Westinghouse Electric Company LLC
Hematite Decommissioning Project
3300 State Road P
Festus, MO 63028
USA

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Director, Office of Federal and State Materials and Environmental Management Programs
Washington, DC 20555-0001

Direct tel: 314-810-3368
Direct fax: 636-937-6380
e-mail: CoppRD@Westinghouse.com
Our ref: HEM-12-88
Date: July 24, 2012

Subject: FINAL RESPONSES TO NRC REQUESTS FOR ADDITIONAL INFORMATION DATED MAY 1, 2012, ON THE JANUARY 16, 2012, HEMATITE 20.2002 ALTERNATE DISPOSAL REQUEST (LICENSE NO. SNM-00033, DOCKET NO. 070-00036)

Reference
1) NRC (Hayes) letter to Westinghouse (Copp), dated May 1, 2012, “NRC Request for Additional Information from Westinghouse on the January 16, 2012, Hematite 20.2002 Alternate Disposal Request”
2) Westinghouse (Copp) letter HEM-12-2 to NRC (Document Control Desk), dated January 16, 2012, “Request for Additional Alternate Disposal Approval and Exemptions for Specific Hematite Decommissioning Project Waste at US Ecology Idaho”
3) Westinghouse (Copp) letter HEM-12-67 to NRC (Document Control Desk), dated June 19, 2012, “Partial Response to NRC Requests for Additional Information dated May 1, 2012, on the January 16, 2012, Hematite 20.2002 Alternate Disposal Request”

Reference 1 transmitted requests for additional information (RAIs) on the Reference 2 request from Westinghouse Electric Company LLC (Westinghouse) for additional alternate disposal approval and exemptions at the US Ecology Idaho facility. Reference 3 contained partial responses to the RAIs and identified the following remaining items:

- Revision to the main body of Enclosure 1 to Reference 2: “Safety Assessment for Additional Hematite Project Waste at USEI.” Enclosure 1 to this letter is a revision to the main body Enclosure 1 to Reference 2 based on the RAI responses contained in Reference 3.
- Revision to HDP-TBD-WM-906: Enclosure 2 is a revision to HDP-TBD-WM-906 based on the RAI responses contained in Reference 3. This document also includes additional detail on the characterization of materials that are intended for disposal at USEI.

- A procedure for survey/sampling of miscellaneous equipment (except for HEPA units since sufficiency of existing data is explained in Reference 3) and piping that are proposed for consignment to USEI: Enclosure 3 contains sections of a work plan that will be used to perform characterization of concrete and asphalt materials prior to disposal at USEI. Enclosure 4 contains a new section for a procedure that will be used for the characterization of piping prior to disposal at USEI.
- Revision to NSA-TR-HDP-11-11: Enclosure 5 contains Revision 1 to NSA-TR-HDP-11-11, *NCSA of the US Ecology Idaho (USEI) Site for the Land Fill Disposal of Additional Decommissioning Waste from the Hematite Site.*
- In addition, Enclosures 6, 7, and 8 contain revisions to Reference 2's Attachments 4 and 9, and partial revision to Attachment 3, respectively. These updates are based on the RAI responses in Reference 3 and subsequent clarifying discussions with NRC.

Subsequent to Reference 3, HDP has elected to limit the miscellaneous equipment to only those items identified in Table 8.1 of Enclosure 2. No other miscellaneous equipment will be disposed at USEI and as such a separate sampling approach for this type of material has not been provided.

As stated in Reference 3, Westinghouse will collect additional characterization data during removal of concrete and asphalt surfaces. This characterization data will be compared to the limits listed in the contingency plan table provided in Reference 3 and reproduced in Section 5.2.1 of Enclosure 1 and Appendix R to Enclosure 2. Since Reference 2 did not contemplate additional characterization data for concrete and asphalt, the Tc-99 from concrete and asphalt (0.09 Ci) was not included in the contingency plan table values expressed in Reference 2. Accordingly, the Tc-99 quantity limit associated with this additional 20.2002 request was revised from 0.21 Ci with a $UCL_{(0.95)}$ of 0.32 Ci to 0.30 Ci with a $UCL_{(0.95)}$ of 0.45 Ci to include contributions from concrete and asphalt. This would bring the total quantity of Tc-99 limit associated with both applications to 1.3 Ci with a $UCL_{(0.95)}$ of 2.05 Ci. This change in the contingency plan limit does not reflect a change in the total quantity that will be shipped to USEI, only a change in the method of accounting for characterization data that will be obtained. The dose assessment in Reference 2 is based on disposal of 0.3 Ci of Tc-99.

Please contact Dennis Richardson of my staff at 314-810-3376 should you have questions or need any additional information.

Respectfully,

Robert D. Copp
Director, Hematite Decommissioning Project

Enclosure 1) *Safety Assessment for Additional Hematite Project Waste at USEI*, Revision 1
2) HDP-TBD-WM-906, Revision 1, *Characterization Data Summary in Support of Additional USEI Alternate Disposal Request*

3) Sampling Plan for Concrete and Asphalt (to be incorporated into HDP-OPS12-WP-023, *Concrete and Asphalt Radiological Characterization: Process Buildings, South and West Vault Floors, Pads and Roadways*)
4) Sampling Plan for Piping Destined for USEI (to be incorporated into HDP-PR-WM-905, *Waste Sampling Methods, Labeling and Custody*)
5) NSA-TR-HDP-11-11, Revision 1, *NCSA of the US Ecology Idaho (USEI) Site for the Land Fill Disposal of Additional Decommissioning Waste from the Hematite Site*
6) *RESRAD Input Parameter*s, Revision 1
7) *HDP and USEI Occupational Injury and Illness Data*, Revision 1
8) Revised MicroShield Software Output Results for Stabilization Operator

cc: P. Michalak, NRC/FSME/DWMEP/DURLD/MD
J. J. Hayes, NRC/FSME/DWMEP/DURLD/MD
C. A. Lipa, NRC Region III/DNMS/MIB
M. M. LaFranzo, NRC Region III/DNMS/MCID
J. W. Smetanka, Westinghouse

Enclosure 1 to HEM-12-88

Safety Assessment for Additional Hematite Project Waste at USEI
Revision 1

Westinghouse Electric Company LLC
US Ecology Idaho, Inc.

(18 pages)

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Safety Assessment for Additional Hematite Project Waste at USEI
Westinghouse Electric Company, LLC
US Ecology Idaho, Inc.
Revision 1
(Originally Enclosure 1 to HEM-12-2)

Attachments
(Since Revision 1 is for the main body of this Safety Assessment for Additional Hematite Project Waste at USEI, the attachments are not included)

1) Characterization Data Summary in Support of Additional USEI Alternate Disposal Request, HDP-TBD-WM-906
2) Input Parameters, Microshield®[1] Software 7.02, Westinghouse Electric Company LLC, (08-MSD-7.02-1424).
3) Case Files, Microshield® Software 7.02, Westinghouse Electric Company LLC, (08-MSD-7.02-1424).
4) RESRAD Input Parameters
5) RESRAD Case Files
6) Intruder Dose Calculations – Construction Scenario
7) Intruder Dose Calculations – Intruder Well Drilling Scenario
8) Intruder Dose Calculations – Chronic Exposure for Intruder Well Drilling Scenario
9) HDP and USEI Occupational Injury and Illness Data
10) Nuclear Criticality Safety Assessment of the US Ecology Idaho (USEI) Site for Land Fill Disposal of Decontamination and Decommissioning Waste from the Hematite Site.

[1] MicroShield® is a trademark of Grove Software, Inc., registered in the U.S. and other countries.

1 EXECUTIVE SUMMARY

This information and radiological safety assessment was developed in coordination with USEI's health physics staff. This document addresses the characteristics of the candidate waste material; the proposed manner and conditions of disposal; the nature of the disposal environment; the nature and location of other potentially affected facilities; projects doses to members of the public during transport operations and to USEI workers during railcar receipt, unloading, transport and disposal; and provides an assessment of the potential post-closure doses.

This Safety Assessment also demonstrates that the candidate waste will be several orders of magnitude below the U.S. Department of Transportation's criteria for fissile material and orders of magnitude below concentrations that would present a criticality concern.

The candidate waste comprises approximately 23,000 m^3 of solid materials consisting of a mixture of concrete/asphalt, piping, soil, and miscellaneous equipment. Miscellaneous equipment includes ventilation equipment removed from the former process building as well as contaminated decommissioning equipment. These materials contain low concentrations of both special nuclear material (SNM) and byproduct material contaminants. A description of the waste to be disposed is included in Section 5 and includes physical and chemical properties of the waste required to conservatively assess risk under the proposed disposal conditions. Attachment 1 contains a detailed discussion of the characterization data available for the materials associated with this request. Westinghouse's proposed documentation of waste transfer is also discussed.

Projected alternate disposal would contribute approximately 0.8 mrem per year to any member of the public, well within the several mrem exposure standard set forth in NUREG 1757 for alternate disposal approvals. These findings support NRC approval of alternate disposal in accordance with 10 CFR 20.2002.

This Safety Assessment also supports an NRC concurrence that US Ecology can be exempted from byproduct material and SNM license requirements of 10 CFR 30.3 and §70.3, as allowed in §30.11 and §70.17. Such exemptions from regulation under the Atomic Energy Act for disposal purposes are consistent with the diffuse, low concentrations of contaminants in the waste and with such exemptions issued by NRC for managing equivalent or higher concentration wastes.

2 USEI FACILITY OPERATING HISTORY

USEI's operating history is described extensively in Reference 1. There have been no significant changes to USEI's operating permit, radioactive materials acceptance limits, or regulatory status since the date of Reference 1. USEI's operating history from Reference 1 is incorporated in this request by reference instead of duplication of Reference 1 (ML091480071).

Since May of 2009, USEI has received approval to dispose 200,000 cubic feet of low-activity decommissioning waste from the Pacific Gas & Electric Humboldt Bay nuclear power plant

near Eureka, California (Reference 8). In addition, NRC has approved Westinghouse to dispose approximately 23,000 m^3 of HDP decommissioning waste at USEI (Reference 7). NRC held two public meetings at Rimrock High School (Grand View, ID) to provide information to the local community and solicit public comments during review of exemption requests submitted by Westinghouse. USEI remains in compliance with its operating permit and has maintained VPP "Star" status with the OSHA Voluntary Protection Program. Information on occupational illness and injuries for 2007 through 2011 for both USEI and HDP are provided in Attachment 9.

USEI has been permitted to receive unregulated SNM since 2009. Since that time, there have been a few other shipments of unregulated SNM received at the USEI landfill in addition to the initial shipments from Hematite. These include:

- ~ 140 tons of exempt soil and debris from BASF/Englehard Metals in Massachusetts with average concentrations of 289 pCi/g U-234, 13 pCi/g U-235, and 51 pCi/g U-238. The Massachusetts agreement state license was previously terminated as part of a site decommissioning. NRC was consulted by the Massachusetts Department of Public Health prior to shipping waste to USEI. Using a soil density of 1440 g/L, 13 $pCi^{235}U/g$ equates to 0.009 $g^{235}U/L$.

- ~20 tons of soil from remediation of a historical weapons accident (circa 1958) containing HEU at Dyess AFB in Abilene, TX. Material was classified as 91(b) by the U.S. Air Force. Soils contained the following average concentrations: 379.2 pCi/g U-234, 11.5 pCi/g U-235, and 1.89 pCi/g U-238. Using a soil density of 1440 g/L, 11.5 $pCi^{235}U/g$ equates to 0.008 $g^{235}U/L$.

- ~400 tons of debris from the decommissioning of the Aberdeen Pulse Radiation Facility (APRF). Material was classified as 91(b) by the U.S. Army as part of the Army's Nuclear Reactor Program. The debris contained an average concentration of 0.2 pCi/g U-235. Using a soil density of 1440 g/L, 0.2 $pCi^{235}U/g$ equates to 0.0001 $g^{235}U/L$.

All of this other SNM material was below the average 0.1 $g^{235}U/L$ concentration limit for HDP waste consigned to USEI. The concentration is further reduced since these shipments were received between 2010 and 2011 and were combined with approximately 1.3 million tons of other non-SNM soils and debris in the USEI landfill. Therefore, no additional impact needs to be evaluated.

3 DISPOSAL FACILITY CHARACTERISTICS

A description of the USEI facility and waste placement practices is found in References 1, 2, and 3. Key documents contained in these previous submittals include:

- General Description (IDAPA 58.01.05.012 & 40 CFR 270.14(B)(1)) (Reference 1).
- Hazardous Waste Facility Siting License Application for Cell 16 (Reference 2).
- USEI Radiological Sampling – Air and Soil (Reference 2).
- Summary of Hydrogeologic Conditions and Groundwater Flow Model for US Ecology Idaho Facility, Grand View, Idaho (Reference 3).

The description of USEI from References 1 through 3 is incorporated in this request by reference instead of duplication of the referenced documents (ML091480071, ML100320540, ML100221416).

4 USEI WASTE ACCEPTANCE CRITERIA

USEI's waste acceptance criteria associated with this 20.2002 request were provided to NCR via Westinghouse letter HEM-12-67, dated June 19, 2012.

USEI's waste acceptance criteria are maintained on their website, nominally at: usecology.com/downloads/grand_view_forms/USEI_WAC.pdf

Idaho rules regulating radioactive materials are maintained on their website, nominally at: adm.idaho.gov/adminrules/rules/idapa58/0110.pdf

In summary, USEI is authorized to accept low concentration SNM and byproduct material if:

- The NRC specifically exempts the material under 10 CFR 30.11 §70.17 and
- The sum of all activity within the material is less than 3,000 pCi/g, and
- IDEQ reviews and concurs with the NRC exemption and USEI Safety Assessment.

5 MATERIAL DESCRIPTION & SUITABILITY

5.1. Summary

Westinghouse estimates the volume of the excavated waste that is a candidate for disposal at USEI to be approximately 23,000 cubic meters at an average waste density of 1.5 g/cm^3 (e.g., approximately 38,700 tons). The waste consists of a mixture of solid materials (e.g., concrete/asphalt, piping, soil, and miscellaneous equipment) with low levels of SNM, source material, and byproduct material, specifically uranium enriched in U-235 at levels averaging below 10 percent, elevated levels of Tc-99 and trace concentrations of Pu-239, Am-241, and Np-237. The amounts of radionuclides are shown in Table 1 below.

The technical basis for the radionuclide data contained in Table 1 and the average enrichment are provided in Attachment 1. Material volumes and activity values presented in Table 1 already include an uncertainty multiplier of 1.5 to account for the potential to encounter more material than estimated based on existing data. The average waste density value of 1.5 g/cm^3 is the average ex-situ density over all of the waste that will be shipped under this 20.2002 request. This value is the weighted average of the constituent materials whose density is estimated based on the professional judgment of waste management staff with extensive experience. Ex-situ constituent material density values used in this calculation are 15, 15, 110, and 90 lb/ft^3 (0.24, 0.24, 1.76, and 1.44 g/cm^3) for subsurface piping, miscellaneous equipment, concrete / asphalt, and ex-situ soil, respectively.

Table 1, Expected Radionuclides in Westinghouse Hematite Waste

Shipped Volume (m^3)	U-234 (Ci)	U-235 (Ci)	U-238 (Ci)	Tc-99 (Ci)
22848	2.2	0.1	0.4	0.3

The average total activity concentration (sum of all nuclides and progeny) for this waste is approximately 110 pCi/g or approximately 4 percent of USEI's 3,000 pCi/g total activity concentration limit. Less than 5% of the waste from Westinghouse is expected to contain concentrations of hazardous constituents identified in 40 CFR 261.24, including tetrachloroethylene, trichloroethylene, vinyl chloride, arsenic, mercury, or lead.

5.2. Waste Characterization Plan

Detailed characterization data and an accompanying analysis is contained in Attachment 1. Based on the analysis contained in that document and Westinghouse letters HEM-12-67 and HEM-12-88, additional characterization will be performed prior to shipment of soils, piping, and concrete/asphalt materials covered under this request. The results of these surveys will be used to determine the associated radionuclide inventory. Attachment 1 identifies that no additional sampling will be performed on the specific miscellaneous equipment, which are identified in Table 8.1.

5.2.1. Soils

Westinghouse will subject soils, which may include spent limestone used as backfill, associated with this request to the same sampling plan that was detailed in Reference 6 and will use the same radiological controls and programmatic elements detailed in Reference 2. The Tc-99 soil concentrations and variability associated with this request are lower than in the Reference 7 approval. The mean Tc-99 concentration and standard deviation associated with soils considered in this request are 13 pCi/g and 36 pCi/g respectively (Attachment 1). The mean Tc-99 concentration and standard deviation used to develop the sampling approach approved by Reference 7 are 27 pCi/g and 225 pCi/g respectively (Reference 6).

The approach used to sample soils associated with this request will be identical to that approved by Reference 7, subject to the following changes to reflect the lower quantities of Tc-99 in this request:

1. It is intended that the additional soil and debris under consideration in this application will be added to the prior application (Reference 6, Attachment 1, Section 10) and will not be treated separately. The following revision to the contingency plan considers both the proposed and approved 20.2002 requests. The contingency plan table is revised as follows:

Table 2, Contingency Plan Table
Prior to shipment, the following conditions will be evaluated, combining results for this and the 20.2002 request approved in Amendment 58 to SNM-33:

Parameter	Action Level	How Monitored	Actions
Total Quantity of Tc-99 shipped to USEI (mean)	>1.3 Ci	Running total activity (both shipped and pending shipment), based on laboratory sample results prior to shipment	• Reanalyze composite sample and/or analyze individual aliquots used to create the composite sample; • Resample stockpile and re-evaluate[a]; • Ship material to alternate facility.
95% Upper Confidence Level of the mean Tc-99 shipped to USEI (UCL(0.95)).	>2.05 Ci	Running confidence interval (both shipped and pending shipment) based on laboratory sample data prior to shipment	• Reanalyze composite sample and/or analyze individual aliquots used to create the composite sample; • Resample stockpile and re-evaluate[a]; • Ship material to alternate facility.
Total activity contribution from all radionuclides within individual railcar	>3000 pCi/g > 40 μR/hr[b]	Laboratory sample results for stockpile evaluated at 95% UCL prior to shipment Gamma radiation levels on railcars prior to shipment.	• Analyze additional aliquot of composite sample; • Unload railcar (at HDP) and re-load with material containing lower concentration (either blended or alternate material from onsite waste stream)[a]; • Ship material to alternate facility.
Unexpected Tc-99 results for stockpile samples	>99th percentile of the site wide dataset (599 pCi/g)[c]	Laboratory sample results for stockpile evaluated prior to shipment	• Analyze additional aliquot of composite sample; • Resample stockpile and re-evaluate[a]; • Blend with less contaminated material, resample stockpile and re-evaluate; • Ship material to alternate facility.
Unexpected Tc-99 results for stockpile samples (piping internal debris / residue)	>99th percentile of the dataset (5783 pCi/g)	Laboratory sample results for stockpile evaluated prior to shipment	• Analyze additional aliquot of composite sample; • Resample stockpile and re-evaluate[a]; • Blend with less contaminated material, resample stockpile and re-evaluate; • Ship material to alternate facility.
Unexpected Tc-99 results for stockpile samples (piping average concentration)	>99th percentile of the dataset (1118 pCi/g)	Laboratory sample results for stockpile evaluated prior to shipment	• Analyze additional aliquot of composite sample; • Resample stockpile and re-evaluate[a]; • Blend with less contaminated material, resample stockpile and re-evaluate; • Ship material to alternate facility.
Maximum average concentration of Ra-226 and Th-232 within individual railcar	Ra-226 >13 pCi/g Th-232 >16 pCi/g	Laboratory sample results for each railcar evaluated prior to shipment	• Analyze additional aliquot of composite sample; • Resample stockpile and re-evaluate[a]; Blend with less contaminated material, resample stockpile and re-evaluate; • Ship material to alternate facility.

[a] Re-sampling of material will generally occur after down blending of stockpile material. When such sampling is performed, the new sample dataset will replace the initial data for the purpose of subsequent calculations. If re-sampling is performed without down blending (which would be the case if the material was sampled in-situ railcars) then, the additional samples will be used to augment the initial dataset.

[b] Based on analysis previously transmitted in HEM-10-46, 5/24/10.

[c] Value shown is the 99th percentile of the pooled site wide Tc-99 dataset with EP-08-00-SL and EP-10-00-SL excluded using spreadsheet software.

2. Section 13.4 of Reference 6, Appendix A, is revised as follows

13.4 If it is determined that the updated mean Tc-99 activity and 95% UCL are within established limits (i.e., mean of 0.30 Ci and 95% UCL of 0.45 Ci), the material will be authorized for shipment. The $UCL_{(0.95)}$ was set at 1.5 times the mean. The post closure dose associated with this UCL is 1.2 mrem, which is a factor of 1.5 times the dose at the mean concentration. Tc-99 does significantly not contribute to any other dose pathway.

5.2.2. Piping

As indicated in Attachment 1, piping from under Building 240 and 260 will be excluded from this request. Table 3, below, provides a summary of the sampling data for the remainder of the piping. Note that the samples represent concentrations in materials contained within the piping and does not consider the overall mass of the piping walls.

Table 3, Sample Summary Data from Piping for USEI Disposal

Parameter	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
No. Samples	10	10	10	10
Average	33	1479	57	209
Minimum	2	0	0	0
Maximum	174	6944	258	766
St. Dev.	52	2225	84	292

The sampling approach for the site piping was developed considering that a batch of piping would consist of approximately 100 m^3 of material. This volume is equivalent to that of a rail car. The material in a single rail car was considered an appropriate batch of material since that is the unit of volume upon which waste management decisions are based. Accordingly, the number of samples required to ensure that the median concentration within that batch is less than the maximum observed value was determined using Visual Sampling Plan (True Average vs. Fixed Threshold, where the data is neither considered normal nor symmetrical). This analysis was performed for each of the four nuclides Tc-99, U-234, U-235, and U-238. The resultant number of samples required was 14 or one sample per 7.1 m^3. This is equivalent to 1 sample per 250 ft^3. Based on this analysis, HDP will collect a minimum of one sample per 250 ft^3 of piping and will analyze each sample by gamma spectroscopy and for Tc-99. The location of the samples are addressed in Enclosure 3 to HEM-12-88.

5.2.3. Miscellaneous Equipment

The only miscellaneous equipment that is addressed in this request is listed in Table 8.1 of Attachment 1. Characterization data for this material is described in Attachment 1. The Tc-99 scaling factor will be verified through analysis of swipe samples from these items prior to shipment. The associated Tc-99 inventory will be adjusted as necessary based on this data.

6 TRANSPORT AND DISPOSAL RADIOLOGICAL ASSESSMENTS

Using multiple conservative exposure scenarios, the dose equivalent was calculated for the Maximally Exposed Individual (MEI). In all cases the MEI receives less than 1 mrem per year which is consistent with NUREG 1737's Vol.1, Rev.2, Consolidated Decommissioning Guidance - Decommissioning Guidance for Materials Licensees, Final Report, p. 15-31 criteria of a "few millirem/yr" to a member of the public. The transportation workers and workers at the USEI facility are treated as members of the public since the USEI facility is not licensed under the Atomic Energy Act.

Evaluations of both potential external and internal doses to workers are discussed below. Based on the conservatively projected length of time of exposure and proximity to waste, the MEI for transportation and disposal is a USEI excavation operator.

6.1. Dose Assessment Methodology

External dose rates were modeled for applicable source / receptor geometries using Microshield® Software, version 7.02 with the radionuclide concentrations based on Table 1, above. Microshield® Software input parameters are provided in Attachment 2. Results of these calculations are provided in Attachment 3.

In order to estimate potential internal dose during material handling, an airborne dust study was conducted for representative job categories and work locations at the rail unloading facility and disposal site. In the study, measurements were made of the workers' exposure rates to total and respirable dust. This study indicated that respirable dust levels ranged from 0.17 to 0.23 mg/m^3 with an average of 0.2 mg/m^3. Details of the dust study are contained in Attachment 2 to Reference 2.

Internal dose for all job functions was modeled using the maximum respirable dust loading observed, the dose conversion factors contained in Federal Guidance Report 11, and the radionuclide concentrations based on Table 1, above. The use of respiratory protection is noted in the narrative below; however, no correction is taken for the applicable protection factor.

Gondola railcars will be received at USEI's rail transfer facility (RTF). Based on the anticipated volume of material to be shipped, it is assumed that about 352 gondola cars will be received and that this volume of material will be transferred to the final disposal cell in approximately 1056 truckloads. The project is expected to ship over an 18 month timeframe. No adjustments were made for USEI's respiratory protection program.

Evaluations of both potential external and internal doses to USEI and transportation workers are discussed below. The results for USEI workers are summarized in Table 4.
Even with the conservative assumptions used in this assessment, calculated doses (maximum value of 0.18 mrem) are extremely low and well within the USNRC's "few millirem" criteria for alternate disposal. The excavator operators, truck drivers, stabilization operators and cell operators at the USEI disposal facility do not share job functions.

Dose to transportation workers is presented in Section 6.9.

The numbers of workers sharing the various identified tasks in Sections 6.2 to 6.7 of Enclosure 1 to HEM-12-2 are the minimum number of workers that will share those tasks during USEI operations, even considering circumstances such as layoffs.

6.2. Gondola Railcar surveyor

Prior to being off-loaded, each gondola railcar will be surveyed. This work is shared between 8 personnel. The survey normally takes an operator 20 minutes to complete. The operator will stand approximately one meter from the gondola railcar when conducting the survey. The estimated radiation field, internal and external dose rates per gondola railcar and per surveyor are provided in Table 4. Internal dose is not assigned for this position since the waste in the gondola railcar remains covered during the survey.

6.3. Excavator operator

All unloading operations are conducted within a containment building employing a 24,000 cubic feet per minute (cfm) high efficiency particulate air (HEPA) filtration system. An excavator positioned on a bridge platform above the railcar will transfer the waste into waiting end-dump trucks. Two persons occupy the RTF during trans-loading: the excavator operator and the truck driver. Both remain in the cabs of their vehicles. The cab of each vehicle is air conditioned, with all air drawn through commercial HEPA filtration systems. The excavator operator is also equipped with respiratory protection during all active transload activities. Non-essential personnel are not permitted to enter the RTF building during waste trans-loading to minimize physical hazards.

An excavator operator removes the material from the gondola railcar and loads it into dump trucks for transport to the disposal site. It normally takes the excavator operator less than 45 minutes to unload a gondola railcar into multiple trucks. The operator occupies a position approximately 2 meters from the material. Four excavator operators share the unloading job. The estimated radiation field, internal and external dose rates per gondola railcar and per operator are provided in Table 4.

6.4. Gondola Railcar Cleanout

After unloading, USEI personnel manually remove any residual material in each gondola railcar using shovels and brooms. The operation normally takes 10 minutes to complete. The eight personnel sharing this task stand inside an effectively empty gondola railcar. For the purposes of dose modeling, the dose rate at 30 cm from a 1/2 inch layer of waste material is used. The estimated radiation field, internal and external dose rates per gondola railcar and per person are provided in Table 4.

6.5. Truck Surveyor

After each truck and its trailer are loaded, both are surveyed prior to driving to the disposal site. The survey usually requires five minutes to perform and the task is shared among eight personnel. The surveyor will stand an average of one meter from the exterior of the truck.

The estimated radiation field and external dose rates per truck and per surveyor are provided in Table 4. Internal dose is not assigned for this position since the truck bed is covered prior to the survey step.

6.6. Truck Driver

The time for transloading waste to each truck (about 3-5 minutes) and the trip to the disposal site is a total of 45 minutes. The truck transport work is shared between 14 truck drivers. The estimated radiation field and external dose rates per truck and per surveyor are provided in Table 4. Internal dose is not assigned for this position since the truck bed remains covered during the survey.

6.7. Stabilization Operator

Less than 5 percent of the waste from Westinghouse is expected to contain constituents identified in 40 CFR 261.24 Tetrachloroethylene (D039), Trichloroethylene (D040), Vinyl Chloride (D043), Arsenic (D004), Mercury (D009), and Lead (D008). USEI's RCRA Part B permit allows the facility to accept this waste, treat it to meet USEPA Land Disposal Restrictions and dispose it in the facility's disposal cell. Treating the waste for hazardous metals or organics will require wetting the waste and mixing it with the appropriate reagents in a below-grade, RCRA-compliant treatment tank. All treatment activities will be conducted inside a containment building, with 50,000 cfm of negative airflow. The waste will be mixed by a stabilization operator. Six stabilization operators share this task. It normally takes the stabilization operator up to 45 minutes to perform this operation. The operator occupies a position approximately 2.8 meters from the material. The estimated radiation field, internal and external dose rates per gondola railcar and per operator are provided in Table 4 (based on 5 percent of the 352 gondola cars containing waste with constituents requiring stabilization).

6.8. Cell Operator

Some dose will also be accrued by the two disposal cell workers who will spread and compact the material once it has been deposited in the cell. For this exposure scenario, a dose rate from the deposited material was calculated based on the amount of material contained in one gondola railcar. Assuming 15 minutes to spread and compact each gondola railcar's contents, the total dose to each of those workers for the project was calculated. The estimated radiation field, internal and external dose rates per gondola railcar and per operator are provided in Table 4.

6.9. Transport Dose to Public

Transportation will be by gondola railcar. The contents of each gondola railcar will be entirely enclosed in form-fitting, sift-proof, and closable wrappers meeting U.S. Department of Transportation (DOT) Industrial Type-1 Package (IP-1) requirements. The IP-1 package precludes dispersal of waste to the air or loss of material during transport.

The dose rate at 1m from a loaded gondola railcar is 0.18 μR/hr. The dose rate at 1 foot would be 0.25 μR/hr based on Microshield® Software calculations (Attachment 3). The

maximum dose to a site worker is 190 μR as shown in Table 4, below. In order for the dose to a bystander during transportation to exceed that of the site worker and therefore be bounding, the individual would have to spend 1007 hr at 1 meter from the gondola or 793 hr at 1 foot, which are not credible external exposure scenarios during transportation. Since the waste within the gondola railcars is contained during transport, no internal dose would be assigned to a by-stander. Information on transportation exposure times previously submitted (Response to Question 4 in Reference 4) demonstrates that the exposure times indicated above are orders of magnitude greater than the expected exposure times of less than 20 hours.

Table 4, Summary of Doses to USEI Workers during Transport, Treatment and Disposal of Westinghouse Hematite Waste

	Input Parameters				External dose rate (mrem/hr)	Dose (mrem/conveyance)		Individual Dose (mrem/worker)		
	No. of Workers	Minutes to perform task[1]	Distance from object (meters)	Type of conveyance modeled (count)[2]		Internal[3]	External[4]	Internal[5]	External[6]	Total[7]
Gondola surveyor	8	20	1	Gondola (352)	1.1E-04	9.3E-04	3.75E-05	NA[8]	1.6E-03	1.6E-03
Excavator operator	4	45	2	Gondola (352)	4.1E-05	2.1E-03	3.1E-05	1.8E-01	2.7E-03	1.9E-01
Gondola Cleanout	8	10	1	Gondola (352)	2.3E-04	4.6E-04	3.8E-05	2.0E-02	1.7E-03	2.2E-02
Truck Surveyor	8	5	1	Truck (1056)	1.9E-04	2.3E-04	1.6E-05	NA[8]	2.1E-03	2.1E-03
Truck Driver	14	45	0.6	Truck (1056)	2.2E-04	2.1E-03	1.6E-04	NA[8]	1.2E-02	1.2E-02
Stabilization Operator	6	45	2.8	Cube (18)	4.1E-05	2.1E-03	3.1E-05	6.1E-03	1.4E-05	6.3E-03
Cell Operator	2	15	1	Gondola (352)	1.8E-04	6.9E-04	4.4E-05	1.2E-01	7.8E-03	1.3E-01

1 The minutes assigned for each job function listed in Table 4 are the times estimated by knowledgeable and experienced site personnel for one person to perform each function one time.
2 Calculations based on volume of material in a gondola railcar.
3. Internal dose per conveyance calculated based on the product of the intake quantity of 0.23 mg/m3 of respirable dust, 1.2 m3/hr inhalation rate, individual radionuclide concentrations based on Table 1, dose conversion factors from FGR 11, and the handling times shown.
4 External dose per conveyance calculated based on the product of the external dose rate and handling time indicated.
5 Internal dose per individual worker calculated based on the internal dose per conveyance times the number of conveyances per year and divided by the total number of workers.
6 External dose per individual worker calculated based on the external dose per conveyance times the number of conveyances per year and divided by the total number of workers.
7 Total dose per individual worker is the sum of the internal dose per individual and external dose per individual.
8 Internal dose is not applicable for this job function because waste remains in the conveyance and is covered.

7 POST-CLOSURE DOSE TO THE GENERAL PUBLIC

7.1. Post Closure Analysis

The USEI disposal permit requires the operator to demonstrate that no person will receive a dose in excess of 15 millirem for 1,000 years after closure of the facility. The RESRAD code is used to establish post closure dose estimates. Most of the site-specific parameters are explained in the 2005 report titled "Site-specific RESRAD Water Pathway Parameters for the Contaminated Soil, Vadose Zone, and Saturated Zone" provided in Attachment 5 to Reference 2. For those parameters not described in the 2005 report, justification was provided in Reference 4. A technical basis for the long-term stability of the USEI site is also provided in Reference 4.

For purposes of its permit, USEI must demonstrate compliance with this limit where all radionuclides are assumed to be distributed homogeneously over the volume of the contaminated zone. In response to the NRC's comments in Reference 2, an additional model with more consolidated waste placement was generated for this analysis.

Westinghouse estimates that the waste material referenced in this submittal will be entirely removed and disposed of at USEI within an 18 month time period. Because Westinghouse's waste will be comingled with all other waste receipts at USEI over this time period, the consolidated placement is based on the average volume of waste received over the duration of the project. Over the past 5 years USEI has received an average of 725,000 tons of waste per year, so this analysis assumes the shipped materials from Westinghouse will be evenly distributed over 725,000 tons total waste.

In the RESRAD model, all waste is modeled as uniformly contaminated soil, rather than volumes of concrete and metal. The density of the contaminated zone is adjusted, however, to the average density of the materials received, including concrete rubble, soil, asphalt, piping and other metal debris (e.g., HEPA units and associated ductwork). The site-specific RESRAD model approved by the State of Idaho and incorporated into USEI's operating permit designates the Contaminated Zone Surface Area as 88,221 m^2. This area was established based on planned disposal cell construction and assumes disposal of radiological material across the entire aerial extent of the Contaminated Zone Surface Area. USEI estimates that the majority of the Hematite waste would most likely be disposed across approximately 40,468 m^2 based on the majority of disposal activities are occurring within two construction phases of the currently active disposal cell with a surface area of approximately 10 acres or roughly half of the cell (which is 88,221 m^2).

For the purpose of the RESRAD model specific to Hematite waste, the height of the waste material in the disposal cell was calculated by dividing volume of waste disposed by the cell area. In a similar manner, the radionuclide concentration within the disposal cell was adjusted to account for dilution when mixed with non-Hematite waste. This dilution factor was determined by dividing the mass of Hematite waste by the total mass of waste received during this same time period. The only nuclide contributing to the post closure dose was

determined to be Tc-99, resulting in a dose of 0.8 mrem at 247 years. The dose contributions from Uranium 234, 235, and 238 are 1.4E-22 mrem, 5.1E-30 mrem, and 5.7E-26 mrem, respectively. Attachment 4 contains a detailed explanation of the RESRAD input parameters. Attachment 5 contains the RESRAD Case Files.

When combined with the post closure dose of 1.9 mrem associated with the previous HDP Submittal (Reference 5) the total dose from both applications is 2.7 mrem.

7.2. Intruder Construction Scenario

The intruder construction scenario performed for this request is based on the same methodology used in the prior request (Reference 4). This scenario is partly based on NUREG-0782 in which the inadvertent intruder is assumed to excavate or construct a building on a disposal site following a breakdown in institutional controls. The intruder is exposed to dust particles through the inhalation pathway, and may also be exposed to direct gamma radiation resulting from airborne particulates and from working directly in the waste-soil mixture.

For the Average Cell Concentration scenario, the waste is diluted by a factor of 0.053 to account for mixing within the USEI cell with 725,000 tons total waste. The 0.053 factor is calculated by taking the ratio of Hematite waste to total waste received (38,710 tons / 725,000 tons). For the One-Foot Layer scenario, the concentration is diluted by a factor of 0.31 (12 in/39 in) to account for USEI's practice of layering materials into pits in 1-ft layers and an assumption of 1 meter (39 in) of waste at the time of intrusion. The dose from the inhalation and from external gamma exposure is evaluated for a duration of 500 working hours, or a construction period of 3 months.

In the analysis supporting the Reference 1 request, an additional dilution factor of 0.5 was applied based on placement of non-containerized waste. This factor was not applied in the analysis performed for this request.

The intruder construction scenario performed for this request did not assume any credit for the mixing of the waste with the cover material, which ranges from 0.76 m (2.5 ft.) across the top to 6.10 m (20 ft.) down the side slopes (Reference 2). Since USEI restricts the emplacement of any radioactive waste to within 3.6 meters of the surface of the finished cap of the cell, the construction scenario could be disregarded as not being feasible. Furthermore, no credit was assumed for decay up to the intrusion event, or for waste form. The bounding dose for the construction intruder that Westinghouse calculates is 15 mrem, and assumes waste shipped at the WAC values is encountered in a one-ft layer.

Attachment 6 to this request contains the detailed assessment associated with the Intruder Construction Scenario.

7.3. Intruder Well Drilling Scenario

The inadvertent intruder analysis for this request is the same as that submitted with the prior request (Reference 4). The scenarios evaluated are based on the intruder construction scenario and the intruder well drilling scenario described in Appendix G of NUREG0782, "Draft Environmental Impact Statement on 10 CFR Part 61 Licensing Requirements for Land Disposal of Radioactive Waste". The Pathway Dose Conversion Factors (PDCFs) applied are taken from NUREG/CR– 4370, Volume 1.

In all intruder analyses two different assumptions for the concentration shipped from Hematite to USEI were applied. The first assumption utilized average concentration values based on Table 1. The second assumed that the total sum of radionuclide material shipped is at the USEI Waste Acceptance Criteria (WAC). Two dilution scenarios were also applied for the waste that the intruder contacts. One scenario, the Average Cell Concentration scenario, assumes waste is uniformly mixed within the USEI cell. The second, the One-Foot Layer scenario, assumes the intruder contacts a one-foot layer of waste at its shipping concentration. The Average Cell Concentration scenario was not evaluated for material received at the WAC since it would not be possible for Hematite to ship all of its waste under this request at the WAC. Regardless, this excluded scenario is not bounding (based on calculations submitted in Reference 4).

Two intruder well-driller scenarios were considered by Westinghouse. One was the acute well-driller. The other was the chronic well-driller.

The acute well-driller scenario assumes that the intruder digs a well by drilling through the waste disposal cell to reach the underlying aquifer at a depth of 93.1 m. The total period of exposure is 40 hours, 8 of which occur during the drilling through the contaminated layer. Therefore, for 8 hours, the driller is exposed to undiluted drill cuttings, and for the remaining 32 hours, the driller is exposed to the cuttings diluted by the ratio (0.31/93.1 or 3.3E-3) of the 1-ft contaminated layer (0.31 m) to the total well depth of 93.1 m. This dilution ratio is multiplied by the average cell concentration or the WAC concentrations. Westinghouse calculated a dose to the acute well-driller of 2.7 mrem based upon the intruder drilling through a 1-ft layer at the WAC concentrations.

The chronic well-driller scenario assumes that the intruder spreads the exhumed drill cuttings around the residence and grows a garden in soil containing the drill cuttings. The dose to the chronic well-driller calculated by Westinghouse was 0.5 mrem/yr based upon exposure to material exhumed during well drilling through 1 foot of waste at the WAC concentration (this scenario results in the maximum concentration for the exhumed material).

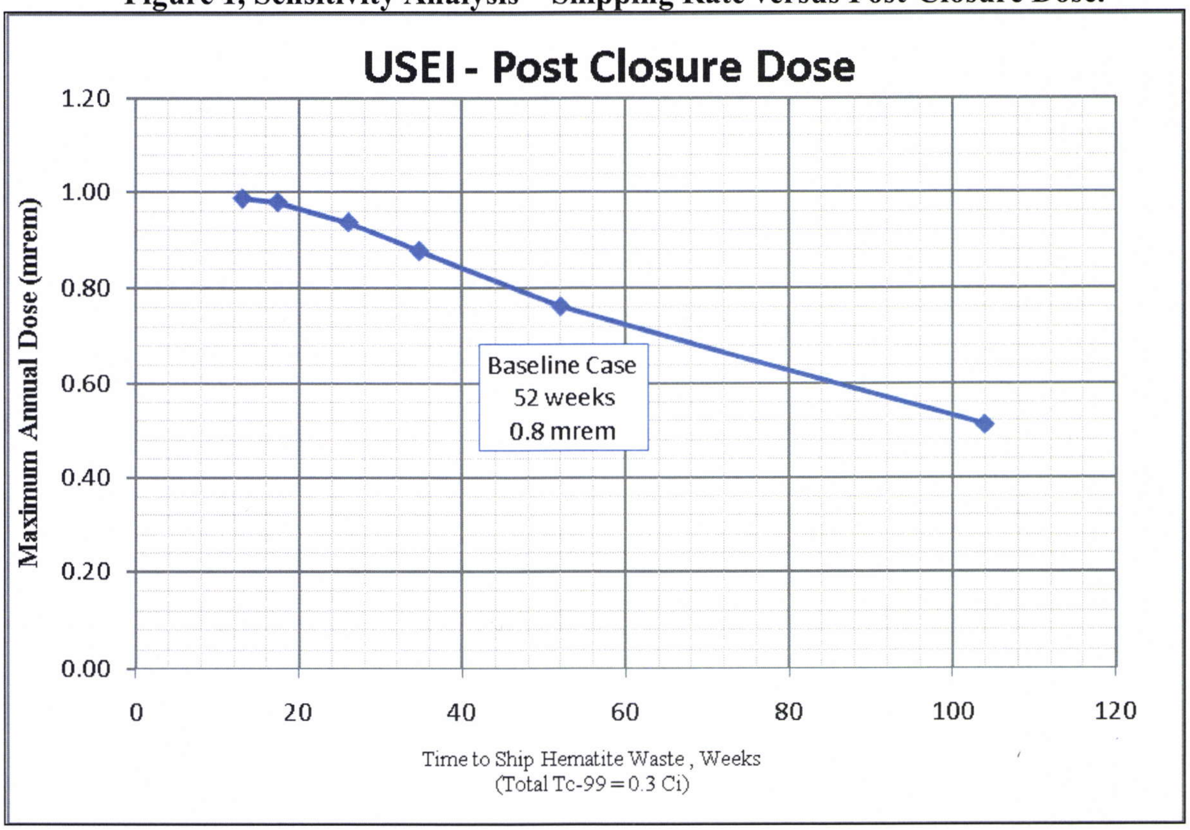
Attachments 7 and 8 this request contain the detailed assessment associated with Intruder Well Drilling Scenario.

7.4. Sensitivity Analysis

A sensitivity analysis was performed to evaluate the impact of project duration and average waste concentration on the post closure dose.

Variation in project duration results in a change in the volume of non-Hematite waste that is available for mixing and subsequently impacts the waste height and dilution factor. The results of this sensitivity analysis are contained in Figure 1, below. Input factors used in the RESRAD analysis are contained in Attachment 4. As shown in this Figure, the post closure dose increases only slightly as the shipment time decreases, remaining below 1.0 mrem for a 13 week duration.

Figure 1, Sensitivity Analysis – Shipping Rate versus Post-Closure Dose.



A scenario was also evaluated in which all waste would be shipped at the USEI WAC containing Uranium at the same mixture as observed on average and containing no Tc-99. Since the Tc-99 exposure is entirely based on post closure dose and is inventory based, evaluation of shipment at higher concentration is not necessary as the exposure in the case of Tc-99 scales linearly with the total quantity of Tc-99 shipped. For the intruder scenario, the lack of an agricultural pathway for the intruder scenario precludes pathways the Tc-99 to significantly contribute to the dose when compared to uranium. Accordingly, only uranium is considered for the intruder scenario, which is a conservative approach.

For the case of Uranium, increases in both worker and intruder dose would be seen. The maximally exposure on-site worker would remain the excavator operator with an annual exposure of 5.4 mrem. Post-closure intruder dose would be 2.9, 3.0, and 16 mrem for the Acute Well Driller, Chronic Well Driller, and Construction scenarios, respectively. Detailed calculations are provided in Westinghouse letter HEM-12-67, dated June 18, 2012

7.5. Cumulative Doses

For all scenarios, the cumulative doses for this 20.2002 request and the 20.2002 request approved in Amendment 58 are provided.

Table 5, Cumulative Doses for Various Scenarios

Scenario	Maximum Dose This 20.2002 Request (mrem/yr)	Maximum Dose 20.2002 Request Approved in Amendment 58 (mrem/yr)	Cumulative Maximum Dose (mrem/yr)
Individual Worker	0.18	0.47	0.65
Intruder Construction	15	9	24
Intruder Acute Well Drilling	2.7	2.9	5.6
Intruder Chronic Well Drilling	0.5	2	2.5

Table 6, Cumulative Doses for Worker Job Functions

Job Function	Maximum Individual Worker Dose (mrem/yr)		
	This 20.2002 Request	20.2002 Request Approved in Amendment 58	Total
Gondola surveyor	1.61E-03	1.10E-01	1.12E-01
Excavator Operator	**1.86E-01**	4.70E-01	**6.56E-01**
Gondola Cleanout	2.21E-02	5.90E-02	8.11E-02
Truck Surveyor	2.05E-03	9.30E-02	9.51E-02
Truck Driver	1.22E-02	**4.90E-01**	5.02E-01
Stabilization Operator	6.26E-03	1.60E-02	2.23E-02
Cell Operator	1.30E-01	3.80E-01	5.10E-01

(**Bold** Font indicates maximum value)

8 NUCLEAR CRITICALITY SAFETY

A criticality safety assessment (Attachment 10) demonstrates that the disposal of Hematite decommissioning waste at the USEI site can be safely performed. The assessment has determined that there are very large margins of safety under normal (i.e., expected) conditions and that there is considerable tolerance to abnormal conditions. Under all foreseen abnormal conditions a criticality event is considered either not credible or is precluded by controls in place at the Hematite site.

This analysis applies to disposal of Hematite decommissioning wastes with a maximum average fissile nuclide concentration of 0.1g ^{235}U/L at the USEI site. The scope of this assessment is limited to wastes with the following attributes:

1. Debris generated from the demolition of the remaining auxiliary buildings/structures at the Hematite site; and
2. Subterranean structures such as subterranean piping, underground utilities, sewage, and soil in the vicinity of the aforementioned subsurface structures; and
3. Concrete and asphalt removed to gain access to underground utilities, piping and contaminated soil, and the septic drain field; and
4. Miscellaneous items/components generated from the demolition of the former process buildings; and
5. Miscellaneous contaminated equipment generated during Decontamination and Decommissioning operations.

As discussed in Section 1 above, non-HDP SNM material shipped to USEI has been below the average 0.1 g^{235}U/L concentration limit for HDP waste consigned to USEI. The non-HDP SNM concentration is further reduced since these other shipments were received between 2010 and 2011 and were combined with approximately 1.3 million tons of other non-SNM soils and debris in the USEI landfill. Therefore, no additional impact needs to be evaluated.

9 RECORDS OF TRANSFER

10 CFR 70.42 (d)(2) requires a written certification by the transferee that the recipient is authorized by license or registration certificate to receive the type, form, and quantity of SNM to be transferred, specifying the license or registration certificate number, issuing agency, and expiration date. Since USEI would be exempted from the 10 CFR 70.3 requirement of an NRC licensee to possess SNM, the §70.42 requirement would not apply. However, Westinghouse will maintain as an alternative written registration certificate a copy of the permit issued to USEI by the State of Idaho and NRC approval of this additional alternate disposal request for specific HDP wastes. DOE/NRC Form 741, *Nuclear Material Transaction Report*, would be used by Westinghouse to document transfers of SNM to the disposal facility. USEI will report SNM receipts using its existing account with the Nuclear Materials Management & Safeguards System.

10 REQUESTED NRC ACTIONS

For the reasons noted above, Westinghouse requests that NRC take the following actions:

1. Approve 10 CFR 20.2002 alternate disposal of the specific HDP waste at USEI.
2. Issue 10 CFR 30.11 and 10 CFR 70.17 exemptions from the 10 CFR 30.3 and §70.3 license requirements for USEI to possess byproduct material and SNM for the specific waste disposal.

Enclosure 2 to HEM-12-88

HDP-TBD-WM-906
Characterization Data Summary in Support of Additional USEI Alternate Disposal Request
Revision 1

Westinghouse Electric Company LLC
US Ecology Idaho, Inc.

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Westinghouse

Hematite Decommissioning Project

Technical Basis Document

NUMBER: HDP-TBD-WM-906

TITLE: Characterization Data Summary In Support Of Additional USEI Alternate Disposal Request

REVISION: 1

EFFECTIVE DATE: See Final Approved Date Below

Approvals:

Author: Joseph S. Guido*

Owner / Manager: Gerald J. Rood*

*** Electronically approved records are authenticated in the electronic document management system. This record was final approved on Jul-23-2012. (This statement was added by the EDMS system to the quality record upon its validation.)***

REVISION LOG	
Revision No	**Change(s)**
0 01/17/2012	This is a new technical basis document.
1 See Cover Page	This technical basis document has been extensively revised, therefore sidebars are not used. This document has been revised to incorporate RAI's as transmitted in HEM-12-67

1. PURPOSE

This Technical Basis Document (TBD) defines the physical characteristics and radionuclide concentrations associated with concrete, asphalt, miscellaneous equipment, piping, and soil that are proposed for disposal at US Ecology of Idaho. (USEI)

2. APPLICABILITY

This document is applicable to a variety of materials that include:

- Concrete slabs and subsurface footings associated with:
  - 115, Fire/Diesel Pump House (including walls and roof)
  - 235, West Vault (including walls and roof)
  - 245, Pump House
  - 252, South Vault
  - 101, Tile Barn
  - 120, Wood Barn
  - Sewage Treatment Shed (including walls and roof)
  - 240, Process Building
  - 253, Process Building
  - 254, Process Building
  - 255, Process Building
  - 256, Process Building
  - 260, Process Building
  - Limestone Building
  - Cistern Burn Pit
  - Site Dam
  - Exterior concrete pads, roadways, and sidewalks
- Miscellaneous equipment such as process building HEPA units and associated ductwork
- Subsurface piping both under the process building and site wide
- Soil and soil-like waste

3. REFERENCES

3.1. HDP-TBD-WM-901, *Scaling Factors for Radioactive Waste Associated with the Above Slab Portion of the Process Buildings*

4. SUMMARY

The material proposed for disposal at USEI consists of approximately 2 million cubic feet of material such as concrete, asphalt, underground piping, miscellaneous equipment and soil.

The total volume and activity associated with each of these waste streams is summarized in Table 4-1, below. Note that the volume estimates (and associated total activity) in this table reflect a multiplier of 1.5 that is intended to account for uncertainty inherent in the excavation and removal of material. Volumes for each category are estimates and are not intended to represent a commitment. Disposal will be limited to 22,848 m^3 and 0.3 Ci of Tc-99.

Table 4-1, Summary of Material Volume and Total Radioactivity

Material	Shipped Volume (m^3)	U-234 (Ci)	U-235 (Ci)	U-238 (Ci)	Tc-99 (Ci)	wt % U-235
Concrete / Asphalt	8,249	1.4E+00	6.3E-02	2.9E-01	4.0E-02	3.3
Piping	348	1.1E-01	3.9E-03	1.2E-02	2.6E-03	5.0
Miscellaneous Equipment	39	3.0E-03	1.7E-04	5.4E-04	3.8E-05	4.5
Soil	14,212	6.2E-01	3.2E-02	1.4E-01	2.1E-01	3.4
Total Volume / Total Radioactivity	**22,848**	**2.2E+00**	**9.9E-02**	**4.4E-01**	**2.5E-01**	

Each of the following sections provides a summary and evaluation of the characterization data for these various types of materials and as applicable, plans for any additional characterization. Appendix P provides a summary of DQOs for the additional characterization measurements, and Appendix Q provides a process flow diagram for additional characterization efforts.

5. VOLUME ESTIMATES – CONCRETE AND ASPHALT

The volume and weight of materials as installed associated with the structures defined above were based on visual inspection and physical measurements of the buildings and paved surfaces. The weight estimates for these materials were made based on the following assumptions:

- Concrete walls have an installed density of 75 pounds per cubic foot.
- Poured concrete has an installed density of 150 pounds per cubic foot.
- Asphalt has an installed density of 120 pounds per cubic foot.

The basic formula for calculating weight is:

Weight = (Installed Volume)(Installed Density)

The weights and volumes of concrete and asphalt are detailed in Appendices A through C.

6. ACTIVITY ESTIMATES – BUILDING MATERIALS

The radiological characterization of the process building concrete slab and outlying concrete and asphalt areas was conducted in multiple phases during 2010 and 2011. During the initial phase of characterization, 21 sample cores were collected and each sectioned into the top ¼ inch, next ½ inch and remainder of the core. In building 240 this sample regime was applied to the overlying concrete cap and the original concrete surface below.

An additional 29 sample locations (locations 31 - 59) were included in a second phase of sampling with the intent of bounding areas of elevated activity identified in the first phase of sampling. Samples collected during the second phase were either analyzed as whole cores (locations 36 – 55); were sectioned into the top 3 inches and the remainder of the core (locations 31 – 35 located in the Red Room); or consisted of the top ¼ inch and the next ½ inch portion only (locations 56 – 59). The final four samples (locations 56 - 59) were

collected to provide additional bounding data and were not sampled below ¾ inch based on existing information indicating that contamination was limited to the top concrete layer only (i.e., there were no cracks and/or seems evident in the sampling locations). Laboratory analysis included isotopic uranium, Tc-99, Am-241, Np-237, Pu-239, Ra-226, and Th-232. Following building demolition, the building floor surfaces became available for a second gamma walkover survey with readings being logged using a global positioning system (GPS). This walkover survey was used as supplemental information for interpreting the sampling results in order to determine the total activity present in the material. A detailed depiction of the process building slab gamma walkover survey as well as the associated sampling data is contained in Appendix D.

6.1. Evaluation of Trace Radionuclides

The top ¼ inch from the initial 21 sampling locations, and the two ¼ inch samples taken beneath the over-poured concrete floor layer in Building 240 were analyzed for Am-241, Np-237 and Pu-239 by alpha spectroscopy (see appendix D, Table 2 for sample results). A summary of these sample results is provided in table 6-1, below.

Table 6-1, Concentration of Transuranic Nuclides in Process Building Slab Samples

Radionuclide	**Samples Analyzed**	**Sample Results Exceeding MDC (pCi/g)**	**MDC (pCi/g)**	**U-total (pCi/g)**
Am-241	23	0	0.14 – 0.27	NA
Np-237	23	Location 01: 0.08 Location 07: 0.29 Location 17: 0.13	0.03 0.28 0.12	193 4,522 1,461
Pu-239	23	Location 01: 0.11 Location 09: 0.03 Location 21: 0.14	0.10 0.03 0.08	193 13,851 200,048

As indicated in Table 6-1, above, the concentrations of transuranic radionuclides were less than the MDA at 18 of 23 sample locations, and only slightly above the MDA in the 5 remaining sample locations. Considering the relative concentration of uranium at these sample locations (also shown in Table 6-1, above), these radionuclides are considered to be only present at trace levels and are not carried forward into subsequent inventory calculations.

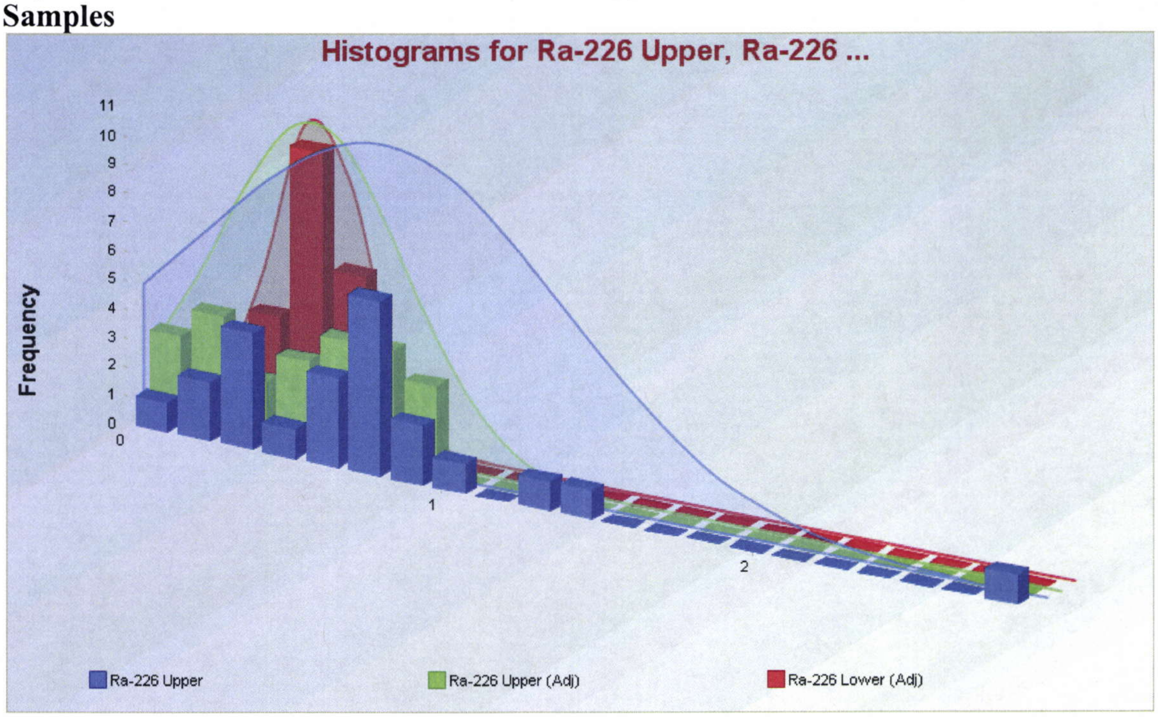
6.2. Evaluation of Ra-226 in Building Materials

The top ¼ inch, and the balance of the core (from ¾ inch to the bottom of the core sample) were anlayzed for Ra-226 by gamma counting of radium progeny after ingrowth. Sample results are detailed in Appendix D, Table 3.

In order to evaluate the presence of Ra-226 in excess of that naturally present in buiding materials, the concentration within the top ¼ inch was compared to that in the bottom portion. The basis for this methodology is the observation that the vast majority of the sample activity was identified in top-most ¼ inch of depth, and relatively little activity was found within the concrete at a depth below ¼ inch.

These data indicate that the Ra-226 concentration observed in the top ¼ inch samples tends to fluctuate along with the corresponding U-234 concentration. The highest three Ra-226 sample results (3.1, 1.6, and 1.5 pCi/g) were obtained from locations containing the three highest U-234 concentration values of 170,561; 37,544; and 36,426 pCi/g, respectively. Based on this observation, the Ra-226 concentration was adjusted by subtracting the product of the lowest observed Ra-226 to U-234 ratio (1.8 E-5) and the corresponding U-234 concentration from each Ra-226 result. The resulting concentration profile is shown in Figure 6-1, below. This figure demonstrates the similarity of the upper and lower core sample concentrations once this adjustment is performed. A detailed analysis of the two sample populations (upper and lower) is contained in Appendix E, the conclusion of which is that the upper sample population (adjusted) is less than or equal to the lower one. Since the Ra-226 contribution within the upper portion of the core samples is at least a factor of 1.8 E-5 times the corresponding U-234 concentration and is otherwise equal to the background concentration, Ra-226 is not considered further in this evaluation.

Figure 6-1, Ra-226 Concentration Profile - Upper, Adjusted Upper and Lower Core Samples



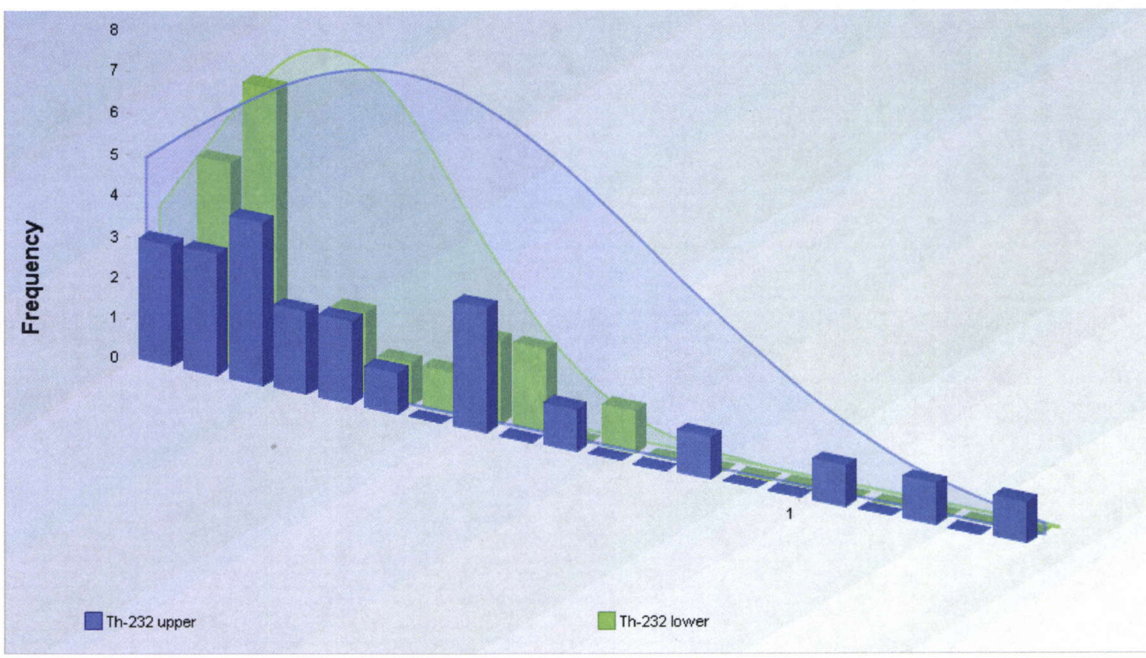
6.3. Evaluation of Th-232 in Building Materials

The top ¼ inch and balance of core (from ¼ inch to the bottom of the core sample) from the initial 21 sample locations were analyzed for Th-232 by alpha spectroscopy. Sample results are detailed in Appendix D, Table 3.

The relative Th-232 concentration in the upper ¼ inch building slab samples as compared to the concentrations in the remaining core material is shown in Figure 6-2. As indicated by this figure, the top ¼ inch sample portion appears contain elevated levels of Th-232 at some locations. Th-232 concentrations in the top ¼ inch sample portions range from non-detect to 1.4 pCi/g, as compared to an upper bound of 0.75 pCi/g for the lower sample portions. The ratio of Th-232 activity to U-234 in the top ¼ inch sample portions that were greater than the MDC ranged from 4.1 E-3 to 3.7 E-6 and averaged 5.2 E-4.

Considering the concentration of uranium at these sample locations, Th-232 is considered to be only present at trace levels, and therefore Th-232 is not carried forward into subsequent inventory calculations.

Figure 6-2, Th-232 Concentration Profile - Upper, Adjusted Upper and Lower Core Samples



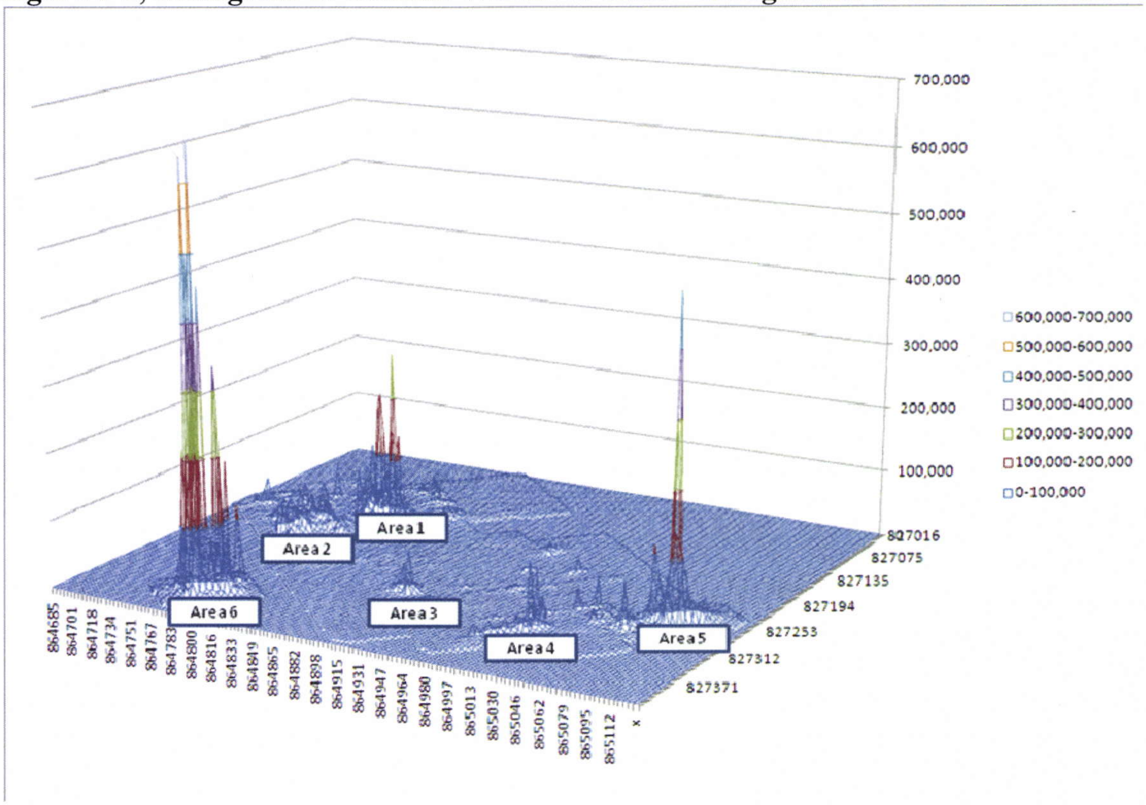
6.4. Evaluation of Tc-99 and Uranium Series Concentrations in Building Materials

As indicated earlier, a detailed gamma walkover survey was performed after the buildings were dismantled and most of the sampling effort was complete. (with exception to the samples at locations 56 – 59) A detailed map showing the gamma walkover data is contained in Appendix D, Figure 1. An earlier 100 percent walkover survey was conducted in conjunction with the first round of sampling (locations 1 – 21). However, since the process buildings were still standing, a GPS guided map of the gamma results could not be generated at that time.

The gamma walkover data were used to delineate the areas associated with elevated sample measurements and to separate areas of elevated activity from those that were relatively non-contaminated. Figure 6-3, below, provides a depiction of the relative

magnitude of the observed gamma results. As indicated on this figure and consistent with the data contained in Appendix D, six areas of elevated activity were identified within the slabs of the process buildings and Building 252.

Figure 6-3, Histogram of Gamma Walkover Data - Designation of Elevated Areas

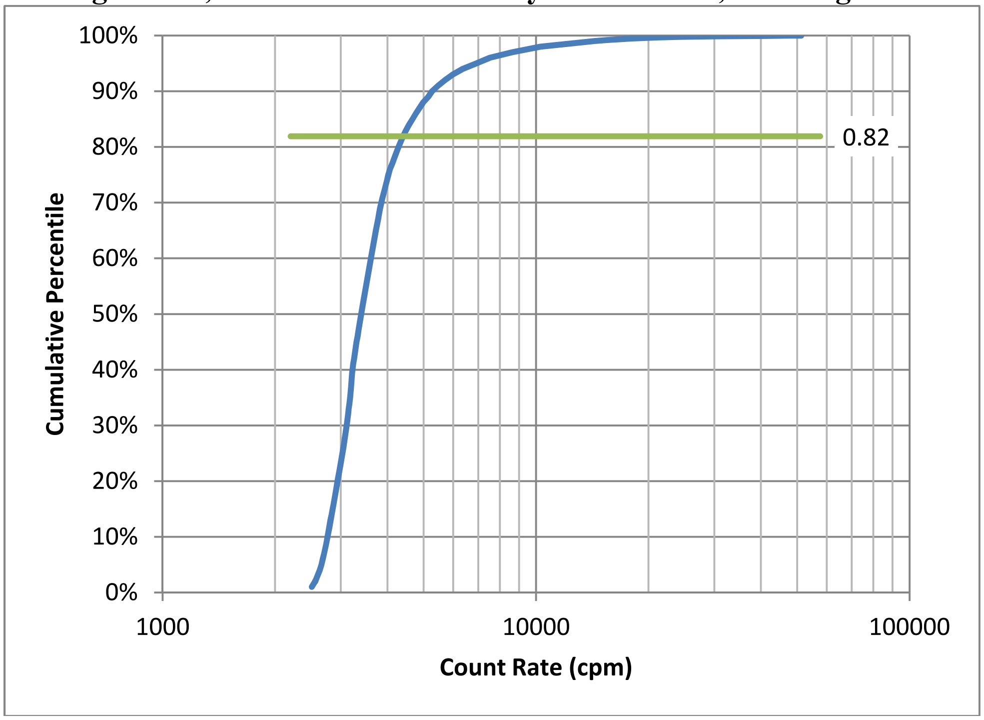


Radionuclide concentrations for each of these 6 areas were determined using data from sample locations from each respective area. Appendix D, Figure 1 combines the results of the gamma walkover surveys and the individual sample locations that delineate these six areas. The cooresponding sample data is contained in Appendix D, Tables 1 – 4.

Given the magnitude and variability in concentration within the northeast portion of Area 1 and the entire Area 5 shown in Appendix D, Figure 1, this material will be excluded from disposal at USEI (see section 6.5, below). Therefore, the sample data obtained from the northeast portion of Area 1 and Area 5 are also excluded from the following analysis for the weighted average concentration of activity in the slab.

In order to account for small areas of elevated activity that may not have been identified as one of the six identified areas, a cumulative probability distribution was constructed using the one square meter average readings from the remaining slab areas. As shown in Figure 6-4, below, 82 percent of the floor space outside the six identified areas exhibited a count rate less than 4,400 cpm. This value (4,400 cpm) was conservatively selected to separate the slab data into two groups since it was twice the minimum average value for each one square meter.

Figure 6-4, Cumulative Probability Distribution, Building Slab



For the total slab area, a weighted average of samples collected from elevated areas (18%) and those from the general areas (82%) was used to determine the average concentration. Tables 6-2 and 6-3 provide details on the calculation of these two activity components.

Table 6-2, Determination of Average Activity in Elevated Areas*

Sample #	Location (Building)	Concentration (pCi/g)			
		Tc-99	U-234	U-235	U-238
1	240 Resp. Wash	0.1	81	3.9	8.8
4	240 Red Room	4.0	2,837	146	1,010
5	240 Green Room	1.8	1,909	92	563
6	240 Maintenance Shop	2.7	1,053	58	308
7	240 Maintenance Shop	0.2	145	6.4	47
8	253	15	178	6.1	24
10	254	0.2	1,374	48	221
13	255	1.0	394	15	46
14	255 Erbia Lab	0.4	282	13	7.1
16	260 SW HVAC Rm	13	565	22	140
17	255	1.3	748	29	158
18	255/260	0.3	293	15	156
56	South Vault	1.6	2,103	90	165
57	South Vault	3.4	1,603	69	2.3
58	254	0.78	961	39	147
59	254	2.1	2,687	116	423
Average		**3.0**	**1,076**	**48**	**214**

***Sample locations excluded since in areas that will not be shipped to USEI: 2, 3, 20, 21 and 35.**

Table 6-3, Determination of Average Activity for Remaining Slab Area that is Not Included in the Six Identified Areas

Sample #	Location (Building)	Concentration, pCi/g			
		Tc-99	U-234	U-235	U-238
9	254	0.6	585	20	78
11	254	-0.3	120	4.7	23
12	254	0.3	127	4.7	19
15	255	1.6	38	1.7	7
19	260	0.7	189	7.4	46
31	240 Red Room	1.7	1.1	0.1	0.2
32	240 Red Room	1.9	0.4	0.0	0.2
33	240 Red Room	1.8	1.2	0.1	0.3
34	240 Red Room	2.2	9.7	0.5	0.8
36	253 Ring Storage	2.0	0.4	0.0	0.2
38	260 UF6 Vaporizer	3.7	13	0.7	2.8
39	260 UF6 Vaporizer	2.7	11	0.6	2.8
40	260 UF6 Vaporizer	10.9	44	2.4	12
41	260 UF6 Vaporizer	7.6	39	2.2	9.3
42	260 UF6 Vaporizer	5.0	12	0.6	3.2
43	240 Laundry	1.7	1.1	0.1	0.5
44	240 Green Room	1.7	5.4	0.3	1.7
45	240 Maintenance Shop	2.5	2.7	0.1	1.9
46	240 Maintenance Shop	1.7	15	0.8	6.2
47	253 Ring Storage	1.7	1.4	0.1	0.4
48	253 Waste Prep	2.5	3.0	0.2	0.7
49	254 Ceramic	1.7	0.2	0.0	0.1
50	256 Pellet	1.8	0.3	0.0	0.2
51	256 Warehouse	1.7	0.2	0.0	0.2
52	South Vault	8.4	51	2.8	10
53	South Vault	3.0	40	2.2	4.4
54	West Vault	1.8	9.2	0.5	0.8
55	West Vault	2.0	34	1.7	1.0
Average		**2.7**	**48**	**1.9**	**8.3**

In order to determine the concentration within Area 3, it was necessary to determine the average contribution from below the top ¾-inch section of concrete since the two samples collected in this area were collected only in the 0 – ¾-inch range. As shown in Table 6-4, below, sample results from the lower (below ¾ inch) portion from areas not associated with cracks, seams and wall joints were used to determine the contribution below ¾ inch in Area 3.

Table 6-4, Determination of Average Activity below ¾ inch in Elevated Area 3*

Station ID	Sample Mass (g)	Tc-99 (pCi/g)			U-234 (pCi/g)			U-235 (pCi/g)			U-238 (pCi/g)		
		Conc.	±2σ	MDC	Conc.	±2σ	MDC	Conc.	±2σ	MDC	Conc.	±2σ	MDC
2	1,366	0.46	0.86	2.1	4.7	-	-	0.2	0.2	0.1	0.3	3.0	1.8
3	1,301	2.8	1.1	2.2	4.6	-	-	0.2	0.2	0.1	3.8	3.4	1.7
5	1,620	0.45	0.85	1.9	12.0	-	-	0.6	0.3	0.2	4.5	4.0	2.1
7	1,250	0.041	0.79	2.1	4.7	-	-	0.3	0.1	0.1	0.9	2.8	1.6
8	1,090	1.8	0.93	2.2	10.0	-	-	0.3	0.2	0.1	-0.4	9.6	2.1
9	1,340	0.57	0.79	2.1	2.4	-	-	0.1	0.1	0.1	1.4	2.5	1.3
10	1,780	0.073	0.83	1.9	29.0	-	-	1.6	0.4	0.1	13.2	4.0	0.6
11	1,110	-0.40	0.78	2.0	39.0	-	-	2.1	0.4	0.1	13.8	4.1	0.9
12	2,050	0.31	0.33	1.2	0.5	-	-	0.0	0.1	0.1	0.3	2.7	1.6
15	1,190	1.6	0.39	1.2	15.0	-	-	0.8	0.2	0.1	2.9	3.0	1.5
19	3,040	0.32	0.36	0.90	8.9	-	-	0.5	0.2	0.1	4.8	3.9	1.8
	Maximum	**2.8**			**39**			**2.1**			**14**		
	Average	**0.64**			**11**			**0.59**			**4.2**		

* Sample Locations excluded since portion will not be shipped to USEI: 1, 4, 6, 13, 14, 16, 17, 18, 20, 21

Review of concentration data in Areas 1and 5 indicated concentrations of Tc-99 (Area 1) and Uranium (Area 5) such that a large fraction of the total radionuclide inventory would come from a small area. In each of these areas, it was determined that the 3,000 pCi/g limit on railcar radionuclide activity could be obtained from an area of such small size (less than 500 ft^3) as to require operational restrictions to ensure that such a contiguous area be prevented from being placed in a single railcar. Accordingly, the northeast portion of Area 1, which consists of the 3 inch over-poured floor surface, and Area 5 will be excluded from disposal at USEI. Based on this determination, the concentration in these areas presented in this document excludes samples from these areas.

The radionuclide activity for areas outside the process building and vaults was conservatively estimated using the data presented in Table 6-4, above. Use of this data is valid based on existing gamma survey data indicating an absence of areas of elevated contamination in these materials such as those present in the process building and vaults.

Table 6-5, below provides a summary of the activity assigned to the materials discussed.

Table 6-5, Summary of Radionuclide Concentration in Building Slabs

Location	Waste Volume (m^3)	Tc-99		U-234		U-235		U-238	
		pCi/g	Ci	pCi/g	Ci	pCi/g	Ci	pCi/g	Ci
Elevated Area 1 - Bldg 240, Red Room	64	2	0.000	574	0.064	30	0.003	204	0.02
Elevated Area 2 - Bldg 240, Green Room	56	6.1	0.001	459	0.045	23	0.002	126	0.01
Elevated Area 3 - Bldg 254	8.8	2.6	0.000	262	0.004	12	0.000	48	0.00
Elevated Area 4 -Bldg 266 / 260	21	4.9	0.000	295	0.011	12	0.000	51	0.00
Elevated Area 6 - Bldg 232 (South Vault)	40	4.2	0.000	156	0.011	7.1	0.000	15	0.00
Bldg 235 (West Vault)	12	1.9	0.000	22	0.000	1.9	0.000	2.7	0.00

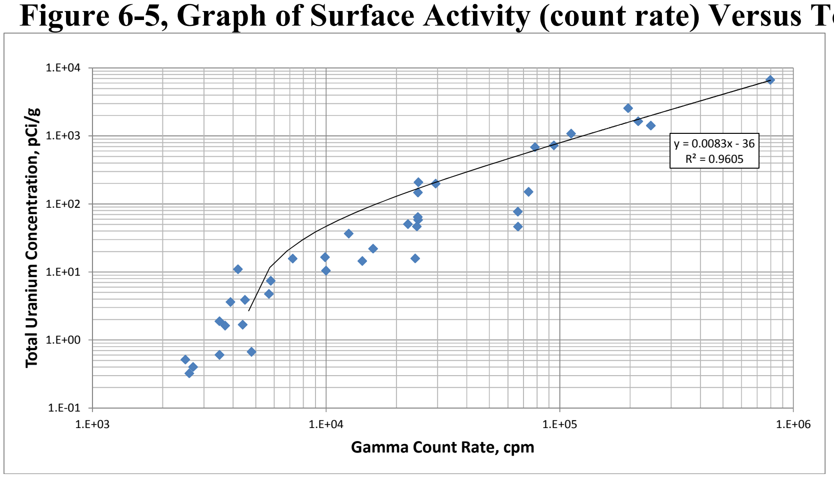
Location	Waste Volume (m^3)	Tc-99		U-234		U-235		U-238	
		pCi/g	Ci	pCi/g	Ci	pCi/g	Ci	pCi/g	Ci
Total - Elevated Areas	**200**	**3.9**	**0.0014**	**385**	**0.14**	**19**	**0.007**	**110**	**0.039**
Balance of Process Buildings Excluding: Areas (1-4), area 1 cap, area 5 and Vaults	1,152	2.7	0.0055	233	0.47	10	0.021	45	0.09
Building Total	**1,353**	**2.9**	**0.0069**	**256**	**0.610**	**11.5**	**0.028**	**55**	**0.13**
Concrete outside process buildings	3,035	2.7	0.014	48	0.26	1.94	0.010	8.3	0.04
Asphalt	1,112	2.7	0.005	48	0.095	1.94	0.004	8.3	0.016
Total for Site	**5,499**	**2.7**	**0.026**	**99**	**0.96**	**4.3**	**0.042**	**19.8**	**0.19**

6.5. Evaluation of Characterization Data

Data from 50 sample locations has been obtained during sampling efforts. Of these 50 samples, 33 were targeted in and around areas of elevated activity. The remaining 17 locations were dispersed throughout the remainder of the building. A GPS logged gamma walkover survey was conducted. This survey demonstrates that areas with elevated activity were sampled. This fact is clearly evident upon inspection of Figure 6-3 and Appendix D, Figure 1.

The suitability of the GPS walkover data to identifying elevated uranium activity can be seen in Figure 6-5, below, in which the gamma count rate and total uranium activity at each sample location is plotted.

Figure 6-5, Graph of Surface Activity (count rate) Versus Total Uranium Activity



The axis for the plot in Figure 6-5 was selected to indicate 0.4 pCi/g total uranium at a gamma count rate of 4400 cpm. These values were selected to represent ambient conditions based on the baseline gamma response within the building and on the total

uranium activity at locations 49, 50, and 51, which are away from any area of elevated activity. Sample locations with known subsurface activity were excluded, since these are accounted for in the samples within each elevated area.

Areas in which Tc-99 was present (based on historical information) were included in the targeted sampling within Buildings 240 and 260. Specifically, Tc-99 was present in materials handled in Areas 1, 2, and 6. The concentration of Tc-99 inside and outside these areas is presented below in Table 6-6. As indicated by this tabulation, the concentration of Tc-99 within the concrete material outside of the areas with a history of Tc-99 use is negligible in comparison to that within areas with such a history. Areas with a history of Tc-99 were targeted for sampling. Outside of these areas, the variation in the Tc-99 is low by comparison such that the remaining samples provide effective characterization without the need for use of a surrogate to identify Tc-99.

Table 6-6, Comparison of Tc-99 and Total Uranium Concentrations Inside and Outside Areas with History of Tc-99

Location	No. of Samples	Tc-99 (pCi/g)			U total (pCi/g)		
		Min	Max	Avg	Min	Max	Avg
Inside areas with history of Tc-99 (Bldg 240 and 260)	18	0.2	2,041	198	0.7	6,659	1,125
Outside areas with history of Tc-99.	32	-0.3	12.6	2.4	0.3	3,226	455

Exclusion of portions of the concrete in Building 240 and 260 drastically reduces the variability of Tc-99 concentration within the remaining material. These two areas combined contain 88 percent of the Tc-99 inventory within the process building yet comprise only 3 percent of the material volume. The mean Tc-99 concentration at all sample locations is 73 ± 326 (at 1 sigma). Table 6-7, below, shows a summary of sample results divided into those that fall within the areas to be excluded and those that do not. Removing the two areas mentioned above reduces the mean Tc-99 concentration to 2.5 ± 3.2 (at 1 sigma).

Table 6-7, Comparison of Tc-99 and Total Uranium Concentrations Inside and Outside Areas That Will Be Excluded from Disposal at USEI

Location	No. of Samples	Tc-99, pCi/g			U total, pCi/g		
		Min	Max	Avg	Min	Max	Avg
Inside Areas that will be excluded from disposal	8	3.4	3,663	828	12	6,659	1,788
Outside Areas that will be excluded from disposal	46	-0.3	15.4	2.5	0.3	3,993	500

Based on nature and extent of characterization data available for this material, it is concluded that the data are of sufficient quality to be used as both an estimate of the total activity present in these materials, and to serve as the basis for determining the radionuclide concentration in materials shipped. Therefore, no additional characterization is planned.

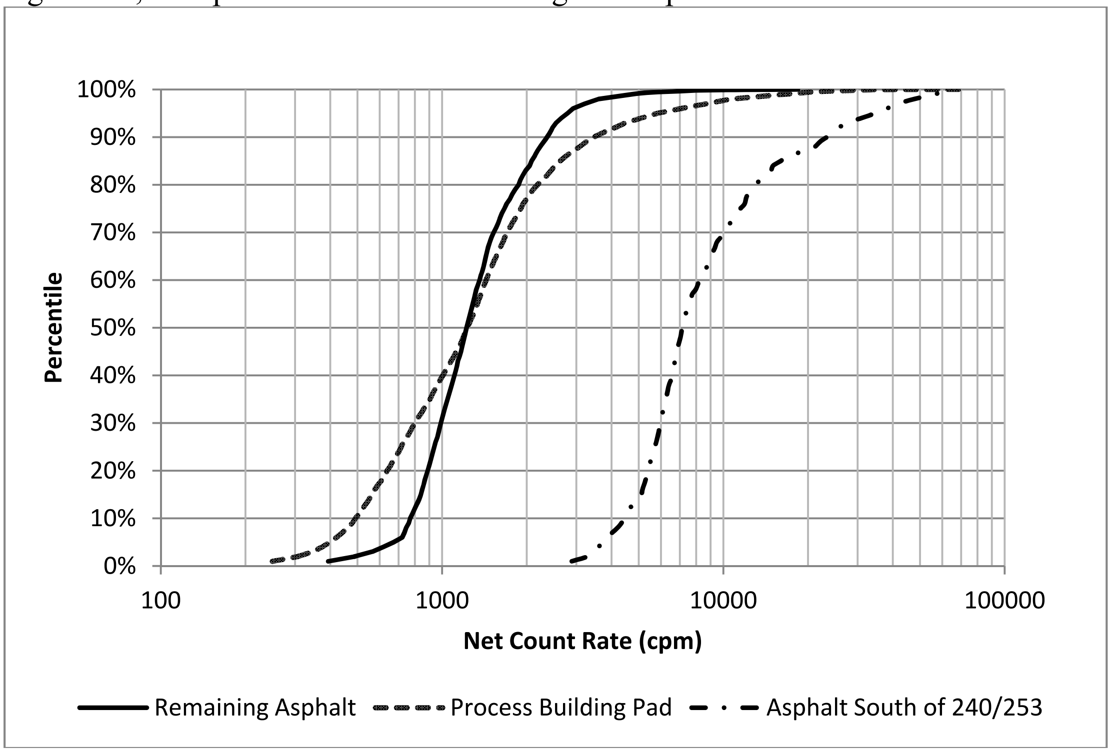
6.6. Additional Characterization Data

Although the existing data are adequate to support this alternate disposal request, additional sampling on a systematic grid will be performed and used as a basis for determination of the activity in material prior to it being shipped. Data quality objectives specific to this sampling are provided in Appendix P. A process flow diagram outlining the characterization effort is shown in Appendix Q.

Appendix K contains the report generated by Visual Sampling Plan (VSP) software for determination of a confidence interval on a mean that is specific to HDP. The half-width of the confidence interval was set to ½ of the mean Tc-99 concentration outside the 5 identified elevated areas. The standard deviation of this same data set was also used. Additional design parameters are indicated on the attached sampling plan which indicates the nominal number of systematic samples to be 20 for each sampling area. Each building (240, 253, 254, 255, 256, 260) with the exception of 252 and 235 (which were combined) was considered a separate sampling area resulting in a total of about 140 samples for the entire process building slabs. The systematic samples will be taken from two depth intervals (0 – 0.75 inch and 0.75 inch to 1.5 inches. The 0.75 inch to 1.5 inch sample will be used in assessing the contamination within the remaining thickness of the concrete slab since the existing data set establishes that the radioactivity of concern is in the top 0.75 inch of the slab. The merging of the data sets will be 2 separate groups – results from the top 0.75 inches and results from the 0.75 inches to bottom of the slab.

Gamma walkover survey data indicates that, with the exception of the asphalt immediately south of Building 240/253, levels at the remaining concrete and asphalt areas are generally bounded by those associated with the process building general area. This is illustrated within Figure 6.6 where it can be seen that greater than 83% of the 1 meter average readings from the asphalt were less than 2,000 cpm while the percentage within the same grouping for the process building pad is only 78%. While the area immediately south of Buildings 240 and 253 appear to be more elevated, the maximum reading in this area is 60,000 cpm as compared to 69,000 cpm on the process building pad. A 100% scan of concrete pad outside Building 231 indicated that fixed alpha and beta/gamma levels did not exceed background levels.

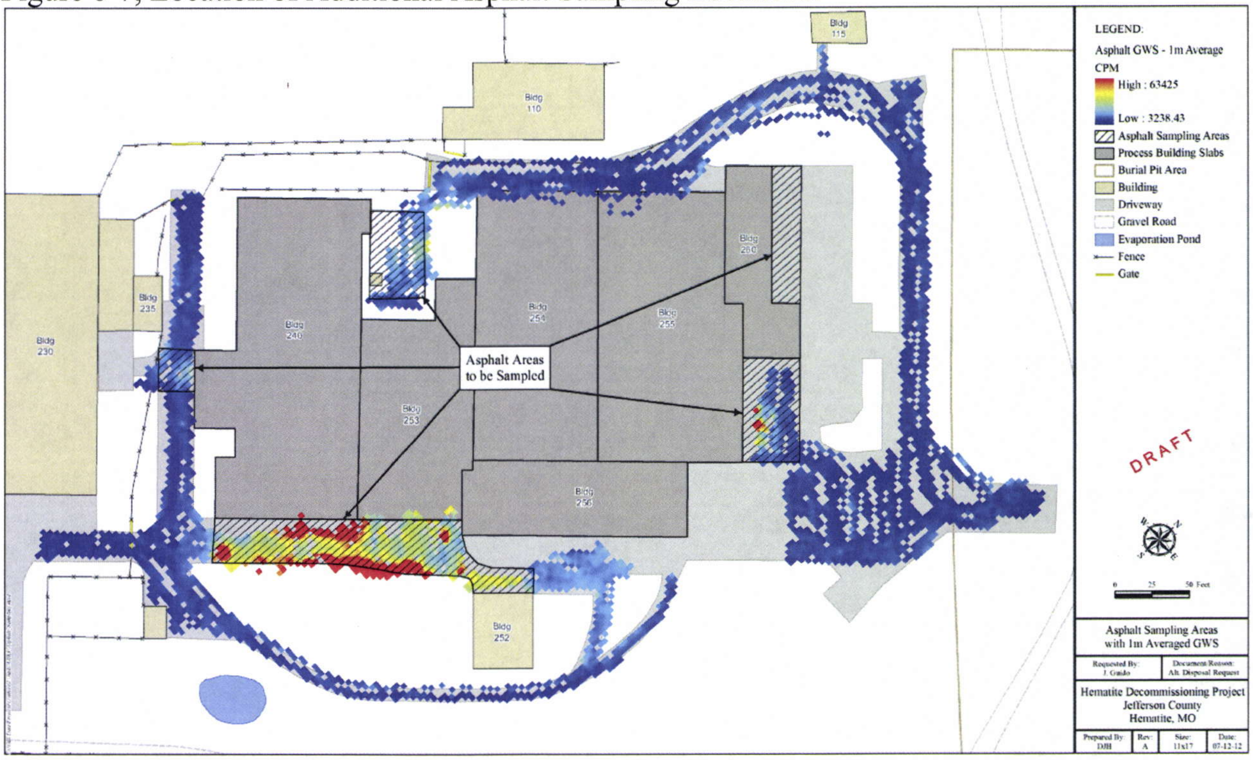
Figure 6-6, Comparison of Process Building and Asphalt Gamma Walkover datasets



Based on this evaluation, with the exception of the area immediately south of Building 240/253, the sample dataset for process building general areas (Table 6-3) can be used to represent activity present in the asphalt and concrete materials.

For the areas south of Buildings 240/253, biased sampling will be performed based on the gamma walkover data discussed above, and based on the potential presence of Tc-99 in this area. An area to the east of building 260 will also be further characterized, based on the potential for Tc-99 contamination and coincident with elevated gamma walkover results. The areas that will be subject to additional sampling are indicated on Figure 6-7, below. Twenty samples will be collected in these areas based on the sample density defined for the process building. Actual sample locations will biased based on fixed beta survey results, additional randomly selected sample locations will be added, as needed, to achieve the required number of samples. Data quality objectives specific to this sampling are provided in Appendix P. A process flow diagram outlining the characterization effort is shown in Appendix Q.

Figure 6-7, Location of Additional Asphalt Sampling Locations.



7. VOLUME / WEIGHT /ACTIVITY ESTIMATES – UNDERGROUND PIPING

The volumes and weights of underground piping were calculated based on the physical characteristics of the piping (e.g., inside and outside diameter, length, density of piping walls and amount of contained material) obtained from engineering drawings and through remote visual inspection.

The information regarding the amount of contained material (scale/sediment), and piping wall density are provided in Tables 7-1 and 7-2, below. Data on individual piping segments is presented in Appendix F. Radionuclide concentrations and inventory estimates are presented below in Table 7-3 and are based on the remote video inspection, radiological survey and sampling data collected during the 2010 in-pipe inspection program which is summarized in Appendix G.

Table 7-1, Piping Debris Content Expressed as Percent of Total Available Volume

Bldg / Area	Assumed Fill[1]
110	10%
230	40%
240	40%
255	40%
254	40%
253	40%
O/S	10%

1. Estimate for amount of fill based in video inspection.

Table 7-2, Material Density Used in Weight Calculations

Material	Density (g/cm3)
Cast Iron	7.2
Debris	1.5
HDPE	1.5
PVC	1.36
RCP	2.5
RFCP	2.5
Vitrified Clay	1.5

Table 7-3, Summary of Underground Piping Radionuclide Concentration[1] and Inventory

Location	Wall Mass (g)	Debris Mass (g)	Total Mass (g)	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
Building 240 Northernmost System	3.3E+06	7.1E+05	4.0E+06	6.3E+03	4.7E+04	1.6E+03	3.3E+03
Building 240 Middle System	3.9E+06	7.8E+05	4.7E+06	6.3E+03	4.7E+04	1.6E+03	3.3E+03
Building 240 Southernmost System	2.2E+06	3.2E+05	2.6E+06	6.3E+03	4.7E+04	1.6E+03	3.3E+03
Building 260	2.7E+05	4.3E+04	3.1E+05	1.4E+02	5.5E+04	2.3E+03	8.2E+03
Building 255 Northernmost Process System	2.9E+06	4.6E+05	3.4E+06	1.7E+02	6.9E+03	2.6E+02	7.7E+02
Building 255 Southernmost Process System	3.7E+06	3.2E+05	4.0E+06	1.7E+02	6.9E+03	2.6E+02	7.7E+02
Building 255 Sanitary Lines	1.2E+05	1.9E+05	3.1E+05	1.7E+02	6.9E+03	2.6E+02	7.7E+02
Building 255 Sanitary and Grey Water lines	2.3E+05	6.0E+05	8.3E+05	1.7E+02	6.9E+03	2.6E+02	7.7E+02
Building 254	1.9E+07	2.3E+06	2.1E+07	1.7E+02	6.9E+03	2.6E+02	7.7E+02
Building 253	2.3E+05	2.3E+05	4.6E+05	1.7E+02	6.9E+03	2.6E+02	7.7E+02
Building 253 Sanitary and Grey Water lines	1.9E+04	3.1E+04	5.0E+04	1.7E+02	6.9E+03	2.6E+02	7.7E+02
Building 253 Storm Water Lines	4.5E+05	7.9E+05	1.2E+06	1.7E+02	6.9E+03	2.6E+02	7.7E+02
Outside	1.9E+07	5.2E+06	2.4E+07	1.7E+02	6.9E+03	2.6E+02	7.7E+02

Note: 1 Radionuclide concentration applies to activity in debris within piping (i.e., does not include mass of piping walls)

7.1. Evaluation of Characterization Data

Activity estimates for this material are based on radiological surveys and analysis of swipe and scale/sediment samples collected during an extensive in-pipe survey and remote video inspection effort that was conducted in 2010 to assist in quantifying the residual mass of ^{235}U in underground piping. Samples collected during these surveys were generally targeted at areas with either elevated gamma radiation measurements (as determined by a G-M detector attached to a remote camera) or from areas with debris buildup. Accordingly, uranium sample results are likely to be biased in the upward direction due to the tendency to sample areas with higher photon activity. While these measurements would not be indicative of Tc-99 activity, the bias toward sample areas with debris buildup would tend to bias both uranium and Tc-99 inventory estimates in the upward direction as well.

In order investigate potential actions to reduce the uncertainty associated with the radionuclide content in the site piping, an analysis was performed comparing the radionuclide inventory associated with Buildings 240 and 260 versus the balance of the site. Tables 7-4 and 7-5 contains the summary data associate with these two datasets.

Table 7-4, Radionuclide Inventory for Underground Piping Buildings 240 and 260

Location	Piping Volume (m^3)	Tc-99 (Ci)	U-234 (Ci)	U-235 (Ci)	U-238 (Ci)
Building 240 Northernmost System	1.7E+01	4.5E-03	3.3E-02	1.1E-03	2.3E-03
Building 240 Middle System	2.0E+01	5.0E-03	3.6E-02	1.2E-03	2.6E-03
Building 240 Southernmost System	1.1E+01	2.0E-03	1.5E-02	5.0E-04	1.0E-03
Building 260	1.3E+00	5.9E-06	2.4E-03	9.7E-05	3.5E-04
Total	**4.8E+01**	**1.1E-02**	**8.7E-02**	**2.9E-03**	**6.3E-03**

Table 7-5, Radionuclide Inventory for Underground Piping, Excluding Buildings 240 and 260

Location	Piping Volume (m^3)	Tc-99 (Ci)	U-234 (Ci)	U-235 (Ci)	U-238 (Ci)
Building 255 Northernmost Process System	1.4E+01	8.0E-05	3.2E-03	1.2E-04	3.5E-04
Building 255 Southernmost Process System	1.7E+01	5.5E-05	2.2E-03	8.2E-05	2.4E-04
Building 255 Sanitary Lines	1.3E+00	3.3E-05	1.3E-03	4.9E-05	1.5E-04
Building 255 Sanitary and Grey Water lines	3.4E+00	1.0E-04	4.2E-03	1.6E-04	4.6E-04
Building 254	8.8E+01	4.0E-04	1.6E-02	5.9E-04	1.7E-03
Building 253	1.9E+00	4.0E-05	1.6E-03	6.0E-05	1.8E-04
Building 253 Sanitary and	2.1E-01	5.4E-06	2.2E-04	8.0E-06	2.4E-05

Grey Water lines					
Building 253 Storm Water Lines	5.2E+00	1.4E-04	5.5E-03	2.0E-04	6.1E-04
Outside	1.0E+02	9.1E-04	3.6E-02	1.3E-03	4.0E-03
Total	**2.3E+02**	**1.8E-03**	**7.0E-02**	**2.6E-03**	**7.8E-03**

As indicated by these two tables, 87 percent of the Tc-99 within the piping is contained within Buildings 240 and 260, while these two locations contain only 17 percent of the total volume of piping. When all of the sample data is considered, the resultant mean Tc-99 concentration is 403 pCi/g, with a standard deviation of 1,261 pCi/g. Excluding the piping in Buildings 240 and 260 from consideration results in a mean concentration of 16 pCi/g, with a standard deviation of 39 pCi/g. Based on this analysis, the piping from these two areas will excluded from disposal at USEI. The location of this piping to be excluded is shown on Figure 1 of Appendix G. This will result in a significant reduction in the average concentration and its associated uncertainty.

7.2. Additional Characterization of Piping

Because of the limited data available for the building piping and difficulty in performing additional direct measurements until the time of removal, additional characterization of this material will be performed prior to shipment.

Considering that contamination within the piping is likely to be heterogeneous (e.g., accumulation of debris in low points and low-flow areas), two sampling approaches were considered. The first approach was based on a confidence interval (similar to concrete and soil), and the second approach included a verification that the extent of the contamination within the piping is well understood. The latter approach was based on comparison of the mean concentration to a fixed threshold. In this case, the maximum sample activity observed during characterization was selected for comparison with the mean.

The first sampling approach for the site piping was developed considering that a batch of piping would consist of approximately 100 m^3 of material. This volume is approximately equivalent to that of a rail car. The material in a single rail car was considered an appropriate batch of material since that is the unit of volume upon which waste management decisions are based. Accordingly, the number of samples required to ensure that the median concentration within that batch is less than the maximum observed value was determined using Visual Sampling Plan (True Average vs. Fixed Threshold, where the data are neither considered normal nor symmetrical). This analysis was performed for each of the four nuclides Tc-99, U-234, U-235, and U-238. It was determined that Tc-99 would be the most limiting (i.e. highest maximum value to standard deviation ratio). The resultant number of samples required was 14, or one sample per 7.1 m^3. This is equivalent to 1 sample per 250 ft^3. Based on this analysis, HDP will collect a minimum of one sample per 250 ft^3 of piping (either crushed or intact). and will analyze each sample by gamma spectroscopy and for Tc-99. Details of this calculation are contained in Appendix O.

The second sampling approach determined the number of samples to define the confidence interval on the mean activity where the half-width of the confidence interval was set to ½ the mean concentration. The required sample frequency based on the characteristics of the piping evaluated in the current application (mean of 33 pCi/g and standard deviation of 52 pCi/g) is 29 samples over 348 m^3 of piping (based on a 16.5 pCi/g confidence interval half-width and standard deviation of 52 pCi/g). This corresponds to one sample per 12 m^3 of piping. The more conservative sample density (1 sample per 7.1 m^3) will be applied to the sampling of piping.

Additionally, biased sampling will be performed based on materials with are determined be screening measurements to exceed the nuclear criticality safety threshold values (i.e., > 0.1 g/L). Details of this calculation and the method for sampling are contained in Appendix N.

8. VOLUME / WEIGHT / ACTIVITY ESTIMATES – MISCELLANEOUS EQUIPMENT

During the process building demolition, HEPA units and associated ducting were categorized as: 1) materials with sufficiently low specific activity to be disposed at Bulk Survey for Release (BSFR); 2) materials that exceed the BSFR criteria but which are suitable for disposal at USEI, and 3) materials that are unacceptable for disposal at USEI. Table 8-1 provides a summary of the characterization data for each component.

The U-234, U-238 and Tc-99 activity (Table 8-2) as well as other trace radionuclides (Table 8-3) were determined using scaling factors contained in HDP-TBD-WM-901, *Scaling Factors for Radioactive Waste Associated with the Above Slab Portion of the Process Buildings* (Reference 3.1), and enrichment of 4.5 percent. Use of the scaling data is justified since the scaling factors were derived from equipment equivalent to that under consideration. The HEPA units were installed and used during the period of commercial work at Hematite (post 1974) and as such were not exposed to uranium with an enrichment of greater than 4.5 percent.

Table 8-1, Summary of HEPA Unit and Associated Ducting Characterization Data – Total U-235 and Material Dimensions

Item	Item U-235 (grams)	Weight (lb)	volume (ft^3)
HEPA 1 240-12	8.03	2,580	6.45E+01
HEPA 2 240-12	7.08	2,580	6.45E+01
HEPA 3 253-26	7.08	2,580	6.45E+01
HEPA 7 254-35	13.88	2,580	6.45E+01
HEPA 18 255-51	9.25	2,580	6.45E+01
HEPA exhaust duct 240-12; y-duct at blower 240-12	1.68	450	1.13E+01
240-4 stack duct	1.68	134	3.35E+00
stack flange-240	1.33	450	1.13E+01
Total	**50**	**13,934**	**348**

Table 8-2, Uranium and Tc-99 Activity in HEPA Units and Associated Ducting

Item	U-234 (pCi)	U-235 (pCi)	U-238 (pCi)	Tc-99 (pCi)
HEPA 1 240-12	3.2E+08	1.8E+07	5.8E+07	8.05E+06
HEPA 2 240-12	2.8E+08	1.6E+07	5.1E+07	7.10E+06
HEPA 3 253-26	2.8E+08	1.6E+07	5.1E+07	1.59E+06
HEPA 7 254-35	5.5E+08	3.1E+07	1.0E+08	2.45E+06
HEPA 18 255-51	3.7E+08	2.0E+07	6.7E+07	1.63E+06
hepa exhaust duct 240-12; y-duct at blower 240-12	6.7E+07	3.7E+06	1.2E+07	1.69E+06
240-4 stack duct	6.7E+07	3.7E+06	1.2E+07	1.68E+06
stack flange-240	5.3E+07	2.9E+06	9.6E+06	1.33E+06
Total Activity (Ci)	**2.0E-03**	**1.1E-04**	**3.6E-04**	**2.6E-05**

As indicated in Table 8-3, below, the contribution from these trace radionuclides is of such a low concentration relative to the associated uranium also present (2.6 E-5 to 6.7 E-4) as to be considered to be present only at trace levels and are not carried forward into subsequent inventory calculations.

Table 8-3, Trace Element Activity in HEPA Units and Associated Ducting

Item	U-total (pCi)	Th-230 (pCi)	Th-232 (pCi)	Np-237 (pCi)
HEPA 1 240-12	4.0E+08	8.94E+04	1.04E+04	1.38E+04
HEPA 2 240-12	3.5E+08	7.88E+04	9.17E+03	1.21E+04
HEPA 3 253-26	3.5E+08	7.88E+04	9.17E+03	1.21E+04
HEPA 7 254-35	6.8E+08	1.55E+05	1.80E+04	2.38E+04
HEPA 18 255-51	4.6E+08	1.03E+05	1.20E+04	1.59E+04
HEPA exhaust duct 240-12; y-duct at blower 240-12	8.3E+07	1.87E+04	2.18E+03	2.89E+03
240-4 stack duct	8.3E+07	1.87E+04	2.18E+03	2.88E+03
stack flange-240	6.5E+07	1.48E+04	1.72E+03	2.27E+03
Total Activity (Ci)	**2.5E-03**	**5.6E-07**	**6.5E-08**	**8.6E-08**

8.1. Evaluation of Characterization Data

Activity estimates for the HEPA units that is described above are based on measurements of gamma radiation levels performed during the characterization of remaining equipment in 2008. The gamma radiation levels were subsequently interpreted using the MNCP code to determine the amount and enrichment of U-235, and the amount of total uranium in each component. The total uranium activity within the items ranged from 400 to 800 pCi/g, with the exception of one low mass item (130 lb) that showed total uranium activity at 1,800 pCi/g. It is likely that all of these materials will be shipped in a single

package, and as such the average concentration of the package would be approximately 520 pCi/g, or 17 percent of the 3,000 pCi/g limit.

The overall amount of Tc-99 activity was determined based on waste scaling factors derived from the laboratory analytical data obtained during the initial characterization surveys and sampling performed in 2008, and subsequently published in HDP-TBD-WM-901, *Scaling Factors for Radioactive Waste Associated with the Above Slab Portion of the Process Buildings* (Reference 3.1). The waste scaling factors for Tc-99 to U-235 described in this document are appropriate since they were based on samples obtained from the surfaces that were exposed to the same radionuclide mixture. The Tc-99 concentrations within the individual items ranged from 1.4 to 28 pCi/g; and averaged 4 pCi/g (standard deviation was 8.6pCi/g). Consistent with process history that indicated that this equipment was not directly involved in processes that would have involved Tc-99, the concentration of Tc-99 contributed only a small fraction of the total activity in the source term. The Tc-99 scaling factor used in the above calculations will be verified through analysis of swipe samples from these items prior to shipment. The associated Tc-99 inventory will be adjusted as necessary based on this data.

9. VOLUME / WEIGHT / ACTIVITY ESTIMATES - SUB-SLAB SOIL

Conceptual excavation contours for soils (including limestone backfill) beneath the former process buildings are shown on Figure H-1. These contours are based on soil sample results exceeding the DCGLs or exceeding the chemical Remediation Goals (RGs), and includes a projected average excavation depth of 2 feet within the footprint of the former Process Buildings.

The soils beneath the process building slabs were initially characterized during the site remedial investigation. Additional samples were collected during the 2010 and 2011 concrete slab characterization efforts. Finally, a series of core samples available from the earlier remedial investigation report were analyzed. Analysis of these samples provided data for soils down to the 16.5 ft below the surface. Sample locations are shown on Figure H-2. Note that different symbols are used to discern samples collected immediately under the building slab (e.g., initial 6 inches), versus samples collected subsurface, and the samples collected from archived cores (e.g., 4 foot composite samples down to 16.5 ft)

This combined data was used to develop an estimate of the radionuclide concentration within the sub-slab soil that is likely to be excavated. Analytical results for samples obtained from the areas within the excavation contours shown in Figure H-1 are presented in Tables H-1 through H-12 Data presented in Appendix H is summarized below in Table 9-1.

Table 9-1, Concentration Summary for Soil Beneath the Process Buiding Slab

Area	Volume Shipped	Tc-99	U-234	U-235	U-238
	m^3	Ci	Ci	Ci	Ci
Excluding Beneath Building 253					
0 - 0.5 ft	1,408	0.0055	0.21	0.011	0.065
0.5 - 5 ft	4,573	0.022	0.13	0.0064	0.018
5 ft - 20 ft	1,684	0.00045	0.0073	0.0004	0.004
Under Building 253					
0 - 0.5 ft	159	0.033	0.0070	0.00037	0.0010
0.5 - 5 ft	997	0.067	0.054	0.0030	0.0079
5 ft - 20 ft	653	0.012	0.0040	0.0002	0.0015
Total					
total - (0 - 20 ft)	9,474	0.14	0.41	0.022	0.10

9.1. Evaluation of Characterization Data

A total of 94 soil samples were collected from the area beneath the former process building to a depth of 16.5 ft. The results of these samples are shown in Table 9-2, below. Included in this group are 48 samples collected immediately beneath the building slab. (depth 0 – 0.5 ft)

The samples collected beneath Building 253 were evaluated seperately from the rest of the sample data. The reason for this separation is that this area contains the majority of the Tc-99 activity within the sub-slab soil and showed a maximum concentration of 168 pCi/g, a weighted average concentration of 43 pCi/g, and a standard deviation of 30 pCi/g. A total of 5 samples were collected in this area and the locations are shown in Figure H-2.

The balance of the areas outside of the area immediately below Building 253 showed a maximum Tc-99 concentration is 30 pCi/g, and a weighted average concentration of 3 pCi/g.

Table 9-2, Tc-99 results summary

Location	Volume Shipped (m^3)	No. Samples	Min (pCi/g)	Max (pCi/g)	Arithmetic Mean (pCi/g)	Std Dev. (pCi/g)
Excluding Beneath Building 253						
0 - 0.5 ft	1,408	43	-0.40	12	3	3
0.5 - 5 ft	4,573	12	-0.3	30	3	9
5 ft - 20 ft	1,684	22	-0.3	1	0.2	0.4
Under Building 253						
0 - 0.5 ft	159	5	109	168	143	30
0.5 - 5 ft	997	5	7.50	151	47	60

5 ft - 20 ft	653	7	5.22	28	13	8
Total						
Total: 9,474 m^3		Total # Samples: 94			Weighted Mean: 10 pCi/g	

Taken as a single dataset, the average Tc-99 concentration was 13 pCi/g, with a standard deviation of 36 pCi/g. This data was input into Visual Sample Plan©[1] Software (Appendix I) to determine the number of samples required to construct a $UCL_{(0.95)}$ with a half-width of 6.5 pCi/g. Based on this analysis, it was determined that 85 samples would need to be collected over the 14,213 m^3 volume of material. As indicated above, there are a total of 96 samples from this area already analyzed. Although it is apparent that an appropriate sample set is available for the sub-slab soil, additional characterization is planned based on the inaccessibility of the material prior to remediation of the slabs. The sampling approach currently being used for soils will be extended to include the additional soils under the new exemption request. The sampling frequency for the prior request is appropriate since the variability in Tc-99 concentration for soils in the current application is less than in the prior (36 pCi/g as compared to 225 pCi/g).

10. APPENDICES

Appendix A, Volume Estimates for Process Buildings Slabs
Appendix B, Volume Estimates for Concrete Not Including Process Building Slabs
Appendix C, Volume Estimates for Asphalt Surfaces
Appendix D, Process Building Slab – Sampling data and Gamma Walkover Survey (GWS)
Appendix E, Process Building Slab –Radium 226 Data, Two Sample t-test
Appendix F, Volume Estimates for Underground Piping
Appendix G, Radiological Sampling Results – Underground Piping
Appendix H, Sub-Slab Sample Data Summary
Appendix I, Visual Sample Plan©[1] Software Evaluation
Appendix J, Sample Locations
Appendix K, Visual Sample Plan© Software Evaluation – Supplemental Concrete Sampling
Appendix L, Calculation of Soil Volumen Beneath Process Buildings
Appendix M, Calculation of Activity – Concrete and Asphalt
Appendix N, Calculation of Sample Size – Piping (confidence interval)
Appendix O, Calculation of Sample Size – Piping (comparison against threshold value)
Appendix P, DQO Matrix, Sampling Approach
Appendix Q, Process Flow Diagrams
Appendix R, Contingency Plans

[1] Software copyright (c) 2011 Battelle Memorial Institute. All rights reserved.

Appendix A
Volume Estimates for Process Buildings Slabs

	Item	Quantity	L (ft)	W (ft)	H (ft)	Volume (ft^3)	Weight (lb)	Area (ft^2)
Building Slabs	Bldg. 240	1	60	83.08	0.5	2,492	373,860	4,985
		1	60.16	83	0.5	2,497	374,496	4,993
		1	40	83.08	0.75	2,492	373,860	3,323
		1	40.5	83.16	0.5	1,684	252,599	3,368
	Bldg. 253	1	69	131.5	0.5	4,537	680,513	9,074
	Bldg. 254	1	83	161.25	0.5	6,692	1,003,781	13,384
	Locker Rooms	1	166	18	0.5	1,494	224,100	2,988
	Bldg. 255	1	159.5	83.08	0.5	6,626	993,845	13,251
	Bldg. 256-1 – Slab	1	70	50	0.5	1,750	262,500	3,500
	Bldg 256-1 Thick-End Slab	1	27	2	1	54	8,100	54
	Bldg. 256-2	1	81	50	0.5	2,025	303,750	4,050
	Bldg. 256-2	1	29.6	17.5	0.42	218	32,634	518
	Bldg. 256-2	1	37.6	31.67	0.67	798	119,675	1,191
	Bldg. 256-2	1	36	31.67	0.67	764	114,582	1,140
	Bldg. 256-2 Sump	1	5.5	7.5	3	124	18,563	41
	Limestone Bldg.	1	36.5	38	0.58	804	120,669	1,387
	Bldg. 252	1	41	50	0.5	1,025	153,750	2050
	Bldg. 235	1	35.08	17	0.5	298	44,727	596
Total Processing Buildings Slabs						**36,373**	**5,456,002**	**69,893**
Total Processing Buildings Slabs Available for Disposal						**35,031**	**5,254,627**	**67,833**

Appendix B
Volume Estimates for Concrete Not Including Process Building Slabs

	Item	Quantity	L (ft)	W (ft)	H (ft)	Volume (ft^3)	Weight (lb)
Building 240	Interior Footings	18	4.25	4.25	1	325	48,769
	Piers	18	1	1	2.6	47	7,020
	Footing Base	5	83.08	1.5	1	623	93,465
	Footing	2	161.5	1.5	1	485	72,675
Bldg 253	Interior Footings	1	9.5	9.5	1.75	158	23,691
	Interior Footings	1	12	12	2	288	43,200
	Interior Footings	1	10	10	1.75	175	26,250
	Interior Footings	1	7.5	7.5	1.25	70	10,547
	Interior Footings	1	9	5	1.5	68	10,125
	Interior Footings	2	8	6	2	192	28,800
	Interior Footings	1	9.5	9.5	1.75	158	23,691
	Interior Footings	1	12	12	2	288	43,200
	Interior Footings	1	10	10	1.75	175	26,250
	Interior Footings	1	7.5	7.5	1.25	70	10,547
	Interior Footings	2	5.5	5.5	1	61	9,075
	Interior Footings	1	12	5	2	120	18,000
	Interior Footings	1	8	5	1	40	6,000
	Interior Footings	1	16.83	4	2	135	20,196
	Interior Footings	1	7	4	1	28	4,200
	Interior Footings	1	4	35	1	140	21,000
	Piers	23	2	2	1.25	115	17,250
	Footing Base	1	40	3.7	0.83	123	18,426
	Footing Pier	1	40	1	3	120	18,000
	Footing Base	1	61.5	3.7	0.8	182	27,306
	Footing Pier	1	61.5	3	1	185	27,675
Bldg 254	A-2 Footing	1	27	6	2	324	48,600
	A-2 Pier	1	2	2	1.25	5	750
	B-2 Footing	1	44	6	2	528	79,200
	B-2 Pier	1	2	2	1.25	5	750
	C-2 Footing	1	34	6	2	408	61,200
	C-2 Pier	1	2	2	1.25	5	750
	D-2 Footing	1	6.67	9.67	2	129	19,350
	E-2 Footing	2	13	13	2	676	101,400
	E-2 Pier	2	3	4	1.25	30	4,500
	F-2 Footing	2	4	4	1.25	40	6,000
	G-3 Footing	8	8	8	1.25	640	96,000
	G-3 Pier	8	2	2	1.25	40	6,000
	H-3 Footing	4	5	5	1.25	125	18,750
	H-3 Pier	4	2	2	1.25	20	3,000
	I-3 Footing	1	27	7	2	378	56,700
	J-3 Footing	1	11	11	2	242	36,300
	J-3 Footing Part 2	1	2	2	1.67	7	1,002
	J-3 Footing Part 3	1	1.5	1.5	1.67	4	564
	K-3	1	9	9	1.5	122	18,225
	K-3 Pier	1	2	2	1.25	5	750
	N/s Block Wall Footing	3	161	1	1	483	72,450
	EW Block Wall Footing	6	83	1	1	498	74,700
	EW Footing	2	83	3	1	498	74,700
	EW footing Pier	2	83	2.5	1	415	62,250
	NS Footing	1	161.25	3	1	484	72,563

Appendix B
Volume Estimates for Concrete Not Including Process Building Slabs

	Item	Quantity	L (ft)	W (ft)	H (ft)	Volume (ft^3)	Weight (lb)
	NS Footing Pier	1	161.25	1	2.5	403	60,469
Men and Women Locker Rooms	Footing	2	101	3.5	3.5	2,475	371,175
	Footing Pier	2	101	1.25	2	505	75,750
Building 255	Interior Footing	10	7	7	1.25	613	91,875
	Pier	10	1.17	1.17	2.25	31	4,620
	Pilaster Footing	10	6	6	1	360	54,000
	Pilaster Pier	10	2.5	1.75	1.42	62	9,319
	E/W Footing	2	83.08	2.5	1	415	62,310
	EW Piers	2	83.08	2.5	1	415	62,310
	NS Footing	2	159.5	2.25	1	718	107,663
	NS Footing Piers	2	159.5	0.75	2.5	598	89,719
Building 256-1	Loading Dock Floor	1	46	65	0.67	2,003	300,495
	Sump Location	1	65	15	0.67	653	97,988
	Dock Wall Base	1	4	46	1	184	27,600
	Dock Wall Base	1	47	0.83	5.83	227	34,114
	Dock Sides2	2	46	0.83	65	4,963	744,510
	Footings A-6	2	6.5	6.5	1	85	12,675
	Footing A6 Pier	2	70	2	3.7	1,036	155,400
	Footing B-6	2	7.5	7.5	1	113	16,875
	Footing B-6 Pier	2	50	2	2	400	60,000
	Footing C-6	1	5	7.5	1	38	5,625
	Footing C-6 Pier	1	2	2	2	8	1,200
	D-6 Footing	1	6.83	1.25	1	9	1,281
Building 256-2	A6 Footing Base	3	6.5	6.5	1	127	19,013
	A6-Pier	3	2.16	2.16	81	1,134	170,061
	B-6 Base	2	7.5	7.5	1	113	16,875
	B-6 Pier	2	2	2	2	16	2,400
Building 260	Interior Footings	3	8	8	1.5	288	43,200
	Interior Piers	3	1.6	1.5	3.16	23	3,413
	Center Footings	1	35	6	3.16	664	99,540
	Center Piers	1	35	5	1.67	292	43,838
	S. Footing	1	31	6	5.67	1,055	158,193
	Pier 4 Base	4	3	3	1.16	42	6,264
	Pier 4 Pier	4	3.67	1	1	15	2,202
	Pier 3 Bases	5	4	7	1.5	210	31,500
	Pier 3 Piers	5	1	1	2.16	11	1,620
	Modified Pier 3	1	7	9	1.6	101	15,120
	Mod. Pier 3 Pier	1	1	1	2.16	2	324
	Footing	1	112	1.5	1.67	281	42,084
Limestone Building	Pier 1	4	1.16	1.16	3.16	17	2,551
	Pier 2	1	1.16	1.75	3.16	6	962
	Footing	4	5	5	1	100	15,000
	Footing	1	38	3.16	0.67	80	12,068
	Footing	1	5.5	17	0.67	63	9,397
	Footing	1	5.5	15	0.67	55	8,291
	Interior Footing	1	14.5	1	0.67	10	1,457
	Interior Footing	1	12	1	0.67	8	1,206
	Interior Footing	1	22	1	0.67	15	2,211
Building 252	Footings Base	2	41	2	1	164	24,600

Appendix B
Volume Estimates for Concrete Not Including Process Building Slabs

	Item	Quantity	L (ft)	W (ft)	H (ft)	Volume (ft^3)	Weight (lb)
	Footing Piers	2	41	1.25	1	103	15,375
	Footing Base	2	50	2	1	200	30,000
	Footing Piers	2	50	2	1	200	30,000
Building 235	Footing Base	1	106	1	1.5	159	23,850
	Footing Pier	1	106	1	2	212	31,800
	Walls	1	106	15	0.67	1,065	79,898
	Interior Walls	4	30	10	0.67	804	60,300
Septic Tank	Walls	2	24	0.5	8.5	204	30,600
	Walls	3	6	0.5	8.5	77	11,475
	Top and Bottom	2	24	6	0.5	144	21,600
Other Areas	Site Dam	1	39	4	7	1,092	163,800
	Head Wall	1	70	3	0.67	141	21,105
	Cistern Burn Pit	1	50	5	0.5	125	18,750
	Tile Barn Ramp	1	38	8	0.5	152	22,800
	Tile Barn Slab	1	124	37	2	9,176	1,376,400
	Wood Barn Footings	1	220	4	0.67	590	88,440
	Slab N of 260	1	95	54	0.5	2,565	384,750
	Tank base N of Lime	1	34	34	1	1,156	173,400
	Slab N of 255	1	79	11	0.5	435	65,175
	S of 253 Basin	1	11	11	1	121	18,150
	Basin s of 240	1	22	8	1	176	26,400
	Piers S of 240	2	2	5	3	60	9,000
	Office W of 240	1	41	13	1	533	79,950
	Vent Room W of 240	1	28	73	1	2,044	306,600
	Side Walks	1	300	8	0.5	1,200	180,000
	230 Pad	1	250	150	0.67	25,125	3,768,750
Total Concrete outside except processing building Slabs						**79,538**	**11,790,538**

Concrete total volume = 1.16E+05 ft3
Concrete total Weight = 1.72E+07 lb
Concrete total Weight = 7.83E+09 g

Appendix C
Volume Estimates for Asphalt Surfaces

	Item	Quantity	L (ft)	W (ft)	H (ft)	Volume (ft^3)	Weight (lb)
Asphalt	Asphalt	1	52	15	0.5	390	46,800
		1	9	150	0.5	675	81,000
		1	38	10	0.5	190	22,800
	Asphalt Around Plant	1	1700	24	0.6	24,480	2,937,600
	Asphalt Pads	1	100	100	0.6	6,000	720,000
	Cushman Road	1	500	10	0.6	3,000	360,000
	L Debbie Pad	1	50	50	0.5	1,250	150,000
Total Asphalt						**35,985**	**4,318,200**

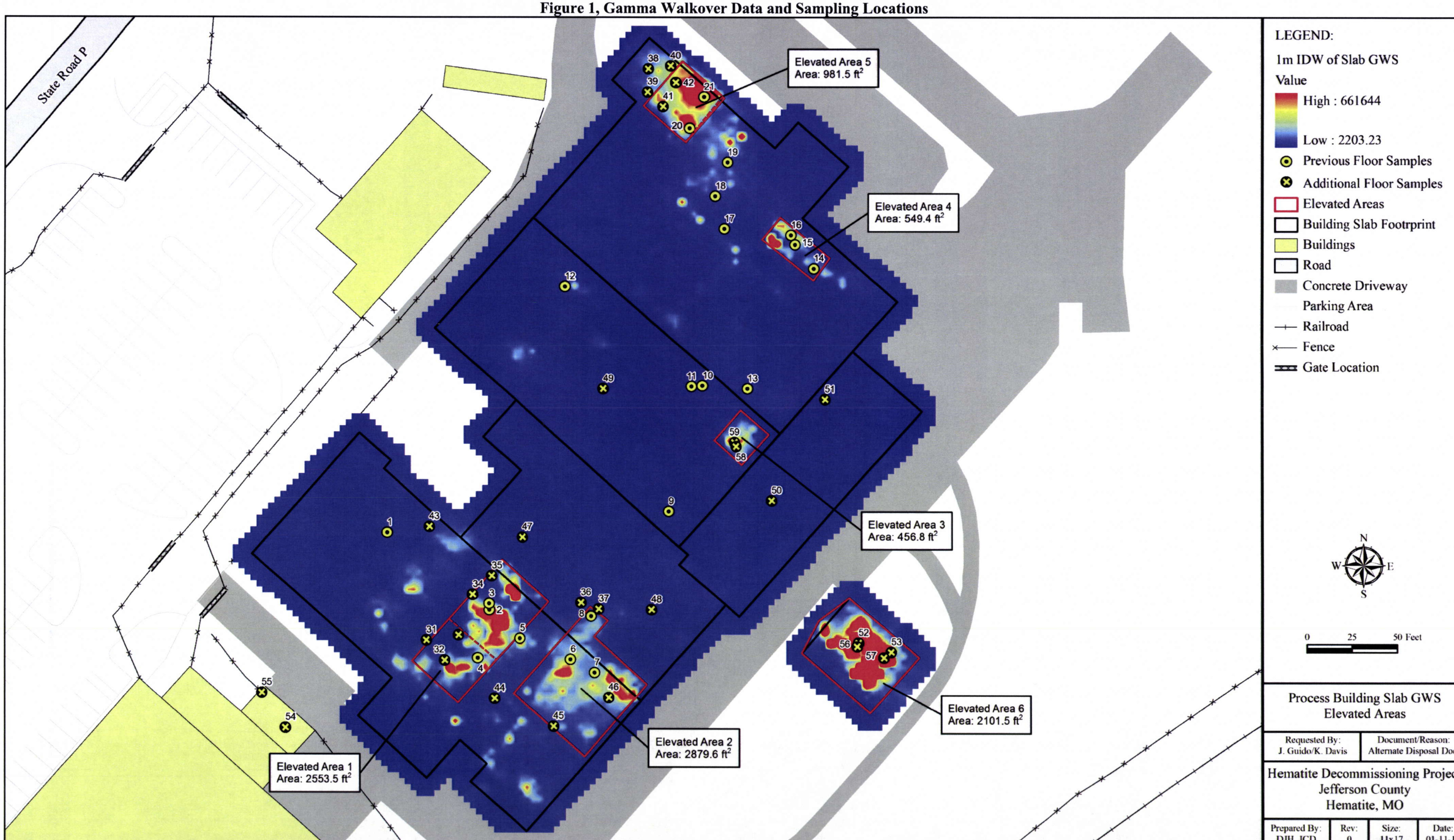
Asphalt total volume = 3.60E+04 ft3

Asphalt total Weight, lb = 4.32E+06 lb

Asphalt total Weight, g = 1.96E+09 g

Appendix D
Process Building Slab – Sampling Data and Gamma Walkover Survey (GWS)

Figure 1, Gamma Walkover Data and Sampling Locations



Appendix D
Process Building Slab – Sampling Data and Gamma Walkover Survey (GWS)

Table 1, Sample Results, Stations 1 – 21 (Tc-99, U-234, U-235, and U-238)

Station ID	Sample ID	Description	Sample Type: Resurfaced Concrete Region	Sample Type: Expansion Joint, Crack, Seam. Near Wall	Sample Type: Identified as a Hot Spot	Sample Type: Representative of General Area	Sample Mass (g)	Tc-99 (pCi/g) Conc.	Tc-99 ±2s	Tc-99 MDC	U-234 (pCi/g) Conc.	U-234 ±2s	U-234 MDC	U-235 (pCi/g) Conc.	U-235 ±2s	U-235 MDC	U-238 (pCi/g) Conc.	U-238 ±2s	U-238 MDC	Notes
1	991-MS-100413-13-1	Concrete sample from Station # 1 - top 1/4 "	-	x	-	-	62	0.58	0.88	2.1	178	26	0.23	5.1	1.2	0.13	9.8	1.9	0.23	
	991-MS-100413-13-2	Concrete sample from Station # 1 - middle 1/2 "					125	-0.13	0.83	1.8	176	28	0.28	6.1	1.4	0.21	8.4	1.7	0.28	
	991-MS-100413-13-3	Concrete sample from Station # 1 - remainder of core					1160	0.068	0.84	1.9	66	-	-	3.7	0.55	0.16	8.8	3.2	0.83	
							-	0.073	-	-	81	-	-	3.9	-	-	8.8	-	-	1
2	992-MS-100413-13-1	Concrete sample from Station # 2 - top 1/4 "	x	-	x	-	60	42738	2950	3.7	34384	4986	95	1255	280	61	5051	834	26	
	992-MS-100413-13-2	Concrete sample from Station # 2 - middle 1/2 "					106	4.5	1.1	2.8	15	2.7	0.097	0.29	0.20	0.097	2.5	0.70	0.19	
	992-MS-100413-13-3a	Concrete sample from Station # 2 - remainder of core A					534	0.72	0.91	2.8	9.1	-	-	0.41	0.050	0.16	11	7.0	4.3	
	992-MS-100413-13-5	1/4 inch Subfloor wafer					85	-0.13	0.88	2.3	123	18	0.29	3.3	0.92	0.13	2.0	0.67	0.13	
	992-MS-100413-13-6	1/2 inch Subfloor wafer					136	-0.17	0.88	1.9	1.4	0.51	0.26	0.063	0.11	0.19	0.95	0.40	0.19	
	992-MS-100413-13-3b	Concrete sample from Station # 2 - remainder of core B					1366	0.46	0.86	2.1	4.7	-	-	0.25	0.24	0.15	0.27	3.0	1.8	
							-	1122	-	-	912	-	-	33	-	-	136	-	-	1
							-	0.37	-	-	11	-	-	0.40	-	-	0.42	-	-	2
3	993-MS-100413-13-1	Concrete sample from Station # 3 - top 1/4 "	x	x	-	-	59	22646	547	2.6	15232	4884	5.6	544	181	3.1	2364	764	6.7	
	993-MS-100413-13-2	Concrete sample from Station # 3 - middle 1/2 "					119	122	14	2.3	6109	2122	2.7	206	74	1.4	904	316	2.7	
	993-MS-100413-13-3a	Concrete sample from Station # 3 - remainder of core A					509	101	13	1.9	1183	-	-	65	2.8	0.77	265	43	9.1	
	993-MS-100413-13-5	1/4 inch Subfloor wafer					75	19	2.9	2.0	107	16	0.27	3.8	0.98	0.23	21	3.6	0.23	
	993-MS-100413-13-6	1/2 inch Subfloor wafer					113	2.5	1.1	1.9	4.2	0.97	0.20	0.13	0.13	0.086	1.3	0.45	0.086	
	993-MS-100413-13-3b	Concrete sample from Station # 3 - remainder of core B					1301	2.8	1.1	2.2	4.6	-	-	0.23	0.21	0.13	3.8	3.4	1.7	
							-	647	-	-	1030	-	-	42	-	-	179	-	-	1
							-	3.6	-	-	9.7	-	-	0.40	-	-	4.5	-	-	2
4	997-MS-100414-13-1	Concrete sample from Station # 4 - top 1/4 "	-	x	-	-	113	18	2.6	2.2	1439	262	1.3	56	12	0.57	311	58	1.1	
	997-MS-100414-13-2	Concrete sample from Station # 4 - middle 1/2 "					122	5.7	0.88	0.85	4661	980	1.9	179	40	1.9	1011	215	1.9	
	997-MS-100414-13-3	Concrete sample from Station # 4 - remainder of core					1290	2.6	0.51	1.0	2787	-	-	151	21	0.57	1071	144	2.9	
							-	4.0	-	-	2837	-	-	146	-	-	1010	-	-	1
5	998-MS-100414-13-1	Concrete sample from Station # 5 - top 1/4 "	-	-	x	-	96	24	1.8	1.4	37544	6057	145	1805	471	101	11035	1947	56	
	998-MS-100414-13-2	Concrete sample from Station # 5 - middle 1/2 "					187	2.1	0.99	2.5	50	8.3	0.24	3.0	0.81	0.20	21	3.7	0.20	
	998-MS-100414-13-3	Concrete sample from Station # 5 - remainder of core					1620	0.45	0.85	1.9	12	-	-	0.63	0.29	0.18	4.5	4.0	2.1	
							-	1.8	-	-	1909	-	-	92	-	-	563	-	-	1
6	1008-MS-100415-13-1	Concrete sample from Station # 6 - top 1/4 "	-	x	-	-	66	16	1.3	1.5	20166	3281	104	1101	312	79	5896	1086	79	
	1008-MS-100415-13-2	Concrete sample from Station # 6 - middle 1/2 "					120	2.9	1.0	2.1	1.4	0.46	0.20	0.095	0.11	0.086	0.64	0.30	0.17	
	1008-MS-100415-13-3	Concrete sample from Station # 6 - remainder of core					1080	1.9	0.91	2.1	2.2	-	-	0.12	0.19	0.11	0.93	2.9	1.6	
							-	2.7	-	-	1053	-	-	58	-	-	308	-	-	1
7	1000-MS-100415-13-1	Concrete sample from Station # 7 - top 1/4 "	-	-	x	-	61	1.5	0.46	0.78	3304	868	5.6	145	43	1.9	1074	286	3.6	
	1000-MS-100415-13-2	Concrete sample from Station # 7 - middle 1/2 "					118	0.64	0.85	2.2	2.7	0.68	0.21	0.12	0.12	0.079	1.4	0.44	0.15	
	1000-MS-100415-13-3	Concrete sample from Station # 7 - remainder of core					1250	0.041	0.79	2.1	4.7	-	-	0.26	0.14	0.13	0.89	2.8	1.6	
							-	0.15	-	-	145	-	-	6.4	-	-	47	-	-	1

Appendix D
Process Building Slab – Sampling Data and Gamma Walkover Survey (GWS)

Table 1, Sample Results, Stations 1 – 21 (Tc-99, U-234, U-235, and U-238)

Station ID	Sample ID	Description	Sample Type: Resurfaced Concrete Region	Sample Type: Expansion Joint, Crack, Seam. Near Wall	Sample Type: Identified as a Hot Spot	Sample Type: Representative of General Area	Sample Mass (g)	Tc-99 (pCi/g) Conc.	Tc-99 ±2s	Tc-99 MDC	U-234 (pCi/g) Conc.	U-234 ±2s	U-234 MDC	U-235 (pCi/g) Conc.	U-235 ±2s	U-235 MDC	U-238 (pCi/g) Conc.	U-238 ±2s	U-238 MDC	Notes
8	999-MS-100414-13-1	Concrete sample from Station #8 - top 1/4 "	-	-	x	-	85	163	4.1	4.1	2599	463	1.7	89	18	1.1	370	68	1.1	
	999-MS-100414-13-2	Concrete sample from Station # 8- middle 1/2 "					125	34	1.5	8.2	0.73	0.31	0.19	0.029	0.058	0.080	0.29	0.19	0.15	
	999-MS-100414-13-3	Concrete sample from Station # 8 - remainder of core					1090	1.8	0.93	2.2	10	-	-	0.31	0.21	0.12	-0.40	9.6	2.1	
							-	15	-	-	178	-	-	6.1	-	-	24	-	-	1
9	1009-MS-100415-13-1	Concrete sample from Station # 9 - top 1/4 "	-	x	-	x	75	0.54	0.39	0.81	11874	2919	4.8	403	103	1.6	1574	391	1.6	
	1009-MS-100415-13-2	Concrete sample from Station # 9 middle 1/2 "					114	0.77	0.88	2.0	0.70	0.33	0.25	0.069	0.11	0.22	0.38	0.25	0.25	
	1009-MS-100415-13-3	Concrete sample from Station # 9 - remainder of core					1340	0.57	0.79	2.1	2.4	-	-	0.12	0.11	0.057	1.4	2.5	1.3	
							-	0.58	-	-	585	-	-	20	-	-	78	-	-	1
10	1010-MS-100415-13-1	Concrete sample from Station # 10- top 1/4 "	-	-	x	-	73	0.97	0.41	0.88	36426	5775	82	1267	346	82	5657	1056	46	
	1010-MS-100415-13-2	Concrete sample from Station # 10- middle 1/2 "					120	1.0	0.82	1.8	1.6	0.53	0.28	0.033	0.066	0.091	0.33	0.21	0.091	
	1010-MS-100415-13-3	Concrete sample from Station # 10 - remainder of core					1780	0.073	0.83	1.9	29	-	-	1.6	0.37	0.11	13	4.0	0.63	
							-	0.16	-	-	1374	-	-	48	-	-	221	-	-	1
11	1011-MS-100415-13-1	Concrete sample from Station # 11 - top 1/4 "	-	-	-	x	73	-0.12	0.35	1.2	1523	257	1.1	50	9.9	0.39	205	36	0.61	
	1011-MS-100415-13-2	Concrete sample from Station # 11 - middle 1/2 "					118	0.80	0.87	2.0	8.6	1.6	0.28	0.34	0.20	0.15	1.5	0.46	0.20	
	1011-MS-100415-13-3	Concrete sample from Station # 11 - remainder of core					1110	-0.40	0.78	2.0	39	-	-	2.1	0.41	0.15	14	4.1	0.87	
							-	-0.27	-	-	120	-	-	4.7	-	-	23	-	-	1
12	1017-MS-100416-13-1	Concrete sample from Station # 12 - top 1/4 "	-	-	-	x	63	-0.11	0.34	1.3	4481	949	2.2	165	38	1.0	650	141	2.2	
	1017-MS-100416-13-2	Concrete sample from Station # 12 middle 1/2 "					120	1.1	0.84	1.7	0.60	0.29	0.17	0.032	0.062	0.086	0.19	0.16	0.20	
	1017-MS-100416-13-3	Concrete sample from Station # 12 - remainder of core					2050	0.31	0.33	1.2	0.53	-	-	0.028	0.14	0.077	0.32	2.7	1.6	
							-	0.34	-	-	127	-	-	4.7	-	-	19	-	-	1
13	1018-MS-100416-13-1	Concrete sample from Station # 13- top 1/4 "	-	x	-	-	102	3.8	0.59	0.92	2154	378	1.1	74	15	0.48	259	47	0.89	
	1018-MS-100416-13-2	Concrete sample from Station # 13- middle 1/2 "					137	0.37	0.34	0.90	585	92	0.30	15	2.7	0.096	2.8	0.76	0.19	
	1018-MS-100416-13-3	Concrete sample from Station # 13 - remainder of core					870	0.78	0.36	0.82	158	-	-	8.7	1.3	0.19	28	6.1	0.70	
							-	1.0	-	-	394	-	-	15	-	-	46	-	-	1
14	1019-MS-100416-13-1	Concrete sample from Station # 14 - top 1/4 "	-	x	-	-	53	5.0	0.48	1.9	534	79	0.38	16	3.1	0.16	46	7.5	0.29	
	1019-MS-100416-13-2	Concrete sample from Station # 14 - middle 1/2 "					138	1.2	0.41	0.74	407	65	0.33	13	2.4	0.22	40	6.7	0.22	
	1019-MS-100416-13-3	Concrete sample from Station # 14 - remainder of core					2530	0.29	0.34	0.72	270	-	-	13	1.8	0.23	4.5	3.4	1.6	
							-	0.43	-	-	282	-	-	13	-	-	7.1	-	-	1
15	1025-MS-100419-13-1	Concrete sample from Station # 15 - top 1/4 "	-	-	-	x	70	2.8	0.55	0.74	495	76	0.50	18	3.6	0.45	85	14	0.50	
	1025-MS-100419-13-2	Concrete sample from Station # 15 middle 1/2 "					125	1.2	0.41	0.75	0.78	0.31	0.22	0.049	0.068	0.066	0.39	0.20	0.066	
	1025-MS-100419-13-3	Concrete sample from Station # 15 - remainder of core					1190	1.6	0.39	1.2	15	-	-	0.84	0.24	0.11	2.9	3.0	1.5	
							-	1.6	-	-	38	-	-	1.7	-	-	6.8	-	-	1
16	1026-MS-100419-13-1	Concrete sample from Station # 16- top 1/4 "	-	x	x	-	104	125	6.3	2.1	10714	3817	8.5	415	155	6.8	2572	922	9.0	
	1026-MS-100419-13-2	Concrete sample from Station # 16- middle 1/2 "					133	2.4	0.49	0.87	1.2	0.40	0.20	0.18	0.14	0.071	0.47	0.23	0.12	
	1026-MS-100419-13-3	Concrete sample from Station # 16 - remainder of core					1750	6.7	0.91	0.86	5.0	-	-	0.23	0.16	0.078	5.8	2.9	0.77	
							-	13	-	-	565	-	-	22	-	-	140	-	-	1

Appendix D
Process Building Slab – Sampling Data and Gamma Walkover Survey (GWS)

Table 1, Sample Results, Stations 1 – 21 (Tc-99, U-234, U-235, and U-238)

Station ID	Sample ID	Description	Sample Type				Sample Mass (g)	Radionuclide Concentration												Notes
			Resurfaced Concrete Region	Expansion Joint, Crack, Seam. Near Wall	Identified as a Hot Spot	Representative of General Area		Tc-99 (pCi/g)			U-234 (pCi/g)			U-235 (pCi/g)			U-238 (pCi/g)			
								Conc.	±2s	MDC	Conc.	±2s	MDC	Conc.	±2s	MDC	Conc.	±2s	MDC	
17	1027-MS-100419-13-1	Concrete sample from Station # 17 - top 1/4 "	-	x	x	-	147	5.8	0.71	1.2	1125	199	1.2	39	8.6	0.47	297	54	1.4	
	1027-MS-100419-13-2	Concrete sample from Station # 17 - middle 1/2 "					230	2.4	0.54	0.85	4494	982	4.5	172	43	1.9	841	189	1.9	
	1027-MS-100419-13-3	Concrete sample from Station # 17 - remainder of core					1290	0.53	0.36	0.72	37	-	-	1.9	0.41	0.14	21	5.5	1.1	
							-	1.3	-	-	748	-	-	29	-	-	158	-	-	1
18	1028-MS-100419-13-1	Concrete sample from Station # 18 - top 1/4 "	-	x	-	-	90	1.8	0.41	1.1	629	108	1.2	23	5.4	0.42	222	39	0.42	
	1028-MS-100419-13-2	Concrete sample from Station # 18 - middle 1/2 "					138	0.60	0.39	0.77	793	189	1.2	41	11	0.52	327	79	1.2	
	1028-MS-100419-13-3	Concrete sample from Station # 18 - remainder of core					1100	0.094	0.35	0.84	203	-	-	11	1.6	0.25	129	20	1.4	
							-	0.26	-	-	293	-	-	15	-	-	156	-	-	1
19	1031-MS-100420-13-1	Concrete sample from Station # 19- top 1/4 "	-	-	-	x	73	7.1	0.73	1.4	3925	857	3.8	142	34	2.1	797	177	2.8	
	1031-MS-100420-13-2	Concrete sample from Station # 19- middle 1/2 "					124	7.5	1.3	0.70	2409	742	2.4	98	32	1.9	618	192	2.6	
	1031-MS-100420-13-3	Concrete sample from Station # 19 - remainder of core					3040	0.32	0.36	0.90	8.9	-	-	0.47	0.24	0.099	4.8	3.9	1.8	
							-	0.75	-	-	189	-	-	7.4	-	-	46	-	-	1
20	1032-MS-100420-13-1	Concrete sample from Station # 20 - top 1/4 "	-	x	-	-	82	643	32	2.1	1929	560	0.88	73	22	0.48	322	95	0.48	
	1032-MS-100420-13-2	Concrete sample from Station # 20 - middle 1/2 "					120	52	6.1	0.87	3.6	0.96	0.32	0.14	0.15	0.12	1.4	0.53	0.24	
	1032-MS-100420-13-3	Concrete sample from Station # 20 - remainder of core					2450	16	1.9	0.88	2.0	-	-	0.083	0.15	0.083	3.0	3.0	1.5	
							-	37	-	-	62	-	-	2.3	-	-	13	-	-	1
21	1033-MS-100420-13-1	Concrete sample from Station # 21 - top 1/4 "	-	-	x	-	74	750	37	2.1	170561	26694	389	5692	1488	328	24175	4433	181	
	1033-MS-100420-13-2	Concrete sample from Station # 21 - middle 1/2 "					124	2086	35	6.0	64	10	0.29	2.4	0.72	0.11	12	2.3	0.34	
	1033-MS-100420-13-3	Concrete sample from Station # 21 - remainder of core					2400	22	1.9	1.3	773	-	-	43	6.0	0.39	209	31	2.3	
							-	141	-	-	5575	-	-	202	-	-	882	-	-	1

Notes: 1 - weighted average over entire core
2 - weighted average over core,excluding top 3 inches

Appendix D
Process Building Slab – Sampling Data and Gamma Walkover Survey (GWS)

Table 2, Sample Results, stations 1 – 21 (Am-241, Np-237, and Pu-239)

Station ID	Description	Am-241 (pCi/g)			Np-237 (pCi/g)			Pu-239/240 (pCi/g)		
		Conc.	±2s	MDC	Conc.	±2s	MDC	Conc.	±2s	MDC
1	Concrete sample from Station # 1 - top 1/4 "	0.023	0.075	0.18	**0.077**	**0.054**	**0.026**	**0.11**	**0.079**	**0.10**
2a	Concrete sample from Station # 2 - top 1/4 "	0.045	0.078	0.15	0.099	0.12	0.18	0.067	0.063	0.088
2b	Concrete sample from Station # 2 - top 1/4" Subfloor	-0.022	0.0080	0.15	0.010	0.044	0.093	-0.040	0.056	0.14
3a	Concrete sample from Station # 3 - top 1/4 "	-0.025	0.0080	0.16	0.000	0.11	0.32	0.010	0.077	0.15
3b	Concrete sample from Station # 3 - top 1/4" Subfloor	-0.023	0.037	0.18	0.027	0.040	0.066	-0.018	0.058	0.13
4	Concrete sample from Station # 4 - top 1/4 "	0.000	0.048	0.16	0.071	0.11	0.19	0.010	0.045	0.095
5	Concrete sample from Station # 5 - top 1/4 "	0.024	0.059	0.14	0.085	0.10	0.16	0.010	0.093	0.18
6	Concrete sample from Station # 6 - top 1/4 "	0.062	0.11	0.23	0.041	0.14	0.34	-0.040	0.072	0.16
7	Concrete sample from Station # 7 - top 1/4 "	-0.023	0.038	0.18	**0.29**	**0.21**	**0.28**	-0.045	0.069	0.16
8	Concrete sample from Station #8 - top 1/4 "	-0.031	0.093	0.26	-0.030	0.057	0.25	0	0.059	0.13
9	Concrete sample from Station # 9 - top 1/4 "	0.00	0.092	0.24	0.037	0.13	0.31	**0.032**	**0.036**	**0.029**
10	Concrete sample from Station # 10- top 1/4 "	0.011	0.086	0.21	0.000	0.040	0.16	0.049	0.064	0.11
11	Concrete sample from Station # 11 - top 1/4 "	0.011	0.10	0.25	0.067	0.11	0.22	0.0090	0.038	0.081
12	Concrete sample from Station # 12 - top 1/4 "	0.021	0.066	0.16	0.098	0.30	0.74	-0.029	0.056	0.14
13	Concrete sample from Station # 13- top 1/4 "	0.053	0.11	0.23	0.070	0.098	0.095	-0.020	0.062	0.14
14	Concrete sample from Station # 14 - top 1/4 "	-0.019	0.042	0.16	0.000	0.069	0.22	0.021	0.041	0.078
15	Concrete sample from Station # 15 - top 1/4 "	0.00	0.064	0.18	0.015	0.055	0.11	-0.0070	0.030	0.076
16	Concrete sample from Station # 16- top 1/4 "	0.078	0.12	0.22	-0.028	0.038	0.21	-0.029	0.060	0.14
17	Concrete sample from Station # 17 - top 1/4 "	-0.096	0.064	0.27	**0.13**	**0.095**	**0.12**	0.072	0.062	0.076
18	Concrete sample from Station # 18 - top 1/4 "	0.046	0.087	0.18	0.076	0.13	0.25	0.0090	0.054	0.11
19	Concrete sample from Station # 19- top 1/4 "	-0.023	0.084	0.25	0.067	0.10	0.19	0.019	0.054	0.10
20	Concrete sample from Station # 20 - top 1/4 "	0.11	0.13	0.24	0.033	0.065	0.090	0.040	0.051	0.083
21	Concrete sample from Station # 21 - top 1/4 "	0.056	0.11	0.23	0.032	0.064	0.088	**0.14**	**0.082**	**0.098**

Note: Highlighted results (underlined /bold) indicates results > MDC.

Appendix D
Process Building Slab – Sampling Data and Gamma Walkover Survey (GWS)

Table 3, Sample Results, stations 1 – 21 (Ra-226, Th-232, and U-234)

Station ID	Description	Ra-226 (pCi/g)			Th-232 (pCi/g)			U-234 (pCi/g)		
		Conc.	±2s	MDC	Conc.	±2s	MDC	Conc.	±2s	MDC
1	Concrete sample from Station # 1 - top 1/4 "	0.76	0.29	0.068	0.19	0.16	0.20	178	26	0.23
	Concrete sample from Station # 1 - remainder of core	0.64	0.11	0.026	0.46	0.12	0.060	66	-	-
2	Concrete sample from Station # 2 - top 1/4 "	0.95	2.0	1.2	0.068	0.095	0.092	34384	4986	95
	Concrete sample from Station # 2 - remainder of core A	0.23	0.054	0.067	0.14	0.11	0.20	9.1	-	-
	1/4 inch Subfloor wafer	0.42	0.26	0.11	0.51	0.27	0.21	123	18	0.29
	Concrete sample from Station # 2 - remainder of core B	0.73	0.13	0.030	0.57	0.13	0.051	4.7	-	-
3	Concrete sample from Station # 3 - top 1/4 "	0.45	0.65	0.36	0.12	0.14	0.23	15232	4884	5.6
	Concrete sample from Station # 3 - remainder of core A	0.23	0.097	0.13	0.055	0.15	0.26	1183	-	-
	1/4 inch Subfloor wafer	0.78	0.30	0.090	0.20	0.17	0.22	107	16	0.27
	Concrete sample from Station # 3 - remainder of core B	0.59	0.094	0.031	0.38	0.11	0.10	4.6	-	-
4	Concrete sample from Station # 4 - top 1/4 "	0.69	0.30	0.12	0.39	0.23	0.088	1439	262	1.3
	Concrete sample from Station # 4 - remainder of core	0.53	0.15	0.049	0.51	0.13	0.065	2787	-	-
5	Concrete sample from Station # 5 - top 1/4 "	1.5	0.64	0.64	0.50	0.25	0.16	37544	6057	145
	Concrete sample from Station # 5 - remainder of core	0.73	0.12	0.034	0.75	0.14	0.067	12	-	-
6	Concrete sample from Station # 6 - top 1/4 "	0.87	1.1	1.3	1.1	0.41	0.24	20166	3281	104
	Concrete sample from Station # 6 - remainder of core	0.72	0.13	0.024	0.60	0.12	0.049	2.2	-	-
7	Concrete sample from Station # 7 - top 1/4 "	1.0	0.65	0.23	0.87	0.38	0.24	3304	868	5.6
	Concrete sample from Station # 7 - remainder of core	0.68	0.12	0.031	0.56	0.11	0.048	4.7	-	-
8	Concrete sample from Station #8 - top 1/4 "	0.35	0.21	0.27	0.0090	0.070	0.21	2599	463	1.7
	Concrete sample from Station # 8 - remainder of core	0.41	0.093	0.028	0.16	0.10	0.089	10	-	-
9	Concrete sample from Station # 9 - top 1/4 "	0.71	0.87	0.48	0.18	0.15	0.082	11874	2919	4.8
	Concrete sample from Station # 9 - remainder of core	0.28	0.077	0.023	0.093	0.065	0.070	2.4	-	-
10	Concrete sample from Station # 10- top 1/4 "	1.6	0.95	0.39	0.19	0.18	0.24	36426	5775	82
	Concrete sample from Station # 10 - remainder of core	0.38	0.096	0.025	0.11	0.065	0.073	29	-	-
11	Concrete sample from Station # 11 - top 1/4 "	0.33	0.29	0.16	0.24	0.21	0.28	1523	257	1.1
	Concrete sample from Station # 11 - remainder of core	0.33	0.077	0.021	0.32	0.098	0.052	39	-	-
12	Concrete sample from Station # 12 - top 1/4 "	0.20	0.25	0.68	1.4	0.50	0.10	4481	949	2.2
	Concrete sample from Station # 12 - remainder of core	0.35	0.083	0.025	0.18	0.096	0.073	0.53	-	-
13	Concrete sample from Station # 13- top 1/4 "	0.31	0.39	0.26	0.34	0.24	0.28	2154	378	1.1
	Concrete sample from Station # 13 - remainder of core	0.47	0.10	0.025	0.15	0.078	0.068	158	-	-
14	Concrete sample from Station # 14 - top 1/4 "	0.026	0.34	0.20	0.011	0.086	0.26	534	79	0.38
	Concrete sample from Station # 14 - remainder of core	0.52	0.11	0.023	0.16	0.11	0.073	270	-	-
15	Concrete sample from Station # 15 - top 1/4 "	1.1	0.31	0.14	0.22	0.18	0.23	495	76	0.50
	Concrete sample from Station # 15 - remainder of core	0.61	0.12	0.025	0.14	0.076	0.072	15	-	-

Appendix D
Process Building Slab – Sampling Data and Gamma Walkover Survey (GWS)

Table 3, Sample Results, stations 1 – 21 (Ra-226, Th-232, and U-234)

Station ID	Description	Ra-226 (pCi/g)			Th-232 (pCi/g)			U-234 (pCi/g)		
		Conc.	±2s	MDC	Conc.	±2s	MDC	Conc.	±2s	MDC
16	Concrete sample from Station # 16- top 1/4 "	0.82	0.51	0.24	1.2	0.47	0.27	10714	3817	8.5
	Concrete sample from Station # 16 - remainder of core	0.62	0.13	0.026	0.077	0.040	0.090	5.0	-	-
17	Concrete sample from Station # 17 - top 1/4 "	0.80	0.33	0.093	0.13	0.15	0.24	1125	199	1.2
	Concrete sample from Station # 17 - remainder of core	0.67	0.13	0.036	0.17	0.078	0.074	37	-	-
18	Concrete sample from Station # 18 - top 1/4 "	0.51	0.26	0.25	0.51	0.27	0.092	629	108	1.2
	Concrete sample from Station # 18 - remainder of core	0.55	0.13	0.034	0.21	0.090	0.077	203	-	-
19	Concrete sample from Station # 19- top 1/4 "	0.85	0.42	0.15	0.30	0.24	0.27	3925	857	3.8
	Concrete sample from Station # 19 - remainder of core	0.59	0.13	0.030	0.17	0.077	0.077	8.9	-	-
20	Concrete sample from Station # 20 - top 1/4 "	0.91	1.0	0.58	0.093	0.14	0.24	1929	560	0.88
	Concrete sample from Station # 20 - remainder of core	0.53	0.11	0.024	0.10	0.078	0.069	2.0	-	-
21	Concrete sample from Station # 21 - top 1/4 "	3.1	0.96	1.1	0.64	0.33	0.11	170561	26694	389
	Concrete sample from Station # 21 - remainder of core	0.53	0.13	0.034	0.30	0.11	0.057	773	-	-

Appendix D
Process Building Slab – Sampling Data and Gamma Walkover Survey (GWS)

Table 4, Sample Results, stations 31 – 59 (Tc-99, U-234, U-235, and U-238)

Station ID	Sample ID	Sample Depth	Building / Room	Tc-99 (pCi/g)			U-234 (pCi/g)			U-235 (pCi/g)			U-238 (pCi/g)			Notes
				Conc.	±2s	MDC	Conc.	±2s	MDC	Conc.	±2s	MDC	Conc.	±2s	MDC	
31	1855-MS-110621-9-1	0" - 3.5"	240-11 Red Room	0.0	0.11	1.7	0.38			0.020	0.0019	0.0044	0.20	0.018	0.0001	
	1869-MS-110621-9-1	3.5" - 10.5"		0.0	0.11	1.7	1.4			0.078	0.0083	0.0044	0.21	0.020	0.0001	
				1.7			1.1			0.1			0.2			1
32	1852-MS-110620-9-1a	0" - 3"	240-11 Red Room	2.3	0.26	1.7	0.56			0.030	0.0042	0.0044	0.23	0.021	0.0001	
	1868-MS-110620-9-1	3" - 11.5"		0.0	0.032	1.7	0.38			0.020	0.0025	0.0044	0.22	0.020	0.0001	
				1.9			0.43			0.02			0.22			1
33	1855-MS-110621-9-3	0" - 3"	240-11 Red Room	0.0	0.18	2.0	0.92			0.050	0.0052	0.0044	0.34	0.031	0.0001	
	1869-MS-110621-9-2	3" - 9.5"		0.0	0.019	1.7	1.4			0.075	0.0091	0.0044	0.30	0.028	0.0001	
				1.8			1.2			0.1			0.3			1
34	1855-MS-110621-9-5	0" - 3"	240-11 Red Room	3.4	0.38	2.0	9.3			0.51	0.051	0.0040	2.2	0.20	0.0001	
	1869-MS-110621-9-3	3" - 10.5"		0.0	0.13	1.7	9.8			0.48	0.044	0.0040	0.26	0.024	0.0001	
				2.2			9.7			0.5			0.8			1
35	1855-MS-110621-9-6	0" - 2.5"	240-11 Red Room	725	66	2.0	46			2.5	0.23	0.0040	10.0	0.95	0.0001	
	1869-MS-110621-9-4	2.5" - 10"		1.8	0.16	1.7	1.1			0.061	0.0063	0.0044	0.25	0.023	0.0001	
				183			12			1			3			1
36	1856-MS-110622-9-7	0" - 6"	253-26 Ring Storage	0.0	0.15	2.0	0.39			0.021	0.0034	0.0044	0.19	0.018	0.0001	
37	1856-MS-110622-9-9	0" - 6"	253-26 Ring Storage	2.5	0.26	2.2	2.8			0.16	0.015	0.0040	0.66	0.063	0.0001	
38	1856-MS-110622-9-15	0" - 6"	260-65 UF6 Vapor	3.7	0.35	1.7	13			0.69	0.065	0.0040	2.8	0.30	0.0001	
39	1866-MS-110623-9-1	0" - 11.75"	260-65 UF6 Vapor	2.7	0.26	2.3	11			0.63	0.058	0.0040	2.8	0.27	0.0001	
40	1866-MS-110623-9-3	0" - 11.25"	260-65 UF6 Vapor	11	1.2	2.0	44			2.4	0.22	0.0040	12	1.1	0.0000	
41	1866-MS-110623-9-5	0" - 11.25"	260-65 UF6 Vapor	7.6	0.74	2.6	39			2.2	0.20	0.0040	9.3	0.89	0.0000	
42	1866-MS-110623-9-7	0" - 11.5"	260-65 UF6 Vapor	5.0	0.55	2.2	12			0.65	0.060	0.0040	3.2	0.29	0.0001	
43	1856-MS-110622-9-3	0" - 6"	240-9 Laundry	0.0	0.11	1.7	1.1			0.057	0.0066	0.0044	0.52	0.048	0.0001	
44	1852-MS-110620-9-7	0" - 5.75"	240-3 Green Room	0.0	0.12	1.7	5.4			0.30	0.027	0.0040	1.7	0.16	0.0001	
45	1852-MS-110620-9-5	0" - 7.25"	240-14 Maint Shop	0.0	0.056	2.5	2.7			0.14	0.014	0.0040	1.9	0.18	0.0001	
46	1852-MS-110620-9-3	0" - 6.5"	240-14 Maint Shop	0.0	0.047	1.7	15			0.78	0.071	0.0040	6.2	0.58	0.0001	
47	1856-MS-110622-9-5	0" - 5.7"	253-25 Ring Storage	0.0	0.10	1.7	1.4			0.080	0.0089	0.0044	0.41	0.040	0.0001	
48	1856-MS-110622-9-11	0" - 5"	253-29 Waste Prep	2.5	0.28	1.7	3.0			0.17	0.017	0.0040	0.72	0.066	0.0001	
49	1856-MS-110622-9-13	0" - 7.5"	254-33 Ceramic	0.0	0.057	1.7	0.18			0.0090	0.0016	0.0044	0.13	0.013	0.0001	
50	1867-MS-110624-9-3	0" - 5.5"	256-38 Pellet Kardex	0.0	0.050	1.8	0.32			0.017	0.0020	0.0044	0.18	0.018	0.0001	
51	1867-MS-110624-9-1	0" - 5.5"	256-64 Warehouse	0.0	0.061	1.7	0.23			0.012	0.0014	0.0044	0.16	0.015	0.0001	
52	1852-MS-110620-9-1b	0" - 7.5"	252 South Vault	8.4	0.85	1.7	51			2.8	0.26	0.0040	10	0.96	0.0000	
53	1843-MS-110617-9-1	0" - 8.5"	252 South Vault	3.0	0.31	1.7	40			2.2	0.20	0.0040	4.4	0.41	0.0000	

Appendix D
Process Building Slab – Sampling Data and Gamma Walkover Survey (GWS)

Table 4, Sample Results, stations 31 – 59 (Tc-99, U-234, U-235, and U-238)

Station ID	Sample ID	Sample Depth	Building / Room	Tc-99 (pCi/g)			U-234 (pCi/g)			U-235 (pCi/g)			U-238 (pCi/g)			Notes
				Conc.	±2s	MDC	Conc.	±2s	MDC	Conc.	±2s	MDC	Conc.	±2s	MDC	
54	1867-MS-110624-9-5	0" - 8.25"	235 West Vault	0.0	0.052	1.8	9.2			0.50	0.048	0.0040	0.75	0.068	0.0001	
55	1867-MS-110624-9-7	0" - 7.25"	235 West Vault	0.0	0.059	2.0	34			1.7	0.15	0.0040	0.98	0.093	0.0001	
56	1902-MS-110810-09-05	0 - 0.25"	South Vault	1.8	0.71	1.0	2290	200	2.0	92	15	1.0	140	18	2.0	
	1902-MS-110810-09-06	0.25" - 0.75"		1.4	0.67	1.0	2010	180	3.0	89	19	5.0	177	26	4.0	
				1.6			2103.3			90.0			164.7			1
57	1902-MS-110810-09-07	0 - 0.25"	South Vault	0.89	0.79	1.3	1150	200	40	64	48	41	7.0	20	42	
	1902-MS-110810-09-08	0.25" - 0.75"		4.6	0.94	1.1	1830	290	60	71	54	27	0.0	7.0	22	
				3.4			1603.3			68.7			2.3			1
58	1902-MS-110810-09-01	0 - 0.25"	254 (Elevated Area 3)	0.14	0.69	1.2	2010	180	2.0	80	14	2.0	313	35	2.0	
	1902-MS-110810-09-02	0.25" - 0.75"		-0.42	0.59	1.1	437	44	2.0	18	5.8	2.1	64	11	2.0	
				0.8			961.3			38.8			147.0			1
59	1902-MS-110810-09-03	0 - 0.25"	254 (Elevated Area 3)	2.2	0.86	1.3	3260	280	2.0	147	21	1.0	524	53	3.0	
	1902-MS-110810-09-04	0.25" - 0.75"		2.0	0.80	1.2	2400	210	3.0	101	17	3.0	372	40	2.0	
				2.1			2686.7			116.3			422.7			1

Notes: 1 - weighted average over entire core

Appendix E
Process Building Slab –Radium 226 Data, Two Sample t-test (upper and lower samples)

Figure E-1, Q-Q Plot for Ra-226 Concentration in Upper Core Section, Adjusted to Account for U-234 Corrolated Component

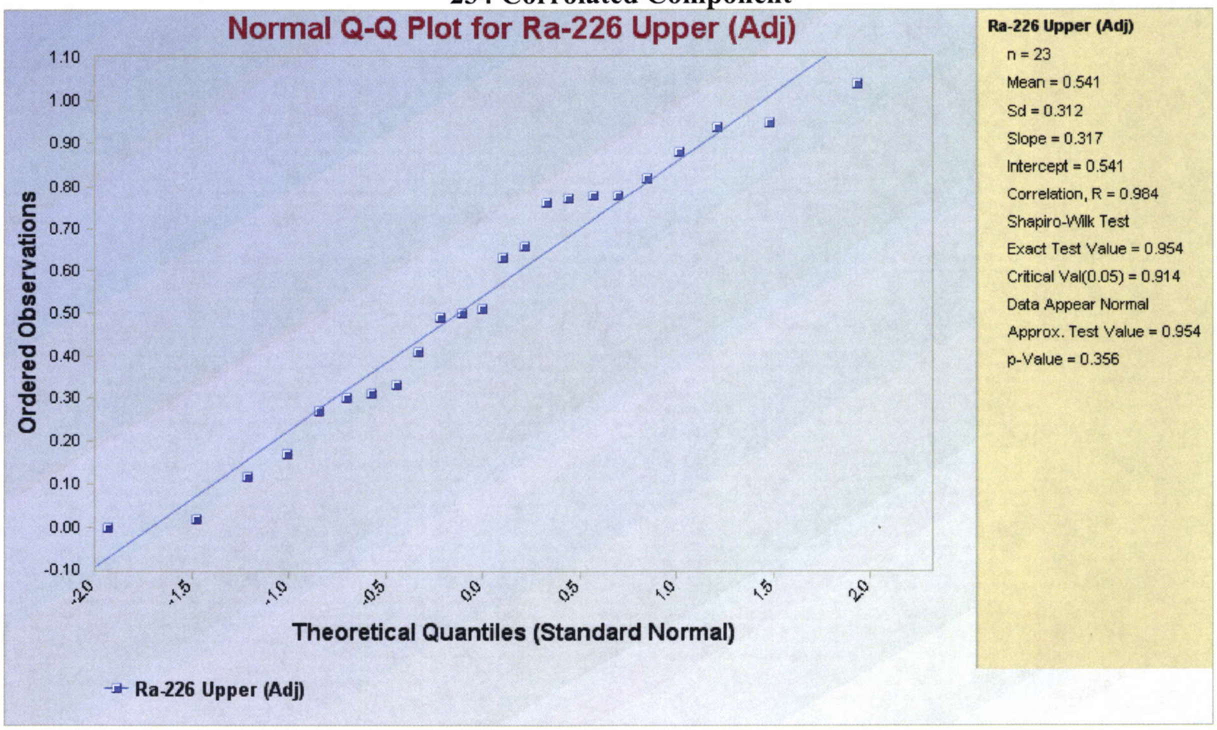
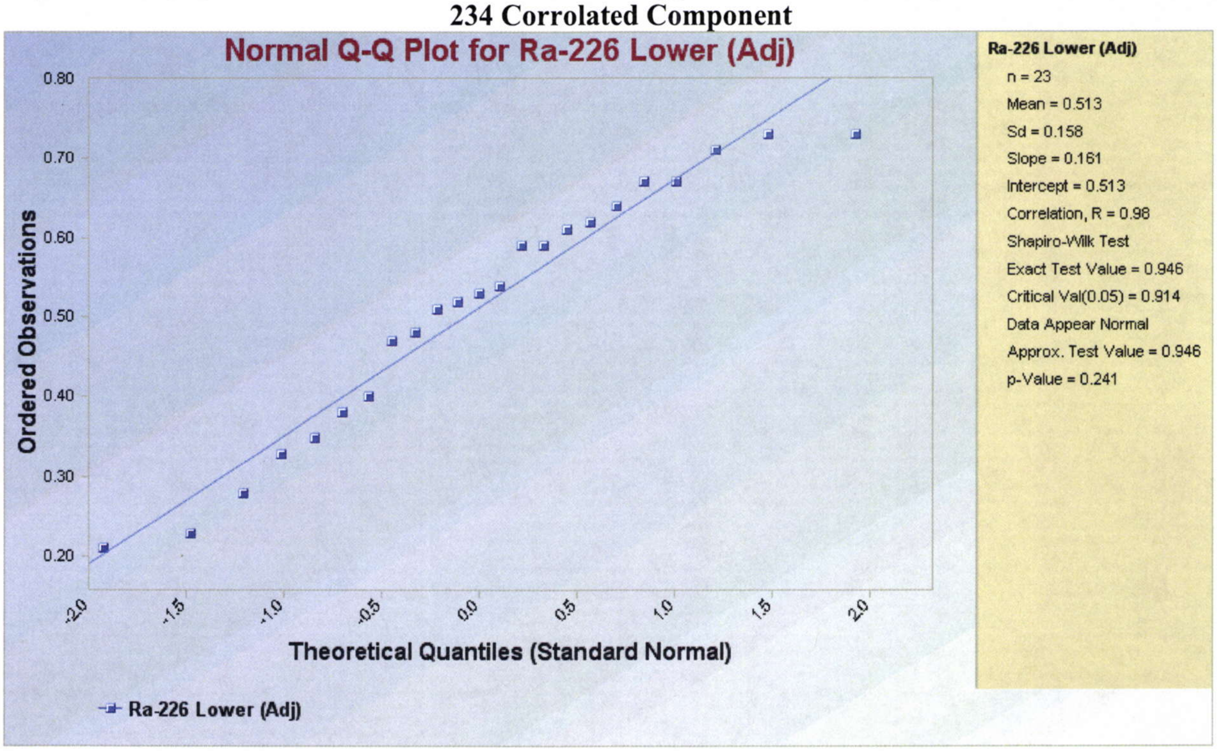


Figure E-2, Q-Q Plot for Ra-226 Concentration in Upper Core Section, Adjusted to Account for U-234 Corrolated Component



Appendix E
Process Building Slab –Radium 226 Data, Two Sample t-test (upper and lower samples)

Figure E-3, Pro-UCL Two-Sample T-Test, Ra-226 in Upper and Lower Core Segments

t-Test Site vs Background Comparison for Full Data Sets without NDs

User Selected Options

From File	P:\hematite project\US Ecology\Concrete 2\characterization data\radium data.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference (S)	0
Selected Null Hypothesis	Site or AOC Mean Less Than or Equal to Background Mean (Form 1)
Alternative Hypothesis	Site or AOC Mean Greater Than the Background Mean

Area of Concern Data: Ra-226 Upper (Adj)
Background Data: Ra-226 Lower (Adj)

Raw Statistics	Site	Background
Number of Valid Observations	23	23
Number of Distinct Observations	22	20
Minimum	0	0.21
Maximum	1.04	0.73
Mean	0.541	0.513
Median	0.51	0.53
SD	0.312	0.158
SE of Mean	0.065	0.033

Site vs. Background Two-Sample t-Test
H0: Mu of Site - Mu of Background <= 0

Method	DF	t-Test Value	Critical t (0.050)	P-Value
Pooled (Equal Variance)	44	0.388	1.68	0.35
Welch-Satterthwaite (Unequal Variance)	32.7	0.388	1.692	0.35

Pooled SD 0.247
Conclusion with Alpha = 0.050
* Student t (Pooled) Test: Do Not Reject H0, Conclude Site <= Background
* Welch-Satterthwaite Test: Do Not Reject H0, Conclude Site <= Background

Test of Equality of Variances

Variance of Site	0.0971
Variance of Background	0.0251

Numerator DF	Denominator DF	F-Test Value	P-Value
22	22	3.87	0.002

Conclusion with Alpha = 0.05
* Two variances are not equal

Appendix F
Volume Estimates for Underground Piping

Building-Room	Line Designation		Direction	Length (ft)	Pipe OD (in)	Pipe ID (in)	Pipe Material of Construction	Volume (wall) (ft^3)	Volume (interior) (ft^3)	% Filled (debris)	Mass (wall) (g)	Mass (debris) (g)
	From	To/Toward										
Building 230 Northernmost System												
230	CO-231	CO-301	South	37	4.5	4.026	PVC	0.82	3.27	40%	3.1E+04	5.6E+04
230	WC-301	CO 231 - CO301	East	5	4.5	4.026	PVC	0.11	0.44	40%	4.2E+03	7.5E+03
230	FD-308	CO 231 - CO301	East	8	4.5	4.026	PVC	0.18	0.71	40%	6.8E+03	1.2E+04
230	WC-303	CO 232 - CO302	West	11	4.5	4.026	PVC	0.24	0.97	40%	9.3E+03	1.7E+04
230	CO-232	CO302	South	37	4.5	4.026	PVC	0.82	3.27	40%	3.1E+04	5.6E+04
230	FD-304	CO 232 - CO302	East	8	4.5	4.026	PVC	0.18	0.71	40%	6.8E+03	1.2E+04
230	FD-312	CO 232 - CO302	West	6	4.5	4.026	PVC	0.13	0.53	40%	5.1E+03	9.0E+03
230	WC-302	CO 231 - CO301	West	7	4.5	4.026	PVC	0.15	0.62	40%	5.9E+03	1.1E+04
230	FD-306	CO 232 - CO302	SouthWest	8	4.5	4.026	PVC	0.18	0.71	40%	6.8E+03	1.2E+04
230	FD-307	FD-306	North	8	4.5	4.026	PVC	0.18	0.71	40%	6.8E+03	1.2E+04
230	WC-303	CO 231 - CO301	West	11	4.5	4.026	PVC	0.24	0.97	40%	9.3E+03	1.7E+04
230	FD-309	CO 232 - CO301	West	7	4.5	4.026	PVC	0.15	0.62	40%	5.9E+03	1.1E+04
230	CO-301	CO-303	East	34	4.5	4.026	PVC	0.75	3.00	40%	2.9E+04	5.1E+04
230	FD-310	CO 301 - CO303	West	11	4.5	4.026	PVC	0.24	0.97	40%	9.3E+03	1.7E+04
230	FD-308	CO 232 - CO 302	East	8	4.5	4.026	PVC	0.18	0.71	40%	6.8E+03	1.2E+04
230	FD-311	CO 302 - CO 303	South	8	4.5	4.026	PVC	0.18	0.71	40%	6.8E+03	1.2E+04
230	CO-302	CO-304	East	35	4.5	4.026	PVC	0.77	3.09	40%	3.0E+04	5.3E+04
230	CO-303	MH 05 - MH 21	SouthEast	70	4.5	4.026	PVC	1.54	6.19	40%	5.9E+04	1.1E+05
230	CO-304	MH 04 - MH 13	SouthEast	60	4.5	4.026	PVC	1.32	5.30	40%	5.1E+04	9.0E+04
Building 230 Middle System												
230	CO-305	MH 04 - MH 13	East	72	4.5	4.026	PVC	1.59	6.36	40%	6.1E+04	1.1E+05
230	FD 312	CO 305	West	15	4.5	4.026	PVC	0.33	1.33	40%	1.3E+04	2.3E+04
230	FD 313	FD 312	South	8	4.5	4.026	PVC	0.18	0.71	40%	6.8E+03	1.2E+04
230	FD 315	CO 305	North	10	4.5	4.026	PVC	0.22	0.88	40%	8.5E+03	1.5E+04
230	FD-316	CO-305	North	10	4.5	4.026	PVC	0.22	0.88	40%	8.5E+03	1.5E+04
Building 230 Southernmost System												
230	CO-233	FD-319	East then SouthEast	21 20	4.5	4.026	PVC	0.90	3.62	40%	3.5E+04	6.2E+04
230	FD-317	CO-233	South	1	4.5	4.0	PVC	0.00	0.09	40%	0.0E+00	1.5E+03
230	FD-318	CO-233	South	4	4.5	4.026	PVC	0.09	0.35	40%	3.4E+03	6.0E+03
230	FD-319	MH 22 - MH 01	East then South	40 73	4.5	4.026	PVC	2.49	9.98	40%	9.6E+04	1.7E+05
Northernmost System Building 240												

Appendix F
Volume Estimates for Underground Piping

Building-Room	Line Designation		Direction	Length (ft)	Pipe OD (in)	Pipe ID (in)	Pipe Material of Construction	Volume (wall) (ft^3)	Volume (interior) (ft^3)	% Filled (debris)	Mass (wall) (g)	Mass (debris) (g)
	From	To/Toward										
240-09	FD 203	SD-204- MH 17	North then	4	5.0	4.0	Cast Iron	1.18	2.09	40%	2.4E+05	3.6E+04
			South	20								
240-09	FD-202	FD-320	North	44	5.0	4.0	Cast Iron	2.16	3.84	40%	4.4E+05	6.5E+04
240-09	FD-201	FD-202	East	2	5.0	4.0	Cast Iron	0.10	0.17	40%	2.0E+04	3.0E+03
240-05	FD-320	FD-321 (CO-Lab_North)	West	50	5.0	4.0	Cast Iron	2.45	4.36	40%	5.0E+05	7.4E+04
240-09	CO-306	FD-321	West	8	5.0	4.0	Cast Iron	0.39	0.70	40%	8.0E+04	1.2E+04
240-07	FD-321 (Co Lab North)	CO-308	South	35	5.0	4.0	Cast Iron	5.84	10.38	40%	1.2E+06	1.8E+05
			West	84								
240-09	CO-306	FD-321	West	8	5.0	4.0	Cast Iron	0.39	0.70	40%	8.0E+04	1.2E+04
240-09	FD-322	FD-321	West	3	5.0	4.0	Cast Iron	0.15	0.26	40%	3.0E+04	4.4E+03
240-07	FD-326	FD-321	West	8	5.0	4.0	Cast Iron	0.39	0.70	40%	8.0E+04	1.2E+04
240-07	FD-327	FD-321	West	8	5.0	4.0	Cast Iron	0.39	0.70	40%	8.0E+04	1.2E+04
240-07	CO-307	MH 04 - MH-13	West	18	4.5	4.0	PVC	3.54	13.35	40%	1.4E+05	2.3E+05
			North	46								
			West	89								
240-07	CO-308	FD-321	West then	32	5.0	4.0	Cast Iron	1.86	3.31	40%	3.8E+05	5.6E+04
			North	6								
240-07	FD-325	CO-307	North	2	4.5	4.0	PVC	0.05	0.17	40%	1.8E+03	3.0E+03
240-07	FD-328	CO-307	North	2	4.5	4.0	PVC	0.05	0.17	40%	1.8E+03	3.0E+03
240-07	FD-324	CO-307	North	2	4.5	4.0	PVC	0.05	0.17	40%	1.8E+03	3.0E+03
240-07	FD-329	CO-307	West	8	4.5	4.0	PVC	0.19	0.70	40%	7.1E+03	1.2E+04
Middle System Building 240												
240-02	Co-209	8" Process Drain	West	110	5.0	4.0	Cast Iron	5.40	9.59	100%	1.1E+06	4.1E+05
240-02	PD-209	Co-209	South	6	5.0	4.0	Cast Iron	0.29	0.52	40%	6.0E+04	8.9E+03
240-02	PD-208	Co-209	South	5	5.0	4.0	Cast Iron	0.25	0.44	40%	5.0E+04	7.4E+03
240-02	PD-207	Co-209	North	3	5.0	4.0	Cast Iron	0.15	0.26	40%	3.0E+04	4.4E+03
240-02	CO-37	Co-209	North	57	5.0	4.0	Cast Iron	2.80	4.97	20%	5.7E+05	4.2E+04
240-02	PD-37	CO-37	North	5	5.0	4.0	Cast Iron	0.25	0.44	40%	5.0E+04	7.4E+03
240-03	PD-336	PD-333	West	46	5.0	4.0	Cast Iron	2.26	4.01	40%	4.6E+05	6.8E+04
240-03	PD-335	PD-336	North	37	5.0	4.0	Cast Iron	1.82	3.23	40%	3.7E+05	5.5E+04
240-03	PD-334	PD-335	East	18	5.0	4.0	Cast Iron	0.88	1.57	40%	1.8E+05	2.7E+04
240-03	PD-332	PD-333	North	38	5.0	4.0	Cast Iron	1.86	3.31	40%	3.8E+05	5.6E+04
240-03	PD-333	Co-209	North	56	5.0	4.0	Cast Iron	2.75	4.88	40%	5.6E+05	8.3E+04
240-02	FP-36	PD-333	West	4	5.0	4.0	Cast Iron	0.20	0.35	40%	4.0E+04	5.9E+03

Appendix F
Volume Estimates for Underground Piping

Building-Room	Line Designation		Direction	Length (ft)	Pipe OD (in)	Pipe ID (in)	Pipe Material of Construction	Volume (wall) (ft^3)	Volume (interior) (ft^3)	% Filled (debris)	Mass (wall) (g)	Mass (debris) (g)
	From	To/Toward										
240-03	PD-331	PD-333	West	4	5.0	4.0	Cast Iron	0.20	0.35	40%	4.0E+04	5.9E+03
240-03	PD-330-1	PD-333	West	4	5.0	4.0	Cast Iron	0.20	0.35	40%	4.0E+04	5.9E+03
Southernmost System Building 240												
240-14	CO-311 (NEMS)	8" Process Drain	West	88	5.0	4.0	Cast Iron	4.32	7.68	40%	8.8E+05	1.3E+05
240-14	PD-339	CO-311	South	4	5.0	4.0	Cast Iron	0.20	0.35	40%	4.0E+04	5.9E+03
240-14	PD-338	CO-311	South	4	5.0	4.0	Cast Iron	0.20	0.35	40%	4.0E+04	5.9E+03
240-14	PD-41	CO-311	South	4	5.0	4.0	Cast Iron	0.20	0.35	40%	4.0E+04	5.9E+03
240-14	PD-337	CO-311	North	35	5.0	4.0	Cast Iron	1.72	3.05	40%	3.5E+05	5.2E+04
240-14	CO-312	PD-337	West	20	5.0	4.0	Cast Iron	0.98	1.74	40%	2.0E+05	3.0E+04
240-14	CO-313	CO-311	West	31	5.0	4.0	Cast Iron	1.52	2.70	40%	3.1E+05	4.6E+04
240-14	PD-44	CO-313	East	9	5.0	4.0	Cast Iron	0.44	0.79	40%	9.0E+04	1.3E+04
240-14	PD-43	CO-313	West	10	5.0	4.0	Cast Iron	0.49	0.87	40%	1.0E+05	1.5E+04
240-14	CO-45	CO-311	East	19	5.0	4.0	Cast Iron	0.93	1.66	20%	1.9E+05	1.4E+04
Northernmost Process System in Building 255												
255	PD-340	CO-226	South	15	5.0	4.0	Cast Iron	0.74	1.31	40%	1.5E+05	2.2E+04
255	PD-233	CO-226	South	15	5.0	4.0	Cast Iron	0.74	1.31	40%	1.5E+05	2.2E+04
255	PD-341	CO-226	South	15	5.0	4.0	Cast Iron	0.74	1.31	40%	1.5E+05	2.2E+04
255	PD-342	CO-226	South	15	5.0	4.0	Cast Iron	0.74	1.31	40%	1.5E+05	2.2E+04
255	PD-226	CO-225	West	74	5.0	4.0	Cast Iron	3.63	6.45	15%	7.4E+05	4.1E+04
255	Co-225	MH 15 - MH-12	South	40	5.0	4.0	PVC	1.96	**6.11**	40%	7.6E+04	1.0E+05
			West	30								
255	PD-343	CO-225	South	10	5.0	4.0	Cast Iron	0.49	0.87	40%	1.0E+05	1.5E+04
255	CO-315	CO-316	West	74	5.0	4.0	Cast Iron	3.63	6.45	40%	7.4E+05	1.1E+05
255	CO-344	CO-315	North	24	5.0	4.0	Cast Iron	1.18	2.09	40%	2.4E+05	3.6E+04
255	CO-345	CO-315	South	3	5.0	4.0	Cast Iron	0.15	0.26	40%	3.0E+04	4.4E+03
255	PD-229	CO-315	North	24	5.0	4.0	Cast Iron	1.18	2.09	40%	2.4E+05	3.6E+04
255	PD-228	CO-315	South	2	5.0	4.0	Cast Iron	0.10	0.17	20%	2.0E+04	1.5E+03
255	CO-316	CO-225	North	15	5.0	4.0	Cast Iron	0.74	1.31	40%	1.5E+05	2.2E+04
Southernmost Process System in Building 255												
255	CO-320	MH 15 - MH 12	West	100	5.0	4.0	Cast Iron	4.91	8.72	10%	1.0E+06	3.7E+04
255	PD-142	CO-320	South	40	5.0	4.0	Cast Iron	1.96	3.49	10%	4.0E+05	1.5E+04
255	Co-232	CO-320	North	39	5.0	4.0	Cast Iron	1.91	3.40	10%	3.9E+05	1.4E+04

Appendix F
Volume Estimates for Underground Piping

Building-Room	Line Designation		Direction	Length (ft)	Pipe OD (in)	Pipe ID (in)	Pipe Material of Construction	Volume (wall) (ft^3)	Volume (interior) (ft^3)	% Filled (debris)	Mass (wall) (g)	Mass (debris) (g)
	From	To/Toward										
255	PD-232	CO-320	North	8	5.0	4.0	Cast Iron	0.39	0.70	10%	8.0E+04	3.0E+03
255	PD-231	CO-320	North	8	5.0	4.0	Cast Iron	0.39	0.70	40%	8.0E+04	1.2E+04
255	PD-153	CO-320	South	15	5.0	4.0	Cast Iron	0.74	1.31	40%	1.5E+05	2.2E+04
255	PD-152	CO-320	South	15	5.0	4.0	Cast Iron	0.74	1.31	40%	1.5E+05	2.2E+04
255	CO-319	CO-320	South	30	5.0	4.0	Cast Iron	1.47	2.62	40%	3.0E+05	4.4E+04
255	CO-230	CO-320	North	41	5.0	4.0	Cast Iron	2.01	3.58	25%	4.1E+05	3.8E+04
255	CO-317	CO-318	West	64	5.0	4.0	Cast Iron	3.14	5.58	40%	6.4E+05	9.5E+04
255	PD-345	CO-317	North	3	5.0	4.0	Cast Iron	0.15	0.26	40%	3.0E+04	4.4E+03
255	PD-346	CO-317	North	3	5.0	4.0	Cast Iron	0.15	0.26	40%	3.0E+04	4.4E+03
255	PD-230	CO-317	North	3	5.0	4.0	Cast Iron	0.15	0.26	40%	3.0E+04	4.4E+03
Sanitary Lines in Building 255												
255	FD-120	MH 10 - FD224	North East North	9 15 50	4.5	4.0	PVC	1.71	6.45	40%	6.6E+04	1.1E+05
255	FD-121	FD-120	North	5	4.5	4.0	PVC	0.12	0.44	40%	4.5E+03	7.4E+03
255	FD-122	FD-120	south	4	4.5	4.0	PVC	0.09	0.35	40%	3.6E+03	5.9E+03
255	FD-123	FD-120	South	4	4.5	4.0	PVC	0.09	0.35	40%	3.6E+03	5.9E+03
255	FD-124	FD-120	North	8	4.5	4.0	PVC	0.19	0.70	40%	7.1E+03	1.2E+04
255	CO-220	FD-120	North	34	4.5	4.0	PVC	0.79	2.97	40%	3.0E+04	5.0E+04
Sanitary and Grey Water lines in Building 255												
255	FD-224	MH-10	North NorthWest West	10 24 50	4.5	4.0	PVC	1.95	7.33	40%	7.5E+04	1.2E+05
255	FD-348	FD-224	North	10	4.5	4.0	PVC	0.23	0.87	40%	8.9E+03	1.5E+04
255	Co-222	MH-11	West North West	10 39 20	4.5	4.0	PVC	1.60	6.02	40%	6.2E+04	1.0E+05
255	FD-347	FD-224	SouthWest	8	4.5	4.0	PVC	0.19	0.70	40%	7.1E+03	1.2E+04
255	FD-349	FD-224	East	12	4.5	4.0	PVC	0.28	1.05	40%	1.1E+04	1.8E+04
255	Co-221	MH-11	East North	25 33	4.5	4.0	PVC	1.34	5.06	40%	5.2E+04	8.6E+04
255	FD-350	FD-221	East	12	4.5	4.0	PVC	0.28	1.05	40%	1.1E+04	1.8E+04
Building 260												

Appendix F
Volume Estimates for Underground Piping

Building-Room	Line Designation From	Line Designation To/Toward	Direction	Length (ft)	Pipe OD (in)	Pipe ID (in)	Pipe Material of Construction	Volume (wall) (ft^3)	Volume (interior) (ft^3)	% Filled (debris)	Mass (wall) (g)	Mass (debris) (g)
260	PD-170	MH-16	East North	20 43	4.5	4.0	PVC	1.46	5.50	5%	5.6E+04	1.2E+04
255	PD-164	MH-16	East	21	5.0	4.0	Cast Iron	1.03	1.83	40%	2.1E+05	3.1E+04
Building 254												
254	FD-354	MH-11 -MH-05	South East North	8 20 30	4.5	4.0	PVC	1.34	5.06	40%	5.2E+04	8.6E+04
254	FD-351	FD-354	North	6	4.5	4.0	PVC	0.14	0.52	40%	5.4E+03	8.9E+03
240-07	FD-355	FD-354	South West	8 33	5.0	4.0	PVC	2.01	3.58	40%	7.7E+04	6.1E+04
254	FD-356	FD-354	North	6	4.5	4.0	PVC	0.14	0.52	40%	5.4E+03	8.9E+03
254	FD-353	FD-354	North East North	8 12 20	4.5	4.0	PVC	0.93	3.49	40%	3.6E+04	5.9E+04
254	352	FD-353	West	8	4.5	4.0	PVC	0.19	0.70	40%	7.1E+03	1.2E+04
254-256	MH-12	MH15	North	225	19.75	15	RCP	202.46	275.98	5%	1.4E+07	5.9E+05
254-256	DS-97	MH15	West	14	19.75	15	RCP	12.60	17.17	40%	8.9E+05	2.9E+05
254-256	DS-96	MH15	West	14	19.75	15	RCP	12.60	17.17	40%	8.9E+05	2.9E+05
254-256	DS-95	MH15	West	14	19.75	15	RCP	12.60	17.17	40%	8.9E+05	2.9E+05
254-256	DS-94	MH15	West	14	19.75	15	RCP	12.60	17.17	40%	8.9E+05	2.9E+05
254-256	DS-93	MH15	West	14	19.75	15	RCP	12.60	17.17	40%	8.9E+05	2.9E+05
Building 253												
253	FD-360	MH10-MH 05	West North	30 100	4.5	4.0	PVC	3.01	11.34	40%	1.2E+05	1.9E+05
253	MH-08	MH-15	East	114	4.5	4.0	PVC	2.64	9.94	5%	1.0E+05	2.1E+04
253	DS-113	MH-15 - MH 08	North	12	4.5	4.0	PVC	0.28	1.05	40%	1.1E+04	1.8E+04
Sanitary and Grey Water lines in Building 253												
253	FD-361	FD-360	East	15	4.5	4.0	PVC	0.35	1.31	40%	1.3E+04	2.2E+04
253	FD-362	FD-361	North	2	4.5	4.0	PVC	0.05	0.17	40%	1.8E+03	3.0E+03
253	FD-363	FD-361	North	2	4.5	4.0	PVC	0.05	0.17	40%	1.8E+03	3.0E+03
253	FD-364	FD-361	South	2	4.5	4.0	PVC	0.05	0.17	40%	1.8E+03	3.0E+03

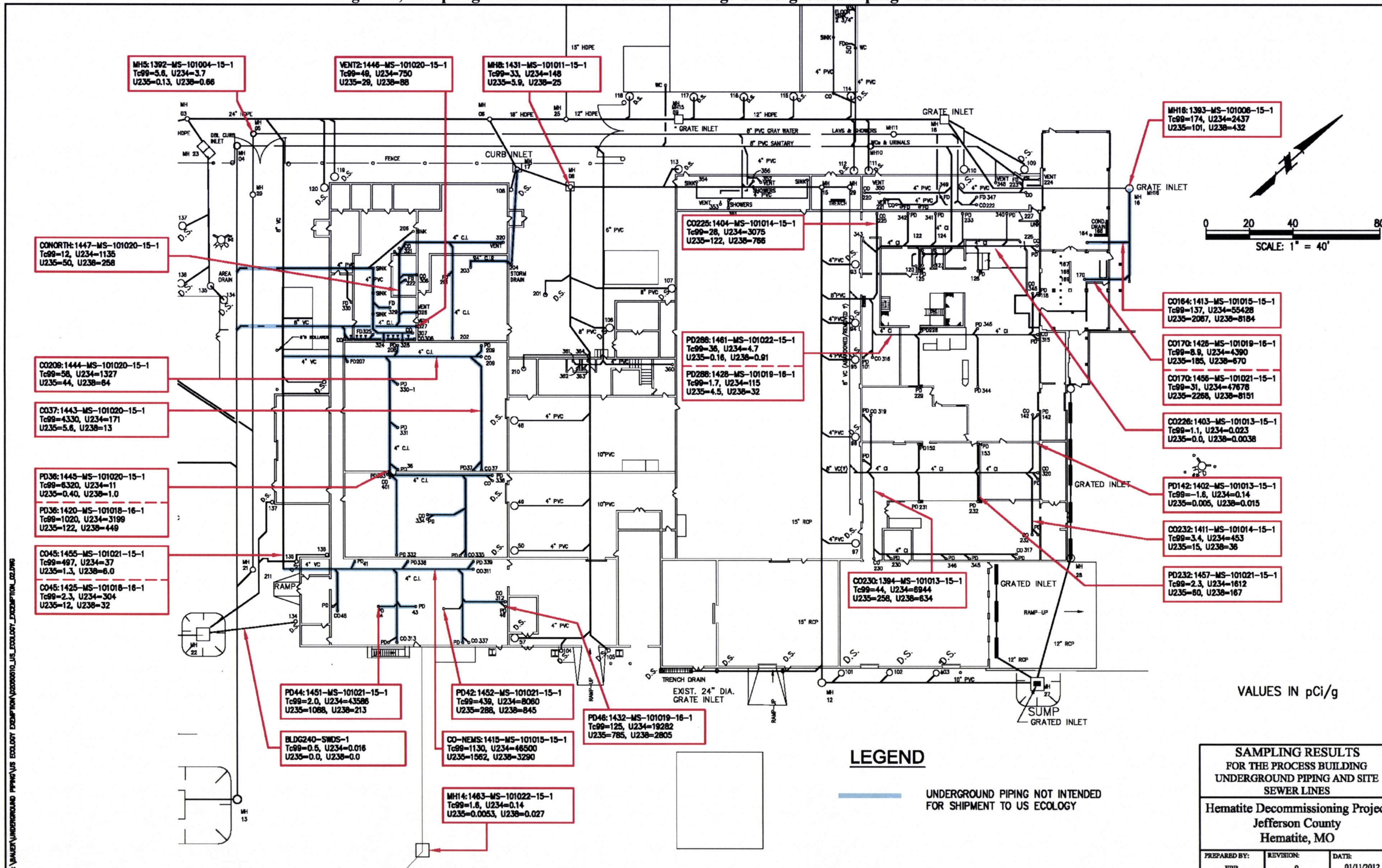
Appendix F
Volume Estimates for Underground Piping

Building-Room	Line Designation		Direction	Length (ft)	Pipe OD (in)	Pipe ID (in)	Pipe Material of Construction	Volume (wall) (ft^3)	Volume (interior) (ft^3)	% Filled (debris)	Mass (wall) (g)	Mass (debris) (g)
	From	To/Toward										
Storm Water Lines Building 253												
253	DS-57	MH08-MH 15	East	35	4.5	4.0	PVC	5.65	21.28	40%	2.2E+05	3.6E+05
			North	209								
253	DS-105	DS-57 - MH 08	West	10	4.5	4.0	PVC	0.23	0.87	40%	8.9E+03	1.5E+04
253	DS-50	DS-57 - MH 08	East	35	4.5	4.0	PVC	0.81	3.05	40%	3.1E+04	5.2E+04
253	DS-49	DS-57 - MH 08	East	35	4.5	4.0	PVC	0.81	3.05	40%	3.1E+04	5.2E+04
253	DS-48	DS-57 - MH 08	East	35	4.5	4.0	PVC	0.81	3.05	40%	3.1E+04	5.2E+04
253	DS-210	DS-57 - MH 08	East	37	4.5	4.0	PVC	0.86	3.23	40%	3.3E+04	5.5E+04
253	DS-106	DS-57 - MH 08	West	18	8.6250	4.0	PVC	1.02	6.28	40%	3.9E+04	1.1E+05
253	DS-107	DS-57 - MH 08	West	48	4.5	4.0	PVC	1.11	4.19	40%	4.3E+04	7.1E+04
253	DS-WH	DS-57 - MH 08	West	18	4.5	4.0	PVC	0.42	1.57	40%	1.6E+04	2.7E+04
Outside												
N/A	MH-40	MH-27	South	150	16.50000	12	RFCP	104.87	117.75	10%	7.4E+06	5.0E+05
N/A	LD Dock	MH-27	South	75	16.5	12	RFCP	52.44	58.88	10%	3.7E+06	2.5E+05
N/A	MH-27	MH-12	West	95	12	10.75	HDPE	14.73	59.85	10%	6.3E+05	2.5E+05
N/A	DS-103	DS-57 - MH 08	South	5	4.5	4.0	PVC	0.12	0.44	10%	4.5E+03	1.9E+03
N/A	DS-104	DS-57 - MH 08	South	5	4.5	4.0	PVC	0.12	0.44	10%	4.5E+03	1.9E+03
N/A	DS-105	DS-57 - MH 08	South	5	4.5	4.0	PVC	0.12	0.44	10%	4.5E+03	1.9E+03
N/A	Storm Grate	MH-12	East	75	12	10.75	HDPE	11.63	47.25	10%	4.9E+05	2.0E+05
N/A	Mh-10	MH-04	East	292	8.625	7.981	HDPE	17.02	101.39	10%	7.2E+05	4.3E+05
N/A	Mh-11	MH-05	East	296	8.625	7.981	HDPE	17.26	102.78	10%	7.3E+05	4.4E+05
N/A	Mh-04	MH-13	South	296	8.625	7.981	HDPE	17.26	102.78	10%	7.3E+05	4.4E+05
N/A	Mh-05	MH-04 MH-13	South	170	8.625	7.981	HDPE	9.91	59.03	10%	4.2E+05	2.5E+05
N/A	Mh-31	CO-311	South	180	8.625	7.981	HDPE	10.49	62.50	10%	4.5E+05	2.7E+05
N/A	Mh-18	MH-09	West	122	12.75	12	HDPE	12.35	95.77	10%	5.2E+05	4.1E+05
N/A	DS-109	MH 09- MH 18	North	34	4.5	4.0	PVC	0.79	2.97	10%	3.0E+04	1.3E+04
N/A	DS-110	MH 09- MH 18	North	28	4.5	4.0	PVC	0.65	2.44	10%	2.5E+04	1.0E+04
N/A	DS-111	MH 09- MH 18	North	25	4.5	4.0	PVC	0.58	2.18	10%	2.2E+04	9.3E+03
N/A	DS-112	MH 09- MH 18	North	25	4.5	4.0	PVC	0.58	2.18	10%	2.2E+04	9.3E+03
N/A	DS-114	MH 09- MH 18	South	12	4.5	4.0	PVC	0.28	1.05	10%	1.1E+04	4.4E+03
N/A	DS-115	MH 09- MH 18	South	12	4.5	4.0	PVC	0.28	1.05	10%	1.1E+04	4.4E+03
N/A	DS-116	MH 09- MH 18	South	12	4.5	4.0	PVC	0.28	1.05	10%	1.1E+04	4.4E+03
N/A	DS-117	MH 09- MH 18	South	12	4.5	4.0	PVC	0.28	1.05	10%	1.1E+04	4.4E+03
N/A	DS-118	MH 09- MH 18	South	12	4.5	4.0	PVC	0.28	1.05	10%	1.1E+04	4.4E+03

Appendix F
Volume Estimates for Underground Piping

Building-Room	Line Designation		Direction	Length (ft)	Pipe OD (in)	Pipe ID (in)	Pipe Material of Construction	Volume (wall) (ft^3)	Volume (interior) (ft^3)	% Filled (debris)	Mass (wall) (g)	Mass (debris) (g)
	From	To/Toward										
N/A	Mh-25	MH-07	North	72	8.625	7.981	HDPE	4.20	25.00	10%	1.8E+05	1.1E+05
N/A	MH-07	MH-19	North	80	8.625	7.981	HDPE	4.66	27.78	10%	2.0E+05	1.2E+05
N/A	Mh-25	MH-03	East	173	8.625	7.981	HDPE	10.09	60.07	10%	4.3E+05	2.6E+05
N/A	Mh-03	Outfall	South	314	8.625	7.981	HDPE	18.31	109.03	10%	7.8E+05	4.6E+05
N/A	Mh-03	DS-134	South	87	4.5	4.0	HDPE	2.02	7.59	10%	8.6E+04	3.2E+04
N/A	DS-136	MH-22 - MH DS	West	14	4.5	4.0	PVC	0.32	1.22	10%	1.2E+04	5.2E+03
N/A	DS-137	MH-22 - MH DS	South	14	4.5	4.0	PVC	0.32	1.22	5%	1.2E+04	2.6E+03
N/A	DS-124	MH-03 - MH 02	North	18	4.5	4.0	PVC	0.42	1.57	10%	1.6E+04	6.7E+03
N/A	DS-121	MH-03 - MH 02	South	14	4.5	4.0	PVC	0.32	1.22	10%	1.2E+04	5.2E+03
N/A	DS-123	MH-03 - MH 02	South	12	4.5	4.0	PVC	0.28	1.05	10%	1.1E+04	4.4E+03
N/A	DS-125	MH-03 - MH 02	South	10	4.5	4.0	PVC	0.23	0.87	10%	8.9E+03	3.7E+03
N/A	DS-126	MH-03 - MH 02	South	11	4.5	4.0	PVC	0.25	0.96	10%	9.8E+03	4.1E+03
N/A	MH-17	MH06	West	25	4.5	4.0	PVC	2.15	8.11	5%	8.3E+04	1.7E+04
		MH08	North	24								
		240 laundry room	West	44								
N/A	DS-137	MH-17	South	8	4.5	4.0	PVC	0.19	0.70	10%	7.1E+03	3.0E+03
N/A	MH-22	MH-01	East	150	8.625	7.981	HDPE	8.74	52.09	10%	3.7E+05	2.2E+05
N/A	DS-133	MH-01 - MH-22	South	8	4.5	4.0	PVC	0.19	0.70	10%	7.1E+03	3.0E+03
N/A	DS-	MH-01 - MH-22	South	8	4.5	4.0	PVC	0.19	0.70	10%	7.1E+03	3.0E+03
N/A	DS-	MH-01 - MH-22	South	8	4.5	4.0	PVC	0.19	0.70	10%	7.1E+03	3.0E+03
N/A	DS-	MH-01 - MH-22	South	30	4.5	4.0	PVC	0.70	2.62	10%	2.7E+04	1.1E+04
N/A	DS-	MH-01 - MH-22	South	11	4.5	4.0	PVC	0.25	0.96	10%	9.8E+03	4.1E+03
N/A	DS-	MH-01 - MH-22	South	8	4.5	4.0	PVC	0.19	0.70	10%	7.1E+03	3.0E+03
N/A	DS-	MH-01 - MH-22	South	8	4.5	4.0	PVC	0.19	0.70	10%	7.1E+03	3.0E+03
N/A	Mh-01	MH-02	North	233	8.625	7.981	HDPE	13.58	80.91	10%	5.8E+05	3.4E+05
N/A	Mh-02	MH-31	North	69	8.625	7.981	HDPE	4.02	23.96	10%	1.7E+05	1.0E+05
Building 110												
110	FD-300	MH04-MH10	South	81	4.5	4.026	PVC	1.78	7.16	10%	6.9E+04	3.0E+04
110	FD-301	FD-300	East	8	4.5	4.026	PVC	0.18	0.71	10%	6.8E+03	3.0E+03
110	FD-302	FD-300	East	8	4.5	4.026	PVC	0.18	0.71	10%	6.8E+03	3.0E+03
110	FD-303	CO-300	South	40	4.5	4.026	PVC	0.88	3.53	10%	3.4E+04	1.5E+04
110	CO-300	FD-300	SouthEast	12	4.5	4.026	PVC	0.26	1.06	10%	1.0E+04	4.5E+03
110	WC-300	MH04-MH10	South	30	4.5	4.026	PVC	0.66	2.65	10%	2.5E+04	1.1E+04

Appendix G
Radiological Sampling Results – Underground Piping
Figure 1, Sampling Results for the Process Buildings Underground Piping and Site Sewer Lines



Appendix G
Radiological Sampling Results – Underground Piping

Table 1

Bldg-Rm	Location ID	Direction	Distance (ft)	UNITS	Tc-99			U-234			U-235			U-238		
					Value	Error	MDC	Value	Error	MDC	Value	Error	MDC	Value	Error	MDC
Building 240																
240-11	PD-36	-	-	pCi/g	1.0E+03	8.7E+01	1.0E+00	3.2E+03	-	1.9E+00	1.2E+02	-	2.7E-03	4.5E+02	-	4.0E-04
240-11	CO-37	north	57	pCi/g	4.3E+03	3.7E+02	6.0E+00	1.7E+02	-	2.2E-03	5.6E+00	-	6.9E-05	1.3E+01	-	9.9E-06
240-11	CO-209	west	23	pCi/g	5.8E+01	5.1E+00	4.0E-01	1.3E+03	-	1.9E-01	4.4E+01	-	6.7E-03	6.4E+01	-	9.9E-03
240-11	PD-36	N/A	N/A	pCi/g	6.3E+03	5.4E+02	8.0E+00	1.1E+01	-	2.2E-03	4.0E-01	-	2.7E-06	1.0E+00	-	4.0E-07
240-14	CO-NEMS	west	to 8	pCi/g	1.1E+03	9.6E+01	1.0E+00	4.7E+04	-	9.3E-01	1.6E+03	-	1.4E-02	3.3E+03	-	4.0E-03
240-14	CO-45	-	7	pCi/g	2.3E+00	3.8E-01	3.9E-01	3.0E+02	-	1.9E-01	1.2E+01	-	2.7E-04	3.2E+01	-	4.0E-05
240-14	PD-46	N/A	N/A	pCi/g	1.3E+02	1.1E+01	5.0E-01	1.9E+04	-	1.9E-01	7.9E+02	-	6.7E-03	2.8E+03	-	9.9E-03
240-14	PD-44	N/A	N/A	pCi/g	2.0E+00	3.7E-01	4.0E-01	4.4E+04	-	4.7E+00	1.1E+03	-	6.8E-02	2.1E+02	-	9.9E-03
240-14	PD-42	N/A	N/A	pCi/g	4.4E+02	3.7E+01	6.0E-01	8.1E+03	-	1.9E-01	2.9E+02	-	6.7E-03	8.4E+02	-	9.9E-03
240-14	CO-45	north	to 7	pCi/g	5.0E+02	4.2E+01	2.0E+00	3.7E+01	-	2.2E-03	1.3E+00	-	6.9E-05	6.0E+00	-	9.9E-06
240-7	Vent 2 Lab	N/A	N/A	pCi/g	4.9E+01	4.3E+00	4.0E-01	7.5E+02	-	1.9E-01	2.9E+01	-	6.7E-03	8.8E+01	-	9.9E-03
240-7	CO-Lab-North	south	to 43	pCi/g	1.2E+01	1.2E+00	4.0E-01	1.1E+03	-	1.9E-01	5.0E+01	-	6.7E-03	2.6E+02	-	9.9E-03
				Average	1.2E+03			1.0E+04			3.3E+02			6.7E+02		
				Min	2.0E+00			4.7E+04			1.6E+03			3.3E+03		
				Max	6.3E+03			1.1E+01			4.0E-01			1.0E+00		
Building 255																
255-47	CO-225	South	to-32	pCi/g	2.8E+01	2.6E+00	5.0E-01	3.1E+03	-	4.7E+00	1.2E+02	-	6.7E-03	7.7E+02	-	9.9E-04
255-53	PD-228	-	13	pCi/g	1.7E+00	3.5E-01	4.0E-01	1.1E+02	-	1.9E-01	4.5E+00	-	2.7E-04	3.2E+01	-	9.9E-03
255-53	PD-228	west	to 12	pCi/g	3.6E+01	3.1E+00	8.0E-01	4.7E+00	-	2.2E-03	1.6E-01	-	2.7E-06	9.1E-01	-	4.0E-07
255-56	CO-230	north	to 35	pCi/g	4.4E+01	3.9E+00	5.0E-01	6.9E+03	-	1.9E+00	2.6E+02	-	2.7E-03	6.3E+02	-	4.0E-04
255-59	PD-232	north	to 12	pCi/g	2.3E+00	4.1E-01	4.2E-01	1.6E+03	-	1.9E-01	6.0E+01	-	6.7E-03	1.7E+02	-	9.9E-03
255-61	CO-232	north	30	pCi/g	3.4E+00	5.4E-01	5.4E-01	4.5E+02	-	1.9E-01	1.5E+01	-	2.7E-04	3.6E+01	-	4.0E-05
				Average	1.9E+01			2.0E+03			7.7E+01			2.7E+02		
				Min	1.7E+00			4.7E+00			1.6E-01			9.1E-01		
				Max	4.4E+01			6.9E+03			2.6E+02			7.7E+02		
Building 260																
260-65	CO-164	east	to 12	pCi/g	1.4E+02	1.2E+01	5.0E-01	5.5E+04	-	4.7E+01	2.1E+03	-	6.8E-02	8.2E+03	-	9.9E-03
260-66	CO-170	-	-	pCi/g	8.9E+00	9.4E-01	4.2E-01	4.4E+03	-	1.9E-01	1.9E+02	-	6.7E-03	6.7E+02	-	9.9E-03
260-66	CO-170	N/A	N/A	pCi/g	3.1E+01	2.8E+00	4.0E-01	4.8E+04	-	4.7E+00	2.3E+03	-	6.8E-02	8.2E+03	-	9.9E-03
				Average	5.9E+01			3.6E+04			1.5E+03			5.7E+03		
				Min	8.9E+00			4.4E+03			1.9E+02			6.7E+02		
				Max	1.4E+02			5.5E+04			2.3E+03			8.2E+03		

Appendix G
Radiological Sampling Results – Underground Piping

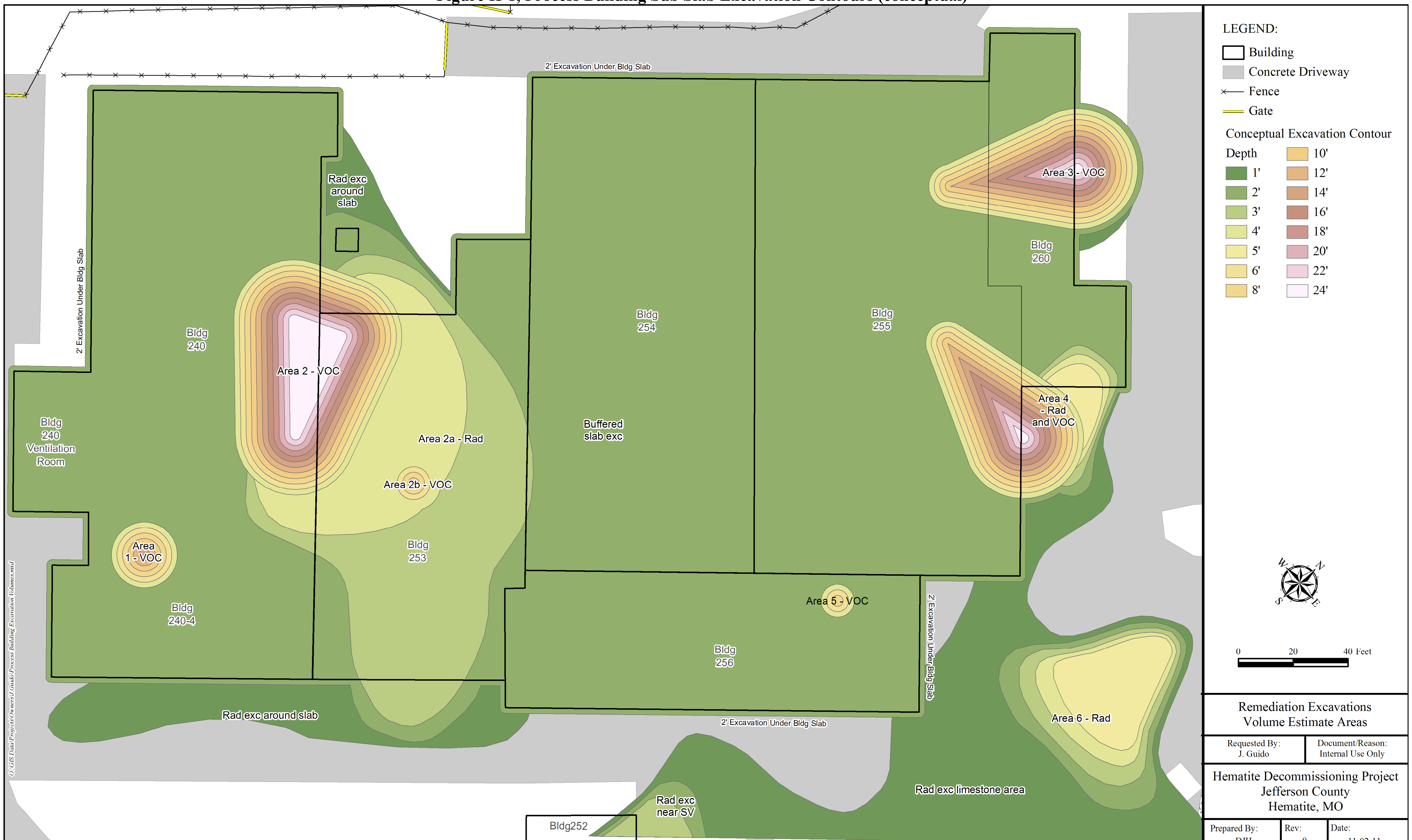
Table 1 (continued)

Bldg-Rm	Location ID	Direction	Distance (ft)	UNITS	Tc-99			U-234			U-235			U-238		
					Value	Error	MDC	Value	Error	MDC	Value	Error	MDC	Value	Error	MDC
Outside Process Building																
N/A	MH-5	east	190	pCi/g	5.6E+00	7.0E-01	5.2E-01	3.7E+00	-	1.9E-01	1.3E-01	-	2.7E-04	6.6E-01	-	4.0E-05
N/A	MH-16	south	47	pCi/g	1.7E+02	1.5E+01	5.0E-01	2.4E+03	-	1.9E+00	1.0E+02	-	2.7E-03	4.3E+02	-	4.0E-04
N/A	MH-8	east	120	pCi/g	3.3E+01	3.0E+00	4.0E-01	1.5E+02	-	1.9E-01	5.9E+00	-	2.7E-04	2.5E+01	-	4.0E-05
N/A	MH-14	northeast	120	pCi/g	1.6E+00	6.2E-01	9.7E-01	1.4E-01	-	2.2E-04	5.3E-03	-	2.7E-07	2.7E-02	-	4.0E-08
				Average	5.4E+01			6.5E+02			2.7E+01			1.1E+02		
				Min	1.6E+00			1.4E-01			5.3E-03			2.7E-02		
				Max	1.7E+02			2.4E+03			1.0E+02			4.3E+02		

APPENDIX H

Sub-Slab Sample Data Summary

Figure H-1, Process Building Sub Slab Excavation Contours (conceptual)



APPENDIX H
Sub-Slab Sample Data Summary
Figure H-2, Process Building Sub Slab Sample Locations

Tc99 Samples Process Building	
Requested By: K. Davis	Document/Reason: Alt. Disposal Presentation

Hematite Decommissioning Project
Jefferson County
Hematite, MO

Prepared By:	Rev:	Size:	Date:
DJH, JCD	0	11X17	01-11-12

APPENDIX H
Sub-Slab Sample Data Summary

Table H-1, Surface CSM Data Summary - Beneath Bldg. 253

	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
Count	5	6	6	6
Count <MDA	0	0	1	0
Minimum, pCi/g	109	10	1	3
Maximum, pCi/g	168	99	5	7
Average, pCi/g	143	31	2	4
st dev	30	34	2	2

Table H-2, Surface CSM - (Bldg. 253) Sample Data

Sample ID	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
Location #08	112	15.5	0.84	6.6
Location #36	160	18.1	0.99	5.1
Location #37	166	98.9	5.0	3.5
Location #36	160	18.1	18.1	5.1
Location #47	109	9.5	0.52	2.9
Location #48	168	19.1	1.1	5.6
BLD253-02-Fill	-	21.9	1.2	2.6

APPENDIX H
Sub-Slab Sample Data Summary

Table H-3, Surface CSM Data Summary - Excluding Bldg. 253

	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
Count	43	48	48	48
Count <MDA	13	0	5	5
Minimum, pCi/g	-0.40	0.28	0.02	0.09
Maximum, pCi/g	12	1842	100	685
Average, pCi/g	3	105	5.4	32
st dev	3	284	15	104

Table H-4, Surface CSM- (Excluding Bldg. 253) Sample Data

Sample ID	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
BD-19-0.5-SL	0.0	3.0	0.2	0.6
BD-24-0.5-SL	0.8	8.6	0.4	2.0
BD-28-0.5-SL	0.7	12.7	0.4	2.0
BLD240-01-Fill	-	106.9	5.9	17.0
BLD240-03-Fill	-	324.3	17.9	71.0
BLD240-04-Fill	-	12.7	0.7	2.6
BLD255-05-Fill	-	3.2	0.2	1.7
BLD260-06-Fill	-	60.7	3.3	16.4
Location #01	-0.40	28.1	1.5	2.8
Location #02	-0.13	2.6	0.049	0.56
Location #03	12	1842.1	100	685
Location #04	-0.18	426.7	23	178
Location #05	1.3	490.5	27	173
Location #06	0.71	6.1	0.31	0.23
Location #07	0.27	1.1	0.059	0.31
Location #09	0.12	8.9	0.49	1.1
Location #11	0.85	0.8	0.038	0.75
Location #12	0	3.0	0.16	1.6
Location #13	0.97	320.8	18	72
Location #14	0.54	408.2	20	11
Location #15	2.1	79.9	4.3	30
Location #16	2.3	103.6	5.5	55

APPENDIX H
Sub-Slab Sample Data Summary

Table H-4, Surface CSM- (Excluding Bldg. 253) Sample Data

Sample ID	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
Location #17	0.23	3.5	0.18	2.3
Location #18	0.31	78.4	4.1	46
Location #19	10	26.6	1.4	13
Location #20	5.2	235.7	13	74
Location #21	11	85.2	4.7	28
Location #31	1.8	0.4	0.020	0.15
Location #32	1.9	0.4	0.020	0.25
Location #33	2.0	0.4	0.022	0.093
Location #34	1.7	3.3	0.18	0.33
Location #35	8.8	52.8	2.4	0.71
Location #38	2.0	2.7	0.15	0.62
Location #39	2.6	4.3	0.24	1.3
Location #40	10	56.1	3.1	14
Location #41	3.9	39.6	2.2	10.0
Location #42	10.0	13.8	0.76	3.1
Location #43	2.0	0.5	0.027	0.19
Location #44	1.7	3.2	0.18	0.90
Location #45	1.9	1.2	0.063	0.51
Location #46	2.0	0.4	0.023	0.27
Location #49	2.0	0.3	0.015	0.12
Location #50	2.2	137.7	6.0	1.5
Location #51	1.8	2.9	0.16	0.53
Location #52	3.9	11.2	0.62	1.7
Location #53	2.1	8.6	0.47	1.3
Location #54	2.2	0.4	0.019	0.30
Location #55	2.2	0.6	0.033	0.29
BLD253-02-01	28.7	16.3	0.9	3.7
BLD255-08-01	30.2	250.8	13.4	17.3
BLD260-06-01	25.2	17.8	0.8	5.0

APPENDIX H
Sub-Slab Sample Data Summary

Table H-5, Root CSM Data Summary – Beneath Bldg. 253

	Tc-99 pCi/g	**U-234 pCi/g**	**U-235 pCi/g**	**U-238 pCi/g**
Count	5	6	6	6
Count <MDA	0	0	2	0
Minimum, pCi/g	8	1	0.1	2
Maximum, pCi/g	151	172	8	11
Average, pCi/g	47	37	2	6
st dev	60	66	3	4

Table H-6, Root CSM - (Bldg. 253) Sample Data

Sample ID	**Tc-99 pCi/g**	**U-234 pCi/g**	**U-235 pCi/g**	**U-238 pCi/g**
BD-30-2.5-SL	151.0	16.1	0.7	3.3
BD-30-4.5-SL	20.2	10.0	2.6	10.4
BD-33-2.5-SL	47.3	8.7	0.4	2.4
BD-33-4.5-SL	7.8	1.4	0.1	2.1
BLD253-02-01	-	16.3	0.9	3.7
BLD253-02-04	7.5	172.0	7.7	11.1

APPENDIX H
Sub-Slab Sample Data Summary

Table H-7, Root CSM Data Summary - Excluding Bldg. 253

	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
Count	12	20	20	20
Count <MDA	7	0 / 9	11	8
Minimum	-0.3	0.6	-0.4	-0.4
Maximum	30	251	13	17
Average	3	20	1	3
st dev	9	56	3	4

Table H-8, Root CSM - (Excluding Bldg. 253) Sample Data

Sample ID	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
BD-17-2.5-SL	5.0	69.0	3.2	11.8
BD-17-4.5-SL	-0.2	2.4	0.1	1.3
BD-18-2.5-SL	-0.1	0.6	0.0	0.6
BD-18-4.5-SL	-0.3	2.2	0.1	0.4
BD-21-2.5-SL	-0.1	3.1	0.1	0.7
BD-21-4.5-SL	0.3	0.7	0.1	0.7
BD-26-2.5-SL	1.9	1.2	0.1	0.7
BD-26-4.5-SL	1.6	0.8	0.0	0.8
BD-29-2.5-SL	1.3	12.2	0.5	2.6
BD-29-4.5-SL	0.0	2.9	0.2	0.7
BD-36-4.5-SL	-0.2	16.4	0.7	1.8
BLD240-01-01	-	2.3	0.1	1.1
BLD240-04-02	-	0.7	0.0	1.7
BLD240-04-04	-	5.4	0.3	0.9
BLD240-05-01	-	1.4	-0.1	1.4
BLD240-05-02	-	1.6	-0.4	1.6
BLD255-07-02	-	1.3	0.1	1.7
BLD255-08-01	30.2	250.8	13.4	17.3
BLD260-06-01	-	17.8	0.8	5.0
BLD260-06-03	-	2.2	0.1	0.6

APPENDIX H
Sub-Slab Sample Data Summary

Table H-9, Deep CSM Data Summary - Excluding Bldg. 253

	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
Count	7	9	9	9
Count <MDA	0	0	9	8
Minimum, pCi/g	5	1	-0.1	1
Maximum, pCi/g	28	7	0	2
Average, pCi/g	13	4	0.2	2
st dev	8	2	0.1	0.3

Table H-10, Deep CSM - (Bldg. 253) Sample Data

Sample ID	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
BD-30-16.5-SL	14.4	3.31	0.18	1.2
BD-30-20.5-SL	8.12	4.78	0.26	1.74
BD-30-8.5-SL	5.22	1.10	-0.13	1.1
BD-30-9-SL	-	3.90	0.21	1.6
BD-33-12.5-SL	-	3.22	0.17	1.7
BD-33-12-SL	15.4	3.36	0.18	1.5
BD-33-16.5-SL	27.5	7.44	0.41	1.78
BD-33-20.5-SL	15.4	5.86	0.32	1.9
BD-33-8.5-SL	5.61	4.92	0.27	1.4

APPENDIX H
Sub-Slab Sample Data Summary

Table H-11, Deep CSM Data Summary - Excluding Bldg. 253

	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
Count	22	31	31	31
Count <MDA	19	0	30	30.0
Minimum	-0.3	0.1	-0.09	0.000
Maximum	1	7	0	3
Average	0	3	0.1	1
st dev	0.4	2	0.1	1

Table H-12, Deep CSM - (Excluding Bldg. 253) Sample Data

Sample ID	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
BD-17-12.5-SL	0.09	3.91	0.21	1.7
BD-17-16.5-SL	-0.31	2.62	0.14	1.2
BD-17-20.5-SL	-0.3	1.10	-0.09	1.1
BD-17-8.5-SL	-	2.54	0.14	0.4
BD-17-8-SL	0.3	4.79	0.26	1.8
BD-18-12.5-SL	-0.2	3.09	0.17	0.84
BD-18-16-SL	-0.17	5.16	0.28	1.9
BD-18-20.5-SL	-0.14	1.63	0.05	0
BD-18-8.5-SL	-	0.71	0.01	1.0
BD-18-8-SL	0.03	2.16	0.1	2.5
BD-21-12-SL	0.21	3.56	0.18	2.7
BD-21-16.5-SL	0.21	2.40	0.13	0.9
BD-21-20.5-SL	0.16	1.77	0.08	2.24
BD-21-8.5-SL	0.45	1.24	0.06	1.2
BD-21-9-SL	-	5.04	0.27	2.3
BD-26-12-SL	0.31	0.14	0.003	1.9
BD-26-16.5-SL	-0.22	2.05	0.11	0.9
BD-26-20-SL	0.36	2.95	0.16	1.1
BD-26-7.5-SL	-	1.22	0.05	2.0
BD-29-12.5-SL	0.87	1.18	0.04	2.7
BD-29-16.5-SL	0.99	5.62	0.31	1.3
BD-29-20.5-SL	1.13	5.58	0.3	2.4

APPENDIX H
Sub-Slab Sample Data Summary

Table H-12, Deep CSM - (Excluding Bldg. 253) Sample Data

Sample ID	Tc-99 pCi/g	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
BD-29-8.5-SL	-	4.39	0.22	1.0
BD-29-8-SL	0.26	2.00	0.1	1.6
BD-36-12.5-SL	-	1.38	0.07	1.0
BD-36-12-SL	-0.06	2.49	0.13	1.46
BD-36-16.5-SL	0.31	1.70	-0.09	1.7
BD-36-8-SL	-0.25	3.66	0.2	1.2
BLD240-01-09	-	4.17	0.23	0.9
BLD255-07-15	-	6.70	0.37	1.1
BLD255-08-08	-	6.18	0.34	0.9

APPENDIX I
Visual Sample Plan© Software Evaluation

VSP© Software Sample Design Report for Calculating a One-Sided Confidence Interval for the Population Mean Using Simple Random Sampling

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Construct a Confidence Interval on the True Mean
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Formula for calculating number of sampling locations	Confidence Limits using Student's t-distribution
Calculated total number of samples	85

Primary Sampling Objective

The primary purpose of sampling at this site is to construct a confidence interval on the true population mean value. After the samples are collected and analyzed, the resulting sample values can be used to construct a one-sided confidence interval. Once the confidence interval is computed (which will be an upper threshold), you can have the specified confidence that the true population mean is less than the upper threshold.

Selected Sampling Approach

A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are true. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling

APPENDIX I
Visual Sample Plan© Software Evaluation

does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a confidence interval calculation using the Student's t-distribution. The formula used to calculate the number of samples is:

$$n = \left[\frac{t_{1-\alpha,df} S_{total}}{d}\right]^2$$

where

n is the recommended minimum sample size for the study area,
S_{total} is the estimated standard deviation due to both sampling and analytical variability,
α is the maximum acceptable probability that the true mean will not lie in the confidence interval (the confidence level is $1-\alpha$),
d is the width of the confidence interval,
$t_{1-\alpha,df}$ is the value of the Student's t-distribution with $df=n-1$ degrees of freedom such that the proportion of the distribution less than $t_{1-\alpha}$ is $1-\alpha$.

Because *n* appears on both sides of the equation (on the right side it appears in the degrees of freedom of the t-statistic), the equation must be solved iteratively. VSP© Software does this automatically using the iteration scheme in Gilbert (1987, pg. 32).

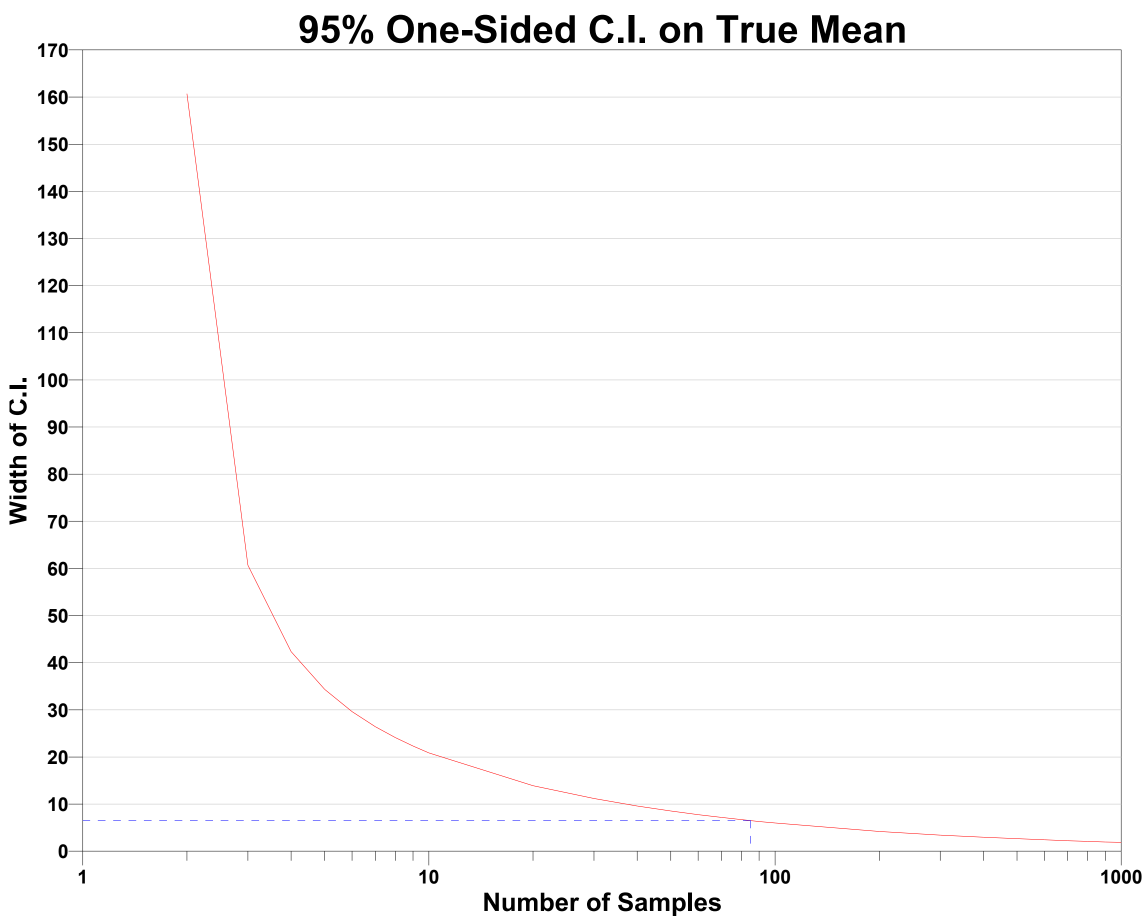
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter			
		S	d	α	$t_{1-\alpha,df}$
Analyte 1	85	36	6.5	5%	1.66388 [a]

[a] This value is automatically calculated by VSP© Software based upon the user defined value of α

The following figure is a graph representing the relationship between the width of the confidence interval and the number of samples. The blue dashed line illustrates the specified maximum desirable confidence interval width. Where this dashed line intersects the red curve is the number of samples calculated by VSP© Software.

APPENDIX I
Visual Sample Plan© Software Evaluation



APPENDIX J
Sample Locations

Details on Sample Locations, Samples 1 - 21

Sample Station ID	Location	Resurfaced Concrete Regions	Expansion Joints, Crack, Seams, and/or Near Walls	Identified as Hot Spot	Comments
1	Building 240		X		
2A*	Building 240	X		X	Station IDs ending with 'A' indicate samples obtained from the newer (resurfaced) concrete region and those ending with 'B' are from the older concrete region
2B*	Building 240	X		X	
3A*	Building 240	X	X		
3B*	Building 240	X	X		
4*	Building 240		X		
5*	Building 240			X	
6*	Building 240		X		
7*	Building 240			X	
8	Building 253			X	
9	Building 254		X		
10	Building 254			X	
11	Building 254				Representative sample of the general area
12	Building 254				Representative sample of the general area
13	Building 255		X		
14	Building 255		X		
15	Building 255				Representative sample of the general area
16	Building 260		X	X	
17	Building 255		X	X	
18	Building 255		X		
19	Building 260				Representative sample of the general area
20*	Building 260		X		
21*	Building 260			X	

*Sample station in area with historical operations involving materials contaminated with Tc-99.

Source: Based on Table 1.1 of NSA-TR-HDP-11-11

APPENDIX J
Sample Locations

Details on Sample Locations, Samples 31 - 55

Sample Station ID	Location	Purpose
31	Building 240	Bound elevated Tc-99
32	Building 240	Bound elevated Tc-99
33	Building 240	Bound elevated Tc-99
34	Building 240	Bound elevated Tc-99
35	Building 240	Bound elevated Tc-99
36	Building 253	Bound elevated Tc-99
37	Building 253	Bound elevated Tc-99
38	Building 260	Bound elevated Tc-99
39	Building 260	Bound elevated Tc-99
40	Building 260	Bound elevated Tc-99
41	Building 260	Bound elevated Tc-99
42	Building 260	Bound elevated Tc-99
43	Building 240	Additional representative sample
44	Building 240	Additional representative sample
45	Building 240	Additional representative sample
46	Building 240	Additional representative sample
47	Building 253	Additional representative sample
48	Building 253	Additional representative sample
49	Building 254	Additional representative sample
50	Building 256	Additional representative sample
51	Building 256	Additional representative sample
52	Building 252	Additional representative sample
53	Building 252	Additional representative sample
54	Building 235	Additional representative sample
55	Building 235	Additional representative sample
56	Building 254	Characterize Elevated Area
57	Building 254	Characterize Elevated Area
58	South Vault	Characterize Elevated Area
59	South Vault	Characterize Elevated Area

Source: Work Package HDP-OPS11-WP-005, Concrete Sampling from Process Building, South Vault and West Vault Floors

APPENDIX K
Visual Sample Plan© Software Evaluation – Supplemental Concrete Sampling
VSP Sample Design Report for Calculating a One-Sided Confidence Interval for the Population Mean Using Systematic Grid Sampling

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field is also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Construct a Confidence Interval on the True Mean
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Systematic with a random start location
Formula for calculating number of sampling locations	Confidence Limits using Student's t-distribution
Calculated total number of samples	20
Number of samples on map [a]	129
Number of selected sample areas [b]	7
Grid pattern	Triangular

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

APPENDIX K
Visual Sample Plan© Software Evaluation – Supplemental Concrete Sampling

Primary Sampling Objective

The primary purpose of sampling at this site is to construct a confidence interval on the true population mean value. After the samples are collected and analyzed, the resulting sample values can be used to construct a one-sided confidence interval. Once the confidence interval is computed (which will be an upper threshold), you can have the specified confidence that the true population mean is less than the upper threshold.

Selected Sampling Approach

A parametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are true. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the

statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a confidence interval calculation using the Student's t-distribution. The formula used to calculate the number of samples is:

$$n = \left[\frac{t_{1-\alpha,df}\, S_{total}}{d}\right]^2$$

where

n is the recommended minimum sample size for the study area,

S_{total} is the estimated standard deviation due to both sampling and analytical variability,

α is the maximum acceptable probability that the true mean will not lie in the confidence interval (the confidence level is $1-\alpha$),

d is the width of the confidence interval,

$t_{1-\alpha,df}$ is the value of the Student's t-distribution with $df=n-1$ degrees of freedom such that the proportion of the distribution less than $t_{1-\alpha}$ is $1-\alpha$.

Because n appears on both sides of the equation (on the right side it appears in the degrees of freedom of the t-statistic), the equation must be solved iteratively. VSP does this automatically using the iteration scheme in Gilbert (1987, pg. 32).

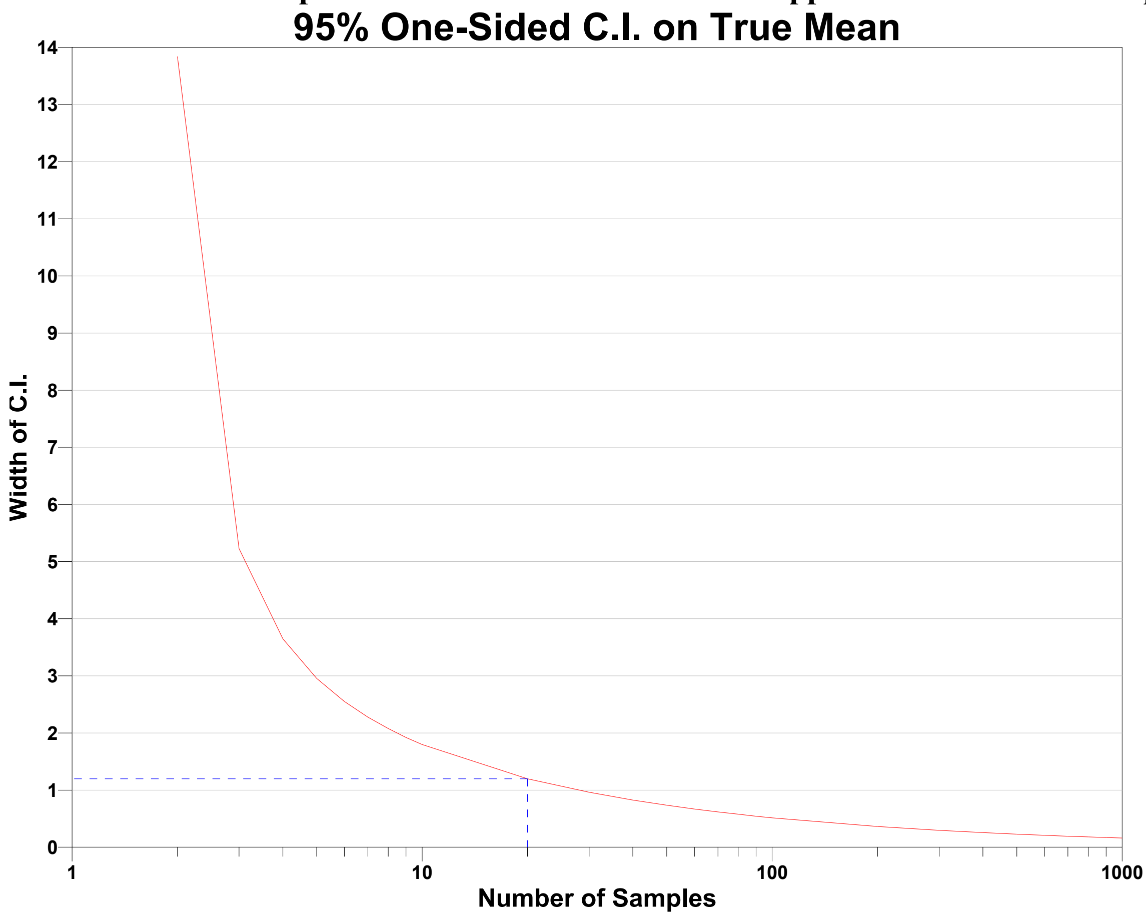
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter			
		S	d	α	$t_{1-\alpha,df}$
Analyte 1	20	3.1	1.2	5%	1.72913 [a]

[a] This value is automatically calculated by VSP based upon the user defined value of α

The following figure is a graph representing the relationship between the width of the confidence interval and the number of samples. The blue dashed line illustrates the specified maximum desirable confidence interval width. Where this dashed line intersects the red curve is the number of samples calculated by VSP.

APPENDIX K
Visual Sample Plan© Software Evaluation – Supplemental Concrete Sampling



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the sample mean is normally distributed,
2. the population values are not spatially or temporally correlated, and
3. the sampling locations will be selected probabilistically.

The first two assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, confidence level (1-α) (%) and width of confidence interval. The following table shows the results of this analysis.

Number of Samples						
	d=0.6		d=1.2		d=1.8	
	s=6.2	s=3.1	s=6.2	s=3.1	s=6.2	s=3.1

APPENDIX K
Visual Sample Plan© Software Evaluation – Supplemental Concrete Sampling

CL=99	582	148	148	40	68	20
CL=97	380	97	97	26	45	13
CL=95	291	75	75	20	34	10
CL=93	235	60	60	17	28	8
CL=91	194	50	50	14	23	7

s = Standard Deviation
CL = Confidence Level (1-α) (%)
d = Width of Confidence Interval

Recommended Data Analysis Activities

Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compute a confidence interval, the data should be assessed in this context. Assuming the data are adequate, at least one statistical test should be done to evaluate whether the data are normally distributed. Appropriate confidence intervals for the mean value should then be calculated. Results of the exploratory and quantitative assessments of the data should be reported, along with conclusions that may be supported by them.

This report was automatically produced* by Visual Sample Plan (VSP) software version 6.0.

Software and documentation available at http://vsp.pnl.gov

* - The report contents may have been modified or reformatted by end-user of software.

APPENDIX L
Calculation of Soil Volume Beneath Process Buildings

Volume

Using in-situ density of 1.69 g/cm^3 and post-excavation density of 1.44 g/cm^3, the calculated in-situ volume is multiplied by 1.69/1.44 to get the post-excavation volume that would be shipped and is presented in Table 9-1 of HDP-TBD-WM-906.

The in-situ volume is calculated using the projected excavation contours shown on Figure H-1 in Appendix H of HDP-TBD-WM-906. These contours are based on both radiological and chemical contamination. The Graphical Information System (GIS) that generated the contours was also used to generate the area covered by the contours.

Since the soil sample data were taken within the depth profiles of 0 – ½ ft, ½ ft – 5 ft, and > 5 ft, separate volume estimates were calculated for each of these profiles. Each of these three volume estimates was then subdivided based on whether the soil was beneath Building 253 or not because data from Building 253 represented a distinct population. Additional detail on how the volume contours shown in Figure H-1were converted to numerical values is included below.

Curie Amounts

Results from samples taken from within these six volume estimates where then averaged (mean). Tables H-1 through H-12 show the sample results and statistics associated with each of the six volume estimates. The locations of the Sample Stations are shown in Figure H-2 in HDP-PR-WM-906. Finally, the average concentration for each radionuclide was multiplied by the volume to arrive at the total activities shown in Table 9-1.

APPENDIX L
Calculation of Soil Volume Beneath Process Buildings

Volume Calculation – all layers

Conversion – in-situ volume to shipped volume
Shipped density is 90 lb/ft3,
In-situ density is 1.69 g/cm3 = 105.4 lb/ft3
Conversion from in-situ volume to shipped = 105.4 / 90 = 1.17
Conversion from cubic yards to cubic meters = 0.765 m3 / yd3
Therefore: Conversion from cubic yards in-situ to cubic meters shipped = 0.765 * 1.17 = 0.895

Volume Calculation - 0 - 1/2 ft layer

Contour Data - 0 - 1/2 ft layer

Row No.	Depth (ft)	SHAPE_Area (ft^2)	Location	Volume (ft^3)	Interval (ft)
A1	1	75	Rad excavation around slab	75	1
A2	1	534	Rad excavation around slab	534	1
A3	1	2383	Rad excavation around slab	2383	1
A4	1	10941	Rad excavation limestone area	10941	1
Total				47259	
				1750	(yd^3)

Calculation Basis: SUM (A1 through A4)*0.5+0.25*B2
1/2 of sum of (A1 through A4) since they are 0 - 1 ft layers and calculation is for 0.5 ft layer
1/4 of buffered slab value (row B2 from calculation table below) added since it is a 0 - 2 foot layer

Total Under BLD 253 = Building Footprint to 1/2 foot
= 9585 ft * 0.5 ft * 1 yd^3 / 27 ft^3 = 178 yd^3 (in-situ)
= 159 m^3 (shipped)

Total Excluding BLD 253 =1750 yd^3 - 178 yd^3 = 1573 yd^3 (in-situ) = 1408 m^3 (shipped)

Volume Calculation - 1/2 - 5 ft layer

Contour Data - 1/2 - 5 ft layer

Row No.	Depth (ft)	SHAPE_Area (ft^2)	Location	Volume (ft^3)	Interval (ft)
B1	2	3038	Area 6 Rad	3038	1

APPENDIX L
Calculation of Soil Volume Beneath Process Buildings

B2	2	80585	Buffered slab excavation	161171	2
B3	2	486	Rad excavation near SV	486	1
B4	4	452	Area 1 VOC	904	2
B5	3	8624	Area 2a Rad and VOC	8624	1
B6	4	2990	Area 2a Rad and VOC	2990	1
B7	4	4066	Area 2a Rad and VOC	8132	2
B8	4	2312	Area 3 VOC	4624	2
B9	3	584	Area 4 Rad and VOC	584	1
B10	4	422	Area 4 Rad and VOC	422	1
B11	4	2248	Area 4 Rad and VOC	4497	2
B12	5	292	Area 4 Rad and VOC	292	1
B13	4	113	Area 5 VOC	226	2
B14	3	2240	Area 6 Rad	2240	1
B15	4	1617	Area 6 Rad	1617	1
B16	5	1144	Area 6 Rad	1144	1
B17	3	274	Rad excavation near SV	274	1
Total				167938	
				6220	(yd^3)

APPENDIX L
Calculation of Soil Volume Beneath Process Buildings

Calculation Basis:	SUM (B1, B3 through B17) + 0.75*B2 + 0.5*SUM (A1 through A4) 3/4 of buffered slab value (B2) since it is a 0 - 2 foot layer 1/2 of SUM (A1 through A4) since they are 0 - 1 ft layers
Total Under BLD 253	= Building Footprint from 1/2 to 2 foot + (Area 2a Rad and VOC) = 9585 * 1.5 * 1/27 + B5 + B6 + 0.5 * B7 = 1113 yd^3 (in-situ) = 997 m^3 (shipped)
Total Excluding BLD 253	= 6220 yd^3 - 1113 yd^3 = 5107 yd^3 (in-situ) = 4573 m^3 (shipped)

APPENDIX L
Calculation of Soil Volume Beneath Process Buildings

Volume Calculation - > 5 ft layer

Contour Data - > 5 ft layer

Row No.	Depth (ft)	SHAPE_Area (ft^2)	Location	Volume (ft^3)	Interval (ft)
C1	6	314	Area 1 VOC	627	2
C2	8	201	Area 1 VOC	401	2
C3	10	113	Area 1 VOC	226	2
C4	12	50	Area 1 VOC	100	2
C5	14	12	Area 1 VOC	25	2
C6	6	3603	Area 2 Rad and VOC	7206	2
C7	8	3165	Area 2 Rad and VOC	6330	2
C8	10	2752	Area 2 Rad and VOC	5504	2
C9	12	2364	Area 2 Rad and VOC	4729	2
C10	14	2002	Area 2 Rad and VOC	4004	2
C11	16	1665	Area 2 Rad and VOC	3329	2
C12	18	1352	Area 2 Rad and VOC	2705	2
C13	20	1066	Area 2 Rad and VOC	2131	2
C14	22	804	Area 2 Rad and VOC	1608	2
C15	24	567	Area 2 Rad and VOC	1135	2
C16	6	113	Area 2b Rad and VOC	226	2
C17	8	50	Area 2b Rad and VOC	100	2
C18	10	12	Area 2b Rad and VOC	25	2
C19	6	1941	Area 3 VOC	3882	2
C20	8	1595	Area 3 VOC	3190	2
C21	10	1275	Area 3 VOC	2549	2
C22	12	979	Area 3 VOC	1958	2
C23	14	717	Area 3 VOC	1435	2
C24	16	496	Area 3 VOC	993	2
C25	18	316	Area 3 VOC	632	2
C26	20	176	Area 3 VOC	352	2
C27	22	77	Area 3 VOC	154	2

APPENDIX L
Calculation of Soil Volume Beneath Process Buildings

Contour Data - > 5 ft layer

Row No.	Depth (ft)	SHAPE_Area (ft^2)	Location	Volume (ft^3)	Interval (ft)
C28	24	18	Area 3 VOC	37	2
C29	6	1886	Area 4 Rad and VOC	3773	2
C30	8	1550	Area 4 Rad and VOC	3100	2
C31	10	1238	Area 4 Rad and VOC	2476	2
C32	12	952	Area 4 Rad and VOC	1904	2
C33	14	698	Area 4 Rad and VOC	1396	2
C34	16	483	Area 4 Rad and VOC	967	2
C35	18	308	Area 4 Rad and VOC	616	2
C36	20	172	Area 4 Rad and VOC	344	2
C37	22	75	Area 4 Rad and VOC	151	2
C38	24	18	Area 4 Rad and VOC	36	2
C39	6	50	Area 5 VOC	100	2
C40	8	12	Area 5 VOC	25	2
	Total			70478	
				2610	(yd^3)

APPENDIX L
Calculation of Soil Volume Beneath Process Buildings

Calculation Basis: Sum (C1 through C40)

Total Under BLD 253 = 1/2 (Area 2 Rad and VOC) + (Area 2b Rad and VOC)
= 1/2 Sum (C6 through C15) + Sum (C16 through C18)
=729 yd^3 (in-situ) = 653 m^3 (shipped)

Total Excluding BLD 253 =2610 yd^3 - 729 yd^3 = 1881 yd^3 (in-situ) = 1684 m^3 (shipped)

APPENDIX M
Calculation of Activity – Concrete and Asphalt

The following tables show the data used in the calculation. For Elevated Locations 1 and 2, the calculations were done conservatively using data that would skew the average high. For Elevated Locations 1 and 2, the tables also show what the result would have been had all of the data been used, as a demonstration of the conservative nature of the original calculation.

The concrete population was grouped based on area and activity levels as follows:

- Elevated Area 1 - Bldg 240, Red Room
- Elevated Area 2 - Bldg 240, Green Room
- Elevated Area 3 - Bldg 254
- Elevated Area 4 -Bldg 255
- Elevated Area 6 - Bldg 252
- Bldg 235
- Balance of Process Buildings Excluding: Areas (1-4), area 1 cap, area 5 and Vaults
- Concrete outside process buildings
- Asphalt

The average concentration, total mass and total activity was determined for each of these areas using sampling data contained in Appendix D, Tables 1 and 4, mass data based on GIS determination area of the Elevated Areas, slab thickness, and concrete density of 150 lb/ft^3, and mass data contained in Appendix A, B, and C in HDP-TBD-WM-906 for other concrete and asphalt. Multiple samples representing different depth intervals were collected at some of the sample locations and are indicated accordingly in Appendix D. The concentration at each measurement location was based on the weighted average of these subsamples and is calculated for each of the following (as indicated in the notations on the right hand 'Notes' column of Appendix D): 1) the entire core, 2) just the upper cap and 3) just the layer below the upper cap.

APPENDIX M
Calculation of Activity – Concrete and Asphalt

Elevated Area 1 - Bldg 240, Red Room

Nine sample locations are associated with elevated area 1. Four samples (2, 3, 4, and 5) were collected at elevated locations and five samples (31, 32, 33, 34, and 35) were collected along the periphery of the observed elevated activity. The average of measurements 2, 3, 4, 5 and 35 were assigned to this area. Note that the concentration excluding the top 3 inches (representing the upper cap) was used for locations 2, 3, 34, and 35 since the cap is excluded from disposal at USEI. With the exception of location 35, the bounding samples were not included in the calculated average as this would have resulted in a less conservative value. Since the concentration was elevated at location 35, it was included in the average. The concentration values shown below were multiplied by the total mass (2.47×10^5 lb calculated from Appendix A of HDP-TBD-WM-906) to arrive at the total concentrations values for Elevated Area 1 tabulated in Table 6-5.

Volume Calculation for Location

area (ft^2)	Thickness (inch)	Volume (ft^3)
1067	6	534
1487	9	1115
	Total	1649

Data Used in Calculation of Average

Sample Station	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
2	0.37	11	0.40	0.42
3	3.6	9.7	0.40	4.5
4	4.0	2837	146	1010
5	0.45	12	0.63	4.5
35	1.8	1.1	0.061	0.25
Average	2.0	574	30	204
Median	1.75	10.76	0.40	4.50
Standard Deviation	1.7	1265	65	451

APPENDIX M
Calculation of Activity – Concrete and Asphalt

Elevated Area 2 - Bldg 240, Green Room

Seven sample locations are associated with elevated area 2. Three samples (6, 7, and 8) were collected at elevated locations and four samples (36, 37, 45, and 46) were collected along the periphery of the observed elevated activity. The average of measurements 6, 7, and 8 were assigned to this area. The bounding samples (36, 37, 45, and 46) were not included in the calculated average as this would have resulted in a less conservative value. The concentration values shown below were multiplied by the total mass (2.16×10^5 lb from Appendix A of HDP-TBD-WM-906) to arrive at the total concentrations values for Elevated Area 2 tabulated in Table 6-5.

Volume Calculation for Location

area (ft^2)	Thickness (inch)	Volume (ft^3)
2880	6.0	1440

Data Used in Calculation of Average

Sample Station	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
6	2.7	1053	58	308
7	0.15	145	6.4	47
8	15	178	6.1	24
Average	6.1	459.0	23.3	126.3
Median	2.70	178.40	6.41	46.74
Standard Deviation	8.2	515	30	158

APPENDIX M
Calculation of Activity – Concrete and Asphalt

Elevated Area 3 - Bldg 254

Two sample locations are associated with elevated area 3 (58 and 59). Since both of these samples were collected from 0 – 0.75 inches, the average concentration within samples below 0.75 inches (shown in Table 6-4) was used to account for the activity in the un-sampled material. The average of these three measurements were assigned to this area. Use of this data results in a conservative determination of the average Tc-99 concentration since the value assigned (2.8 pCi/g) is greater than the average concentration measured in the top 0.75 inch portion (1.4 pCi/g). The sample results included in this calculation are shown below. Note that Tc-99 is the bounding radionuclide from the standpoint of the dose calculated in the 10 CFR 20.2002 application. The concentration values shown below were multiplied by the total mass (3.43 x 10^4 lb from Appendix A of HDP-TBD-WM-906) to arrive at the total concentrations values for elevated area 3 tabulated in Table 6-5.

Data Used in Calculation of Average

Sample Station	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
58*	0.8	961	39	147
59*	2.1	2687	116	423
**	2.8	39	2	14
Average	2.6	262	11.6	48
Median	1.75	10.76	0.40	4.50
Standard Deviation	1.7	1265	65	451

*Sample Depth 0 - 0.75 inch

**Maximum Concentration for each isotope from >0.75" core samples (excluding samples at expansion joints, cracks, seams, and/or near walls) from Table 6-4 of HDP-TBD-WM-906.

APPENDIX M
Calculation of Activity – Concrete and Asphalt

Elevated Area 4 - Bldg 255

Three sample locations are associated with elevated area 4 (14, 15, and 16). The average of these measurements was assigned to this area. The concentration values shown below were multiplied by the total mass (8.24 x 10^4 lb from Appendix A of HDP-TBD-WM-906) to arrive at the total concentrations values for Elevated Area 4 tabulated in Table 6-5.

Data Used in Calculation of Average

Sample Station	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
14	0	282	13	7
15	2	38	2	7
16	13	565	22	140
Average	4.9	295.1	12.1	51.2
Median	1.60	282.09	12.59	7.06
Standard Deviation	6.7	264	10	77

APPENDIX M
Calculation of Activity – Concrete and Asphalt

Elevated Area 6 - Bldg 252

Volume Calculation for Location

area (ft^2)	Thickness (inch)	Volume (ft^3)
2050	6.0	1025

Data Used in Calculation of Average

Sample Station	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
52	8.4	51	2.8	10
53	3.0	40	2.2	4.4
56*	1.6	2103	90	165
57*	3.4	1603	69	2.3
**	2.8	39	2.1	14
Average	4.2	155.6	7.1	14.9
Median	3.00	51.00	2.81	10.30
Standard Deviation	2.6	1007	43	70

*Sample Depth 0 - 0.75 inch

**Maximum Concentration for each isotope from >0.75" core samples (excluding samples at expansion joints, cracks, seams, and/or near walls) from Table 6-4 of HDP-TBD-WM-906.

APPENDIX M
Calculation of Activity – Concrete and Asphalt

Bldg 235

Volume Calculation for Location

area (ft^2)	Thickness (inch)	Volume (ft^3)
596	6.0	298

Data Used in Calculation of Average

Sample Station	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
54	2	9	2.2	4.44
55	2	34	1.7	0.98
Average	1.9	21.6	1.9	2.71
Median	1.90	21.60	1.95	2.71
Standard Deviation	0.1	17.5	0.4	2.4

APPENDIX M
Calculation of Activity – Concrete and Asphalt

Process Buildings - Outside Specified Elevated Areas on Figure 1 of Appendix D in HDP-TBD-WM-906

Volume (ft^3)
29841

Data Used in Calculation of Average

Sample Station	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
***	3.0	1076	48	214
****	2.7	48	1.9	8.3
Weighted Average	2.7	233.3	10.2	45.4

***Average concentration inside areas where GWS exceeded 4,400 cpm or where there are higher Tc-99 samples. Averages are from Table 6-2 of HDP-TBD-WM-906. This average represents 18 percent of the total area and volume.

****Average concentration outside elevated areas where GWS exceeded 4,400 cpm or where there are higher Tc-99 samples. Averages are from Table 6-3 of HDP-TBD-WM-906. This average represents 82 percent of the total area and volume.

APPENDIX M
Calculation of Activity – Concrete and Asphalt

Concrete Outside Processing Buildings

Volume (ft^3)
79538

Data Used in Calculation of Average

Sample Station	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
Average	3	48	2	8

Asphalt

Volume (ft^3)
35985

Data Used in Calculation of Average

Sample Station	Tc-99 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
Average	3	48	2	8

APPENDIX N
Calculation of Sample Size – Piping (confidence interval)

VSP Sample Design Report for Calculating a One-Sided Confidence Interval for the Population Mean Using Simple Random Sampling

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Construct a Confidence Interval on the True Mean
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Formula for calculating number of sampling locations	Confidence Limits using Student's t-distribution
Calculated total number of samples	29

Primary Sampling Objective
The primary purpose of sampling at this site is to construct a confidence interval on the true population mean value. After the samples are collected and analyzed, the resulting sample values can be used to construct a one-sided confidence interval. Once the confidence interval is computed (which will be an upper threshold), you can have the specified confidence that the true population mean is less than the upper threshold.

Selected Sampling Approach
A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are true. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a confidence interval calculation using the Student's t-distribution. The formula used to calculate the number of samples is:

APPENDIX N
Calculation of Sample Size – Piping (confidence interval)

$$n = \left[\frac{t_{1-\alpha,df} \, S_{total}}{d} \right]^2$$

where

n is the recommended minimum sample size for the study area,

S_{total} is the estimated standard deviation due to both sampling and analytical variability,

α is the maximum acceptable probability that the true mean will not lie in the confidence interval (the confidence level is $1-\alpha$),

d is the width of the confidence interval,

$t_{1-\alpha,df}$ is the value of the Student's t-distribution with $df=n-1$ degrees of freedom such that the proportion of the distribution less than $t_{1-\alpha}$ is $1-\alpha$.

Because n appears on both sides of the equation (on the right side it appears in the degrees of freedom of the t-statistic), the equation must be solved iteratively. VSP does this automatically using the iteration scheme in Gilbert (1987, pg. 32).

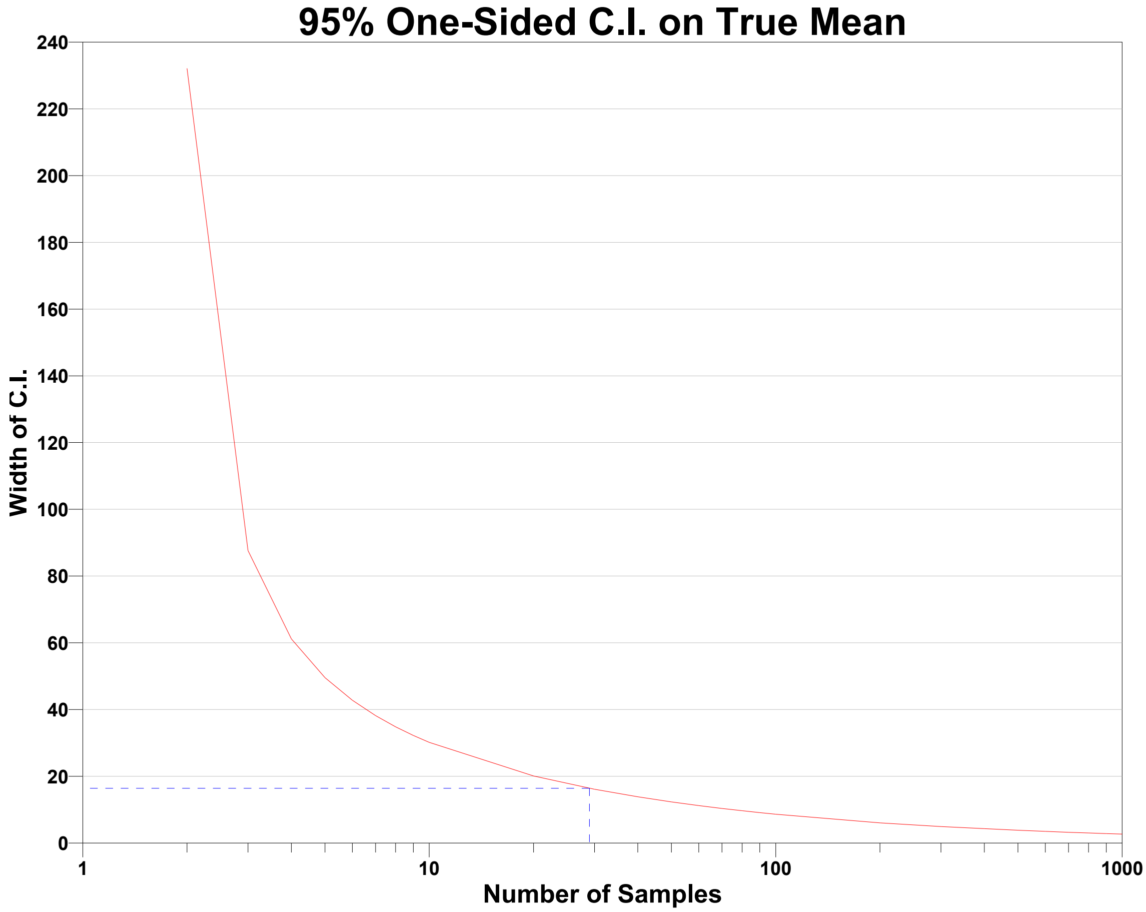
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter			
		S	d	α	$t_{1-\alpha,df}$
Analyte 1	29	52	16.5	5%	1.70113 [a]

[a] This value is automatically calculated by VSP based upon the user defined value of α

The following figure is a graph representing the relationship between the width of the confidence interval and the number of samples. The blue dashed line illustrates the specified maximum desirable confidence interval width. Where this dashed line intersects the red curve is the number of samples calculated by VSP.

APPENDIX N
Calculation of Sample Size – Piping (confidence interval)



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the sample mean is normally distributed,
2. the population values are not spatially or temporally correlated, and
3. the sampling locations will be selected randomly.

The first two assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, confidence level (1-α) (%) and width of confidence interval. The following table shows the results of this analysis.

Number of Samples						
	d=8.25		d=16.5		d=24.75	
	s=104	s=52	s=104	s=52	s=104	s=52
CL=99	864	219	219	57	99	27
CL=97	565	143	143	38	65	18
CL=95	432	110	110	29	50	14
CL=93	348	89	89	24	41	12
CL=91	288	73	73	20	34	10

APPENDIX N
Calculation of Sample Size – Piping (confidence interval)

s = Standard Deviation
CL = Confidence Level (1-α) (%)
d = Width of Confidence Interval

Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compute a confidence interval, the data should be assessed in this context. Assuming the data are adequate, at least one statistical test should be done to evaluate whether the data are normally distributed. Appropriate confidence intervals for the mean value should then be calculated. Results of the exploratory and quantitative assessments of the data should be reported, along with conclusions that may be supported by them.

APPENDIX O
Calculation of Sample Size – Piping (comparison against threshold value)
Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	14

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the

APPENDIX O
Calculation of Sample Size – Piping (comparison against threshold value)

median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**[a]	**Parameter**					
		S	**Δ**	**α**	**β**	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	14	52	87	0.05	0.1	1.64485	1.28155

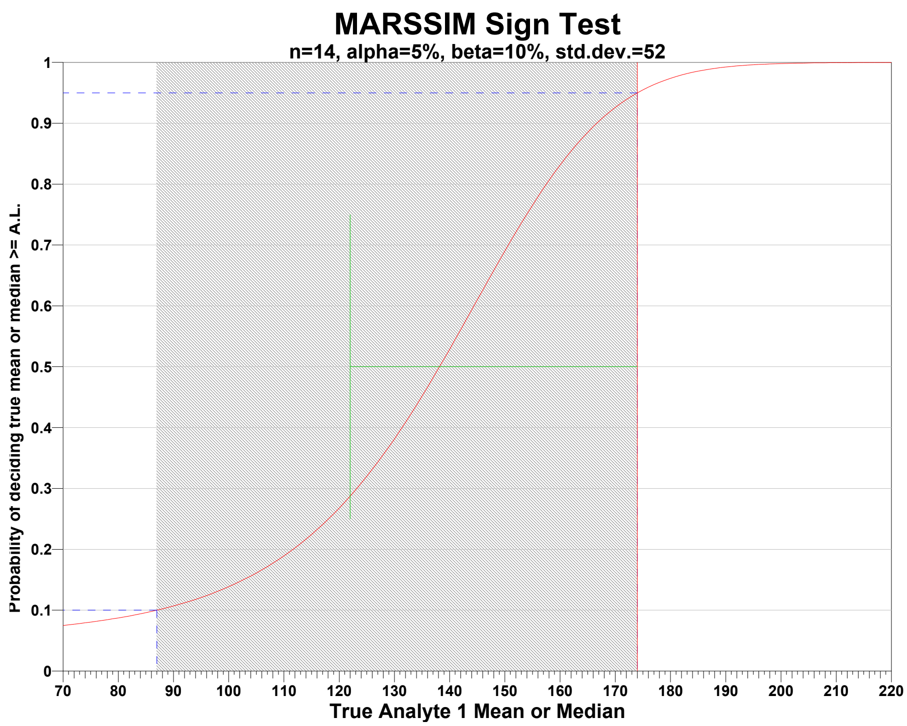
[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.
[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is

APPENDIX O
Calculation of Sample Size – Piping (comparison against threshold value)

positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=174		**α=5**		**α=10**		**α=15**	
		s=104	**s=52**	**s=104**	**s=52**	**s=104**	**s=52**
LBGR=90	**β=5**	736	190	584	150	490	126
	β=10	584	150	448	116	366	95

APPENDIX O

Calculation of Sample Size – Piping (comparison against threshold value)

	β=15	490	126	366	95	293	76
LBGR=80	**β=5**	190	53	150	42	126	36
	β=10	150	42	116	33	95	27
	β=15	126	36	95	27	76	22
LBGR=70	**β=5**	89	29	70	23	59	20
	β=10	70	23	54	18	45	15
	β=15	59	20	45	15	36	12

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Recommended Data Analysis Activities

Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site median(mean) value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

APPENDIX P
DQO Matrix, Sampling Approach

Material	Step 1 State the problem	Step 2 Identify the decisions	Step 3 Identify inputs to the decisions	Step 4 Define study boundaries	Step 5 Develop decision rules	Step 6 Specify limits on errors	Step 7 Optimize sampling design.
Soil	Westinghouse must ensure that the radiological risk from waste material shipped to USEI is within the bounds of the inventory limit specified in the combined safety basis associated with the 2002 disposal applications for USEI, and is acceptable for disposal based on the USEI WAC.	1) Does the waste MATERIAL meet the constraints on the radionuclide INVENTORY (from safety basis) AND concentration (from WAC). 2) Each shipment will be evaluated against the inventory limit, each single railcar will be evaluated against the concentration limits.	1) Characterization data from sub-slab soils (process building slab) as contained in Appendix H of HDP-TBD-WM-906 and summarized in Tables 9-1 and 9-2 of the same document.	Soils – site-wide, subject to the same limitations and exclusions as defined in the previous 20.2002 exemption request (i.e., segregation of high Tc-99 concentration materials from the evaporation pond area).	1) If a shipment of rail cars will cause the total Tc-99 inventory as calculated based on the mean concentration to be greater than 1.3 Ci (total current and previous 20.2002 exemption requests), that material cannot be shipped to USEI 2) If a shipment of railcars will cause the upper 95% confidence interval on the total Tc-99 inventory to be greater than 2.05 Ci (total of current and previous 20.2002 requests), that material cannot be shipped to USEI 3) If the concentration of Ra-226 exceeds 16 pCi/g or the Th-232 concentration exceeds 13 pCi/g, the material can not be shipped to USEI 4) If the total concentration of all radionuclides in a rail car exceeds 3000 pCi/g in any single rail car, the material can not be shipped to USEI.	1) The upper 95% confidence interval on total Tc-99 concentration is set at 1.5 times the mean concentration.	1) Sample frequency based on number of samples to determine the confidence interval on the mean activity. 2) Variability in Tc-99 concentration for soils in the current application is less than in the prior (36 pCi/g as compared to 225 pCi/g). 3) Required sample frequency based on the characteristics of the soil evaluated in the current application (mean of 13 pCi/g and standard deviation of 36 pCi/g) is 85 samples over 14212 m3 of soil (based on a 6.5 pCi/g confidence interval half width and standard deviation of 36 pCi/g). Details of this calculation are contained in Appendix I of HDP-TBD-WM-906. 4) Sample frequency as calculated for the current exemption request (1 sample per 167 m^3) is less restrictive than the currently employed approach for soils (1 sample per 15 – 20 m^3). 5) Soil sampling approach for soils in previous application will be applied to soils in the current.

APPENDIX P
DQO Matrix, Sampling Approach

Material	Step 1 State the problem	Step 2 Identify the decisions	Step 3 Identify inputs to the decisions	Step 4 Define study boundaries	Step 5 Develop decision rules	Step 6 Specify limits on errors	Step 7 Optimize sampling design.
Concrete – Process Buildings (includes buildings 235 and 252)	Westinghouse must ensure that the radiological risk from waste material shipped to USEI is within the bounds of the inventory limit specified in the combined safety basis associated with the 2002 disposal applications for USEI, and is acceptable for disposal based on the USEI WAC.	1) Does the waste MATERIAL meet the constraints on the radionuclide INVENTORY (from safety basis) AND concentration (from WAC). 2) Each shipment will be evaluated against the inventory limit, each single railcar will be evaluated against the concentration limits.	1) Characterization data from areas from which the waste will originate (as basis for standard deviation used in sample planning) and inventory estimate. 2) Additional sampling conducted after waste excavation 3) Maximum Tc-99 inventory for disposal pit (as basis for confidence interval)	Material identified in HDP-TBD-WM-906, Appendix A through C with the exception that materials identified in Table 6-6 (same document).	1) If a shipment of rail cars will cause the total Tc-99 inventory as calculated based on the mean concentration to be greater than 1.3 Ci (total current and previous 20.2002 exemption requests), that material cannot be shipped to USEI 2) If a shipment of railcars will cause the upper 95% confidence interval on the total Tc-99 inventory to be greater than 2.05 Ci (total of current and previous 20.2002 requests), that material cannot be shipped to USEI 3) If the total concentration of all radionuclides in a rail car exceeds 3000 pCi/g in any single rail car, the material can not be shipped to USEI.	1) The upper 95% confidence interval on total Tc-99 concentration is set at 1.5 times the mean concentration.	1) Sample frequency based on number of samples to determine the confidence interval on the mean activity. 2) The number of samples is 20 based on the characteristics of the concrete slab outside of the elevated areas (mean of 2.4 pCi/g and standard deviation of 3.1 pCi/g). 3) Decision unit is selected as each individual building. 4) Additional biased sampling will be based on results of screening measurements peformed for criticality safety.

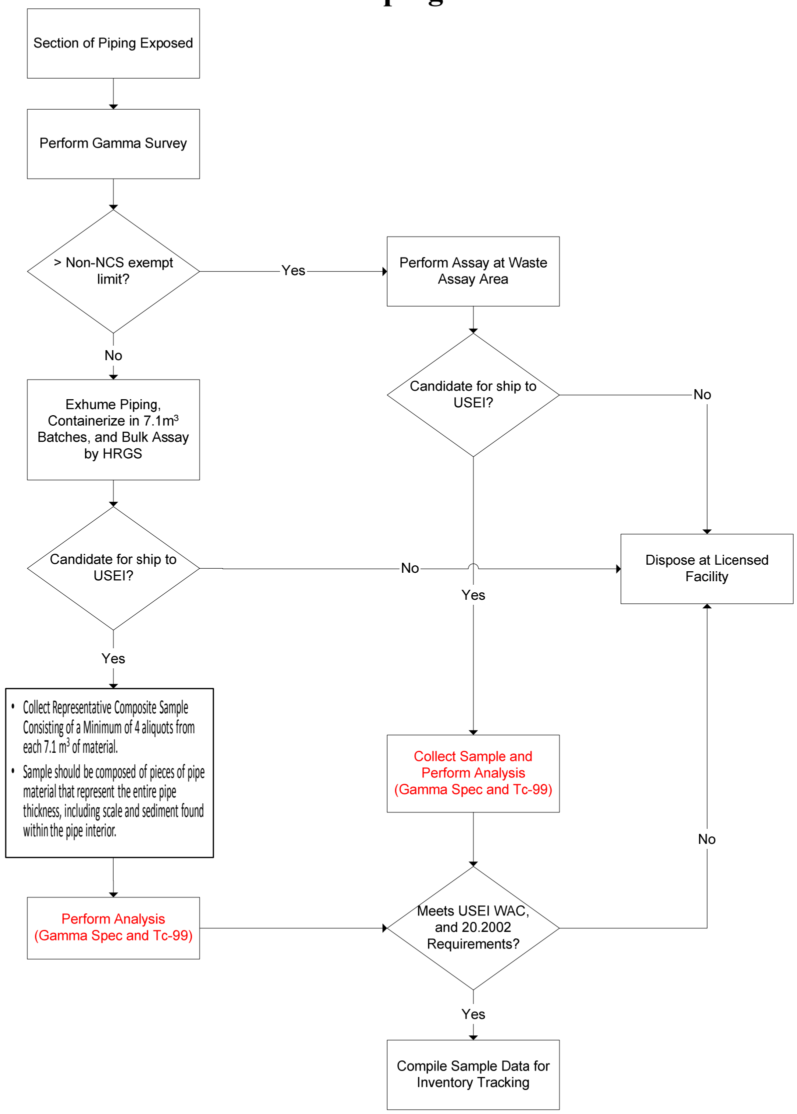
APPENDIX P
DQO Matrix, Sampling Approach

Material	Step 1 State the problem	Step 2 Identify the decisions	Step 3 Identify inputs to the decisions	Step 4 Define study boundaries	Step 5 Develop decision rules	Step 6 Specify limits on errors	Step 7 Optimize sampling design.
Concrete / Asphalt outside process building	Westinghouse must ensure that the radiological risk from waste material shipped to USEI is within the bounds of the inventory limit specified in the combined safety basis associated with the 2002 disposal applications for USEI, and is acceptable for disposal based on the USEI WAC.	1) Does the waste MATERIAL meet the constraints on the radionuclide INVENTORY (from safety basis) AND concentration (from WAC). 2) Each shipment will be evaluated against the inventory limit, each single railcar will be evaluated against the concentration limits.	1) Characterization data from areas in the process building outside of hotspots (as defined in Table 6-3 of HDP-TBD-WM-906. 2) Gamma walkover data from E0-04-001, R1, *Gamma Survey Data Evaluation Report*, May 2004 3) Total beta survey data from DO-04-002, Rev 0, Licensing Evaluation for Removal of Concrete and Asphalt, January 2004 4) Alpha/Beta scan of Building 230 pad, 0388-CH-100405, April 5, 2010	Material identified in HDP-TBD-WM-906, Appendix A through C with the exception that materials identified in Table 6-6 (same document).	1) If a shipment of rail cars will cause the total Tc-99 inventory as calculated based on the mean concentration to be greater than 1.3 Ci (total current and previous 20.2002 exemption requests), that material cannot be shipped to USEI 2) If a shipment of railcars will cause the upper 95% confidence interval on the total Tc-99 inventory to be greater than 2.05 Ci (total of current and previous 20.2002 requests), that material cannot be shipped to USEI 3) If the total concentration of all radionuclides in a rail car exceeds 3000 pCi/g in any single rail car, the material can not be shipped to USEI.	1) The upper 95% confidence interval on total Tc-99 concentration is set at 1.5 times the mean concentration.	1) Gamma walkover survey data for the asphalt areas indicate that the levels are bounded by those associated with the process building general area (Figure 6.4). 2) 100% scan of concrete pad outside building 231 indicates minimal impact from site activities. 3) Sample dataset for process building general areas can be used to represent activity present in asphalt and concrete materials outside the process building. 4) Additional biased sample will be performed for areas with a potential for Tc-99 contamination (outside buildings 253/254 and 260). These areas are corresponding with areas of elevated gamma activity based on the gamma walkover survey.

APPENDIX P
DQO Matrix, Sampling Approach

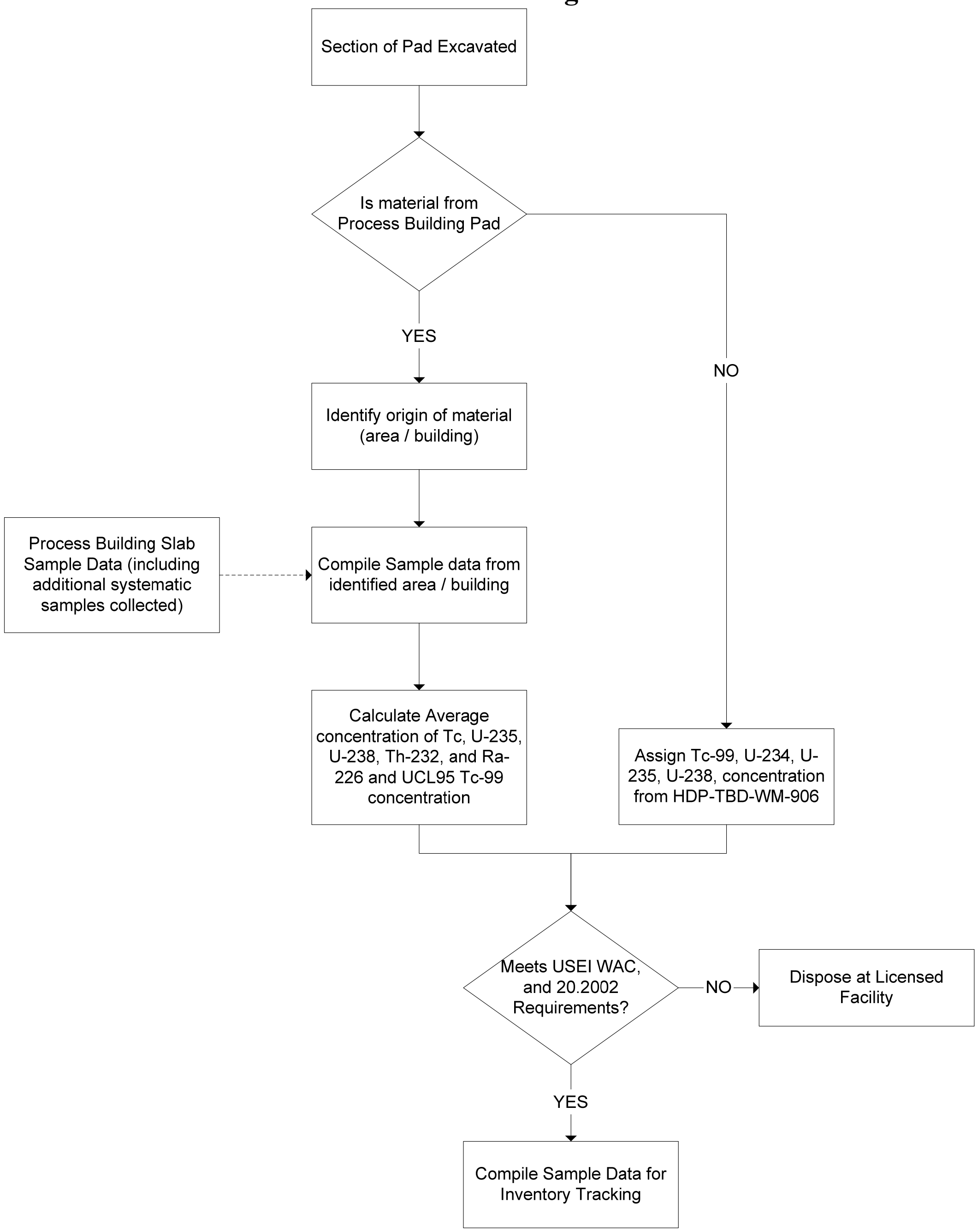
Material	Step 1 State the problem	Step 2 Identify the decisions	Step 3 Identify inputs to the decisions	Step 4 Define study boundaries	Step 5 Develop decision rules	Step 6 Specify limits on errors	Step 7 Optimize sampling design.
Piping	Westinghouse must ensure that the radiological risk from waste material shipped to USEI is within the bounds of the inventory limit specified in the combined safety basis associated with the 2002 disposal applications for USEI, and is acceptable for disposal based on the USEI WAC.	1) Does the waste MATERIAL meet the constraints on the radionuclide INVENTORY (from safety basis) AND concentration (from WAC). 2) Each shipment will be evaluated against the inventory limit, each single railcar will be evaluated against the concentration limits.	1) Characterization data for piping contained in Appendix G of HDP-TBD-WM-906 and as summarized in Table 7.5 of the same document. 2) Gamma Walkover surveys performed prior to exhumation.	Material identified in HDP-TBD-WM-906, Appendix F, with the exception that material identified in Table 7.4 (same document) will be excluded from disposal at USEI due to high Uranium and Tc-99 concentrations within those materials.	1) If a shipment of rail cars will cause the total Tc-99 inventory as calculated based on the mean concentration to be greater than 1.3 Ci (total current and previous 20.2002 exemption requests), that material cannot be shipped to USEI 2) If a shipment of railcars will cause the upper 95% confidence interval on the total Tc-99 inventory to be greater than 2.05 Ci (total of current and previous 20.2002 requests), that material cannot be shipped to USEI 3) If the total concentration of all radionuclides in a rail car exceeds 3000 pCi/g in any single rail car, the material can not be shipped to USEI.	1) The upper 95% confidence interval on total Tc-99 concentration is set at 1.5 times the mean concentration. 2) The median concentration is less than the maximum concentration value (which was used to estimate the Tc-99 inventory in the piping)	1) Sample frequency can be based on number of samples to determine the confidence interval on the mean activity. 2) Required sample frequency based on the characteristics of the piping evaluated in the current application (mean of 33 pCi/g and standard deviation of 52 pCi/g) is 29 samples over 348 m^3 of piping (based on a 16.5 pCi/g confidence interval half width and standard deviation of 52 pCi/g). This corresponds to one sample per 12 m^3 of piping. Details of this calculation are contained in Appendix N of HDP-TBD-WM-906. 3) Sample frequency can be based on number of samples to ensure that the median concentration is less than a maximum value. 4) Required sample frequency based on the characteristics of the piping evaluated in the current application (mean of 33 pCi/g and standard deviation of 52 pCi/g) is 14 samples for each decision unit (100 m^3 based on the decision unit selected as each individual rail car). This corresponds to one sample per 7.1 m^3 of piping. Details of this calculation are contained in Appendix O of HDP-TBD-WM-906. 5) Additional biased sampling will be based on results of screening measurements peformed for criticality safety.

APPENDIX Q
Process Flow Diagram
Piping



Concrete and Asphalt

APPENDIX Q
Process Flow Diagram



APPENDIX R
Contingency Plan Table

Contingency Plan Table

Prior to shipment, the following conditions will be evaluated:

Parameter	Action Level	How Monitored	Actions
Total Quantity of Tc-99 shipped to USEI (mean)	>1.3 Ci	Running total activity (both shipped and pending shipment), based on laboratory sample results prior to shipment	• Reanalyze composite sample and/or analyze individual aliquots used to create the composite sample; • Resample stockpile and re-evaluate[a]; • Ship material to alternate facility.
95% Upper Confidence Level of the mean Tc-99 shipped to USEI (UCL(0.95)).	>2.05 Ci	Running confidence interval (both shipped and pending shipment) based on laboratory sample data prior to shipment	• Reanalyze composite sample and/or analyze individual aliquots used to create the composite sample; • Resample stockpile and re-evaluate[a]; • Ship material to alternate facility.
Total activity contribution from all radionuclides within individual railcar	>3000 pCi/g > 40 μR/hr[b]	Laboratory sample results for stockpile evaluated at 95% UCL prior to shipment Gamma radiation levels on railcars prior to shipment.	• Analyze additional aliquot of composite sample; • Unload railcar (at HDP) and re-load with material containing lower concentration (either blended or alternate material from onsite waste stream)[a]; • Ship material to alternate facility.
Unexpected Tc-99 results for stockpile samples (soil)	>99th percentile of the site wide dataset (599 pCi/g)[c]	Laboratory sample results for stockpile evaluated prior to shipment	• Analyze additional aliquot of composite sample; • Resample stockpile and re-evaluate[a]; • Blend with less contaminated material, resample stockpile and re-evaluate; • Ship material to alternate facility.
Unexpected Tc-99 results for stockpile samples (concrete)	>99th percentile of the site wide dataset (1590 pCi/g)	Laboratory sample results for stockpile evaluated prior to shipment	• Analyze additional aliquot of composite sample; • Resample stockpile and re-evaluate[a]; • Blend with less contaminated material, resample stockpile and re-evaluate; • Ship material to alternate facility.

APPENDIX R
Contingency Plan Table

Contingency Plan Table

Prior to shipment, the following conditions will be evaluated:

Parameter	Action Level	How Monitored	Actions
Unexpected Tc-99 results for stockpile samples (piping internal debris / residue)	>99th percentile of the dataset (5783 pCi/g)	Laboratory sample results for stockpile evaluated prior to shipment	• Analyze additional aliquot of composite sample; • Resample stockpile and re-evaluate[a]; • Blend with less contaminated material, resample stockpile and re-evaluate; • Ship material to alternate facility.
Unexpected Tc-99 results for stockpile samples (piping average concentration)	>99th percentile of the dataset (1118 pCi/g)	Laboratory sample results for stockpile evaluated prior to shipment	• Analyze additional aliquot of composite sample; • Resample stockpile and re-evaluate[a]; • Blend with less contaminated material, resample stockpile and re-evaluate; • Ship material to alternate facility.
Maximum average concentration of Ra-226 and Th-232 within individual railcar	Ra-226 >13 pCi/g Th-232 >16 pCi/g	Laboratory sample results for each railcar evaluated prior to shipment	• Analyze additional aliquot of composite sample; • Resample stockpile and re-evaluate[a]; Blend with less contaminated material, resample stockpile and re-evaluate; • Ship material to alternate facility.

[a] Re-sampling of material will generally occur after down blending of stockpile material. When such sampling is performed, the new sample dataset will replace the initial data for the purpose of subsequent calculations. If re-sampling is performed without down blending (which would be the case if the material was sampled in-situ railcars) then, the additional samples will be used to augment the initial dataset.

[b] Based on analysis previously transmitted in HEM-10-46, 5/24/10.

[c] Value shown is the 99th percentile of the pooled site wide Tc-99 dataset with EP-08-00-SL and EP-10-00-SL excluded using spreadsheet software.

Enclosure 3 to HEM-12-88

Sampling Plan for Concrete and Asphalt
(to be incorporated into HDP-OPS12-WP-023, *Concrete and Asphalt Radiological Characterization: Process Buildings, South and West Vault Floors, Pads and Roadways*)

Westinghouse Electric Company LLC
US Ecology Idaho, Inc.

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Sampling Plan for Concrete and Asphalt
(to be incorporated into HDP-OPS12-WP-023, *Concrete and Asphalt Radiological Characterization: Process Buildings, South and West Vault Floors, Pads and Roadways*)

5 GENERAL INFORMATION

5.1. Data Quality Objectives

Data Quality Objectives (DQO) have been established for this work activity to ensure samples are collected and analyzed per established criteria so the data obtained is of sufficient quality to be used for planning decisions regarding waste disposal. The DQO are as follows:

5.2.1. Samples of concrete shall be obtained at the locations designated in Table 5-1 and Appendix A. Additional locations may be included as directed by the RSO.

5.1.1.1 Two samples will be collected at each concrete sample location. The approximate depth intervals from at each location are from the surface to approximately 0.75 inches and from 0.75 to 1.5 inches.

5.2.2. Samples of asphalt shall be obtained from within the areas designated in Appendix B. Twenty (20) biased sample locations shall be identified by selecting the locations indicating the most elevated beta surface contamination.

5.1.2.1 One sample will be collected at each asphalt sample locations. The sample will be collected through the entire depth of the asphalt material.

5.2.3. The samples from each sampling location will be analyzed for uranium by gamma spectroscopy and for Tc-99.

5.2.4. Duplicate sample will be collected at a frequency of 1 in every 20 sample locations.

5.2.5. A minimum detectable concentration (MDC) of 1 pCi/g should be targeted for these analyses. Additional analysis may be performed as directed by the RSO.

Table 5-1, Concrete Sampling Locations

Sample Station	Building Location	Sample Station	Building Location	Sample Station	Building Location
60	235	114	254	168	260
61	235	115	254	169	260
62	235	116	254	170	260
63	235	117	254	171	260

Sample Station	Building Location	Sample Station	Building Location	Sample Station	Building Location
64	235	118	254	172	260
65	240	119	254	173	260
66	240	120	254	174	260
67	240	121	254	175	260
68	240	122	254	176	260
69	240	123	254	177	260
70	240	124	256	178	260
71	240	125	256	179	260
72	240	126	256	180	260
73	240	127	256	181	260
74	240	128	256	182	260
75	240	129	256	183	260
76	240	130	256	184	252
77	240	131	256	185	252
78	240	132	256	186	252
79	240	133	256	187	252
80	240	134	256	188	252
81	240	135	256	189	252
82	240	136	256	190	252
83	240	137	256	191	252
84	240	138	256	192	252
85	253	139	256	193	252
86	253	140	256	194	252
87	253	141	256	195	252
88	253	142	256	196	252
89	253	143	256	197	252
90	253	144	255	198	252
91	253	145	255	199	TBD*
92	253	146	255	200	TBD*
93	253	147	255	201	TBD*
94	253	148	255	202	TBD*
95	253	149	255	203	TBD*
96	253	150	255	204	TBD*
97	253	151	255	205	TBD*
98	253	152	255	206	TBD*
99	253	153	255	207	TBD*
100	253	154	255	208	TBD*
101	253	155	255	209	TBD*
102	253	156	255	210	TBD*
103	253	157	255	211	TBD*

Sample Station	Building Location	Sample Station	Building Location	Sample Station	Building Location
104	254	158	255	212	TBD*
105	254	159	255	213	TBD*
106	254	160	255	214	TBD*
107	254	161	255	215	TBD*
108	254	162	255	216	TBD*
109	254	163	255	217	TBD*
110	254	164	260	218	TBD*
111	254	165	260	219	TBD*
112	254	166	260	220	TBD*
113	254	167	260		

*Asphalt sampling location – location TBD based on surface activity measurements (beta scan)

6 PROCESSES/WORK STEPS

NOTE: The following steps may be performed in any logical order.

6.1 ASPHALT SAMPLING:

6.2.1. Don Personnel Protective Equipment (PPE) appropriate for the location to be sampled as directed by the RWP and by the PPE requirements form from the AHA.

6.2.2. Perform a 100% beta radioactivity scan of accessible asphalt surface area subject to sampling as identified in Appendix B.

6.2.3. Review scan results with HP Supervision and identify sample locations based on the scan survey results.

6.2.4. Select sample locations from the areas scanned in a manner such that areas with elevated scan activity are preferentially sampled.

6.2.4.1. If necessary, select any additional sample locations at random from the areas outside those identified as elevated by the surface scan to obtain a minimum of 20 sample locations.

6.2.5. Clearly mark the location for sampling and mark any nearby underground utilities with spray paint prior to commencement of coring activities.

6.2.6. Stage the area to be sampled with the proper sampling equipment, materials and collection containers.

6.2.7. Collect a duplicate sample at every 20th sample location.

6.2.8. Obtain sample IDs from the HP Sample Log for each of sample interval to be collected.

6.2.9. Using drill with an appropriate bit or coring machine (as appropriate), collect a sample at the designated sample location through the depth of the material at asphalt sampling locations.

6.2.10. Decontaminate any non-dedicated sampling equipment that has the potential to come in contact with the sample by wiping down so as to remove any visible debris.

6.2.11. At coring/drilling locations that penetrate the full thickness of concrete/asphalt, fill the hole with bentonite clay material. The bentonite may be hydrated after filling to assist expansion.

6.2.12. Measure and record the physical location of each sample locations using civil survey or global positioning equipment.

6.2.13. Complete the Chain of Custody form in accordance with HDP-PR-QA-006, Chain of Custody Process, and submit the samples collected to the laboratory for analysis.

6.2.13.1. The Chain of Custody should include a unique Sample ID for each sample collected, and a Station ID identifying the location where each sample was collected.

6.2.14. Ensure the samples are analyzed per the DQOs specified in Section 5.1.

6.2.15. Solid waste generated during the decontamination will be bagged and provided to Waste Management for disposition.

6.2 CONCRETE SAMPLING:

6.2.1. Don Personnel Protective Equipment (PPE) appropriate for the location to be sampled as directed by the RWP and by the PPE requirements form from the AHA.

6.2.2. Identify the concrete sampling locations using the figure in Appendix A.

6.2.3. Clearly mark the location for sampling and mark any nearby underground utilities with spray paint prior to commencement of coring activities.

6.2.4. Stage the area to be sampled with the proper sampling equipment, materials and collection containers.

6.2.5. Obtain sample IDs from the HP Sample Log for each of sample interval to be collected.

6.2.6. Using drill with an appropriate bit or coring machine (as appropriate), collect a sample at the designated sample location and depth interval at concrete sampling locations.

6.2.7. Collect a duplicate sample at every 20th sample location.

6.2.8. Decontaminate any non-dedicated sampling equipment that has the potential to come in contact with the sample by wiping down so as to remove any visible debris.

6.2.9. At coring/drilling locations that penetrate the full thickness of concrete/asphalt, fill the hole with bentonite clay material. The bentonite may be hydrated after filling to assist expansion.

6.2.10. Measure and record the physical location of each sample locations using civil survey or global positioning equipment.

6.2.11. Complete the Chain of Custody form in accordance with HDP-PR-QA-006, Chain of Custody Process, and submit the samples collected to the laboratory for analysis.

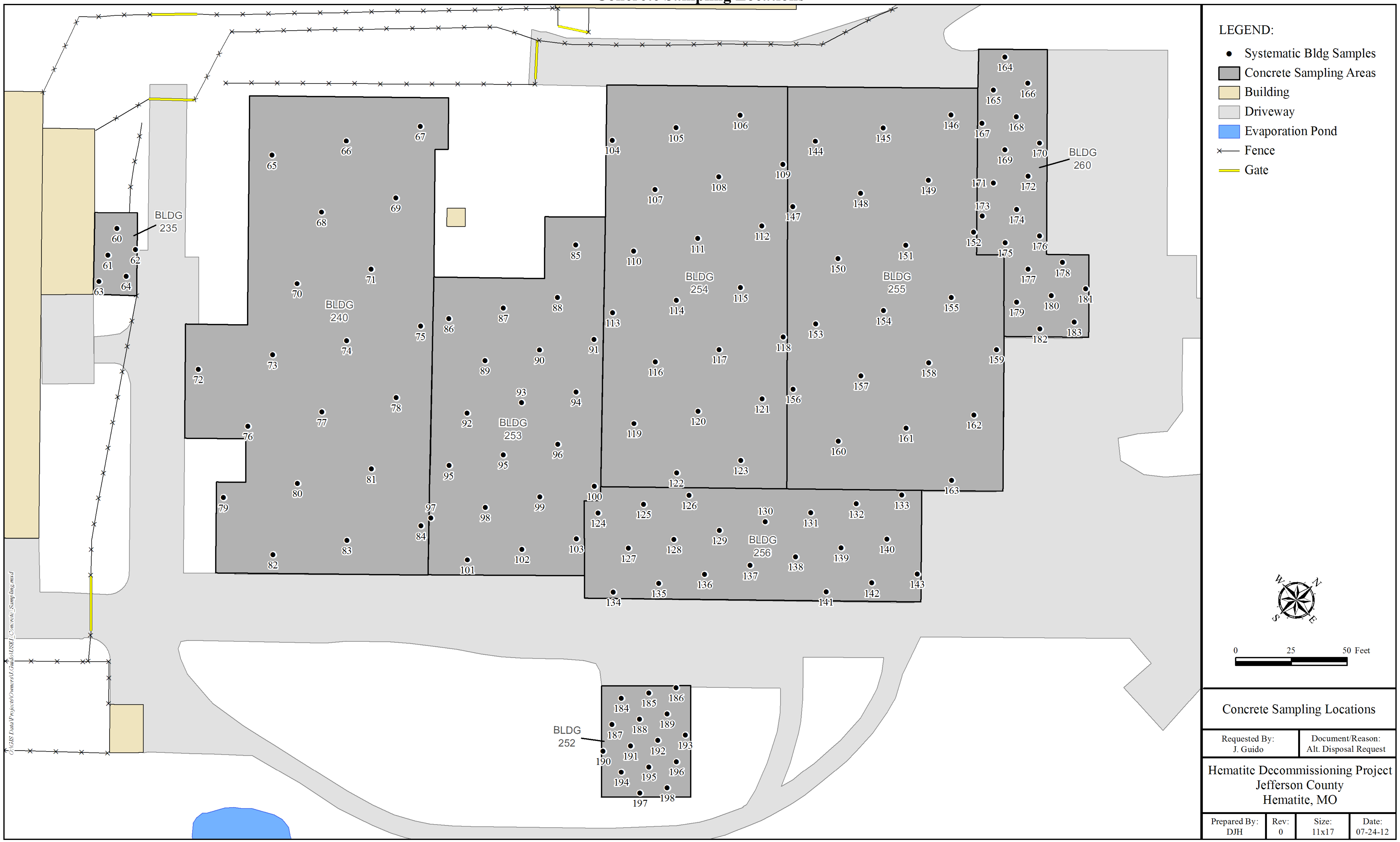
6.2.11.1. The Chain of Custody should include a unique Sample ID for each sample collected, and a Station ID identifying the location where each sample was collected.

6.2.12. Ensure the samples are analyzed per the DQOs specified in Section 5.1.

6.2.13. Solid waste generated during the decontamination will be bagged and provided to Waste Management for disposition.

Enclosure 3 to HEM-12-88
July 24, 2012

Appendix A
Concrete Sampling Locations



Appendix B
Asphalt Sampling Locations