

APPENDIX D
PERFORMANCE ASSESSMENT

Multi-increment Sampling (MIS) Performance Assessment Technical Support for 100/300 Area River Corridor Baseline Risk Assessment (RCBRA)

The fall sampling event, which assessed soil at 20% of the investigation areas, representing all nine environment and site type combinations, was conducted as a performance assessment. The purpose of the performance assessment was to provide information on the 'between-sample' and 'between investigation-area' variability in contaminant concentrations. The multi-increment sampling (MIS) methodology uses ~50 increments of soil, one from each section of the grid established over the study area. Each soil increment is collected from the 0 to 15 cm (0 to 6 in) depth. The soil is sieved to remove any particles and organic materials larger than 2 mm. The results of the performance assessment are used to evaluate the adequacy of the number of samples and increments per investigation area.

Data analysis followed Figure 1 (same as DOE/RL-2005-42 Figure 2-2). The first step in the assessment was to determine if the indicator contaminants in Table 1 (compiled from DOE/RL-2005-42 Tables 1-1 and 1-2) were detected. Detected indicator contaminants were then evaluated to determine if they were present at levels greater than practical quantitation limits (PQLs) or Hanford Site background. If they were detected above these levels then the concentrations were reviewed relative to human health cleanup levels from DOE/RL-2005-42 Table 2-2 (unrestricted soil cleanup levels). Table 1 lists the practical quantitation limits, background concentrations, and cleanup levels for the indicator contaminants. Contaminants that were not detected, and contaminants with concentrations less than quantitation limits or Hanford Site background, do not warrant further consideration in the statistical design. Contaminants that exceeded these criteria were retained for evaluation against cleanup levels. Exclusion criteria are depicted in Figure 1, and noted in the final column of Table 2.

Summary statistics for the indicator contaminants are provided in Table 2; there are two columns provided in Table 2 so that the reader can determine if the contaminant was detected at concentrations greater than the practical quantitation limit or background. Four indicator contaminants (C-14, H-3, TPH-DRO, TPH-GRO) will only be measured in sediment or water and thus were not measured in the performance assessment soil samples.

Concentrations of detected indicator contaminants are presented in Figures 2 through 47. The plots include, as applicable, reference lines at background levels, practical quantitation limits, and cleanup or action levels. The plots show both detected (filled circles) and non-detected (open circles) sample results. One can readily review the magnitude of the sample results relative to the reference lines. Contaminants with concentrations less than background/quantitation limits or much less than the cleanup level do not warrant further consideration in the statistical design. Reviewing these plots led to identifying five indicator contaminants that had concentrations either greater than or approaching cleanup levels and thus warrant further sampling design analyses. These five indicator contaminants are:

- Arsenic
- Hexavalent chromium
- Lead
- Benzo(a)pyrene
- Uranium-233/234

It is noted that radium-226 and radium-228 are measured in two and one results respectively above background; the cleanup levels for these radionuclides are basically at background concentrations. Given the similarity of the measurements to background levels, radium-226 and radium-228 were not evaluated further.

Visual Sampling Plan (VSP) Version 4.0a was used to evaluate the statistical performance of sampling design options. Statistical design parameters were the same as used in the DOE/RL-2005-42 Appendix

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B except that measured standard deviations were used and the delta¹ term was set to 50% of the action level. Tables 3 through 7 provide a summary of the standard deviation for each of the five contaminants by site type. We have provided calculations of the standard deviation with non-detects replaced by 0 and non-detects replaced by half of the PQL as points of comparison. Table 8 provides a summary of the number of samples calculated with the VSP 4.0a software, and the standard deviation of the data as reported was used in these calculations. For most cases the number of recommended MIS samples is either 2 (the minimum number for this VSP design option²) or 3. However, there are three contaminant and site type combinations where the number of MIS samples is greater than 3. These cases are discussed below.

Hexavalent chromium: The concentrations of hexavalent chromium exceeded the cleanup level at the riparian reference site. This led to VSP calculating a very large number of samples. However, consider that any combination of 1 to 5 samples would have come to the same risk conclusion – all hexavalent chromium sample results at the riparian reference site exceeded the cleanup level. This suggests that a large sample size is not needed because even though the concentration is high, variability is not extreme (coefficient of variation [CV] at the riparian reference site was about 63%). The number of samples calculated using VSP was also large at another site (100-F-2) because two sample results were large non-detect values (about 5-10 times larger than the other three sample results).

Lead: One site was noted during MIS collection to have surface and subsurface debris. This site, 600-131, had high and variable levels of lead. Using the lead standard deviation, VSP 4.0a calculated more than two samples at this heterogeneous site.

Confidence levels of the data were evaluated for the two contaminant and site combinations where one or more MIS results were greater than the cleanup level. These contaminant and site combinations are hexavalent chromium at the riparian reference site and lead at site 600-131. The mean and upper confidence level (UCL) of the mean (using the data as reported) for the combinations of 2, 3, 4, and 5 samples are presented in Table 9. The UCLs are less than the overall maximum detect for the hexavalent chromium data in only two cases; the lead UCLs are less than the overall maximum concentration in five cases (about 10x less than the maximum in two of these five cases).

Recommendations based on VSP results, relative standard deviations, confidence levels of the data, and the values in the data relative to cleanup levels:

1. Collect three MIS samples at all riparian sites.
 - a. Riparian sites have no other soil sample data for human health exposure analysis
 - b. Riparian sites, in particular the reference site, have the highest levels of many indicator contaminants.
2. Collect two MIS samples at upland sites with no evidence of debris
 - a. Upland sites generally had low levels of indicator contaminants
 - b. Two is the minimum number of samples recommended by VSP.
3. Collect five MIS samples at upland sites with evidence of lead-containing debris (e.g., batteries, paint chips) in the top 15 cm (6 in.)
 - a. These sites appear to have the greatest heterogeneity of contaminants, including at least one contaminant of significance to human health
 - b. Consider collecting additional increments (i.e. 100 increments per investigation area) at these plots

¹ Delta defines the width of the gray region, which is the concentration range (in this case the difference of true means) that is considered small enough to accept.

² Two samples would be the minimum number of samples that could reject the null hypothesis

Table 1. Summary of Indicator Contaminants.

Group	Indicator contaminant	Units	PQL	Hanford Site Background			HH Direct Exposure CUL	
				Mean	90th percentile	Source		
Inorganic	Aluminum	ug/kg	NA	8080000	11800000	DOE/RL-92-24	NA	
	Antimony	ug/kg	600	15700	NA	DOE/RL-92-24	32000	
	Arsenic	ug/kg	1000	4200	6470	DOE/RL-92-24	20000	
	Barium	ug/kg	500	92700	132000	DOE/RL-92-24	16000000	
	Beryllium	ug/kg	NA	670	810	Ecology 94-115	10400	
	Cadmium	ug/kg	200	450	810	Ecology 94-115	80000	
	Chromium	ug/kg	200	10900	18500	DOE/RL-92-24	12000000	
	Copper	ug/kg	1000	15500	22000	DOE/RL-92-24	2960000	
	Hexavalent Chromium	ug/kg	500	NA	NA	NA	2100	
	Iron	ug/kg	NA	24500000	32600000	DOE/RL-92-24	NA	
	Lead	ug/kg	500	6300	10200	DOE/RL-92-24	250000	
	Lithium	ug/kg	5000	34100	33500	DOE/RL-92-24	1600000	
	Manganese	ug/kg	NA	384000	512000	DOE/RL-92-24	NA	
	Mercury	ug/kg	200	260	330	DOE/RL-92-24	24000	
	Nickel	ug/kg	NA	13000	19100	DOE/RL-92-24	1600000 &	
	Nitrate	ug/kg	2500	30100	52000	DOE/RL-92-24	12800000	
	Silver	ug/kg	200	1600	730	DOE/RL-92-24	400000	
	Tin	ug/kg	NA	NA	NA	NA	NA	
	Uranium	ug/kg	5000	2300	3200	calculated	240000	
	Vanadium	ug/kg	NA	57600	85100	DOE/RL-92-24	NA	
Zinc	ug/kg	1000	53000	67800	DOE/RL-92-24	24000000		
Organics	Acenaphthene	ug/kg	100	NA	NA	NA	4800000	
	Acenaphthylene	ug/kg	100	NA	NA	NA	4800000	
	Anthracene	ug/kg	50	NA	NA	NA	24000000	
	Benzo(a)pyrene	ug/kg	15	NA	NA	NA	137	
	Benzo(ghi)perylene	ug/kg	30	NA	NA	NA	2400000	
	Benzo(k)fluoranthene	ug/kg	15	NA	NA	NA	1400	
	Chrysene	ug/kg	100	NA	NA	NA	14000	
	Dibenz[a,h]anthracene	ug/kg	30	NA	NA	NA	340	
	Fluoranthene	ug/kg	50	NA	NA	NA	3200000	
	Fluorene	ug/kg	30	NA	NA	NA	3200000	
	Indeno(1,2,3-cd)pyrene	ug/kg	30	NA	NA	NA	1370	
	Naphthalene	ug/kg	100	NA	NA	NA	1600000	
	Phenanthrene	ug/kg	50	NA	NA	NA	24000000	
	Pyrene	ug/kg	50	NA	NA	NA	2400000	
	Methoxychlor +	ug/kg	NA	NA	NA	NA	NA	
	1,2,4-trichlorobenzene	ug/kg	330	NA	NA	NA	800000	
	1,2-dichlorobenzene	ug/kg	330	NA	NA	NA	7200000	
	2,4,5-trichlorophenol	ug/kg	330	NA	NA	NA	8000000	
	2,4,6-trichlorophenol	ug/kg	330	NA	NA	NA	91000	
	Dibenzofuran	ug/kg	330	NA	NA	NA	160000	
	Pentachlorophenol	ug/kg	330	NA	NA	NA	8300	
	TPH-DRO **	NA	NA	NA	NA	NA	NA	
	TPH-GRO **	NA	NA	NA	NA	NA	NA	
	Carbon-14 **	NA	NA	NA	NA	NA	NA	
	Radio-nuclides	Cobalt-60	pCi/g	0.05	NA	NA	NA	1.4
		Cesium-137	pCi/g	0.1	0.417	1.05	DOE/RL-96-12	6.2
Europium-152		pCi/g	0.1	NA	NA	NA	3.3	
Europium-154		pCi/g	0.1	NA	NA	NA	3	
Plutonium-238		pCi/g	1	0.00158	0.00378	DOE/RL-96-12	37.4	
Radium-226		pCi/g	0.1	0.561	0.815	DOE/RL-96-12	1.04	
Radium-228		pCi/g	0.2	0.945	1.32	DOE/RL-96-12 ***	1.69	
Strontium-90		pCi/g	1	0.0806	0.178	DOE/RL-96-12	4.5	
Thorium-228		pCi/g	1	0.945	1.32	DOE/RL-96-12 ***	2.26	
Thorium-232		pCi/g	1	0.945	1.32	DOE/RL-96-12	1.3	
Tritium **		NA	NA	NA	NA	NA	NA	
Uranium-233/234		pCi/g	1	0.793	1.1	DOE/RL-96-12	1.1	
Uranium-235		pCi/g	1	0.0515	0.109	DOE/RL-96-12	0.84	
Uranium-238	pCi/g	1	0.763	1.06	DOE/RL-96-12	1.1		

** Not a soil contaminant - thus no soil sample results

*** Th-232 daughter

+ not a soil contaminant but included in the soil suite although not detected in soil samples & cleanup level is from the 100 Area RDR/RAWP

Table 2. Summary Statistics for Indicator Contaminants.

Analyte Type	Indicator Contaminant	Number of samples	Number of detects	Frequency of detection	Units	Detect > PQL?	Max detect > background?	Detects						Non-detects			Elimination Criterion **
								Average concentration	Standard deviation	Min.	Median	Max.	relative standard deviation	Min	Median	Max	
Inorganic	Aluminum	45	45	1.00	ug/kg	NA	no	5820000	1410000	3960000	5230000	9300000	24%	NA	NA	NA	C
	Antimony	45	9	0.20	ug/kg	yes	NA	497	194	190	606	806	39%	190	607	626	Retained
	Arsenic	45	45	1.00	ug/kg	yes	yes	3680	2150	1800	2700	9500	58%	NA	NA	NA	Retained
	Barium	45	45	1.00	ug/kg	yes	no	74000	16500	48600	71000	114000	22%	NA	NA	NA	C
	Beryllium	45	37	0.82	ug/kg	NA	no	389	227	5	410	810	58%	5	5	15	C
	Cadmium	45	25	0.56	ug/kg	yes	yes	625	546	43	655	1600	87%	30	107	110	Retained
	Chromium	45	45	1.00	ug/kg	yes	yes	13400	7490	4500	9900	31300	56%	NA	NA	NA	Retained
	Copper	45	45	1.00	ug/kg	yes	yes	17900	7050	10300	15400	38300	39%	NA	NA	NA	Retained
	Hexavalent Chromium	45	29	0.64	ug/kg	yes	NA	1350	2550	213	407	10400	189%	181	202.5	207	Retained
	Iron	45	45	1.00	ug/kg	NA	no	19600000	2630000	12000000	20000000	24500000	13%	NA	NA	NA	C
	Lead	45	45	1.00	ug/kg	yes	yes	28200	55100	4000	11400	327000	195%	NA	NA	NA	Retained
	Lithium	45	45	1.00	ug/kg	yes	no	6540	1900	4100	5800	10900	29%	NA	NA	NA	C
	Manganese	45	45	1.00	ug/kg	NA	yes	336000	72800	238000	322000	525000	22%	NA	NA	NA	Retained
	Mercury	45	18	0.40	ug/kg	no	no	43.7	27.2	21	41.5	139	62%	19	21	22	B
	Nickel	45	45	1.00	ug/kg	NA	yes	12600	3890	7400	10900	21300	31%	NA	NA	NA	Retained
	Nitrate	15	15	1.00	ug/kg	yes	yes	49700	35600	12100	38300	121000	72%	NA	NA	NA	Retained
	Silver	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	70	212	219	A
Tin	45	33	0.73	ug/kg	NA	NA	2170	1990	530	1400	8400	92%	766	808	814	Retained	
Uranium	45	3	0.07	ug/kg	no	yes	3250	220	3110	3130	3500	7%	970	3120	3230	B	
Vanadium	45	45	1.00	ug/kg	NA	no	45000	7890	24100	44200	63500	18%	NA	NA	NA	C	
Zinc	45	45	1.00	ug/kg	yes	yes	92100	76800	31800	43400	252000	83%	NA	NA	NA	Retained	
Organic	1,2,4-Trichlorobenzene	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	320	330	670	A
	1,2-Dichlorobenzene	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	320	330	670	A
	2,4,5-Trichlorophenol	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	810	830	1700	A
	2,4,6-Trichlorophenol	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	320	330	670	A
	Acenaphthene*	75	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	32.7	330	670	A
	Acenaphthylene*	75	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	32.7	330	670	A
	Anthracene*	75	5	0.07	ug/kg	no	NA	11.5	9.5	3.60	7.10	24	82%	3.27	330	670	B
	Benzo(a)pyrene*	75	20	0.27	ug/kg	yes	NA	19.4	27.2	3.45	8.55	120	140%	3.27	330	670	Retained
	Benzo(ghi)perylene*	75	17	0.23	ug/kg	yes	NA	15.7	17.1	3.41	10.40	69	109%	3.27	330	670	Retained
	Benzo(k)fluoranthene*	75	18	0.24	ug/kg	yes	NA	18.3	32.9	0.00	5.00	140	179%	3.27	330	670	Retained
	Chrysene*	75	18	0.24	ug/kg	no	NA	34.5	58.5	3.85	15.38	260	170%	3.27	330	670	B
	Dibenz[a,h]anthracene*	75	3	0.04	ug/kg	no	NA	19.9	24.5	3.80	7.77	48	123%	3.27	330	670	B
	Dibenzofuran*	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	320	330	670	A
	Fluoranthene*	75	24	0.32	ug/kg	yes	NA	45.2	87.7	7.70	16.75	430	194%	6.53	330	670	Retained
	Fluorene*	75	1	0.01	ug/kg	no	NA	10.3	NA	10.3	10.26	10.258	NA	3.27	330	670	B
	Indeno(1,2,3-cd)pyrene*	75	13	0.17	ug/kg	yes	NA	25.1	25.7	3.15	13.91	79.18	102%	3.27	330	670	Retained
	Methoxychlor	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	0.004	1.3	1.4	A
Naphthalene*	75	2	0.03	ug/kg	no	NA	15.7	0.4	15.39	15.70	16	3%	32.7	330	670	B	
Pentachlorophenol	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	810	830	1700	A	
Phenanthrene*	75	20	0.27	ug/kg	yes	NA	19.4	34.4	3.50	5.92	130	177%	3.27	330	670	Retained	
Pyrene*	75	21	0.28	ug/kg	yes	NA	51.4	92.7	7.49	22.35	430	180%	6.53	330	670	Retained	
Radionuclides	Cesium-137	45	16	0.36	pCi/g	yes	no	0.154	0.062	0.05	0.16	0.24	40%	0.065	0.115	0.24	Retained
	Cobalt-60	45	1	0.02	pCi/g	yes	NA	0.092	NA	0.09	0.09	0.092	NA	0.059	0.099	0.25	Retained
	Europium-152	45	3	0.07	pCi/g	yes	NA	0.431	0.288	0.22	0.32	0.758	67%	0.11	0.235	0.5	Retained
	Europium-154	45	0	0.00	pCi/g	no	NA	NA	NA	NA	NA	NA	NA	0.17	0.3	0.52	A
	Plutonium-238	35	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	-0.059	0	0.22	A
	Radium-226	45	40	0.89	pCi/g	yes	yes	0.451	0.146	0.23	0.44	0.885	32%	0.24	0.27	0.86	Retained
	Radium-228	45	31	0.69	pCi/g	yes	yes	0.716	0.240	0.47	0.64	1.6	33%	0.35	0.62	1.3	Retained
	Thorium-228	45	34	0.76	pCi/g	no	no	0.508	0.118	0.28	0.50	0.777	23%	0.088	0.271	0.395	B
Thorium-228 GEA	45	42	0.93	pCi/g	yes	yes	0.647	0.208	0.29	0.64	1.1	32%	0.15	0.21	0.28	Retained	
Thorium-232	45	32	0.71	pCi/g	no	no	0.478	0.122	0.30	0.47	0.735	26%	0.079	0.281	0.518	B	

Analyte Type	Indicator Contaminant	Number of samples	Number of detects	Frequency of detection	Units	Detect > PQL?	Max detect > back-ground?	Detects						Non-detects			Elimination Criterion **
								Average concentration	Standard deviation	Min.	Median	Max.	relative standard deviation	Min	Median	Max	
	Thorium-232 GEA	45	31	0.69	pCi/g	yes	yes	0.716	0.240	0.47	0.64	1.6	33%	0.35	0.58	1.3	Retained
	Total beta radiostrontium	45	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	0.1	0.25	0.4	A
	Uranium-233/234	45	28	0.62	pCi/g	yes	yes	0.543	0.366	0.16	0.50	1.41	68%	0.077	0.12	0.297	Retained
	Uranium-235	45	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	0.14	0.29	0.5	A
	Uranium-235 GEA	45	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	0.17	0.31	0.54	A
	Uranium-238	45	23	0.51	pCi/g	no	no	0.518	0.263	0.16	0.53	0.967	51%	0.042	0.152	0.288	B
	Uranium-238 GEA	45	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	5.5	10	19	A

* PAHs were measured with two methods; 8270 at all investigation areas (45 samples); 8310 at upland investigation areas only (30 samples); thus, 75 samples total

** Elimination Criteria Code: A = Analyte never detected

B = Max detect < PQL

C = Max detect < Hanford Site Background

Retained = Analyte retained

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Table 3. Arsenic Concentrations from MIS Soil Samples.

Sample location	HEIS Number	Conc. (ug/kg)	Qual	PQL (ug/kg)	Mean as reported (ug/kg)	St. dev. as reported (ug/kg)	St. dev. ND as 0 (ug/kg)	St. dev. ND = 0.5 PQL (ug/kg)
600-131	J10DM5	2400		200	2140	167	NA	NA
	J10DM6	2100		200				
	J10DM7	2200		200				
	J10DM8	2000		200				
	J10DM9	2000		200				
Pit 23	J10DN0	2300		200	2200	100	NA	NA
	J10DN1	2300	J	200				
	J10DN2	2100	J	200				
	J10DN3	2200	J	200				
	J10DN4	2100	J	200				
Upland Native Reference Central Plateau	J10DR5	2700		500	2780	476	NA	NA
	J10DR6	3000		500				
	J10DR7	2100		500				
	J10DR8	2700		500				
	J10DR9	3400		500				
Upland Backfill Elevated 100-F-2	J10DP0	3800		200	3740	391	NA	NA
	J10DP1	3500		200				
	J10DP2	4100		200				
	J10DP3	4100		200				
	J10DP4	3200		200				
Upland Backfill Low 116-DR-1&2	J10DR0	2000		500	2320	311	NA	NA
	J10DR1	2300		500				
	J10DR2	2100		500				
	J10DR3	2400		500				
	J10DR4	2800		500				
Upland Native Elevated JA Jones	J10DT0	2800		500	2200	430	NA	NA
	J10DT1	2500		500				
	J10DT2	1900		500				
	J10DT3	2000		500				
	J10DT4	1800		500				
Riparian Elevated #3	J10DP5	3100		500	2960	297	NA	NA
	J10DP6	2600		500				
	J10DP7	3300		500				
	J10DP8	2700		500				
	J10DP9	3100		500				
Riparian Low #10 Downriver 100-D	J10LJ0	6800		500	6460	207	NA	NA
	J10LJ1	6300	C	500				
	J10LJ2	6300		500				
	J10LJ3	6500		500				
	J10LJ4	6400		500				
Riparian Reference #13 Vernita Bridge	J10DN5	8200		500	8360	658	NA	NA
	J10DN6	7800		500				
	J10DN7	8200		500				
	J10DN8	8100		500				
	J10DN9	9500		500				

J = The reported value is an estimate.

C = The analyte was detected in the associated QC blank above the IDL/MDL.

NA = Not applicable.

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Table 4. Hexavalent Chromium Concentrations from MIS Soil Samples.

Sample location	HEIS Number	Conc. (ug/kg)	Qual	PQL (ug/kg)	Mean as reported (ug/kg)	St. dev. as reported (ug/kg)	St. dev. ND as 0 (ug/kg)	St. dev. ND = 0.5 PQL (ug/kg)
600-131	J10DM5	199	U	200	342	188	274	228
	J10DM6	447		200				
	J10DM7	246		200				
	J10DM8	195	U	200				
	J10DM9	622		200				
Pit 23	J10DN0	256	J	200	222	35	134	80
	J10DN1	200	UJ	200				
	J10DN2	213	J	200				
	J10DN3	259	J	200				
	J10DN4	181	UJ	200				
Upland Native Reference Central Plateau	J10DR5	489		200	287	118	208	161
	J10DR6	205	U	200				
	J10DR7	204	U	200				
	J10DR8	286		200				
	J10DR9	250		200				
Upland Backfill Elevated 100-F-2	J10DP0	437	D	400	994	914	218	405
	J10DP1	200	U	200				
	J10DP2	351		200				
	J10DP3	1990	UD	2000				
	J10DP4	1990	UD	2000				
Upland Backfill Low 116-DR-1&2	J10DR0	400	UD	400	326	83	174	93
	J10DR1	399	UD	400				
	J10DR2	322		200				
	J10DR3	196	U	200				
	J10DR4	315		200				
Upland Native Elevated JA Jones	J10DT0	204	U	200	315	103	214	146
	J10DT1	398		200				
	J10DT2	399		200				
	J10DT3	201	U	200				
	J10DT4	372		200				
Riparian Elevated #3	J10DP5	252		200	344	110	185	146
	J10DP6	407		200				
	J10DP7	440		200				
	J10DP8	200	U	200				
	J10DP9	419		200				
Riparian Low #10 Downriver 100-D	J10LJ0	244		200	557	234	344	310
	J10LJ1	595		200				
	J10LJ2	745		200				
	J10LJ3	398	U	200				
	J10LJ4	801		200				
Riparian Reference #13 Vernita Bridge	J10DN5	10400	D		5940	3700	4310	No PQL reported
	J10DN6	8970	D					
	J10DN7	5600	D					
	J10DN8	2070	UD					
	J10DN9	2670	D					

J = The reported value is an estimate.

U = Analyzed for but not detected above limiting criteria (<= PQL)

D = Sample was analyzed using a secondary dilution factor (i.e., dilution factor different than 1.0).

Appendix D

Table 5. Lead Concentrations from MIS Soil Samples.

Sample location	HEIS Number	Conc. (ug/ kg)	Qual	PQL (ug/k g)	Mean as reported (ug/kg)	St. dev. as reported (ug/kg)	St. dev. ND as 0 (ug/kg)	St. dev. ND = 0.5 PQL (ug/kg)
600-131	J10DM5	327000		200	116000	142000	NA	NA
	J10DM6	198000		200				
	J10DM7	12400		200				
	J10DM8	29400		200				
	J10DM9	12300		200				
Pit 23	J10DN0	4300		200	4360	483	NA	NA
	J10DN1	4000	J	200				
	J10DN2	4100	J	200				
	J10DN3	5200	J	200				
	J10DN4	4200	J	200				
Upland Native Reference Central Plateau	J10DR5	6300	C	500	6300	561	NA	NA
	J10DR6	6100	C	500				
	J10DR7	5500	C	500				
	J10DR8	7000		500				
	J10DR9	6600		500				
Upland Backfill Elevated 100-F-2	J10DP0	10200		200	11200	1390	NA	NA
	J10DP1	10100		200				
	J10DP2	12700		200				
	J10DP3	10200		200				
	J10DP4	12700		200				
Upland Backfill Low 116-DR-1&2	J10DR0	5500		500	5020	630	NA	NA
	J10DR1	4800		500				
	J10DR2	5000		500				
	J10DR3	4100		500				
	J10DR4	5700		500				
Upland Native Elevated JA Jones	J10DT0	7900		500	7880	2080	NA	NA
	J10DT1	7300		500				
	J10DT2	6700		500				
	J10DT3	6100		500				
	J10DT4	11400		500				
Riparian Elevated #3	J10DP5	17800		500	16700	1940	NA	NA
	J10DP6	19500		500				
	J10DP7	15600		500				
	J10DP8	14600		500				
	J10DP9	16100	C	500				
Riparian Low #10 Downriver 100-D	J10LJ0	37200	C	500	36800	3920	NA	NA
	J10LJ1	36400		500				
	J10LJ2	39200		500				
	J10LJ3	40600		500				
	J10LJ4	30400		500				
Riparian Reference #13 Vernita Bridge	J10DN5	49900		500	49700	3640	NA	NA
	J10DN6	47100		500				
	J10DN7	45900	C	500				
	J10DN8	50400		500				
	J10DN9	55300	C	500				

J = The reported value is an estimate.

C = The analyte was detected in the associated QC blank above the IDL/MDL.

NA = Not applicable.

Appendix D

Table 6. Benzo(a)pyrene concentrations from MIS soil samples.

Sample location	HEIS Number	Conc. (ug/kg)	Qual	PQL (ug/kg)	Mean as reported (ug/kg)	St. dev. as reported (ug/kg)	St. dev. ND as 0 (ug/kg)	St. dev. ND = 0.5 PQL (ug/kg)
600-131	J10DM5	8.8		3.27	12.6	11.0	NA	NA
	J10DM6	8.1		3.33				
	J10DM7	8.6		3.33				
	J10DM8	32		3.31				
	J10DM9	5.3		3.28				
Pit 23	J10DN0	3.27	UJ	3.27	3.3	0.0	0.0	0.015
	J10DN1	3.31	UJ	3.31				
	J10DN2	3.33	UJ	3.33				
	J10DN3	3.34	UJ	3.34				
	J10DN4	3.34	UJ	3.34				
Upland Native Reference Central Plateau	J10DR5	3.35	U	3.35	3.3	0.0	0.0	0.005
	J10DR6	3.35	U	3.35				
	J10DR7	3.33	U	3.33				
	J10DR8	3.34	U	3.34				
	J10DR9	3.33	U	3.33				
Upland Backfill Elevated 100-F-2	J10DP0	3.37	U	3.37	8.0	7.4	8.6	8.0
	J10DP1	9.425		3.37				
	J10DP2	3.379		3.36				
	J10DP3	3.37	U	3.37				
	J10DP4	20.376		3.37				
Upland Backfill Low 116-DR-1&2	J10DR0	8.816		3.35	6.0	1.8	NA	NA
	J10DR1	6.633		3.35				
	J10DR2	4.643		3.35				
	J10DR3	4.525		3.35				
	J10DR4	5.625		3.36				
Upland Native Elevated JA Jones	J10DT0	9.235		3.35	26.7	30.2	NA	NA
	J10DT1	10.585		3.33				
	J10DT2	80.197		3.34				
	J10DT3	20.54		3.35				
	J10DT4	13.091		3.35				

J = The reported value is an estimate.

U = Analyzed for but not detected above limiting criteria (<= PQL)

NA = Not applicable.

Appendix D

Table 7. Uranium-233/234 concentrations from MIS soil samples.

Sample location	HEIS Number	Conc. (pCi/g)	Qual	MDA (pCi/g)	Mean as reported (pCi/g)	St. dev. as reported (pCi/g)	St. dev. ND as 0 (pCi/g)	St. dev. ND = 0.5 PQL (pCi/g)
600-131	J10DM5	0.189	U	0.24	0.155	0.072	0.000	0.032
	J10DM6	0.146	U	0.22				
	J10DM7	0.26	U	0.33				
	J10DM8	0.083	U	0.32				
	J10DM9	0.096	U	0.37				
Pit 23	J10DN0	0.12	U	0.31	0.155	0.080	0.000	0.013
	J10DN1	0.134	U	0.26				
	J10DN2	0.105	U	0.27				
	J10DN3	0.297	U	0.32				
	J10DN4	0.119	U	0.3				
Upland Native Reference Central Plateau	J10DR5	0.212	U	0.27	0.306	0.118	0.181	0.137
	J10DR6	0.294		0.28				
	J10DR7	0.505		0.28				
	J10DR8	0.294		0.28				
	J10DR9	0.224		0.21				
Upland Backfill Elevated 100-F-2	J10DP0	0.256		0.15	0.197	0.039	NA	NA
	J10DP1	0.192		0.15				
	J10DP2	0.161		0.15				
	J10DP3	0.212		0.12				
	J10DP4	0.163		0.14				
Upland Backfill Low 116-DR-1&2	J10DR0	0.194		0.14	0.171	0.080	0.126	0.081
	J10DR1	0.077	U	0.15				
	J10DR2	0.228		0.19				
	J10DR3	0.257		0.2				
	J10DR4	0.097	U	0.19				
Upland Native Elevated JA Jones	J10DT0	0.337		0.32	0.178	0.112	0.164	0.089
	J10DT1	0.252		0.21				
	J10DT2	0.085	U	0.22				
	J10DT3	0.088	U	0.34				
	J10DT4	0.13	U	0.33				
Riparian Elevated #3	J10DP5	0.501		0.27	0.516	0.159	0.267	0.183
	J10DP6	0.252	U	0.39				
	J10DP7	0.598		0.42				
	J10DP8	0.668		0.23				
	J10DP9	0.559		0.17				
Riparian Low #10 Downriver 100-D	J10LJ0	0.679		0.13	0.669	0.059	NA	NA
	J10LJ1	0.571		0.12				
	J10LJ2	0.679		0.14				
	J10LJ3	0.688		0.14				
	J10LJ4	0.729		0.15				
Riparian Reference #13 Vernita Bridge	J10DN5	0.879		0.34	1.190	0.198	NA	NA
	J10DN6	1.23		0.25				
	J10DN7	1.15		0.24				
	J10DN8	1.28		0.26				
	J10DN9	1.41		0.26				

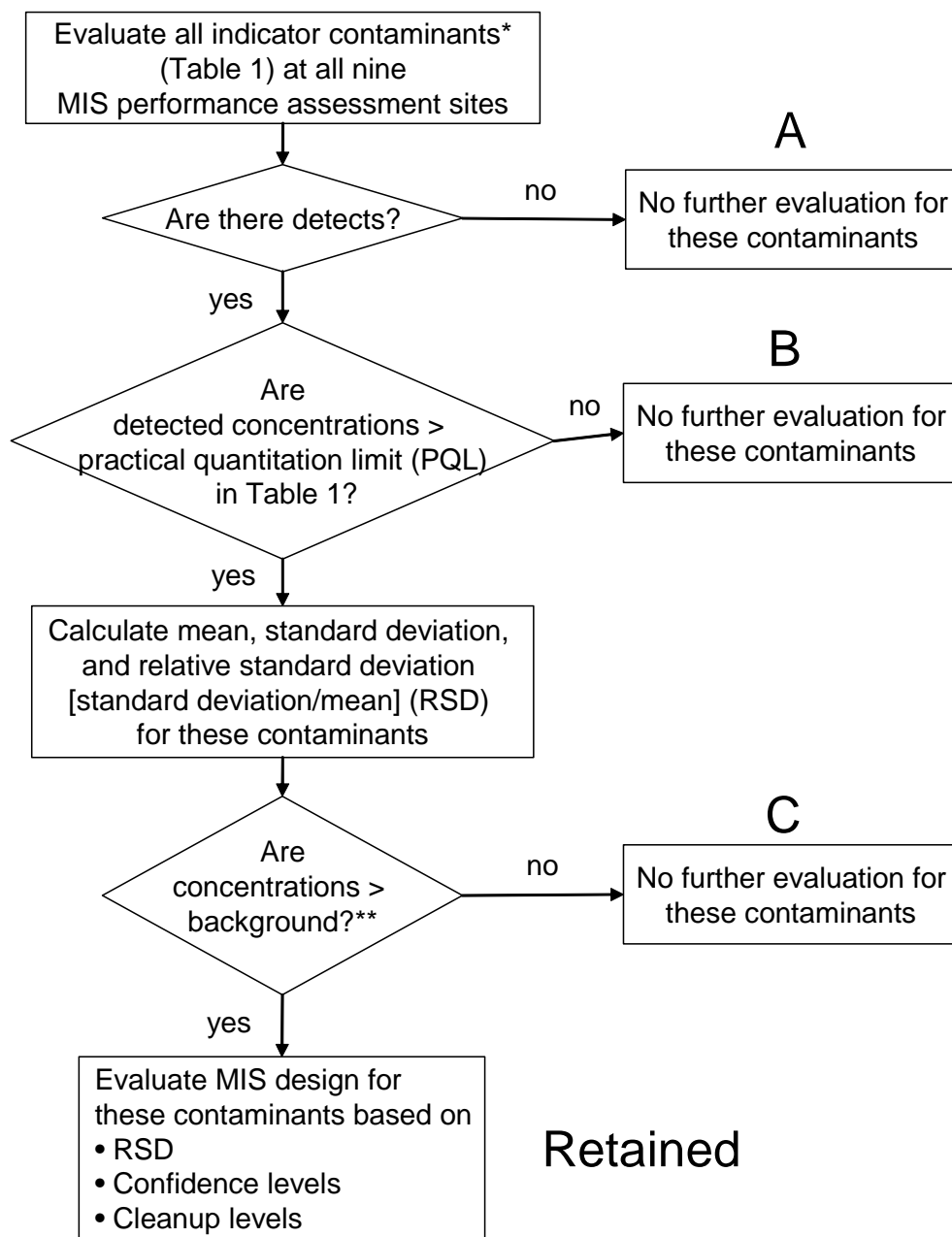
U = Analyzed for but not detected above limiting criteria (<= MDA)
NA = Not applicable.

Table 8. Summary of VSP calculations

Indicator contaminant	Units	Action level	Delta	Site type	St. dev. (s)	Number of samples
Arsenic	ppb	20000	10000	Riparian reference	658	2
				Riparian low	207	2
Hexavalent chromium	ppb	2000	1000	Riparian reference	3700	150
				Riparian low	230	2
				Upland backfill high	914	11
Lead	ppb	250000	125000	Upland native low	142000	16
				Riparian low	3920	2
Benzo(a)pyrene	ppb	137	68	Upland native elevated	23	3
				Upland native low	10	3
				Upland backfill elevated	7	3
Uranium-233/234	pCi/g	1.1	0.55	Riparian reference	0.2	3

Table 9. Summary of confidence levels for combinations of data at two contaminant and site combinations

Contaminant	Site	Units	Number of samples	Mean	UCL
Hexavalent chromium	Riparian reference	ug/kg	2	9680	22500
		ug/kg		8000	51100
		ug/kg	3	6230	81100
		ug/kg		6530	76000
		ug/kg		7280	37600
		ug/kg		5520	67500
		ug/kg		5820	62400
		ug/kg		3830	35600
		ug/kg		4135	30500
		ug/kg		2370	7760
		ug/kg		8320	15800
		ug/kg		7150	20700
		ug/kg		7350	19900
		ug/kg	6020	18700	
		ug/kg	6220	18100	
		ug/kg	5050	19200	
		ug/kg	5550	16000	
		ug/kg	5750	15300	
		ug/kg	4570	16200	
		ug/kg	3450	9190	
		ug/kg	4	6760	13600
		ug/kg		6910	13300
		ug/kg		6030	13900
ug/kg	5180	12200			
ug/kg	4830	10620			
ug/kg	5	5940	11100		
Lead	600-131	ug/kg	2	262000	1420000
		ug/kg		170000	3000000
		ug/kg	3	178000	2850000
		ug/kg		170000	3000000
		ug/kg		105000	1770000
		ug/kg		114000	1630000
		ug/kg		105000	1770000
		ug/kg		20900	174000
		ug/kg		12300	13200
		ug/kg		20850	174000
		ug/kg		179000	660000
		ug/kg		185000	639000
		ug/kg		179000	660000
		ug/kg	123000	661000	
		ug/kg	117000	670000	
		ug/kg	123000	661000	
		ug/kg	79900	392000	
		ug/kg	74200	400000	
		ug/kg	79900	392000	
		ug/kg	18000	48000	
		ug/kg	4	142000	416000
		ug/kg		137000	420000
		ug/kg		142000	416000
ug/kg	95300	380000			
ug/kg	63030	229000			
ug/kg	5	116000	312000		



* All contaminant suites will be analyzed and evaluated in the risk assessment report.

** Use 90th percentile of Hanford background for inorganic chemicals and radionuclides.

Figure 1. Multi-increment soil sampling performance assessment flow chart.

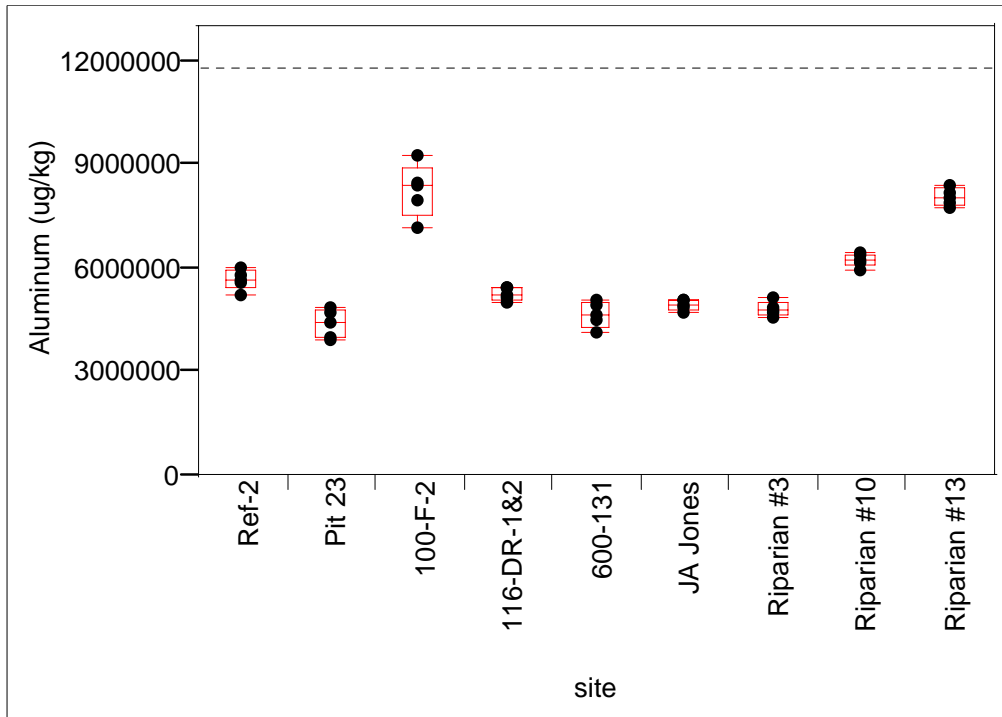


Figure 2. Box plot of aluminum concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

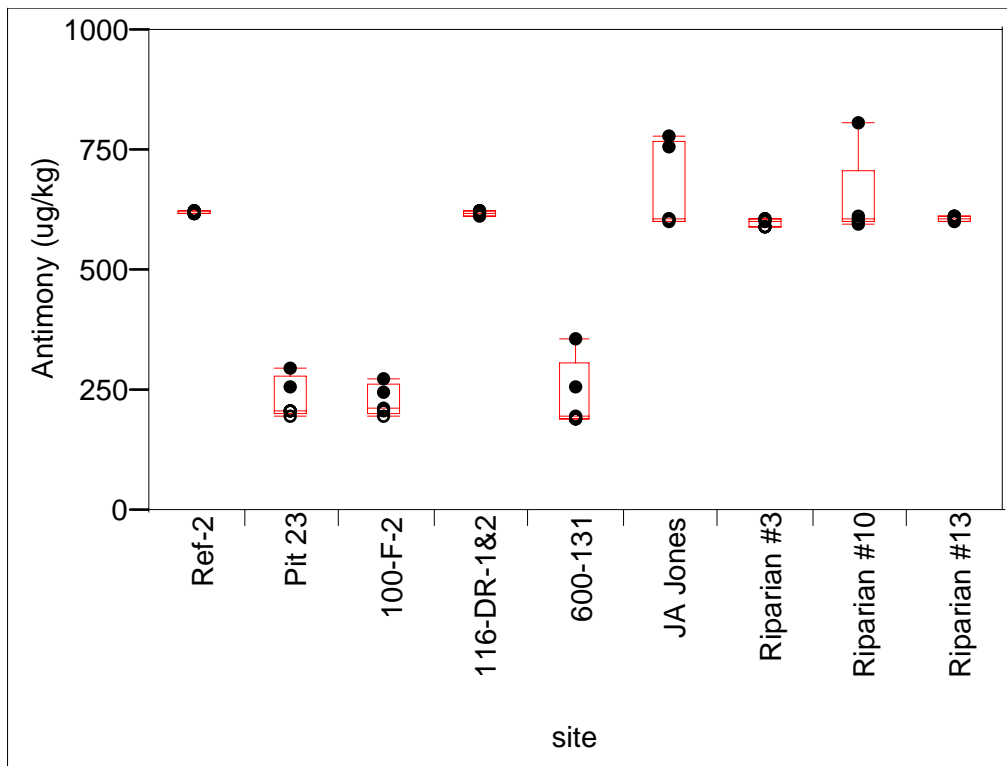


Figure 3. Box plot of antimony concentrations. Open circles are non-detects. No 90th percentile background concentration is available for antimony.

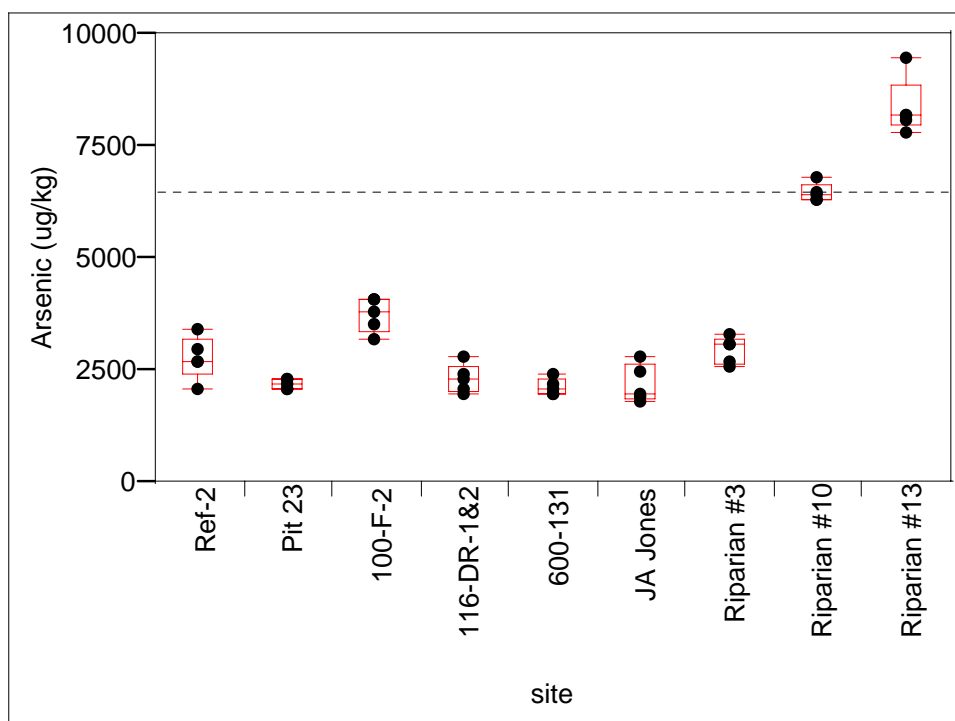


Figure 4. Box plot of arsenic concentrations. Dashed line is the Washington State background level (Ecology 94-115).

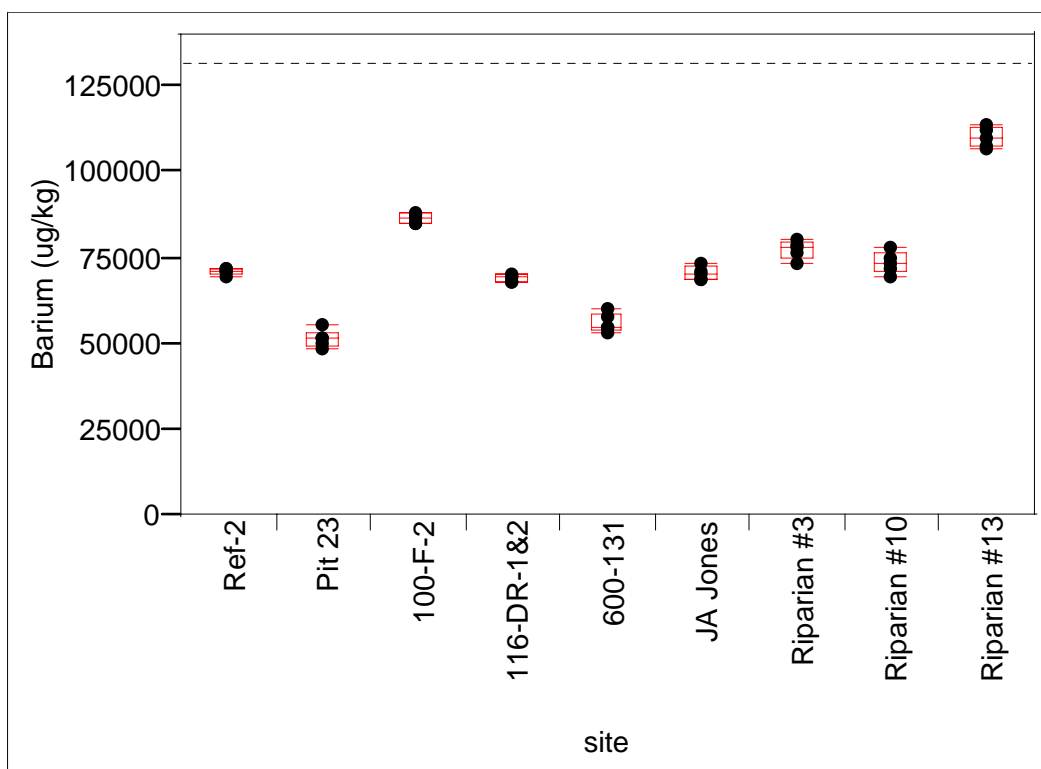


Figure 5. Box plot of barium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

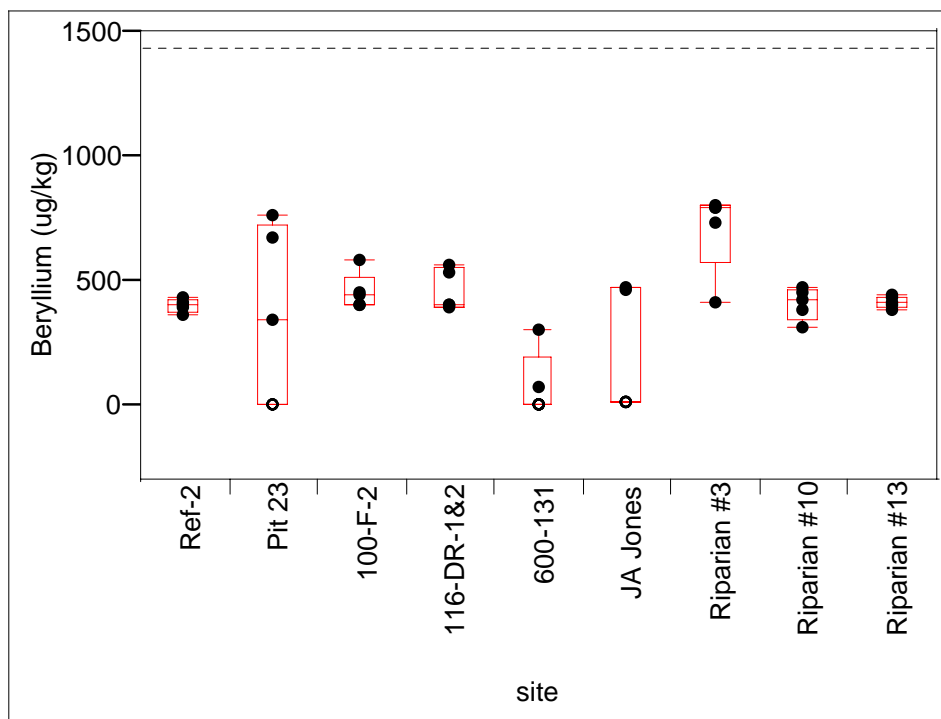


Figure 6. Box plot of beryllium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24). Open circles are non-detects.

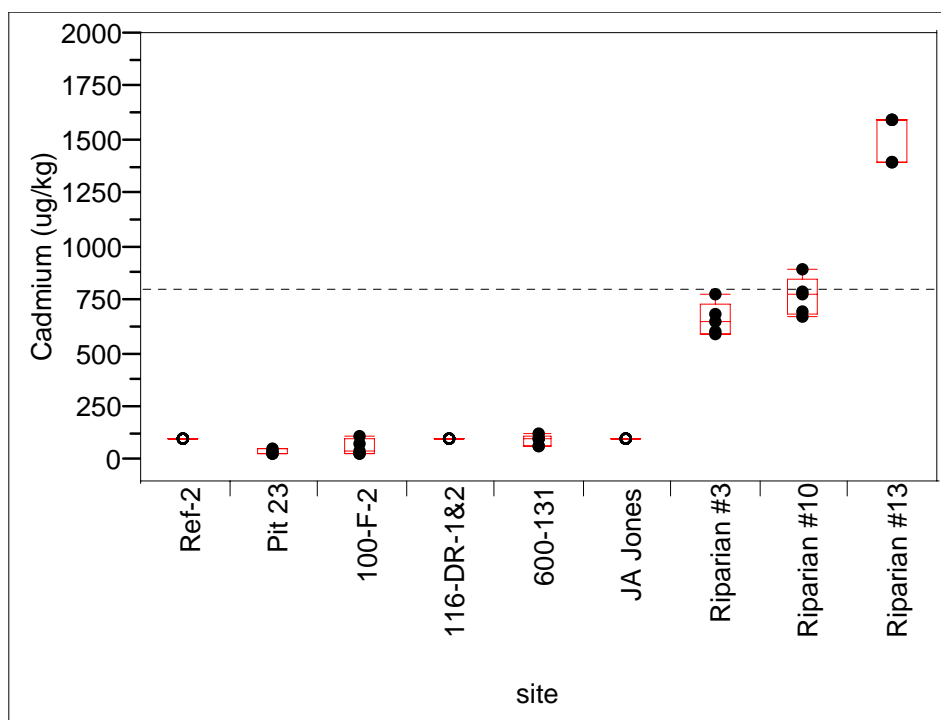


Figure 7. Box plot of cadmium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24). Open circles are non-detects.

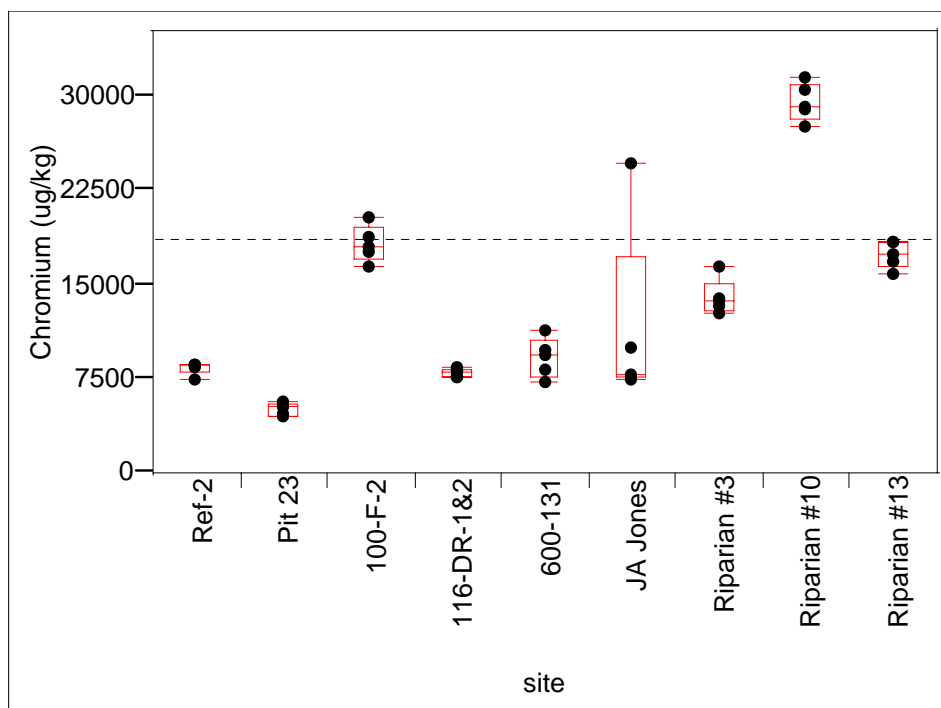


Figure 8. Box plot of chromium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24). Open circles are non-detects.

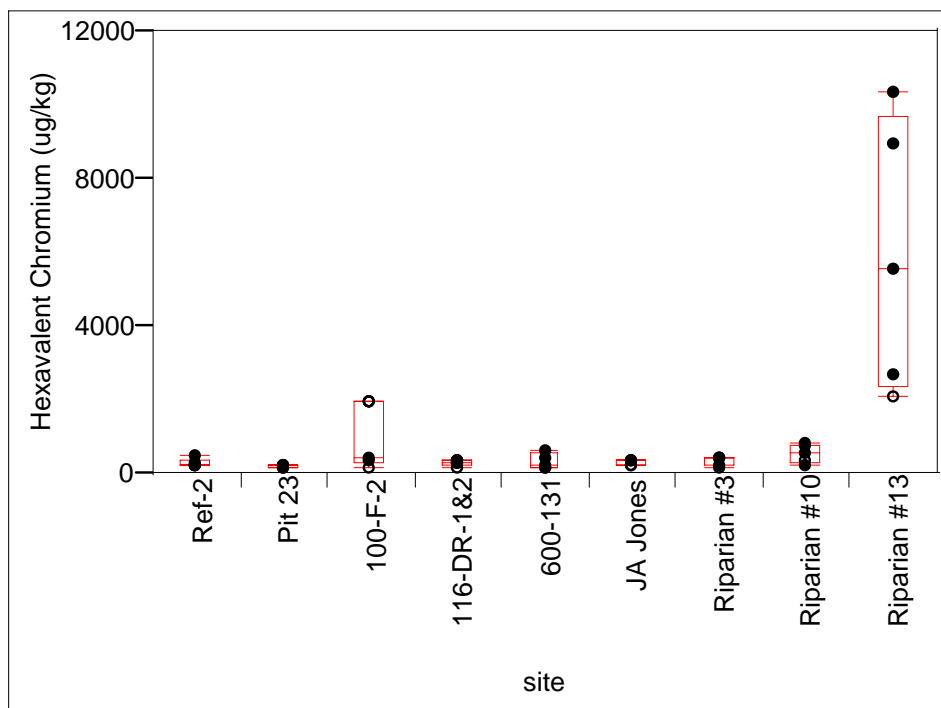


Figure 9. Box plot of hexavalent chromium concentrations. Open circles are non-detects.

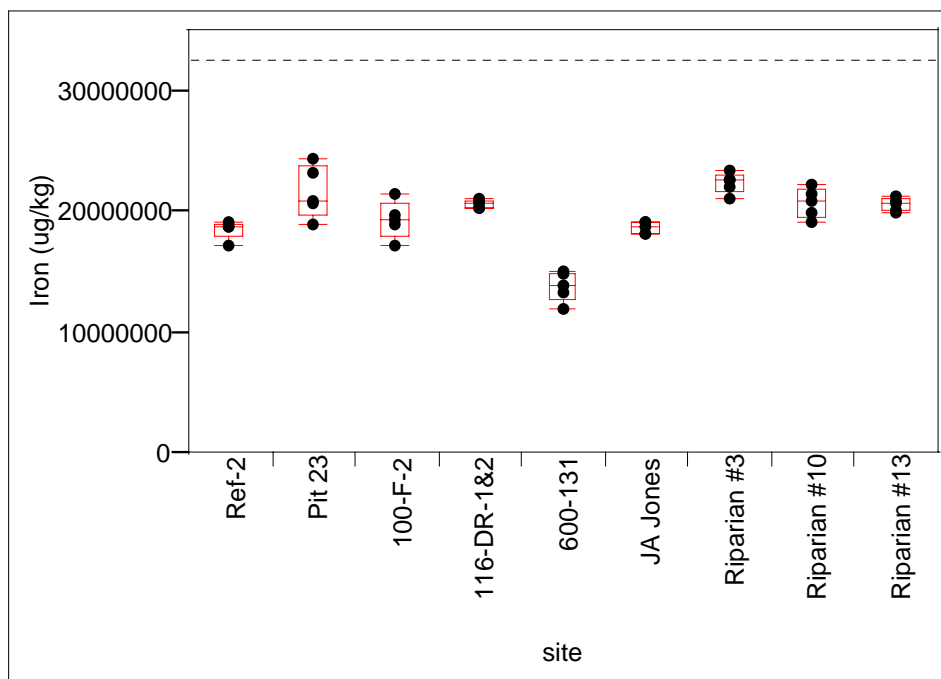


Figure 10. Box plot of iron concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

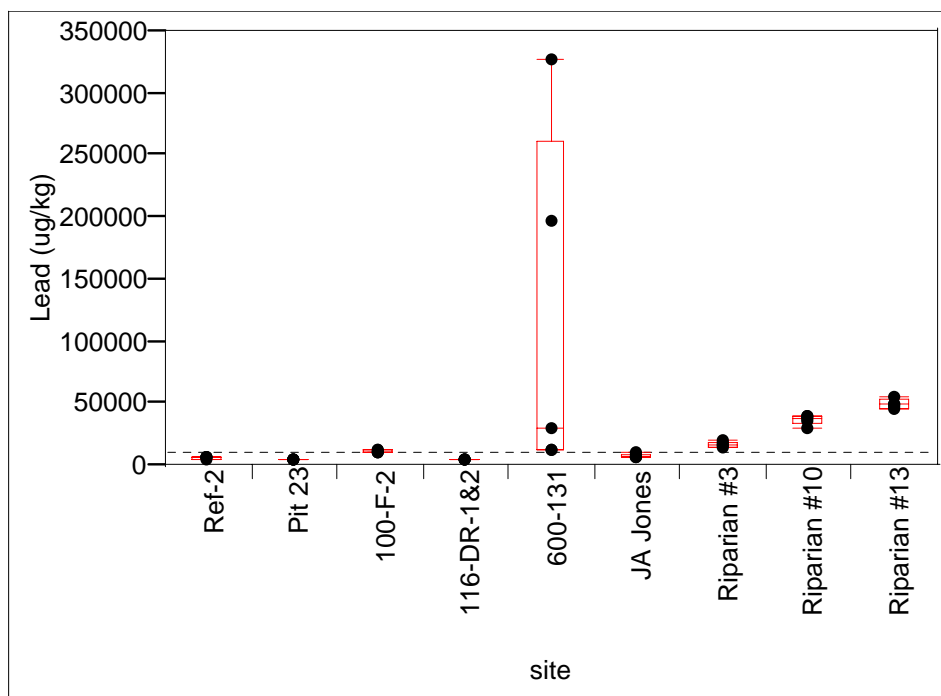


Figure 11. Box plot of lead concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

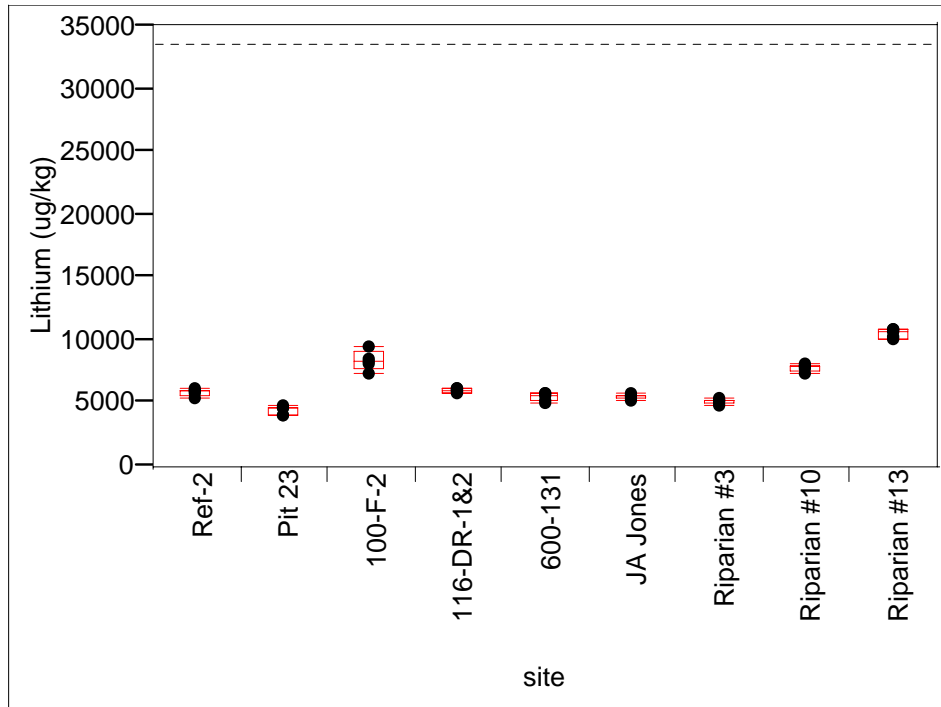


Figure 12. Box plot of lithium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

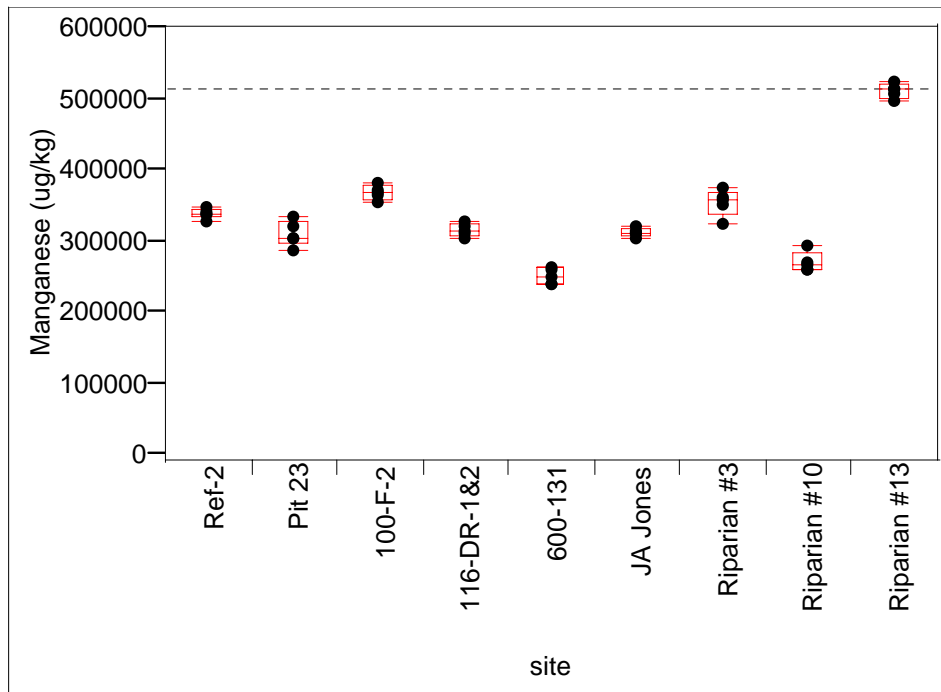


Figure 13. Box plot of manganese concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

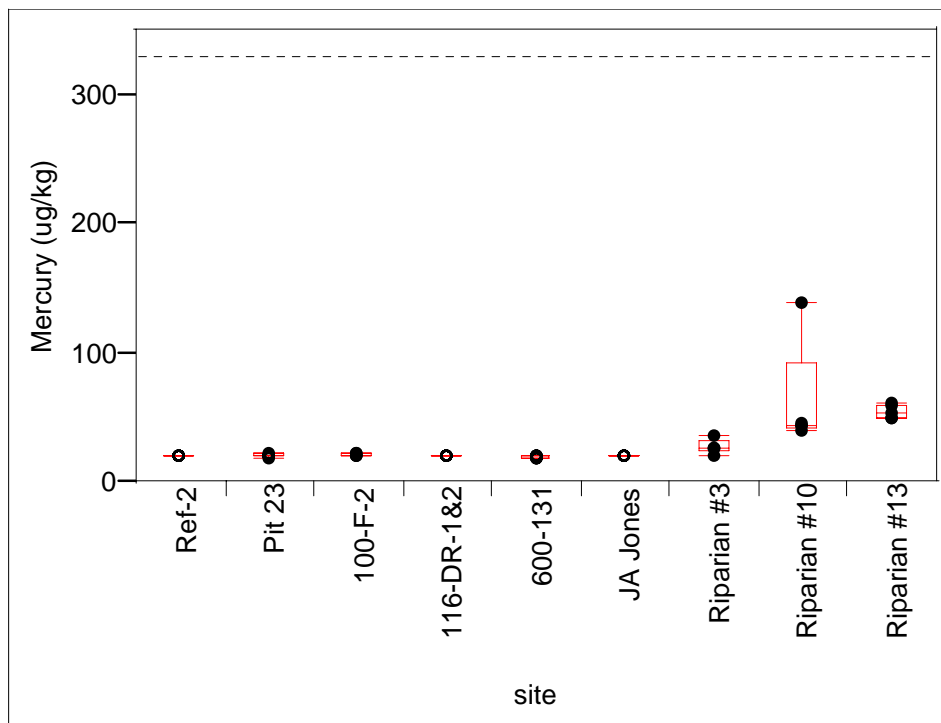


Figure 14. Box plot of mercury concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

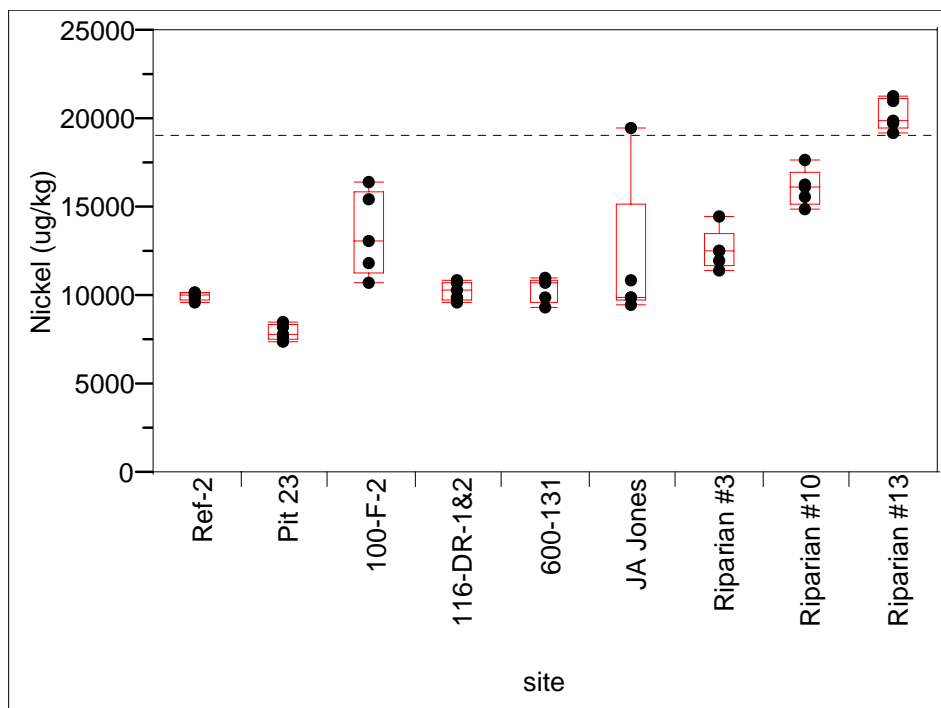


Figure 15. Box plot of nickel concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

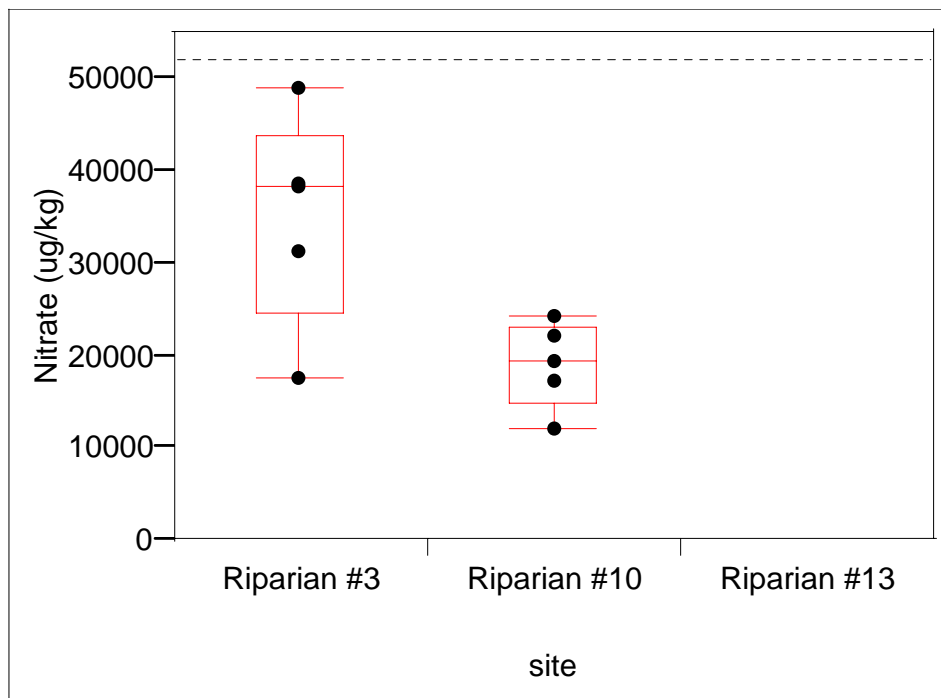


Figure 16. Box plot of nitrate concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

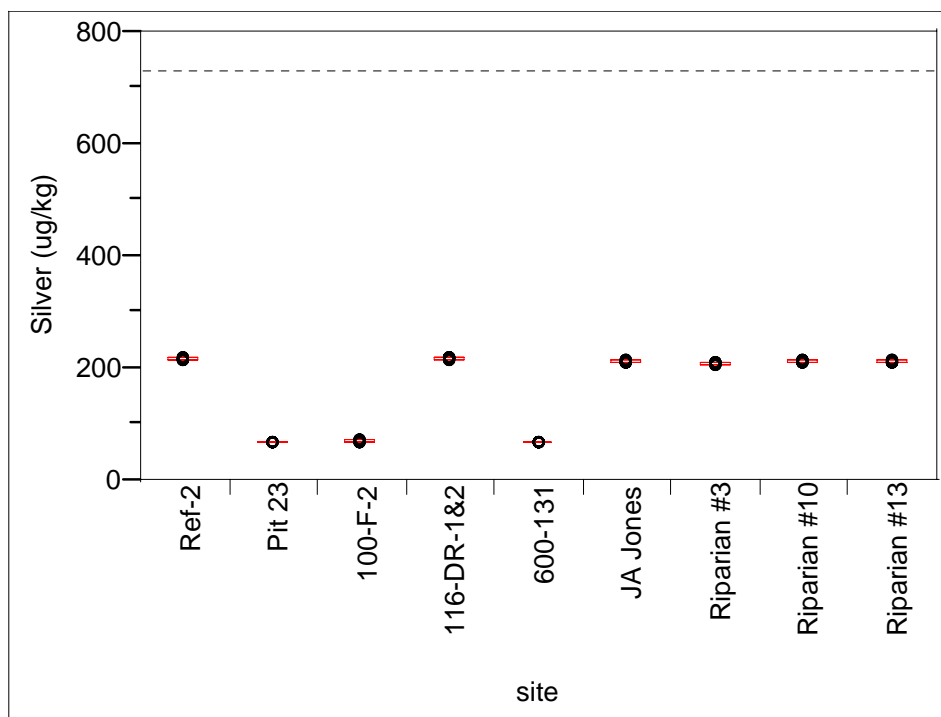


Figure 17. Box plot of silver concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24). Open circles are non-detects.

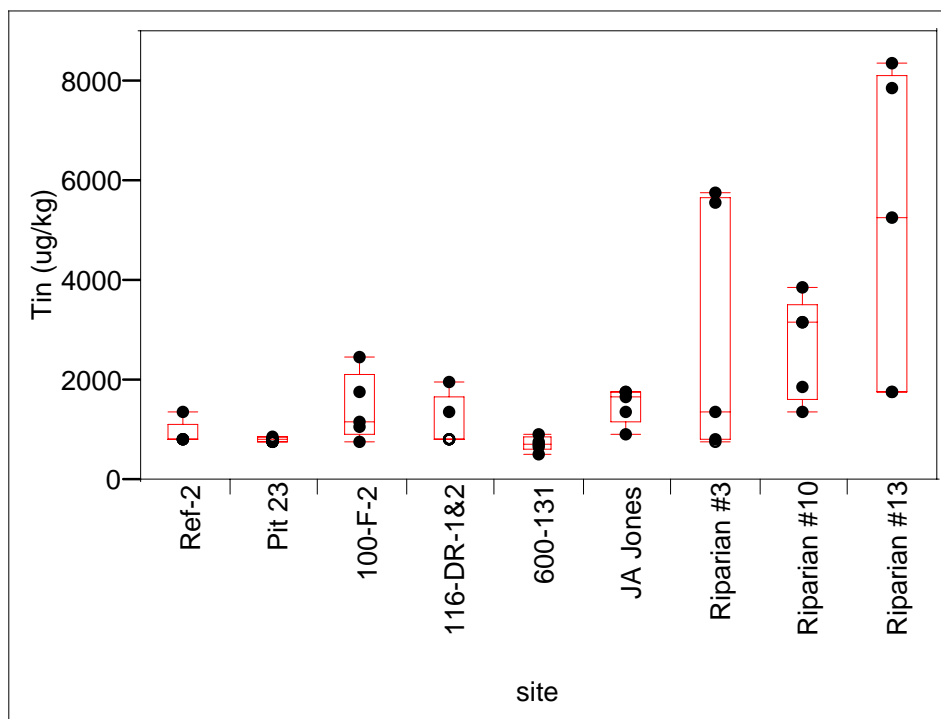


Figure 18. Box plot of tin concentrations. There are no background or cleanup levels for tin. Open circles are non-detects.

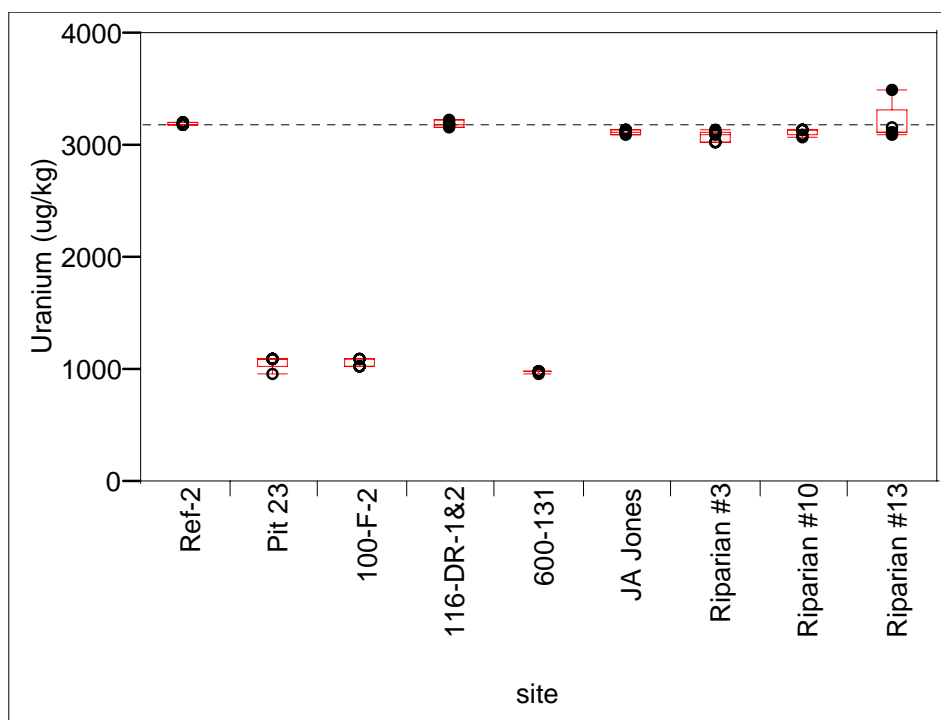


Figure 19. Box plot of uranium concentrations. Dotted line is 90th percentile of background (calculated). Open circles are non-detects.

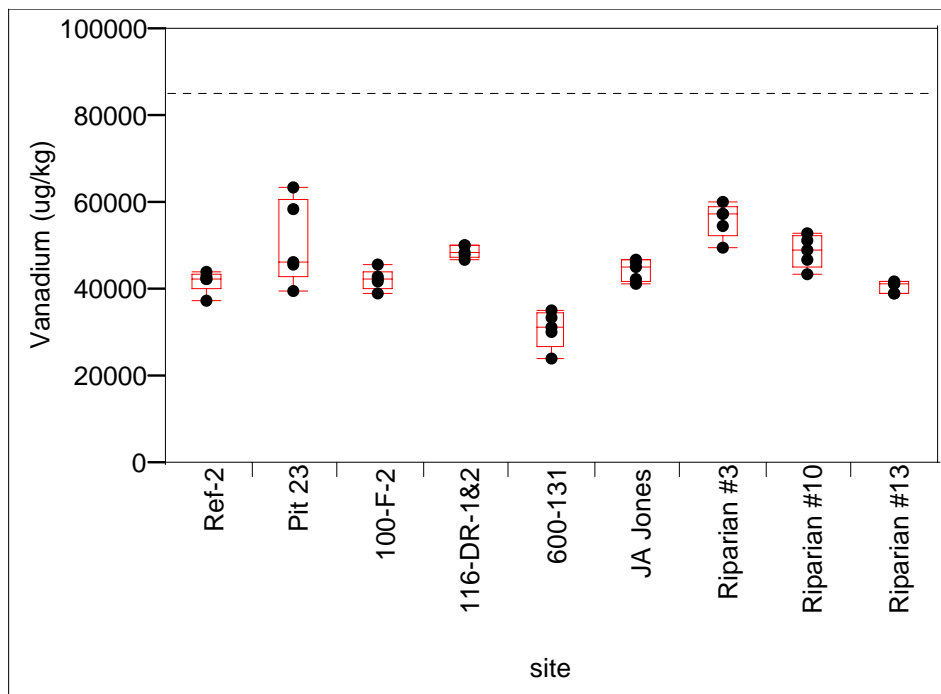


Figure 20. Box plot of vanadium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

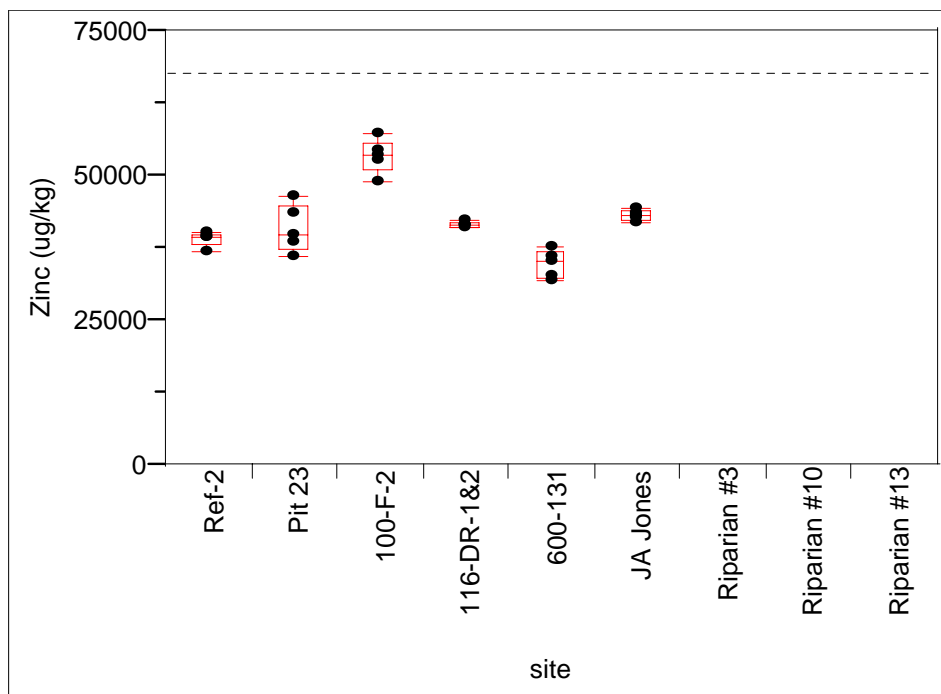


Figure 21. Box plot of zinc concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

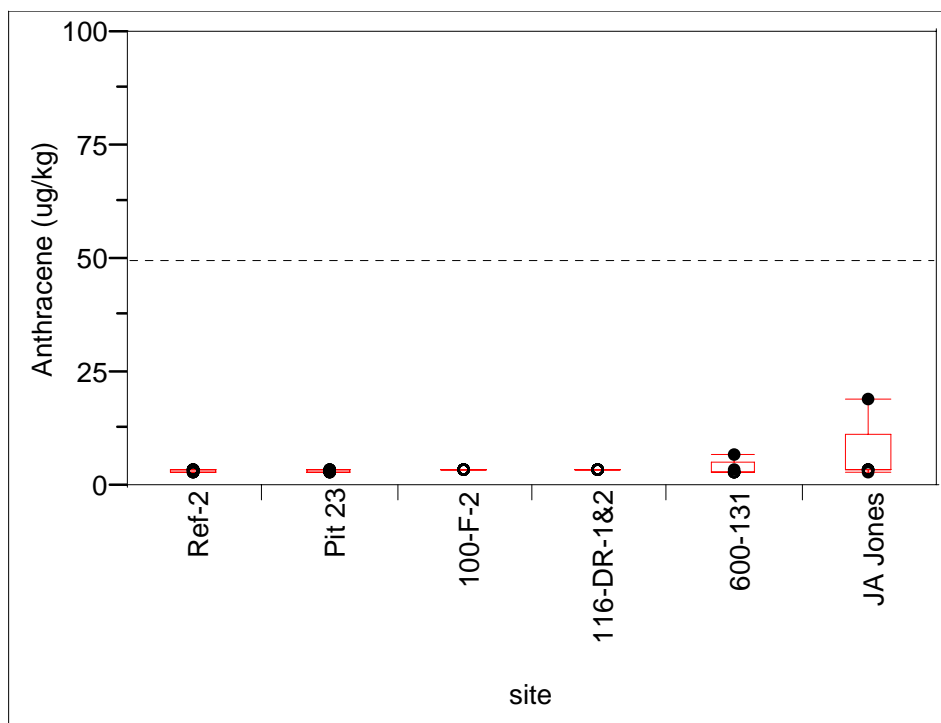


Figure 22. Box plot of anthracene concentrations. Dotted line is the PQL. Open circles are non-detects.

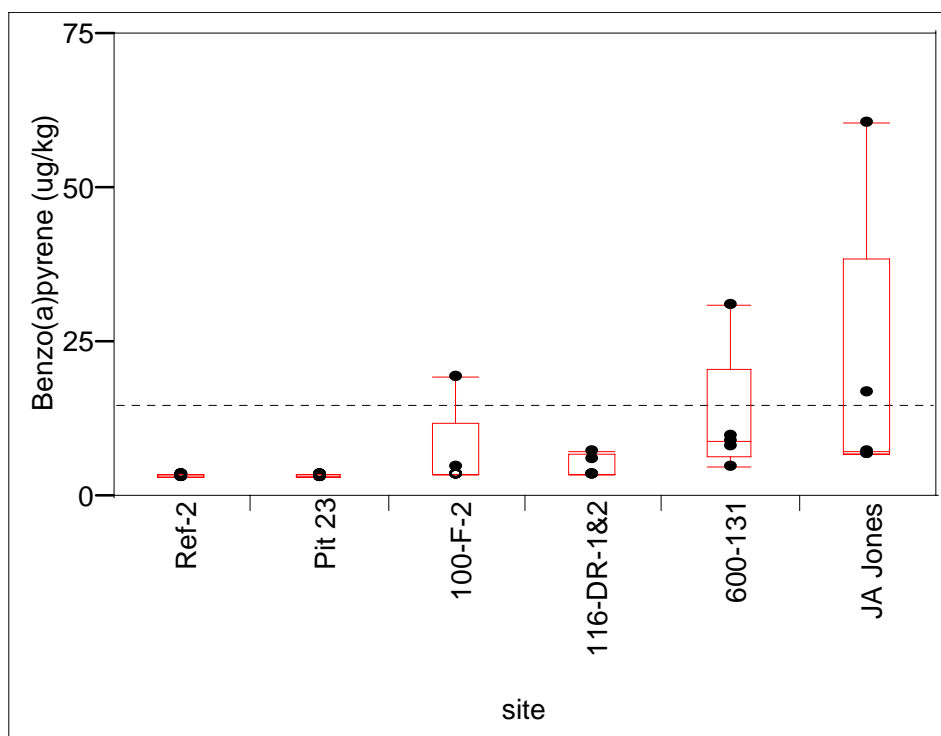


Figure 23. Box plot of benzo(a)pyrene concentrations. Dotted line is the PQL. Open circles are non-detects.

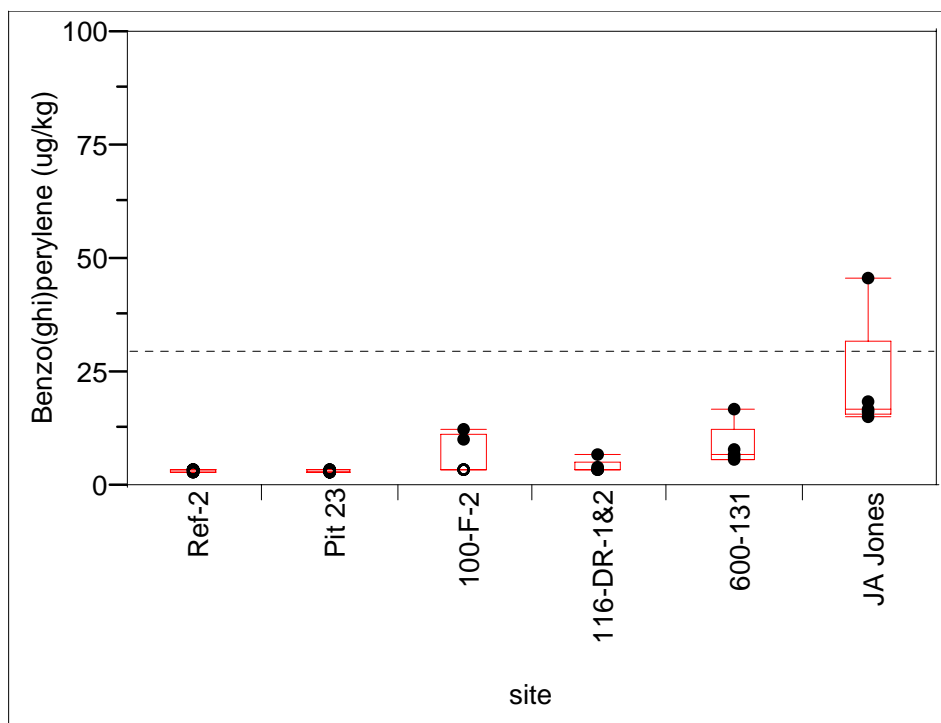


Figure 24. Box plot of benzo(ghi)perylene concentrations. Dotted line is the PQL. Open circles are non-detects.

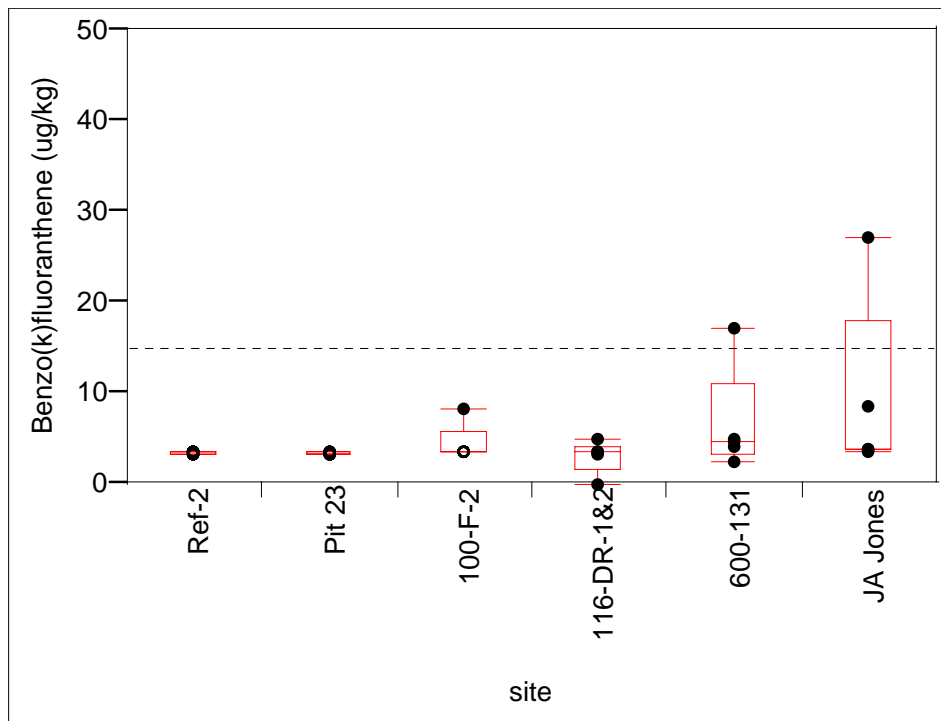


Figure 25. Box plot of benzo(k)fluoranthene concentrations. Dotted line is the PQL. Open circles are non-detects.

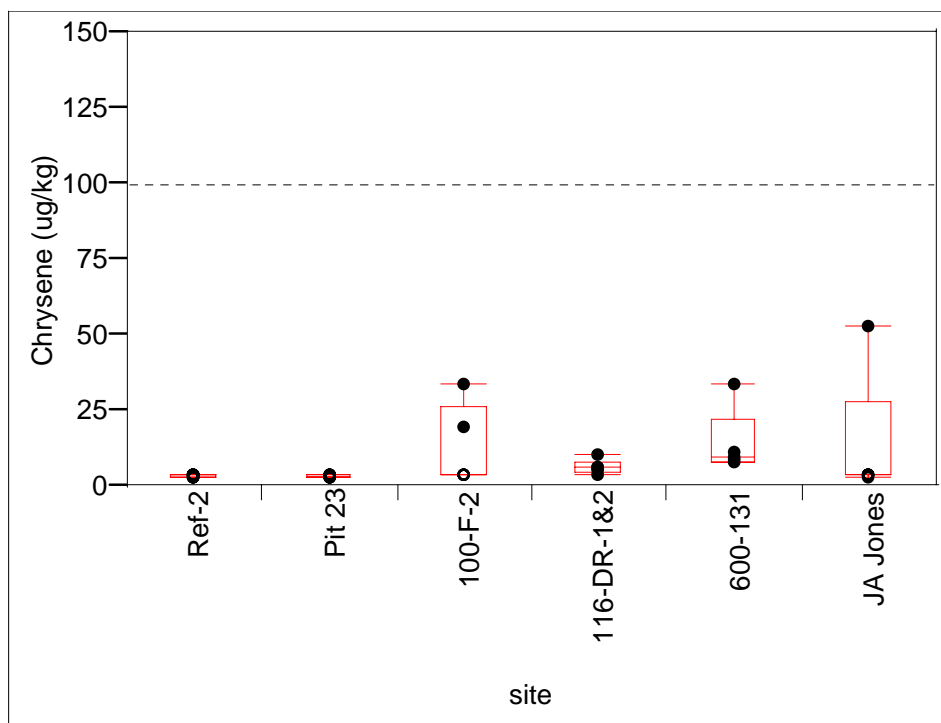


Figure 26. Box plot of chrysene concentrations. Dotted line is the PQL. Open circles are non-detects.

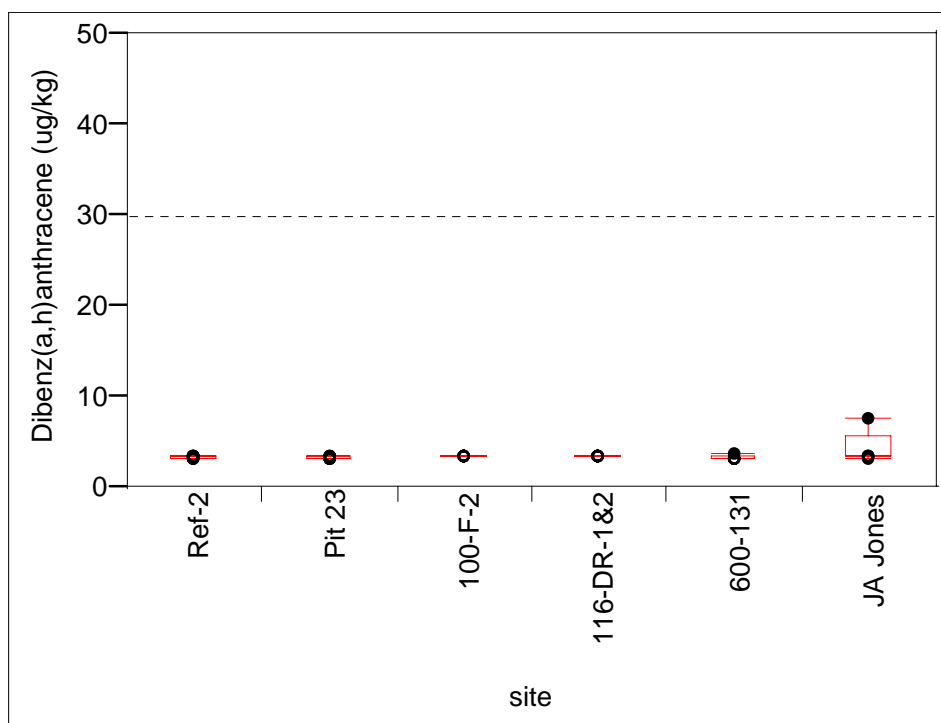


Figure 27. Box plot of dibenz(a,h)anthracene concentrations. Dotted line is the PQL. Open circles are non-detects.

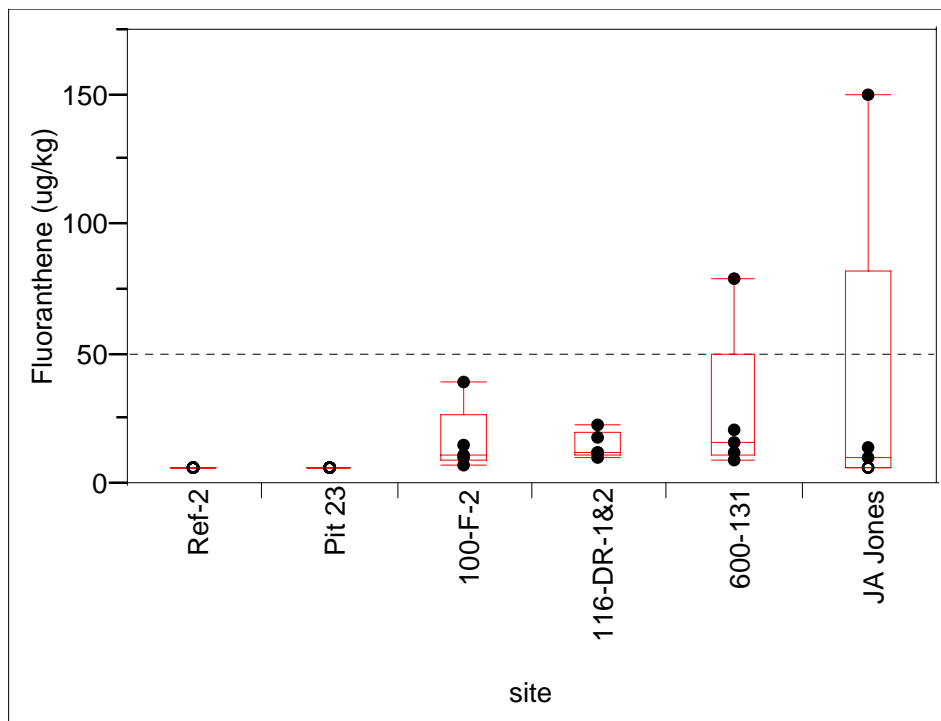


Figure 28. Box plot of fluoranthene concentrations. Dotted line is the PQL. Open circles are non-detects.

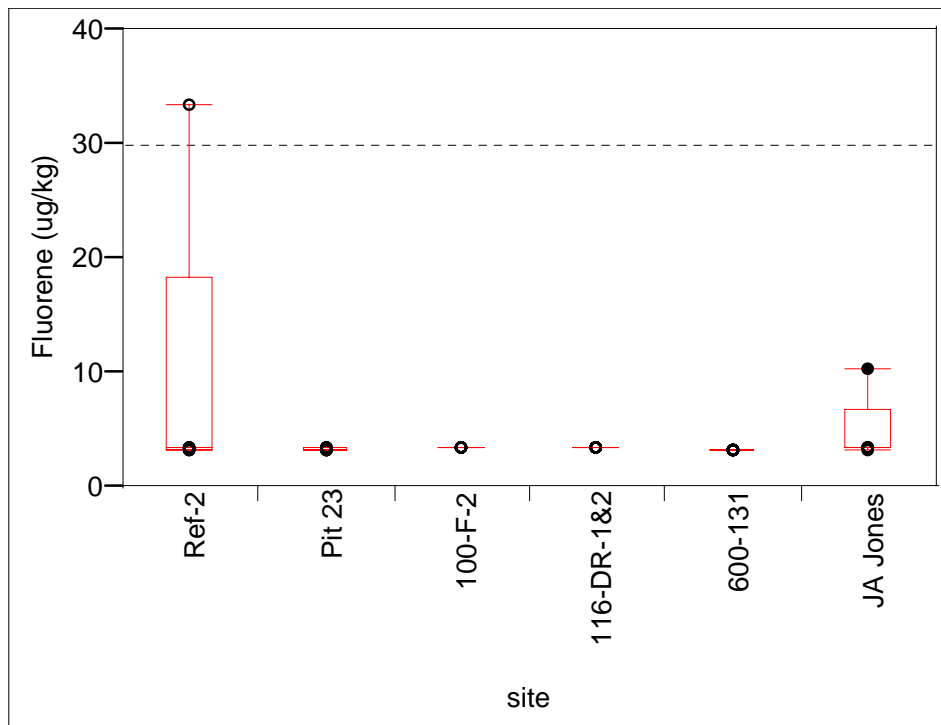


Figure 29. Box plot of fluorene concentrations. Dotted line is the PQL. Open circles are non-detects.

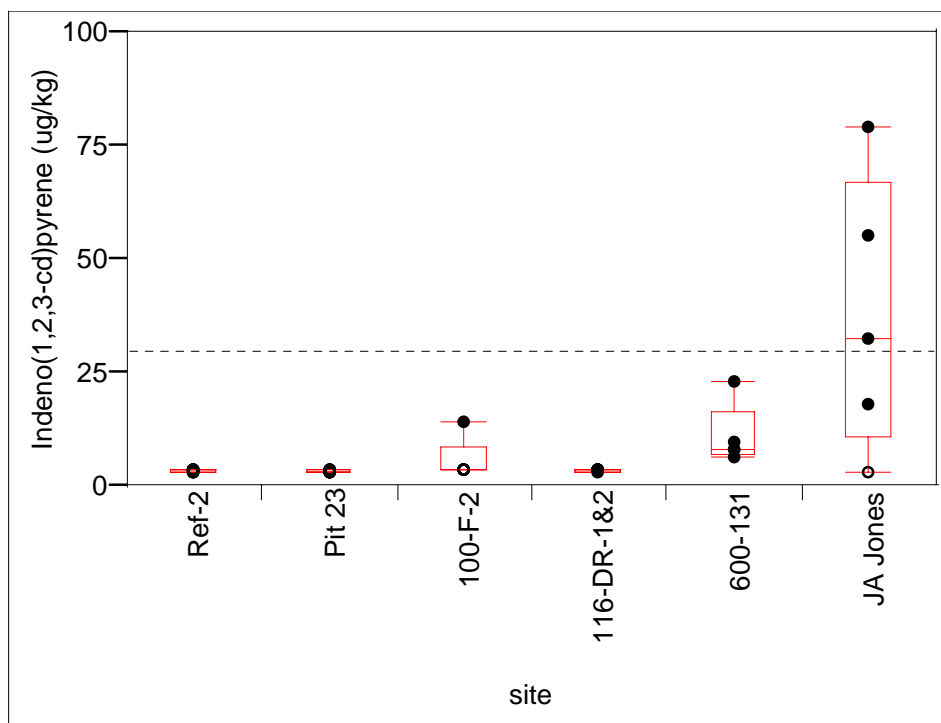


Figure 30. Box plot of indeno(1,2,3-cd)pyrene concentrations. Dotted line is the PQL. Open circles are non-detects.

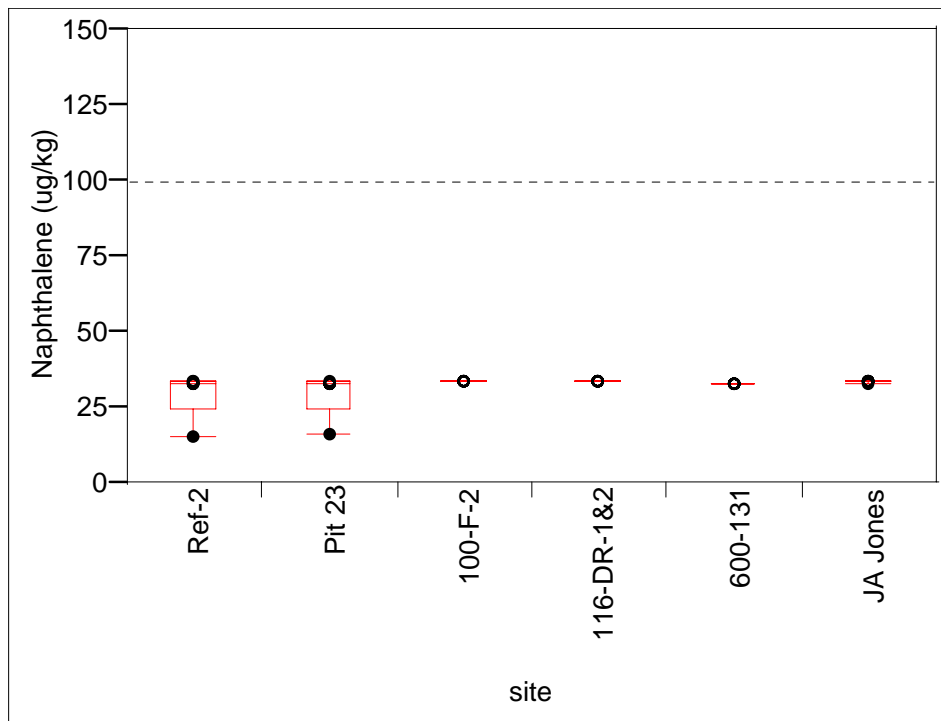


Figure 31. Box plot of naphthalene concentrations. Dotted line is the PQL. Open circles are non-detects.

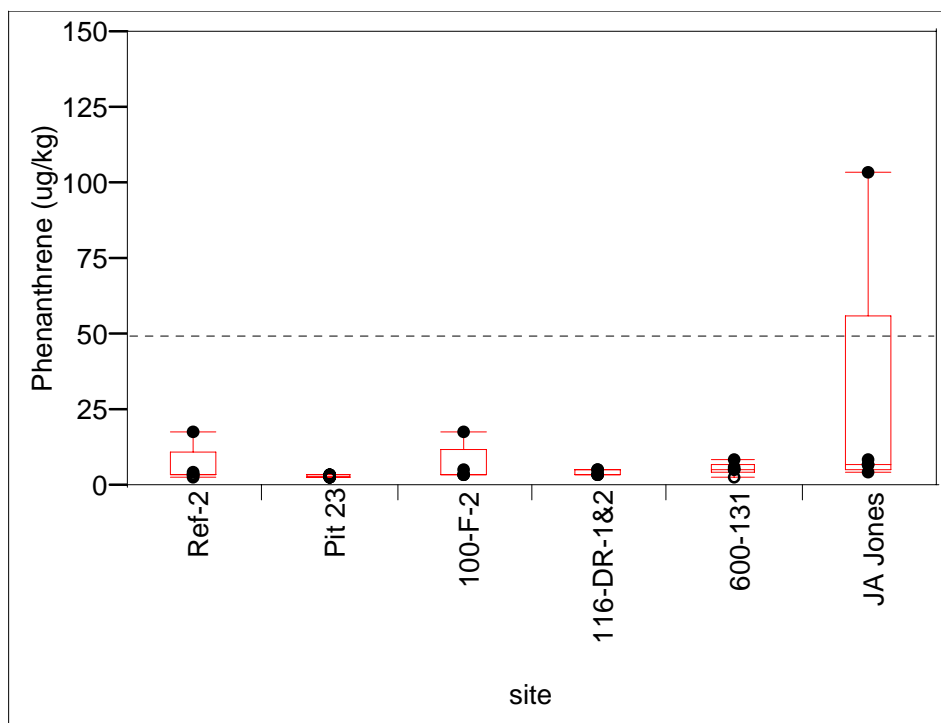


Figure 32. Box plot of phenanthrene concentrations. Dotted line is the PQL. Open circles are non-detects.

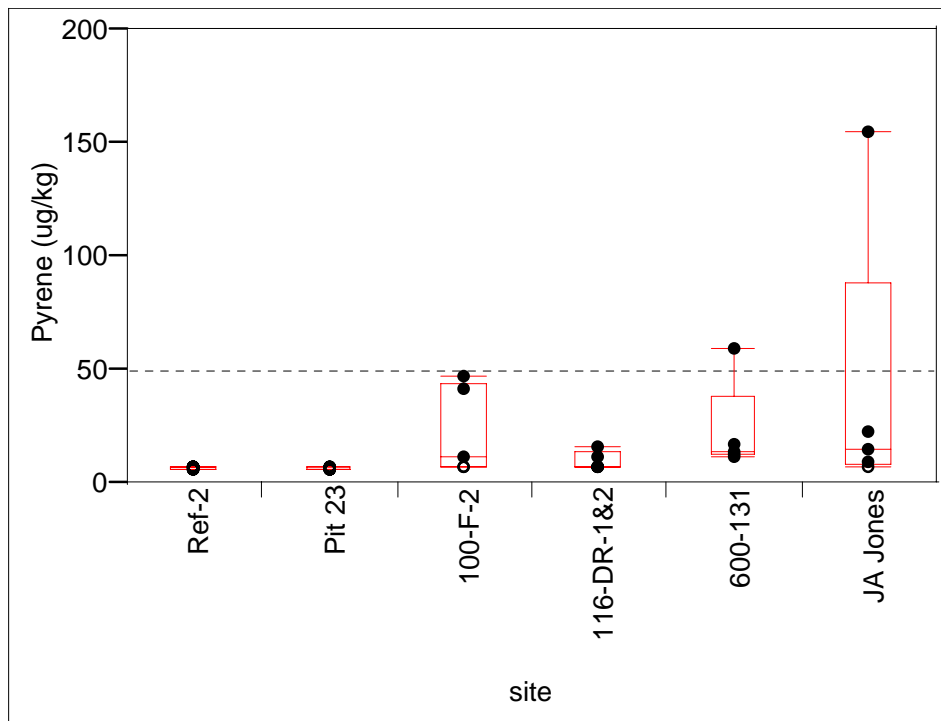


Figure 33. Box plot of pyrene concentrations. Dotted line is the PQL. Open circles are non-detects.

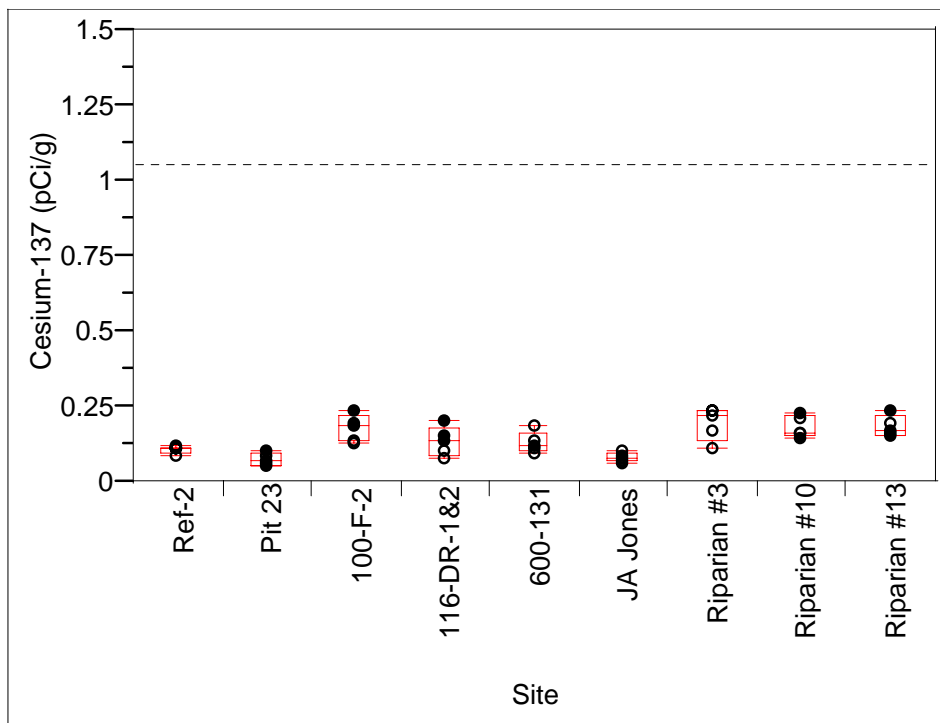


Figure 34. Box plot of cesium-137 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

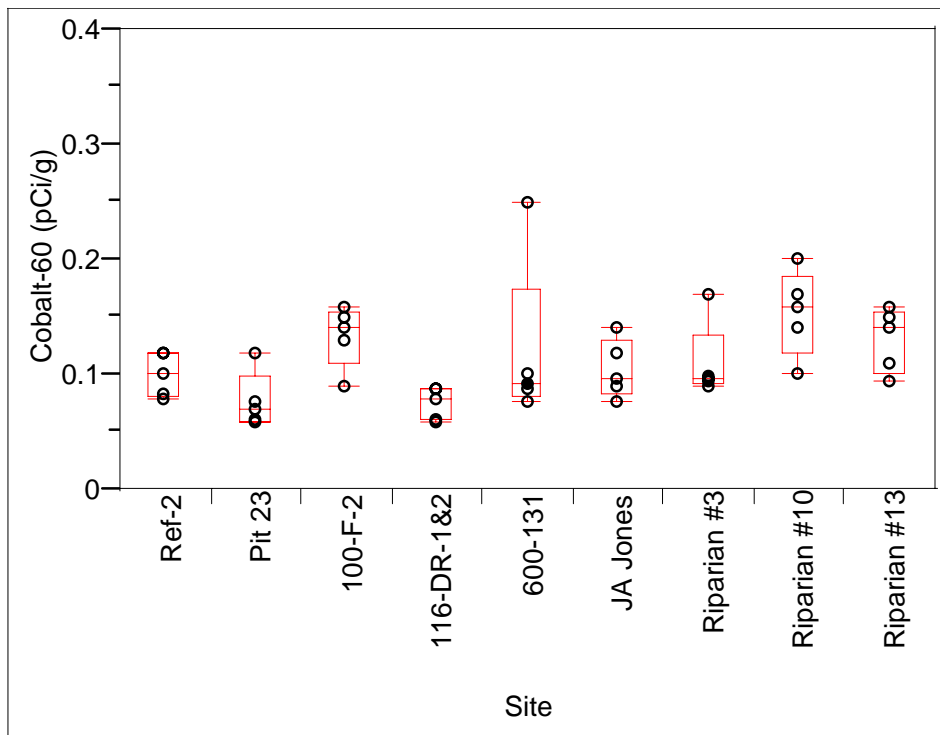


Figure 35. Box plot of cobalt-60 concentrations. Open circles are non-detects.

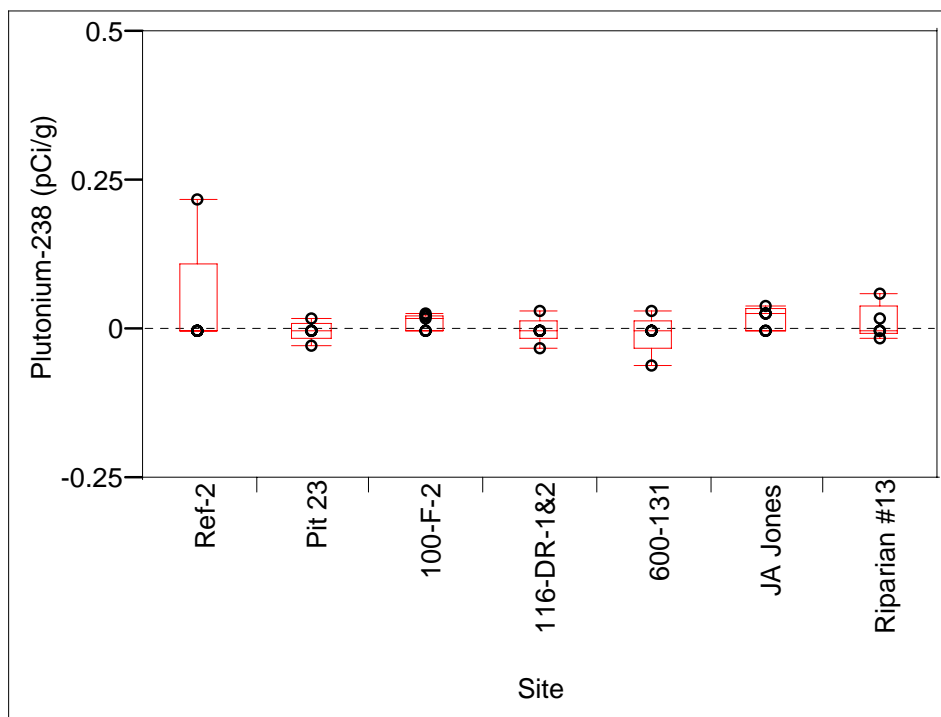


Figure 36. Box plot of plutonium-238 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

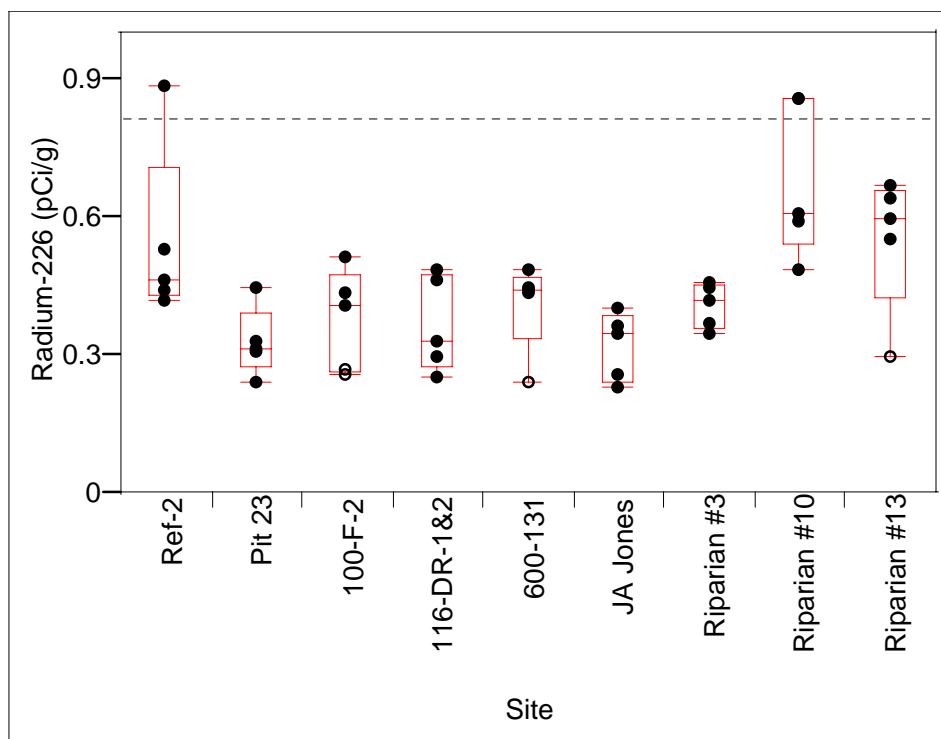


Figure 37. Box plot of radium-226 (by GEA) concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

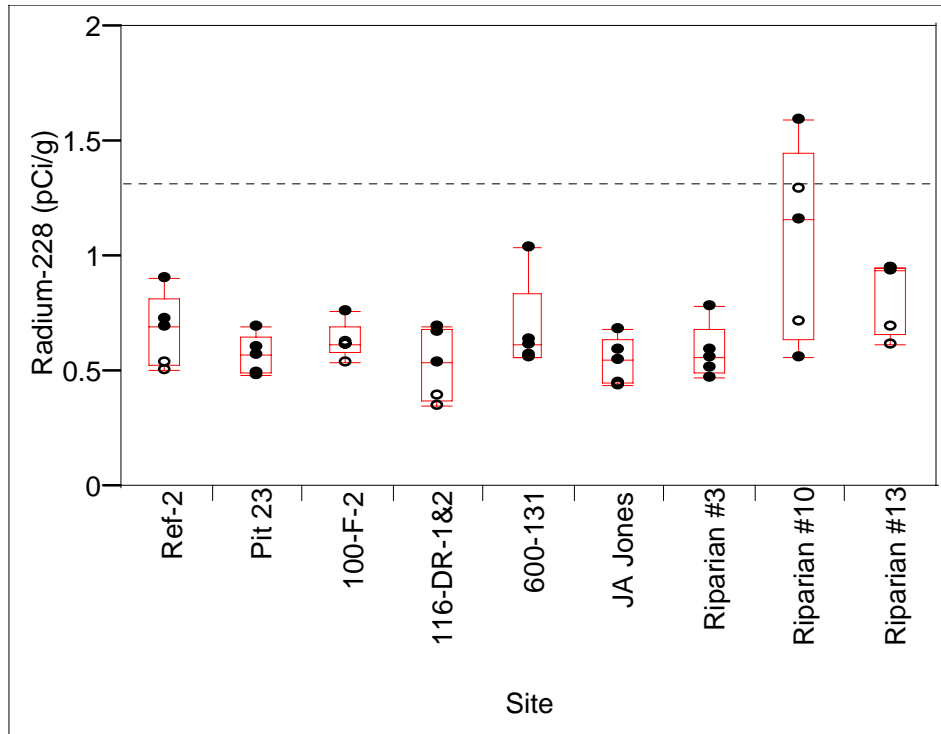


Figure 38. Box plot of radium-228 (by GEA) concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

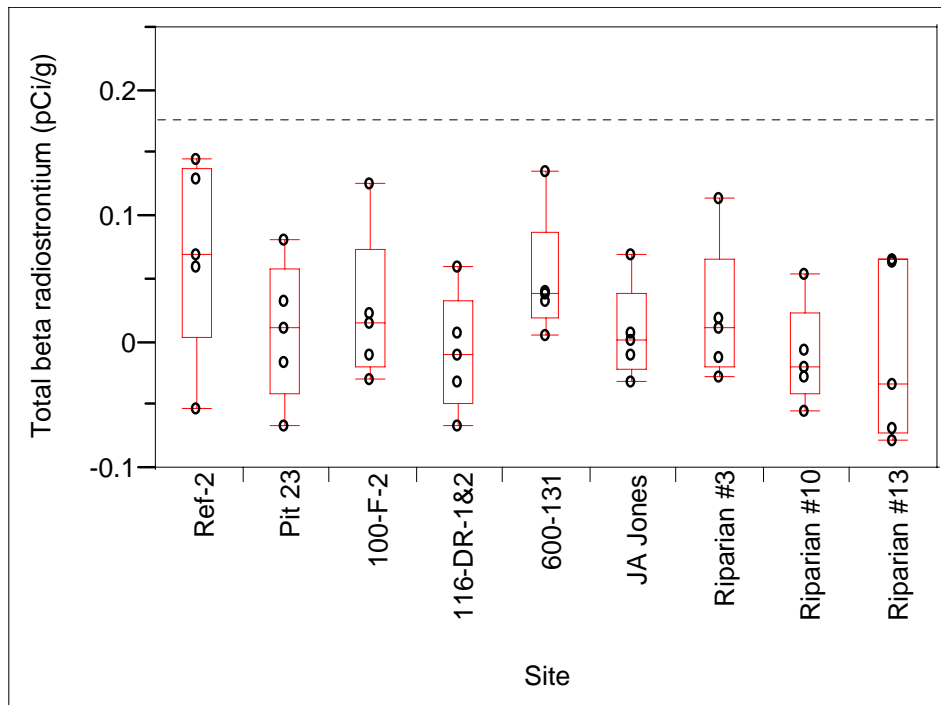


Figure 39. Box plot of total beta radiostrontium concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

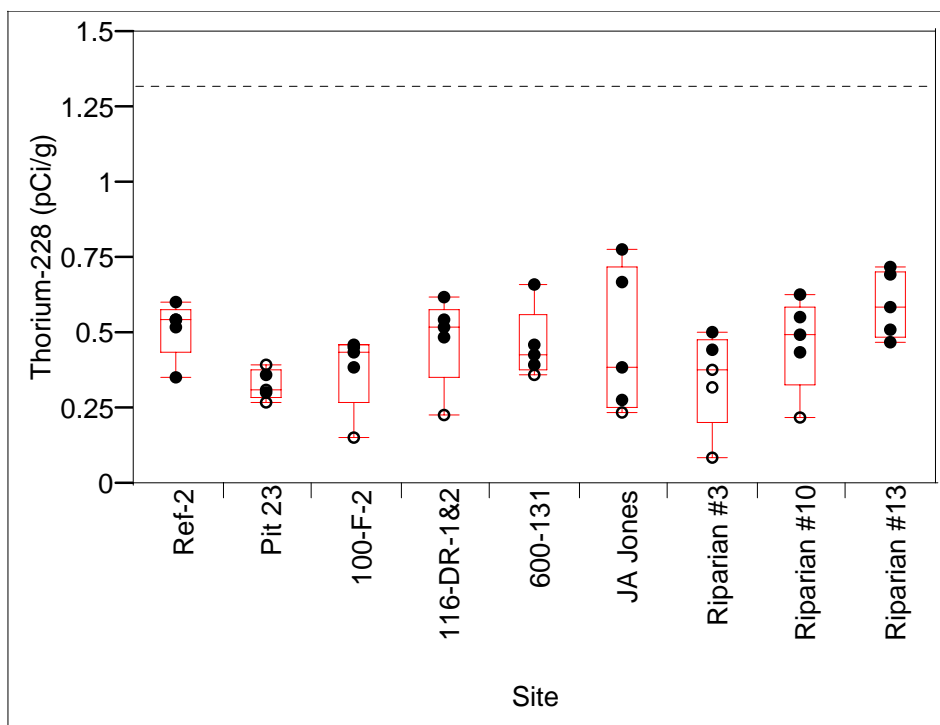


Figure 40. Box plot of thorium-228 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

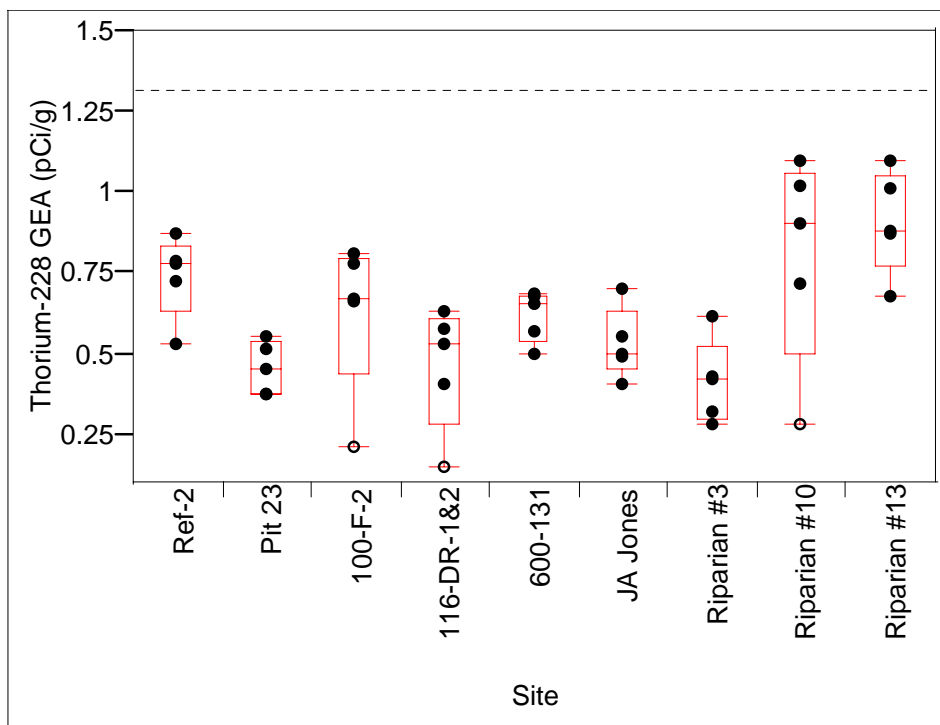


Figure 41. Box plot of thorium-228 (by GEA) concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12).. Open circles are non-detects.

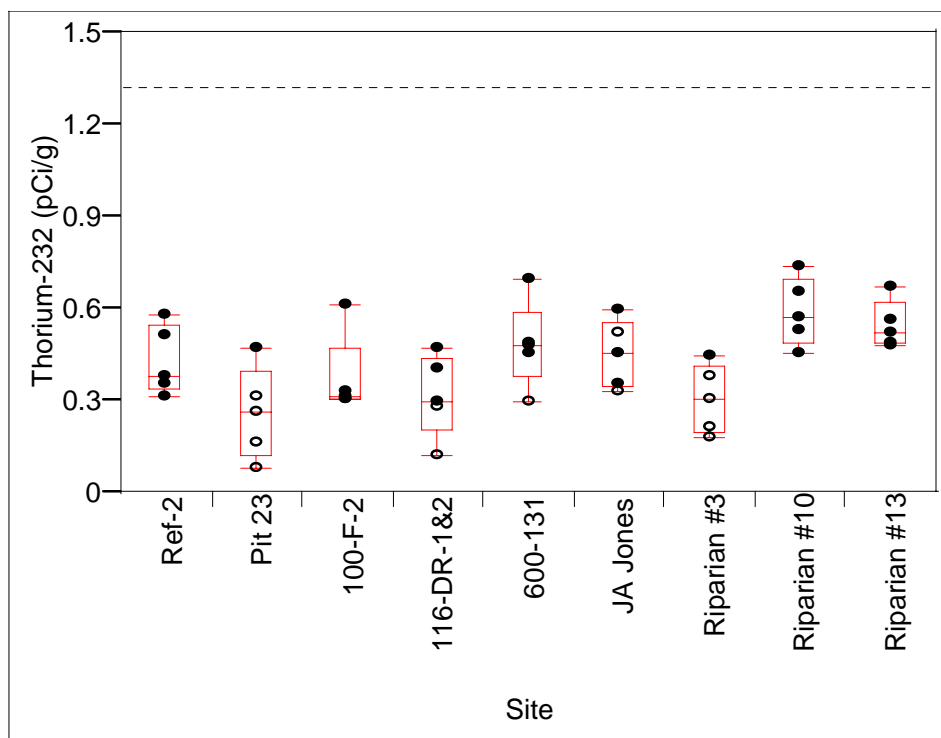


Figure 42. Box plot of thorium-232 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

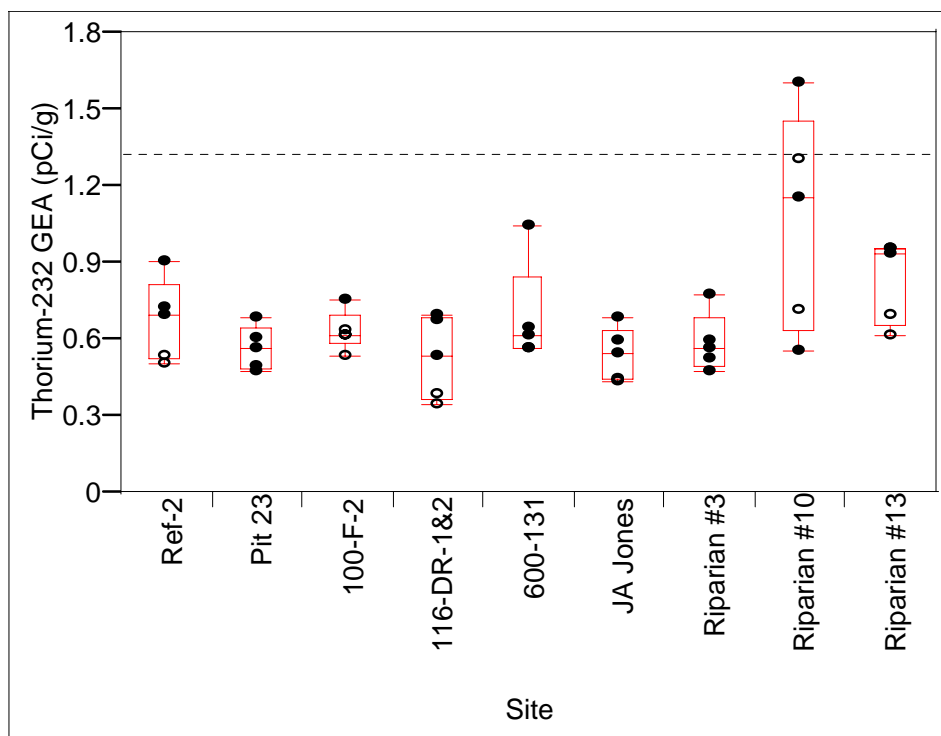


Figure 43. Box plot of thorium-232 (by GEA) concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

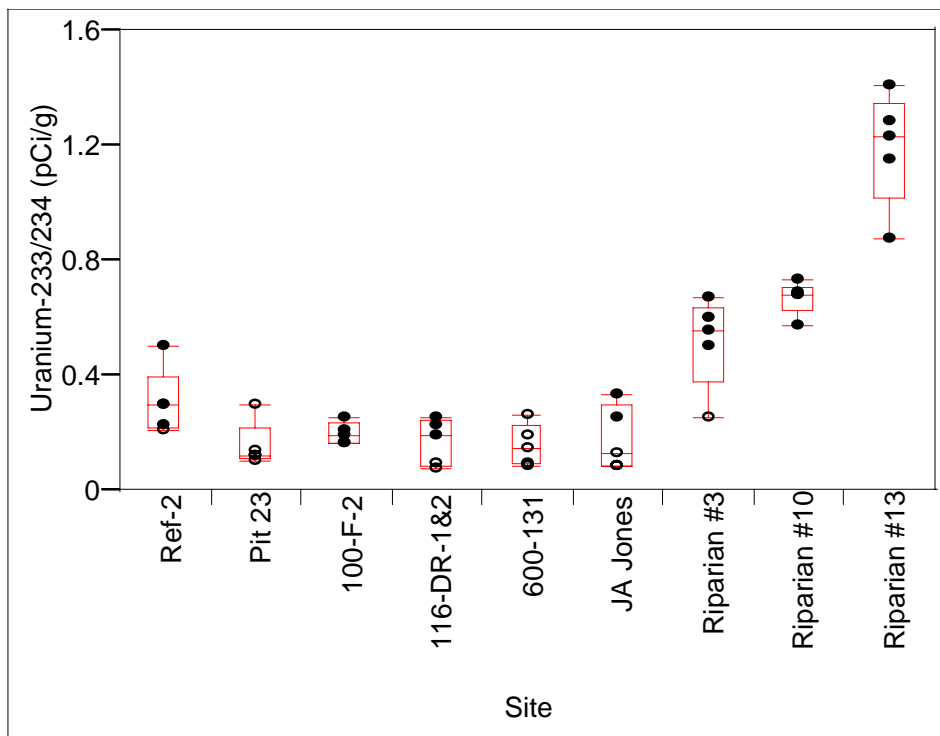


Figure 44. Box plot of uranium-233/234 concentrations. Open circles are non-detects.

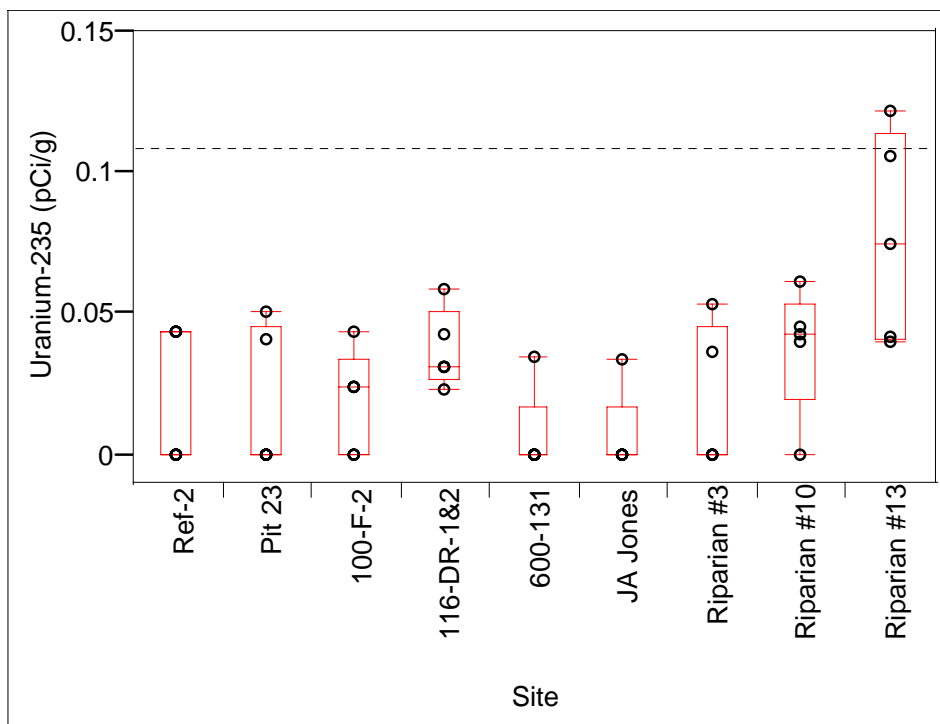


Figure 45. Box plot of uranium-235 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

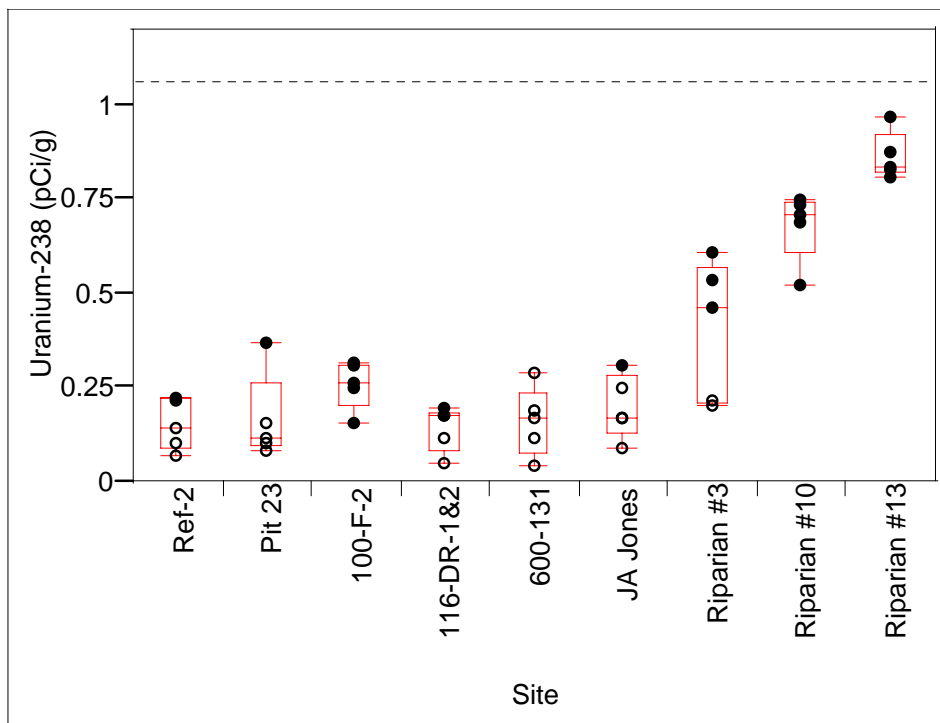


Figure 46. Box plot of uranium-238 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

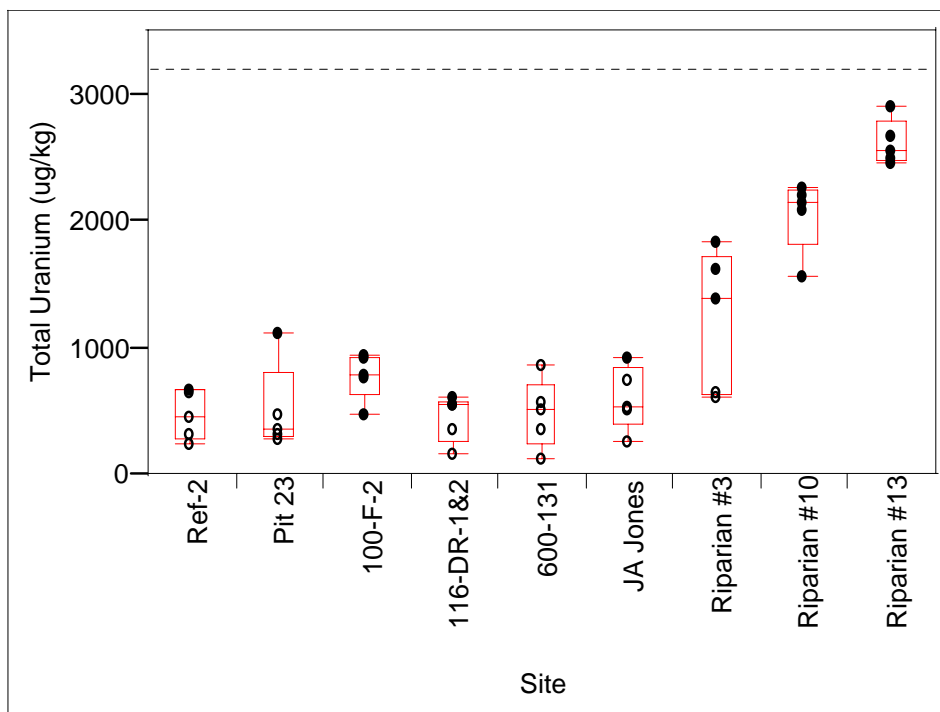


Figure 47. Box plot of total uranium (calculated from the isotopes). Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

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