Path Forward - Waste Characterization

1 Introduction

Hematite Decommissioning Project (HDP) submitted an application to NRC for alternate disposal of waste materials to USEI in accordance with 10 CFR 20.2002. The application proposed to use the median Tc-99 concentration defined by the existing site characterization data, (i.e., 27 pCi/g) as best estimate of the concentration in the source term as input to the USEI post-closure dose assessment. The assessment concluded that the post-closure dose to a member of the public resulting from a concentration of 27 pCi/g Tc-99 within a 22,809 m^3 volume of waste would be approximately 2 mrem/yr, which is within NRC's guideline of a few mrem/yr. Based on that estimate of volume and concentration, the total inventory of Tc-99 that HDP will be allowed to dispose at USEI will be limited to 1 Ci.

NRC staff expressed concern that the median may not be the most applicable statistic to use for estimating the average concentration of Tc-99 (and subsequently estimating the total inventory of Tc-99) due to the relatively high variability of the data set. This variability is predominantly attributable to a limited number of high concentration outliers which were identified to NRC by Westinghouse in a letter dated March 31, 2010 (HEM-10-38).

To address the NRC concern regarding the high variability in the Tc-99 characterization data, and to ensure that the total inventory of Tc-99 actually shipped to USEI is known with sufficient confidence, HDP proposes the following:

1) Develop a statistically based sample plan for the material to be disposed that will include the collection of an adequate population of samples to define the upper limit of the mean concentration (and associated total inventory) at the 95% confidence level.
2) To reduce variability, the area showing elevated outlier concentrations of Tc-99 within the vicinity of the Evaporation Ponds will be further characterized through post-excavation sampling and analysis. Please note that this area to be further characterized was previously identified as "Elevated Area One" in Figure 2, Appendix B, Attachment 1 to Westinghouse letter dated March 31, 2010 (HEM-10-38) and is shown in Attachment 1 to this document. This additional information will be used to define the mean and standard deviation of the population before the elevated material is added to the balance of the material for shipment. .

Fundamental to this plan for defining the concentration of Tc-99 in waste material is the commitment that only the quantitative data from offsite laboratory analyses of soil samples will be used for demonstrating compliance with the limit on total inventory. The existing characterization data and any onsite laboratory data from additional characterization will be used internally by HDP for planning and operational decision-making purposes only.

The methods for implementing the actions described in Items 1 and 2 above and the results of the assessments, as applicable, are provided below.

2 Statistically Based Sample Plan

The statistically based sample plan will demonstrate that the volumetrically averaged mean concentration of Tc-99 in waste material disposed during the duration of the project is well known ; and ensure that a sufficient number of samples are collected to demonstrate that the $UCL_{(0.95)}$ for the total inventory would not result in a post-closure dose estimate in excess of 3 mrem/yr. Demonstrating compliance with the limit of approximately 2 mrem/yr as indicated by the post-closure dose assessment by limiting the $UCL_{(0.95)}$ to 3.0 mrem/yr is a reasonably prudent approach, and consistent with the NRC guideline that the dose from a 2002 disposal should be on the order of a few mrem per year.

This sampling plan is based on the Visual Sampling Plan (VSP) for Calculating a One-Sided Confidence Interval for the Population Mean Using Simple Random Sampling, and an example is provided as Attachment 2 to this document. VSP was used to estimate the sample size necessary to meet the data quality objectives using this standard deviation and a confidence interval width of 14 pCi/g (equivalent to 1 mrem). Using 14 pCi/g as the interval width is the most conservative assumption, and results in the largest sample size, because it applies to the most limiting case where the mean is 27 pCi/g and the corresponding 3 mrem upper 95% CL would then be 41. As the mean decreases, the interval width could increase and still satisfy the 3 mrem/yr upper 95% CL limit. The resultant sample size is 704.

An important observation regarding the selection of standard deviation for determining sample size is that the risk of underestimating the standard deviation is for the most part HDPs risk as opposed to regulatory risk. If the standard deviation of the excavated waste samples is significantly larger than estimated in the VSP sample size calculation the requirement that the 95% CL be less than 3 mrem from Tc-99 may limit the volume of material that HDP can ship. This limitation will emerge as the running mean and 95% CL of the inventory is calculated as Tc-99 analysis results are reported while shipping is ongoing.

A total of 704 samples would be required to meet the data quality objectives for the sampling approach outlined above. Based on the volume of material projected to be shipped (22,809 m^3), this sampling frequency would correspond to one sample for every 42 yd^3 of waste material. In practice, one composite sample will be collected from multiple locations within each 15 – 20 yd^3 of waste material. This sample will be submitted for Tc-99 by an offsite laboratory. This sampling approach (one composite sample for each 15 – 20 yd^3 of waste) will result in an abundance of samples which will allow for a significant number of contingency samples.

3 Additional Characterization of Vicinity of Evaporation Ponds

As stated earlier, material within the vicinity of the evaporation pond will be characterized independently prior to being included with of the balance of the material shipped to USEI. Materials in this area will be mixed during the excavation process and sampled. This material will be sampled at a rate of one per 15-20 yd^3consistent with the material from the balance of the site.
The locations of the samples obtained from this area are illustrated by “Elevated Area One” in Figure 2, Appendix B, Attachment 1 to Westinghouse letter dated March 31, 2010 (HEM-10-38), and by Attachment 1 to this document.

Vicinity of Evaporation Ponds(0 – 1 Foot Samples)

Sample ID	Radionuclide Concentration (pCi/g)				
	Tc-99	Th-232	U-234	U-235	U-238
EP-01-00-SL	183	2	565	31	92
EP-02-00-SL	219	2	549	30	87
EP-04-00-SL	189	3	3,334	184	550
EP-05-00-SL	5	1	336	19	89
EP-06-00-SL	51	0	1,968	97	52
EP-08-00-SL	3,420	1	161	9	27
EP-09-00-SL	111	1	90	5	14
EP-10-00-SL	17,100	0	936	51	272
EP-11-00-SL	112	1	103	4	11
FS-19-1-BIA-1-SO-1	35	1	193	10	137
FS-19-1-BIA-3-SO-1	82	6	4,070	137	389
FS-19-1-BIA-4-SO-1	33	0	230	12	44
FS-19-1-BIA-5-SO-1	32	4	1,320	48	75
SS-E.EVAP-001-SF	243	1	229	7	41
SS-GA-001-SF	376	0	45	2	8
SS-GA-002-SF	43	1	39	2	8
SS-GB-002-SF	24	1	138	8	31
SS-GB-004-SF	15	1	81	4	19
SS-GB-006-SF	19	1	75	4	15
SS-GB-007-SF	7	1	21	1	6
SS-GB-009-SF	56	1	45	3	9
SS-GB-022-SF	27	1	46	3	11
SS-GB-023-SF	17	1	28	2	8
SS-GL-011-SF	31	1	117	6	18
SS-GL-012-SF	290	0	123	7	14
SS-W.EVAP-001-SF	49	1	174	8	31

Vicinity of Evaporation Ponds (1 – 5 Foot Samples)

Sample ID	Radionuclide Concentration (pCi/g)				
	Tc-99	Th-232	U-234	U-235	U-238
EP-19-05-SL	218	1	27	1	10
EP-20-05-SL	46	2	6	0	0
SS-GA-001-SV	166	1	24	1	6
SS-GB-002-SV	1	1	161	9	37
SS-GB-004-SV	3	1	183	10	41
SS-GB-006-SV	7	1	45	2	11
SS-GB-007-SV	2	1	134	7	29
SS-GB-009-SV	90	1	35	2	8
SS-GB-022-SV	7	1	45	2	11
SS-GL-011-SV	6	1	79	4	18
LB32R	25		12	1	3
LB35R	29		11	1	3
NB-74-05-SL	53	1	7	0	1

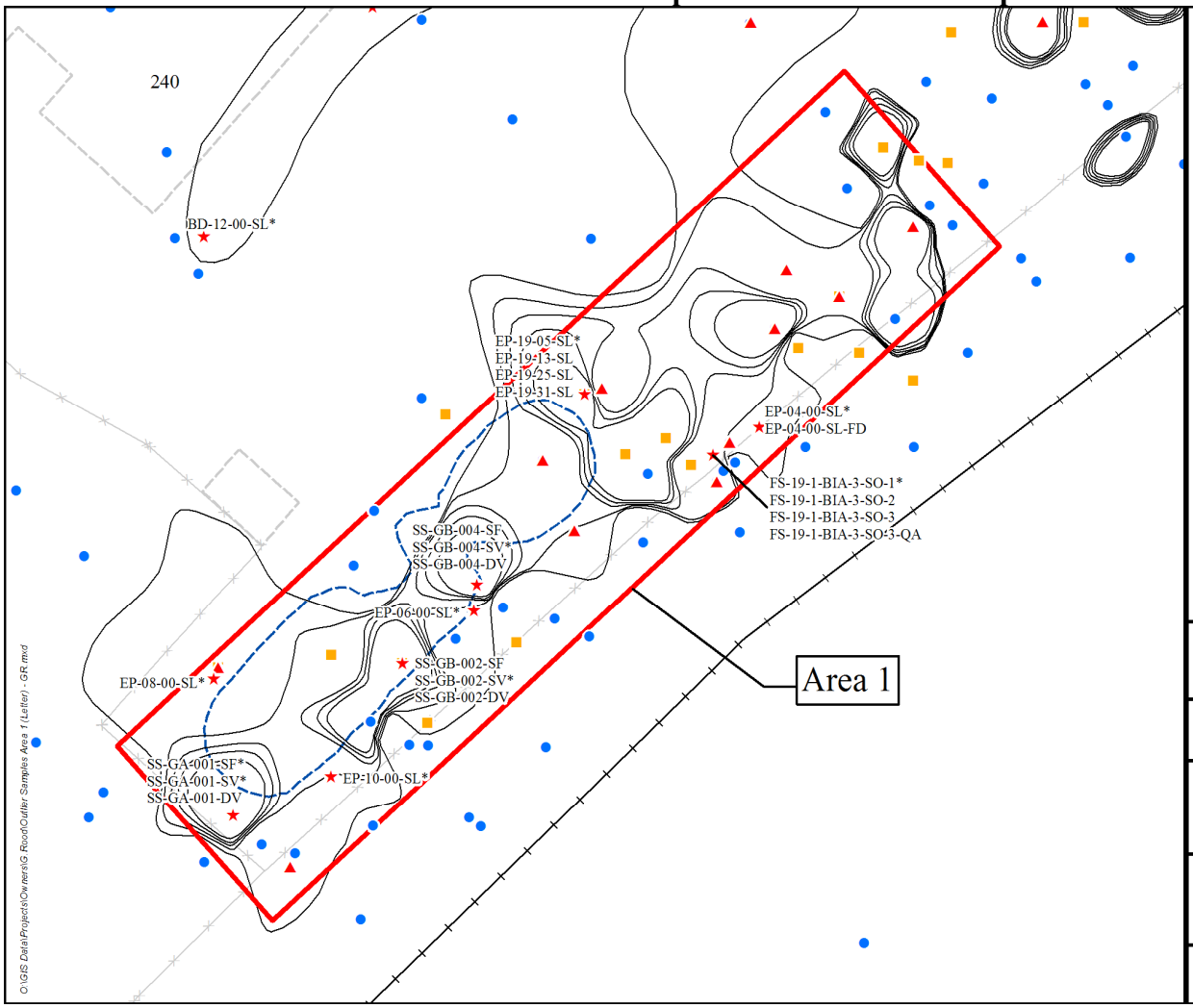
By evaluating the samples listed above that were obtained from the area in the vicinity of the Evaporation Ponds independently, the standard deviation of the remaining dataset for the balance of the site is 225 pCi/g.

4 Considerations for Implementation

Although individual railcars may exceed the nominal 27 pCi/g concentration used in the post-closure dose assessment the mean inventory will not exceed the 1 Ci limit at any time. HDP does not anticipate significant challenges in maintaining the average Tc-99 inventory in shipped material below 1 Ci. Regardless, uncertainties within the assumptions that have lead to this conclusion will only result in the HDP having to divert waste material to an alternate waste disposal site.

Because the 27 pCi/g value is based on a volumetric average and the USEI post-closure assessment for Tc-99 is based on the total inventory and not concentration, onsite compliance calculations during shipping operations, and the final compliance calculation after shipping is completed, will be based on the total inventory shipped. The post-closure assessment assumed 22,809 m^3 and a mean concentration of 27 pCi/g. This corresponds to an inventory of approximately 1 Ci of Tc-99. The 41 pCi/g (3 mrem/yr) limit for the upper 95% CL corresponds to 1.6 Ci. These inventory values will be used to demonstrate compliance. If the final volume shipped is less than 22,809 m^3 the mean concentration could be higher than 27 pCi/g with the inventory limit not being exceeded. This is considered an acceptable outcome if the primary compliance values are satisfied, i.e., the average total inventory, remains below 1 Ci Tc-99 and the upper 95% CL remains below 1.6 Ci.

Attachment 1
Evaporation Pond Area Samples



LEGEND:

- "Outlier" Sample
- SOF >/= 1
- SOF 0.5 - .99
- SOF 0 - 0.5
- Elevated Areas
- 1 Foot Contours
- Buildings
- Evaporation Ponds
- Railroad
- Fence

N W E S

0 20 40 Feet

Note: Outlier sample labels denoted by asterisk.

Figure 2. Elevated Area One

Requested By:	Document/Reason:
G. Rood	NRC RAI

Hematite Decommissioning Project
Jefferson County
Hematite, MO

Westinghouse

Prepared By:	Rev:	Date:
JAL, DJH	1	06-18-10

Attachment 2
VSP Generated Sampling Plan

1 Basis

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

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	704

2 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.

3 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,

$t_{1-\alpha,\mathrm{df}}$ 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	**Parameter**				
	n	***S***	**d**	**α**	$\mathbf{t_{1-\alpha,df}}$
Tc-99	704	225	14	5%	1.64745 [a]

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

4 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.

5 References

Gilbert, RO. 1987. *Statistical methods for environmental pollution monitoring*. Van Nostrand Reinhold, New York. (Same text available as Gilbert, RO. 1997. John Wiley & Sons, New York.)

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