1000	5.01E-02	210	1.12E+10	1.00E-07	1.12E-05	1.00E-07	100	100
²¹⁰ Po	1000	1.38E-04	210	4.20E+09	1.00E-07	4.20E-05	1.00E-07	100	100
²⁰⁶ Pb	1000	4.35E+09	206	4.91E+07	1.00E-07	4.91E-05	1.00E-07	100	100
²⁰⁶ Tl	1000	4.20E-05	206	4.91E+07	1.00E-07	4.91E-05	1.00E-07	100	100
²⁰² Pb	1000	2.14E+01	202	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
²⁰² Bi	1000	1.39E-01	202	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
²⁰² Po	1000	1.38E-06	202	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
²⁰⁸ Tl	1000	3.05E-05	208	5.01E+07	1.00E-07	5.01E-05	1.00E-07	100	100
²⁰⁸ Pb	1000	3.82E+09	208	5.01E+07	1.00E-07	5.01E-05	1.00E-07	100	100
²⁰⁴ Pb	1000	1.41E+01	204	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
²⁰⁴ Bi	1000	1.13E-01	204	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
²⁰⁴ Po	1000	1.38E-06	204	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
²⁰⁰ Tl	1000	7.57E-05	200	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
²⁰⁰ Pb	1000	2.14E+01	200	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
²⁰⁰ Bi	1000	5.01E-02	200	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
²⁰⁰ Po	1000	1.38E-06	200	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
¹⁹⁶ Tl	1000	2.77E-05	196	5.01E+07	1.00E-07	5.01E-05	1.00E-07	100	100
¹⁹⁶ Pb	1000	1.41E+01	196	5.01E+07	1.00E-07	5.01E-05	1.00E-07	100	100
¹⁹² Ir	1000	1.40E+01	192	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
¹⁹² Pt	1000	1.38E+01	192	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
¹⁸⁸ Ir	1000	2.99E-02	188	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
¹⁸⁸ Pt	1000	1.05E-01	188	1.01E+10	1.00E-07	1.01E-05	1.00E-07	100	100
¹⁸⁴ Ir									

[illegible]Total ^{234}U FLOWING-water² Formulas for monthly weights taken from L.A. 523-01-000.

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