Attachment C

PDC Energy, Inc.
Metals Statistical Evaluation Summary

September 5, 2023
Former Werning 3,4-2 Tank Battery
NENW Section 2 T4N R66W
Remediation # 20540

This statistical evaluation summary has been prepared by Tasman, Inc. for the former Werning 3,4-2 Tank Battery.

Metals Evaluation Summary

Background and site data for the following metals of concern (MOC) in soils were compared using the non-parametric Mann-Whitney-Wilcoxon rank-sum test to assess if site concentrations were substantially higher than background concentrations. This method of statistical hypotheses testing is robust, insensitive to outliers, and does not rely on assumptions that site and background data are normally distributed. Site data was pooled together and compared to background values that were offset by a substantial difference, S, defined as $0.25 \times M_b$, where M_b is mean background concentration. This offset is equivalent to COGCC policy of setting the background comparison value to 1.25 × background[1] and is consistent with other guidance for analysis of background conditions[2].

Mean concentrations for the MOCs on site and offset background soils were compared using a one-sided test using the following null and alternative hypotheses (H_0 and H_A):

Hypothesis	Expression	Narrative Description
Null, H_0	$\mu_{site} - (\mu_{bkg} + S) > 0$	Site concentrations exceed 1.25 × background concentrations. *i.e.* The site has substantially higher metal concentration than background. *i.e.* Site impacted.
Alternative, H_A	H_A: $\mu_{site} - (\mu_{bkg} + S) \leq 0$	Site concentrations are not substantially higher than background concentrations. *i.e.* Site not impacted.

Where: μ_{site} is the mean site concentration and μ_{bkg} is the mean background concentration.

[1] COGCC. Series 900 Rules – Environmental Impact Prevention (As of January 15, 2021). Table 915-1, Cleanup Concentrations. Footnote 11. https://cogcc.state.co.us/documents/reg/Rules/LATEST/900%20Series%20-%20Environmental%20Impact%20Prevention.pdf

[2] USEPA. September 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. EPA 540-R-01-003, OSWER 9285.7-41. See Appendix A.2.1. https://www.epa.gov/sites/default/files/2015-11/documents/background.pdf (accessed March 31, 2023).

This form of the hypothesis test establishes an initial presumption that the site is impacted and requires statistically significant evidence before it can be refuted (i.e. rejection of the null hypothesis). The α = 5% confidence level selected for this statistical test is such that, on average, in 95 out of 100 cases, the test would correctly conclude that site concentrations exceed background concentrations by more than S (*i.e.* correctly conclude that an impacted site is impacted). In 5 out of 100 cases, the test would incorrectly conclude that elevated site concentrations do not exceed background by more than S (*i.e.* falsely conclude that an impacted site is clean). Censored data (MOC results less than laboratory reporting limits) were handled by substitution at half of the limit.

Metals Evaluation Results

The results of tests for individual MOCs are summarized in the table below. See Exhibit A for calculations, hypotheses test conditions, and conclusions.

Metal	Sample sizes	Mean/ Median Site Concentrations, mg/kg	Mean/Median Background Concentrations, mg/kg	Substantial Difference ($0.25 * \bar{x}_{bkg}$), mg/kg	Hypothesis Test Result
Arsenic	Site, m = 190 Bkg, n = 20	mean = 0.54 median = 0.27	mean = 1.14 median = 0.78	0.284	Site not impacted
Barium	Site, m = 190 Bkg, n = 20	mean = 21.73 median = 8.00	mean = 39.21 median = 26.05	9.804	Site not impacted
Selenium	Site, m = 190 Bkg, n = 20	mean = 0.32 median = 0.22	mean = 0.57 median = 0.57	0.143	Site not impacted

Conclusion

Based on the results summarized above arsenic, barium, and selenium concentrations recorded in the site data are indicative of native soil conditions.

Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Arsenic (As)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

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Concentrations

Sample ID (Site)	As milligrams per kilogram (mg/kg)	Intermediate (if ND)	Substituted As (mg/kg)
SS01 @ 6'	<0.200	0.200	0.100
SS02 @ 6'	0.84		0.84
SS07 @ 8'	<0.200	0.200	0.10
SS08 @ 8'	0.80		0.80
SS09 @ 2'	1.35		1.35
SS10 @ 5'	0.61		0.61
SS11 @8'	0.453		0.453
SS12 @ 2'	0.69		0.69
SS13 @ 5'	0.752		0.752
SS16 @ 8'	<0.200	0.200	0.10
SS17 @ 2'	0.69		0.69
SS18 @ 5'	<0.200	0.200	0.100
SS19 @ 2'	1.27		1.27
SS20 @ 5'	0.37		0.37
SS21 @ 8'	0.21		0.21
SS22 @ 8'	<0.200	0.200	0.10
SS25 @ 2'	1.12		1.12
SS26 @ 5'	1.19		1.19
SS27 @ 8'	0.47		0.47
SS28 @ 2'	0.47		0.47
SS29 @ 5'	<0.200	0.200	0.10
SS30 @ 2'	0.27		0.27
SS31 @ 5'	<0.200	0.200	0.10
SS32 @ 2'	0.223		0.223
SS33 @ 5'	0.53		0.53
SS34 @ 2'	0.21		0.21
SS35 @ 5'	<0.200	0.200	0.100
SS36 @ 8'	<0.200	0.200	0.100
SS37 @ 8'	<0.200	0.200	0.100
SS38 @ 8'	<0.200	0.200	0.100
SS39 @ 2'	0.262		0.262
SS40 @ 5'	0.519		0.519
SS41 @ 2'	<0.200	0.200	0.100
SS42 @ 5'	0.472		0.472
SS43 @ 8'	<0.200	0.200	0.100
SS44 @ 8'	<0.200	0.200	0.100
SS45 @ 8'	0.527		0.527
SS46 @ 8'	<0.200	0.200	0.100
SS47 @ 2'	<0.200	0.200	0.100
SS48 @ 5'	<0.200	0.200	0.100
SS50 @ 8'	<0.200	0.200	0.100
SS64 @ 2'	<0.200	0.200	0.100
SS65 @ 5'	<0.200	0.200	0.100
SS67 @ 12'	0.662		0.662
SS69 @ 8'	8.920		8.920
SS70 @ 10'	0.458		0.458
SS71 @ 12'	0.205		0.205
SS72 @ 8'	2.370		2.370
SS73 @ 10'	<0.200	0.200	0.100
SS74 @ 8'	5.860		5.860
SS75 @ 10'	0.226		0.226
SS76 @ 12'	0.604		0.604
SS77 @ 8'	3.220		3.220
SS78 @ 10'	0.443		0.443
SS79 @ 12'	0.327		0.327
SS80 @ 8'	1.860		1.860
SS81 @ 10'	1.900		1.900
SS82 @ 8'	2.310		2.310
SS83 @ 10'	0.321		0.321
SS86 @ 12'	0.217		0.217
SS87 @ 12'	<0.200	0.200	0.100
SS90 @ 12'	0.201		0.201
SS91 @ 8'	0.559		0.559
SS92 @ 10'	0.233		0.233
SS93 @ 12'	<0.200	0.200	0.100
SS94 @ 8'	<0.200	0.200	0.100
SS95 @ 10'	<0.200	0.200	0.100
SS96 @ 10'	<0.200	0.200	0.100
SS97 @ 12'	<0.200	0.200	0.100
SS98 @ 10'	<0.200	0.200	0.100
SS99 @ 12'	<0.200	0.200	0.100
SS102 @ 12'	<0.200	0.200	0.100
SS103 @ 12'	<0.200	0.200	0.100
SS104 @ 12'	<0.200	0.200	0.100
SS105 @ 12'	0.234		0.234
SS106 @ 12'	<0.200	0.200	0.100
SS107 @ 10'	1.670		1.670

Sample ID (Background)	As (mg/kg)	Intermediate (if ND)	Substituted As (mg/kg)
BKG02 @ 2'	1.44		1.44
BKG02 @ 5'	0.708		0.708
BKG02 @ 8'	<0.209	0.209	0.1045
BKG03 @ 2'	1.73		1.73
BKG03 @ 5'	1.96		1.96
BKG03 @ 8'	1.45		1.45
BKG05@8'	5.02		5.02
BKG05@10'	0.882		0.882
BKG06@2'	0.61		0.61
BKG06@5'	0.45		0.452
BKG06@8'	0.686		0.686
BKG06@10'	2.350		2.35
BKG07@2'	0.426		0.426
BKG07@5'	1.59		1.59
BKG07@8'	0.25		0.249
BKG07@10'	0.25		0.25
BKG08@2'	0.822		0.822
BKG08@5'	0.797		0.797
BKG08@8'	0.771		0.771
BKG08@10'	0.415		0.415

Source	As (mg/kg)
bkg + substantial difference (S)	1.724
bkg + S	0.992
bkg + S	0.388
bkg + S	2.014
bkg + S	2.244
bkg + S	1.734
bkg + S	5.304
bkg + S	1.166
bkg + S	0.894
bkg + S	0.736
bkg + S	0.970
bkg + S	2.634
bkg + S	0.710
bkg + S	1.874
bkg + S	0.533
bkg + S	0.534
bkg + S	1.106
bkg + S	1.081
bkg + S	1.055
bkg + S	0.699

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SS108 @ 12'	<0.200	0.200	0.100
SS109 @ 12'	<0.200	0.200	0.100
SS110 @ 12'	<0.200	0.200	0.100
SS111 @ 12'	<0.200	0.200	0.100
SS112 @ 12'	<0.200	0.200	0.100
SS113 @ 10'	0.439		0.439
SS114 @ 12'	0.239		0.239
SS115 @ 12'	<0.200	0.200	0.100
SS116 @ 12'	<0.200	0.200	0.100
SS117 @ 12'	0.217		0.217
SS119 @ 12'	<0.200	0.200	0.100
SS120 @ 12'	<0.200	0.200	0.100
SS122 @ 12'	<0.200	0.200	0.100
SS123 @ 12'	<0.200	0.200	0.100
SS124 @ 12'	<0.200	0.200	0.100
SS125 @ 10'	0.663		0.663
SS126 @ 12'	1.260		1.260
SS127 @ 12'	0.363		0.363
SS128 @ 12'	0.265		0.265
SS129 @ 12'	0.337		0.337
SS130 @ 12.5'	0.211		0.211
SS131 @ 8'	1.240		1.240
SS132 @ 10'	1.590		1.590
SS133 @ 12'	<0.200	0.200	0.100
SS134 @ 12'	0.333		0.333
SS135 @ 12'	0.312		0.312
SS136@12'	<0.200	0.200	0.100
SS137 @ 8'	0.399		0.399
SS138 @ 10'	2.820		2.820
SS139 @ 12'	<0.200	0.200	0.100
SS140 @ 12'	<0.200	0.200	0.100
SS141 @ 12.5'	0.269		0.269
SS142 @ 12'	<0.200	0.200	0.100
SS143 @ 12'	<0.200	0.200	0.100
SS144 @ 12'	<0.200	0.200	0.100
SS147 @ 12'	<0.200	0.200	0.100
SS148 @ 8'	<0.200	0.200	0.100
SS149 @ 10'	<0.200	0.200	0.100
SS150 @ 12'	0.211		0.211
SS151 @ 12'	0.284		0.284
SS152 @ 12'	1.310		1.310
SS153 @ 8'	0.910		0.910
SS154 @ 10'	0.488		0.488
SS155 @ 10'	1.200		1.200
SS156 @ 8'	<0.200	0.200	0.100
SS157 @ 10'	1.040		1.040
SS158 @ 12'	1.320		1.320
SS159 @ 12'	0.487		0.487
SS160 @ 12'	<0.200	0.200	0.100
SS161 @ 12'	0.305		0.305
SS162 @ 8'	1.030		1.030
SS163 @ 10'	<0.200	0.200	0.100
SS164 @ 8'	0.736		0.736
SS165 @ 10'	<0.200	0.200	0.100
SS166 @ 12'	0.261		0.261
SS167 @ 12'	0.274		0.274
SS168 @ 12'	0.259		0.259
SS169 @ 8'	0.296		0.296
SS170 @ 10'	0.378		0.378
SS171 @ 8'	0.323		0.323
SS172 @ 10'	0.320		0.320
SS173 @ 12'	0.327		0.327
SS174 @ 8'	0.581		0.581
SS175 @ 10'	0.703		0.703
SS176 @ 12'	<0.200	0.200	0.100
SS177 @ 8'	0.762		0.762
SS178 @ 10'	0.232		0.232
SS181 @ 12'	0.234		0.234
SS183 @ 8'	0.967		0.967
SS184 @ 10'	<0.200	0.200	0.100
SS185 @ 10'	0.340		0.340
SS186 @ 12'	0.427		0.427
SS187 @ 12'	0.443		0.443
SS188 @ 12'	0.357		0.357
SS189 @ 12'	0.276		0.276
SS190 @ 12'	0.247		0.247
SS191 @ 12'	0.273		0.273
SS192 @ 12'	0.328		0.328
SS193 @ 10'	0.392		0.392
SS194 @ 10'	0.280		0.280
SS195 @ 12'	0.419		0.419
SS196 @ 12'	0.296		0.296
SS197 @ 12'	<0.200	0.200	0.100

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SS198 @ 12'	0.970		0.970
SS199 @ 8'	0.785		0.785
SS200 @ 10'	<0.200	0.200	0.100
SS201 @ 12'	0.219		0.219
SS202 @ 8'	0.608		0.608
SS203 @ 10'	<0.200	0.200	0.100
SS204 @ 8'	0.217		0.217
SS205 @ 10'	0.380		0.380
SS206 @ 12'	0.251		0.251
SS207 @ 8'	0.628		0.628
SS208 @ 10'	0.25		0.25
SS209 @ 12'	1.46		1.46
SS210 @ 12'	0.518		0.518
SS211 @ 10'	1.490		1.490
SS212 @ 12'	0.217		0.217
SS215 @ 12'	<0.200	0.200	0.100
SS216 @ 10'	1.470		1.470
SS217 @ 12'	0.523		0.523
SS218 @ 8'	1.390		1.390
SS219 @ 10'	0.329		0.329
SS220 @ 10'	<0.200	0.200	0.100
SS221 @ 8'	4.180		4.180
SS222 @ 10'	0.253		0.253
SS223 @ 12'	<0.200	0.200	0.100
SS224 @ 10'	0.44		0.44
SS225 @ 12'	0.575		0.575
SS226 @ 10'	0.29		0.29
SS227 @ 12'	0.490		0.490
SS229 @ 10'	<0.200	0.200	0.100
SS230 @ 12'	<0.200	0.200	0.10

Site concentrations (m):	190		
bkg concentrations (n):	20		
mean-Site:	0.54	mean-bkg:	1.14
S, based on mean:	0.134	S, based on mean:	0.284
median-Site:	0.27	median-bkg:	0.78
S, based on median:	0.067	S, based on median:	0.196

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Computations				
Source	**Value**	**Rank**	**Site Rank**	**Bkg Rank**
Site	0.10	35	35	
Site	0.100	35	35	
Site	0.100	35	35	
Site	0.100

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Site	0.223	81	81	
Site	0.226	82	82	
Site	0.232	83	83	
Site	0.233	84	84	
Site	0.234	85.5	85.5	
Site	0.234	85.5	85.5	
Site	0.239	87	87	
Site	0.247	88	88	
Site	0.249	89	89	
Site	0.251	90	90	
Site	0.253	91	91	
Site	0.259	92	92	
Site	0.261	93	93	
Site	0.262	94	94	
Site	0.265	95	95	
Site	0.267	96	96	
Site	0.269	97	97	
Site	0.273	98	98	
Site	0.274	99	99	
Site	0.28	100	100	
Site	0.28	101	101	
Site	0.284	102	102	
Site	0.294	103	103	
Site	0.296	104.5	104.5	
Site	0.30	104.5	104.5	
Site	0.305	106	106	
Site	0.312	107	107	
Site	0.320	108	108	
Site	0.321	109	109	
Site	0.323	110	110	
Site	0.327	111.5	111.5	
Site	0.327	111.5	111.5	
Site	0.33	113	113	
Site	0.329	114	114	
Site	0.333	115	115	
Site	0.337	116	116	
Site	0.340	117	117	
Site	0.357	118	118	
Site	0.363	119	119	
Site	0.372	120	120	
Site	0.378	121	121	
Site	0.38	122	122	
bkg + S	0.388	123		123
Site	0.39	124	124	
Site	0.399	125	125	
Site	0.419	126	126	
Site	0.427	127	127	
Site	0.439	128	128	
Site	0.44	129	129	
Site	0.443	130.5	130.5	
Site	0.443	130.5	130.5	
Site	0.453	132	132	
Site	0.458	133	133	
Site	0.472	135	135	
Site	0.472	135	135	
Site	0.472	135	135	
Site	0.487	137	137	
Site	0.488	138	138	
Site	0.49	139	139	
Site	0.52	140	140	
Site	0.519	141	141	
Site	0.523	142	142	
Site	0.527	143	143	
Site	0.531	144	144	
bkg + S	0.533	145		145
bkg + S	0.53	146		146
Site	0.559	147	147	
Site	0.575	148	148	
Site	0.581	149	149	
Site	0.604	150	150	
Site	0.608	151.5	151.5	
Site	0.608	151.5	151.5	
Site	0.628	153	153	
Site	0.662	154	154	
Site	0.663	155	155	
Site	0.689	156	156	
Site	0.692	157	157	
bkg + S	0.699	158		158
Site	0.703	159	159	

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bkg + S	0.710	160		160
bkg + S	0.736	161		161
Site	0.736	162	162	
Site	0.752	163	163	
Site	0.762	164	164	
Site	0.785	165	165	
Site	0.795	166	166	
Site	0.840	167	167	
bkg + S	0.89	168		168
Site	0.910	169	169	
Site	0.967	170	170	
bkg + S	0.97	171		171
Site	0.970	172	172	
bkg + S	0.992	173		173
Site	1.030	174	174	
Site	1.040	175	175	
bkg + S	1.055	176		176
bkg + S	1.08	177		177
bkg + S	1.106	178		178
Site	1.120	179	179	
bkg + S	1.166	180		180
Site	1.190	181	181	
Site	1.200	182	182	
Site	1.240	183	183	
Site	1.260	184	184	
Site	1.270	185	185	
Site	1.310	186	186	
Site	1.320	187	187	
Site	1.350	188	188	
Site	1.390	189	189	
Site	1.460	190	190	
Site	1.470	191	191	
Site	1.49	192	192	
Site	1.590	193	193	
Site	1.670	194	194	
bkg + S	1.724	195		195
bkg + S	1.73	196		196
Site	1.860	197	197	
bkg + S	1.874	198		198
Site	1.900	199	199	
bkg + S	2.014	200		200
bkg + S	2.24	201		201
Site	2.310	202	202	
Site	2.370	203	203	
bkg + S	2.634	204		204
Site	2.820	205	205	
Site	3.220	206	206	
Site	4.18	207	207	
bkg + S	5.304	208		208
Site	5.860	209	209	
Site	8.920	210	210	

Raw Rank Sum (R):	18637	3518
Minimum possible value for Rank Sum:	18145	210
Adjusted Rank Sum (W_0):	492	3308

Sum of all ranks:	22155
n * m:	3800

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Step 1. Null Hypothesis (H_0)

H_0: μ_{site} - (1.25*μ_{bkg}) > 0
Site concentrations exceed 1.25 * background concentrations. (one-sided test)

Step 2. Alternative Hypothesis (H_A)

H_A: μ_{site} - (1.25*μ_{bkg}) ≤ 0
There is no difference between site and 1.25*background concentrations.

Step 3. Test Statistic

m and n > 20, so test statistic is:

$$z_0 = \frac{W_{bkg} - mn/2}{\sqrt{var(W_{bkg})}}$$

Where:

$$var(W_0) = \frac{mn(m+n+1)}{12} - \left\{ \frac{mn}{12(m+n)(m+n-1)} \sum_{j=1}^{g} t_j(t_j^2 - 1) \right\}$$

$$var(W_{bkg}) = Term1 - (Term2 \times SumTerm)$$

m is the sample size for Site data
n is the sample size for bkg data
g is number of tied groups

W_{bkg}:	3308	
m:	190	
n:	20	
most likely W:	1900	
var(W_0)		
tied groups (g):	8	1 group has 69 tied values, 1 group has 4 tied values, 2 groups have 3 tied values, 5 groups have 2 tied values
var(W_0) Term 1:	66817	
var(W_0) Term 2:	0.0072	
var(W_0) Sum Term:	328578	
var(W_0)	64446	

z_{bkg}	
z_{bkg} numerator:	1408
z_{bkg} denominator:	253.9
z_{bkg}:	5.55

Step 4a. Critical Value

False rejection error rate (α):	0.05	falsely conclude that Site ≤ background
False acceptance error rate (β):	0.2	falsely conclude that Site > background

Critical value ($z_{0.95}$):	1.645

Step 4b. p-value

p-value:	1.5E-08

Step 5a. Test Stat compared against Critical Value

Test Statistic (z_{bkg}):	5.55	
Critical Value ($z_{0.95}$):	1.645	
Z_{bkg} > $Z_{0.95}$:	TRUE	reject null hypothesis at 95% confidence level - Site clean

Step 5b. p-value compared against significance level

p-value:	1.5E-08	
significance level:	0.05	
p-value < significance level:	TRUE	reject null hypothesis at 95% confidence level - Site clean

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yellow highlight = tied values

Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Barium (Ba)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

TASMAN

Concentrations										
Sample ID (Site)	Ba milligrams per kilogram (mg/kg)	Intermediate (if ND)	Substituted Ba (mg/kg)		Sample ID (Background)	Ba (mg/kg)	Intermediate (if ND)	Substituted Ba (mg/kg)	Source	Ba (mg/kg)
SS01 @ 6'	5.46		5.460		BKG02 @ 2'	7.52		7.52	bkg + substantial difference (S)	17.324
SS02 @ 6'	7.18		7.18		BKG02 @ 5'	25.0		25	bkg + S	34.804
SS07 @ 8'	4.60		4.60		BKG02 @ 8'	4.23		4.23	bkg + S	14.034
SS08 @ 8'	7.67		7.67		BKG03 @ 2'	11.2		11.2	bkg + S	21.004
SS09 @ 2'	17.6		17.60		BKG03 @ 5'	32.4		32.4	bkg + S	42.204
SS10 @ 5'	41.6		41.60		BKG03 @ 8'	28.7		28.7	bkg + S	38.504
SS11 @8'	35.3		35.300		BKG05@8'	242		242	bkg + S	251.804
SS12 @ 2'	10.2		10.20		BKG05@10'	27.1		27.1	bkg + S	36.904
SS13 @ 5'	36.7		36.700		BKG06@2'	12.5		12.5	bkg + S	22.304
SS16 @ 8'	4.00		4.00		BKG06@5'	16.1		16.1	bkg + S	25.904
SS17 @ 2'	8.00		8.00		BKG06@8'	30.4		30.4	bkg + S	40.204
SS18 @ 5'	7.45		7.450		BKG06@10'	35.1		35.1	bkg + S	44.904
SS19 @ 2'	11.8		11.80		BKG07@2'	15.2		15.2	bkg + S	25.004
SS20 @ 5'	6.32		6.32		BKG07@5'	128		128	bkg + S	137.804
SS21 @ 8'	5.84		5.84		BKG07@8'	41.9		41.9	bkg + S	51.704
SS22 @ 8'	13.3		13.30		BKG07@10'	10.0		10	bkg + S	19.804
SS25 @ 2'	43.2		43.20		BKG08@2'	16.4		16.4	bkg + S	26.204
SS26 @ 5'	53.4		53.40		BKG08@5'	63.6		63.6	bkg + S	73.404
SS27 @ 8'	3.18		3.18		BKG08@8'	27.9		27.9	bkg + S	37.704
SS28 @ 2'	7.65		7.65		BKG08@10'	9.03		9.03	bkg + S	18.834
SS29 @ 5'	4.59		4.59							
SS30 @ 2'	7.52		7.52							
SS31 @ 5'	3.32		3.32							
SS32 @ 2'	9.15		9.150							
SS33 @ 5'	5.44		5.44							
SS34 @ 2'	5.55		5.55							
SS35 @ 5'	6.22		6.220							
SS36 @ 8'	12.5		12.500							
SS37 @ 8'	21.1		21.100							
SS38 @ 8'	6.62		6.620							
SS39 @ 2'	8.20		8.200							
SS40 @ 5'	35.8		35.800							
SS41 @ 2'	8.89		8.890							
SS42 @ 5'	63.6		63.600							
SS43 @ 8'	11.9		11.900							
SS44 @ 8'	55.0		55.000							
SS45 @ 8'	83.8		83.800							
SS46 @ 8'	27.8		27.800							
SS47 @ 2'	7.52		7.520							
SS48 @ 5'	93.8		93.800							
SS50 @ 8'	5.40		5.400							
SS64 @ 2'	9.91		9.910							
SS65 @ 5'	7.10		7.100							
SS67 @ 12'	5.20		5.200							
SS69 @ 8'	167		167.000							
SS70 @ 10'	6.83		6.830							
SS71 @ 12'	15.1		15.100							
SS72 @ 8'	167		167.000							
SS73 @ 10'	4.50		4.500							
SS74 @ 8'	315		315.000							
SS75 @ 10'	7.23		7.230							
SS76 @ 12'	6.85		6.850							
SS77 @ 8'	66.8		66.800							
SS78 @ 10'	5.48		5.480							
SS79 @ 12'	6.55		6.550							
SS80 @ 8'	99.0		99.000							
SS81 @ 10'	73.5		73.500							
SS82 @ 8'	75.5		75.500							
SS83 @ 10'	2.77		2.770							
SS86 @ 12'	3.82		3.820							
SS87 @ 12'	4.93		4.930							
SS90 @ 12'	6.22		6.220							
SS91 @ 8'	31.2		31.200							
SS92 @ 10'	6.59		6.590							
SS93 @ 12'	9.64		9.640							
SS94 @ 8'	5.07		5.070							
SS95 @ 10'	6.51		6.510							
SS96 @ 10'	5.52		5.520							
SS97 @ 12'	5.69		5.690							
SS98 @ 10'	5.10		5.100							
SS99 @ 12'	16.2		16.200							
SS102 @ 12'	3.71		3.710							
SS103 @ 12'	3.88		3.880							
SS104 @ 12'	4.87		4.870							
SS105 @ 12'	16.7		16.700							
SS106 @ 12'	4.03		4.030							
SS107 @ 10'	66.4		66.400							

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Barium (Ba)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

SS108 @ 12'	14.0		14.000
SS109 @ 12'	6.99		6.990
SS110 @ 12'	17.6		17.600
SS111 @ 12'	7.28		7.280
SS112 @ 12'	7.89		7.890
SS113 @ 10'	23.0		23.000
SS114 @ 12'	10.9		10.900
SS115 @ 12'	16.1		16.100
SS116 @ 12'	7.36		7.360
SS117 @ 12'	12.3		12.300
SS119 @ 12'	9.29		9.290
SS120 @ 12'	25.1		25.100
SS122 @ 12'	5.64		5.640
SS123 @ 12'	13.3		13.300
SS124 @ 12'	6.17		6.170
SS125 @ 10'	45.8		45.800
SS126 @ 12'	10.7		10.700
SS127 @ 12'	4.71		4.710
SS128 @ 12'	9.54		9.540
SS129 @ 12'	10.3		10.300
SS130 @ 12.5'	4.40		4.400
SS131 @ 8'	110		110.000
SS132 @ 10'	10.5		10.500
SS133 @ 12'	2.56		2.560
SS134 @ 12'	5.55		5.550
SS135 @ 12'	7.91		7.910
SS136@12'	3.62		3.620
SS137 @ 8'	67.4		67.400
SS138 @ 10'	22.7		22.700
SS139 @ 12'	4.25		4.250
SS140 @ 12'	7.73		7.730
SS141 @ 12.5'	4.42		4.420
SS142 @ 12'	5.56		5.560
SS143 @ 12'	5.55		5.550
SS144 @ 12'	15.0		15.000
SS147 @ 12'	8.23		8.230
SS148 @ 8'	54.0		54.000
SS149 @ 10'	10.7		10.700
SS150 @ 12'	2.16		2.160
SS151 @ 12'	9.76		9.760
SS152 @ 12'	79.2		79.200
SS153 @ 8'	12.3		12.300
SS154 @ 10'	14.9		14.900
SS155 @ 10'	26.1		26.100
SS156 @ 8'	33.1		33.100
SS157 @ 10'	17.8		17.800
SS158 @ 12'	25.4		25.400
SS159 @ 12'	2.69		2.690
SS160 @ 12'	3.87		3.870
SS161 @ 12'	22.6		22.600
SS162 @ 8'	12.7		12.700
SS163 @ 10'	8.91		8.910
SS164 @ 8'	13.0		13.000
SS165 @ 10'	4.17		4.170
SS166 @ 12'	5.43		5.430
SS167 @ 12'	4.45		4.450
SS168 @ 12'	2.80		2.800
SS169 @ 8'	9.80		9.800
SS170 @ 10'	29.3		29.300
SS171 @ 8'	5.22		5.220
SS172 @ 10'	7.80		7.800
SS173 @ 12'	2.71		2.710
SS174 @ 8'	13.3		13.300
SS175 @ 10'	10.6		10.600
SS176 @ 12'	5.97		5.970
SS177 @ 8'	8.47		8.470
SS178 @ 10'	5.36		5.360
SS181 @ 12'	4.72		4.720
SS183 @ 8'	122		122.000
SS184 @ 10'	8.11		8.110
SS185 @ 10'	8.06		8.060
SS186 @ 12'	5.73		5.730
SS187 @ 12'	6.73		6.730
SS188 @ 12'	4.29		4.290
SS189 @ 12'	3.96		3.960
SS190 @ 12'	5.15		5.150
SS191 @ 12'	7.14		7.140
SS192 @ 12'	7.99		7.990
SS193 @ 10'	17.5		17.500
SS194 @ 10'	11.7		11.700
SS195 @ 12'	38.0		38.000
SS196 @ 12'	4.70		4.700
SS197 @ 12'	4.51		4.510

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Barium (Ba)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

SS198 @ 12'	6.26		6.260
SS199 @ 8'	114		114.000
SS200 @ 10'	4.56		4.560
SS201 @ 12'	6.53		6.530
SS202 @ 8'	19.9		19.900
SS203 @ 10'	4.53		4.530
SS204 @ 8'	64.9		64.900
SS205 @ 10'	4.56		4.560
SS206 @ 12'	3.29		3.290
SS207 @ 8'	8.76		8.760
SS208 @ 10'	9.15		9.15
SS209 @ 12'	72.3		72.30
SS210 @ 12'	4.82		4.820
SS211 @ 10'	71.4		71.400
SS212 @ 12'	70.1		70.100
SS215 @ 12'	8.31		8.310
SS216 @ 10'	52.1		52.100
SS217 @ 12'	17.7		17.700
SS218 @ 8'	87.4		87.400
SS219 @ 10'	29.9		29.900
SS220 @ 10'	3.15		3.150
SS221 @ 8'	75.2		75.200
SS222 @ 10'	9.97		9.970
SS223 @ 12'	5.48		5.480
SS224 @ 10'	7.80		7.80
SS225 @ 12'	6.99		6.990
SS226 @ 10'	4.80		4.80
SS227 @ 12'	4.34		4.340
SS229 @ 10'	7.00		7.000
SS230 @ 12'	7.61		7.61

Site concentrations (m):	190		
bkg concentrations (n):	20		
mean-Site:	21.73	mean-bkg:	39.21
S, based on mean:	5.432	S, based on mean:	9.804
median-Site:	8.00	median-bkg:	26.05
S, based on median:	1.999	S, based on median:	6.513

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Barium (Ba)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

Computations				
Source	**Value**	**Rank**	**Site Rank**	**Bkg Rank**
Site	2.16	1	1	
Site	2.56	2	2	
Site	2.69	3	3	
Site	2.71	4	4	
Site	2.77	5	5	
Site	2.80	6	6	
Site	3.15	7	7	
Site	3.18	8	8	
Site	3.29	9	9	
Site	3.32	10	10	
Site	3.62	11	11	
Site	3.71	12	12	
Site	3.82	13	13	
Site	3.87	14	14	
Site	3.88	15	15	
Site	3.96	16	16	
Site	4.00	17	17	
Site	4.03	18	18	
Site	4.17	19	19	
Site	4.25	20	20	
Site	4.29	21	21	
Site	4.34	22	22	
Site	4.40	23	23	
Site	4.42	24	24	
Site	4.45	25	25	
Site	4.50	26	26	
Site	4.51	27	27	
Site	4.53	28	28	
Site	4.56	29.5	29.5	
Site	4.56	29.5	29.5	
Site	4.59	31	31	
Site	4.60	32	32	
Site	4.70	33	33	
Site	4.71	34	34	
Site	4.72	35	35	
Site	4.80	36	36	
Site	4.82	37	37	
Site	4.87	38	38	
Site	4.93	39	39	
Site	5.07	40	40	
Site	5.10	41	41	
Site	5.15	42	42	
Site	5.20	43	43	
Site	5.22	44	44	
Site	5.36	45	45	
Site	5.40	46	46	
Site	5.43	47	47	
Site	5.44	48	48	
Site	5.46	49	49	
Site	5.48	50.5	50.5	
Site	5.48	50.5	50.5	
Site	5.52	52	52	
Site	5.55	54	54	
Site	5.55	54	54	
Site	5.55	54	54	
Site	5.56	56	56	
Site	5.64	57	57	
Site	5.69	58	58	
Site	5.73	59	59	
Site	5.84	60	60	
Site	5.97	61	61	
Site	6.17	62	62	
Site	6.22	63.5	63.5	
Site	6.22	63.5	63.5	
Site	6.26	65	65	
Site	6.32	66	66	
Site	6.51	67	67	
Site	6.53	68	68	
Site	6.55	69	69	
Site	6.59	70	70	
Site	6.62	71	71	
Site	6.73	72	72	
Site	6.83	73	73	
Site	6.85	74	74	
Site	6.99	75.5	75.5	
Site	6.99	75.5	75.5	
Site	7.00	77	77	
Site	7.10	78	78	
Site	7.14	79	79	
Site	7.18	80	80	

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Barium (Ba)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

Site	7.23	81	81	
Site	7.28	82	82	
Site	7.36	83	83	
Site	7.45	84	84	
Site	7.52	85.5	85.5	
Site	7.52	85.5	85.5	
Site	7.61	87	87	
Site	7.65	88	88	
Site	7.67	89	89	
Site	7.73	90	90	
Site	7.80	91.5	91.5	
Site	7.80	91.5	91.5	
Site	7.89	93	93	
Site	7.91	94	94	
Site	7.99	95	95	
Site	8.00	96	96	
Site	8.06	97	97	
Site	8.11	98	98	
Site	8.20	99	99	
Site	8.23	100	100	
Site	8.31	101	101	
Site	8.47	102	102	
Site	8.76	103	103	
Site	8.89	104	104	
Site	8.91	105	105	
Site	9.15	106.5	106.5	
Site	9.15	106.5	106.5	
Site	9.29	108	108	
Site	9.54	109	109	
Site	9.64	110	110	
Site	9.76	111	111	
Site	9.80	112	112	
Site	9.91	113	113	
Site	9.97	114	114	
Site	10.2	115	115	
Site	10.3	116	116	
Site	10.5	117	117	
Site	10.6	118	118	
Site	10.7	119.5	119.5	
Site	10.7	119.5	119.5	
Site	10.9	121	121	
Site	11.7	122	122	
Site	11.8	123	123	
Site	11.9	124	124	
Site	12.3	125.5	125.5	
Site	12.3	125.5	125.5	
Site	12.5	127	127	
Site	12.7	128	128	
Site	13.0	129	129	
Site	13.3	131	131	
Site	13.3	131	131	
Site	13.3	131	131	
Site	14.0	133	133	
bkg + S	14.034	134		134
Site	14.9	135	135	
Site	15.0	136	136	
Site	15.1	137	137	
Site	16.1	138	138	
Site	16.2	139	139	
Site	16.7	140	140	
bkg + S	17.324	141		141
Site	17.5	142	142	
Site	17.6	143.5	143.5	
Site	17.6	143.5	143.5	
Site	17.7	145	145	
Site	17.8	146	146	
bkg + S	18.83	147		147
bkg + S	19.80	148		148
Site	19.9	149	149	
bkg + S	21.004	150		150
Site	21.1	151	151	
bkg + S	22.304	152		152
Site	22.6	153	153	
Site	22.7	154	154	
Site	23.0	155	155	
bkg + S	25.004	156		156
Site	25.1	157	157	
Site	25.4	158	158	
bkg + S	25.90	159		159

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Barium (Ba)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

Site	26.1	160	160	
bkg + S	26.204	161		161
Site	27.8	162	162	
Site	29.3	163	163	
Site	29.9	164	164	
Site	31.2	165	165	
Site	33.1	166	166	
bkg + S	34.804	167		167
Site	35.3	168	168	
Site	35.8	169	169	
Site	36.7	170	170	
bkg + S	36.904	171		171
bkg + S	37.704	172		172
Site	38.0	173	173	
bkg + S	38.504	174		174
bkg + S	40.20	175		175
Site	41.6	176	176	
bkg + S	42.204	177		177
Site	43.2	178	178	
bkg + S	44.904	179		179
Site	45.8	180	180	
bkg + S	51.70	181		181
Site	52.1	182	182	
Site	53.4	183	183	
Site	54.0	184	184	
Site	55.0	185	185	
Site	63.6	186	186	
Site	64.9	187	187	
Site	66.4	188	188	
Site	66.8	189	189	
Site	67.4	190	190	
Site	70.1	191	191	
Site	71.4	192	192	
Site	72.3	193	193	
bkg + S	73.404	194		194
Site	73.5	195	195	
Site	75.2	196	196	
Site	75.5	197	197	
Site	79.2	198	198	
Site	83.8	199	199	
Site	87.4	200	200	
Site	93.8	201	201	
Site	99.0	202	202	
Site	110	203	203	
Site	114	204	204	
Site	122	205	205	
bkg + S	137.804	206		206
Site	167	207.5	207.5	
Site	167	207.5	207.5	
bkg + S	251.804	209		209
Site	315	210	210	

Raw Rank Sum (R):	18802	3353
Minimum possible value for Rank Sum:	18145	210
Adjusted Rank Sum (W_0):	657	3143

Sum of all ranks:	22155
n * m:	3800

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Barium (Ba)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

TASMAN

Step 1. Null Hypothesis (H_0)

H_0: μ_{site} - (1.25*μ_{bkg}) > 0
Site concentrations exceed 1.25 * background concentrations. (one-sided test)

Step 2. Alternative Hypothesis (H_A)

H_A: μ_{site} - (1.25*μ_{bkg}) ≤ 0
There is no difference between site and 1.25*background concentrations.

Step 3. Test Statistic

m and n > 20, so test statistic is:

$$z_0 = \frac{W_{bkg} - mn/2}{\sqrt{var(W_{bkg})}}$$

Where:

$$var(W_0) = \frac{mn(m+n+1)}{12} - \left\{ \frac{mn}{12(m+n)(m+n-1)} \sum_{j=1}^{g} t_j(t_j^2 - 1) \right\}$$

$$var(W_{bkg}) = Term1 - (Term2 \times SumTerm)$$

m is the sample size for Site data
n is the sample size for bkg data
g is number of tied groups

W_{bkg}:	3143	
m:	190	
n:	20	
most likely W:	1900	
var(W_0)		
tied groups (g):	13	2 groups has 3 tied values and 11 groups have 2 tied values
var(W_0) Term 1:	66817	
var(W_0) Term 2:	0.0072	
var(W_0) Sum Term:	114	
var(W_0)	66816	

z_{bkg}	
z_{bkg} numerator:	1243
z_{bkg} denominator:	258.5
z_{bkg}:	4.81

Step 4a. Critical Value

False rejection error rate (α):	0.05	falsely conclude that Site ≤ background
False acceptance error rate (β):	0.2	falsely conclude that Site > background

Critical value ($z_{0.95}$):	1.645

Step 4b. p-value

p-value:	7.6E-07

Step 5a. Test Stat compared against Critical Value

Test Statistic (z_{bkg}):	4.81	
Critical Value ($z_{0.95}$):	1.645	
Z_{bkg} > $Z_{0.95}$:	TRUE	reject null hypothesis at 95% confidence level - Site clean

Step 5b. p-value compared against significance level

p-value:	7.6E-07	
significance level:	0.05	
p-value < significance level:	TRUE	reject null hypothesis at 95% confidence level - Site clean

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Selenium (Se)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

TASMAN

Concentrations										
Sample ID (Site)	Se milligrams per kilogram (mg/kg)	Intermediate (if ND)	Substituted Se (mg/kg)		Sample ID (Background)	Se (mg/kg)	Intermediate (if ND)	Substituted Se (mg/kg)		Source	Se (mg/kg)
SS01 @ 6'	0.312		0.312		BKG02 @ 2'	0.757		0.757		bkg + substantial difference (S)	0.900
SS02 @ 6'	0.301		0.30		BKG02 @ 5'	0.859		0.859		bkg + S	1.002
SS07 @ 8'	<0.260	0.260	0.13		BKG02 @ 8'	0.750		0.75		bkg + S	0.893
SS08 @ 8'	0.297		0.30		BKG03 @ 2'	0.512		0.512		bkg + S	0.655
SS09 @ 2'	0.274		0.27		BKG03 @ 5'	0.753		0.753		bkg + S	0.896
SS10 @ 5'	0.468		0.47		BKG03 @ 8'	0.753		0.753		bkg + S	0.896
SS11 @8'	0.737		0.737		BKG05@8'	1.23		1.23		bkg + S	1.373
SS12 @ 2'	<0.260	0.260	0.13		BKG05@10'	0.354		0.354		bkg + S	0.497
SS13 @ 5'	0.484		0.484		BKG06@2'	<0.175	0.175	0.0875		bkg + S	0.230
SS16 @ 8'	0.290		0.29		BKG06@5'	<0.175	0.175	0.0875		bkg + S	0.230
SS17 @ 2'	<0.260	0.260	0.13		BKG06@8'	<0.175	0.175	0.0875		bkg + S	0.230
SS18 @ 5'	2.11		2.110		BKG06@10'	0.654		0.654		bkg + S	0.797
SS19 @ 2'	0.359		0.36		BKG07@2'	0.389		0.389		bkg + S	0.532
SS20 @ 5'	0.768		0.77		BKG07@5'	1.01		1.01		bkg + S	1.153
SS21 @ 8'	0.436		0.44		BKG07@8'	1.12		1.12		bkg + S	1.263
SS22 @ 8'	0.499		0.50		BKG07@10'	0.368		0.368		bkg + S	0.511
SS25 @ 2'	0.627		0.63		BKG08@2'	0.339		0.339		bkg + S	0.482
SS26 @ 5'	0.567		0.57		BKG08@5'	0.634		0.634		bkg + S	0.777
SS27 @ 8'	0.280		0.28		BKG08@8'	0.469		0.469		bkg + S	0.612
SS28 @ 2'	0.355		0.36		BKG08@10'	0.212		0.212		bkg + S	0.355
SS29 @ 5'	0.275		0.28								
SS30 @ 2'	<0.260	0.260	0.13								
SS31 @ 5'	<0.260	0.260	0.13								
SS32 @ 2'	<0.260	0.260	0.130								
SS33 @ 5'	0.490		0.49								
SS34 @ 2'	0.283		0.28								
SS35 @ 5'	0.475		0.475								
SS36 @ 8'	0.291		0.291								
SS37 @ 8'	0.287		0.287								
SS38 @ 8'	<0.260	0.260	0.130								
SS39 @ 2'	0.283		0.283								
SS40 @ 5'	0.453		0.453								
SS41 @ 2'	<0.260	0.260	0.130								
SS42 @ 5'	0.895		0.895								
SS43 @ 8'	<0.260	0.260	0.130								
SS44 @ 8'	0.584		0.584								
SS45 @ 8'	0.828		0.828								
SS46 @ 8'	0.383		0.383								
SS47 @ 2'	<0.260	0.260	0.130								
SS48 @ 5'	0.834		0.834								
SS50 @ 8'	0.367		0.367								
SS64 @ 2'	<0.260	0.260	0.130								
SS65 @ 5'	<0.260	0.260	0.130								
SS67 @ 12'	<0.260	0.260	0.130								
SS69 @ 8'	1.44		1.440								
SS70 @ 10'	<0.260	0.260	0.130								
SS71 @ 12'	<0.260	0.260	0.130								
SS72 @ 8'	0.652		0.652								
SS73 @ 10'	0.428		0.428								
SS74 @ 8'	0.799		0.799								
SS75 @ 10'	<0.260	0.260	0.130								
SS76 @ 12'	<0.175	0.175	0.088								
SS77 @ 8'	0.806		0.806								
SS78 @ 10'	0.634		0.634								
SS79 @ 12'	<0.175	0.175	0.088								
SS80 @ 8'	0.553		0.553								
SS81 @ 10'	0.829		0.829								
SS82 @ 8'	0.463		0.463								
SS83 @ 10'	0.546		0.546								
SS86 @ 12'	<0.260	0.260	0.130								
SS87 @ 12'	<0.260	0.260	0.130								
SS90 @ 12'	<0.260	0.260	0.130								
SS91 @ 8'	<0.260	0.260	0.130								
SS92 @ 10'	<0.260	0.260	0.130								
SS93 @ 12'	0.268		0.268								
SS94 @ 8'	<0.260	0.260	0.130								
SS95 @ 10'	<0.260	0.260	0.130								
SS96 @ 10'	0.511		0.511								
SS97 @ 12'	0.284		0.284								
SS98 @ 10'	0.198		0.198								
SS99 @ 12'	0.448		0.448								
SS102 @ 12'	<0.175	0.175	0.088								
SS103 @ 12'	0.211		0.211								
SS104 @ 12'	0.283		0.283								
SS105 @ 12'	0.459		0.459								
SS106 @ 12'	0.205		0.205								
SS107 @ 10'	0.613		0.613								

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Selenium (Se)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

SS108 @ 12'	0.277		0.277
SS109 @ 12'	0.249		0.249
SS110 @ 12'	0.229		0.229
SS111 @ 12'	0.306		0.306
SS112 @ 12'	0.225		0.225
SS113 @ 10'	0.327		0.327
SS114 @ 12'	0.257		0.257
SS115 @ 12'	0.191		0.191
SS116 @ 12'	0.374		0.374
SS117 @ 12'	<0.175	0.175	0.088
SS119 @ 12'	0.423		0.423
SS120 @ 12'	0.518		0.518
SS122 @ 12'	0.210		0.210
SS123 @ 12'	0.412		0.412
SS124 @ 12'	0.250		0.250
SS125 @ 10'	0.533		0.533
SS126 @ 12'	0.437		0.437
SS127 @ 12'	<0.175	0.175	0.088
SS128 @ 12'	<0.175	0.175	0.088
SS129 @ 12'	<0.175	0.175	0.088
SS130 @ 12.5'	<0.175	0.175	0.088
SS131 @ 8'	2.04		2.040
SS132 @ 10'	0.651		0.651
SS133 @ 12'	<0.175	0.175	0.088
SS134 @ 12'	<0.175	0.175	0.088
SS135 @ 12'	<0.175	0.175	0.088
SS136@12'	<0.175	0.175	0.088
SS137 @ 8'	0.247		0.247
SS138 @ 10'	1.01		1.010
SS139 @ 12'	<0.175	0.175	0.088
SS140 @ 12'	<0.175	0.175	0.088
SS141 @ 12.5'	0.197		0.197
SS142 @ 12'	0.253		0.253
SS143 @ 12'	<0.175	0.175	0.088
SS144 @ 12'	0.188		0.188
SS147 @ 12'	0.376		0.376
SS148 @ 8'	0.922		0.922
SS149 @ 10'	0.402		0.402
SS150 @ 12'	<0.175	0.175	0.088
SS151 @ 12'	<0.175	0.175	0.088
SS152 @ 12'	<0.175	0.175	0.088
SS153 @ 8'	<0.175	0.175	0.088
SS154 @ 10'	<0.175	0.175	0.088
SS155 @ 10'	1.27		1.270
SS156 @ 8'	0.431		0.431
SS157 @ 10'	0.336		0.336
SS158 @ 12'	0.341		0.341
SS159 @ 12'	0.240		0.240
SS160 @ 12'	0.182		0.182
SS161 @ 12'	0.471		0.471
SS162 @ 8'	0.715		0.715
SS163 @ 10'	0.304		0.304
SS164 @ 8'	<0.175	0.175	0.088
SS165 @ 10'	<0.175	0.175	0.088
SS166 @ 12'	<0.175	0.175	0.088
SS167 @ 12'	<0.175	0.175	0.088
SS168 @ 12'	<0.175	0.175	0.088
SS169 @ 8'	0.294		0.294
SS170 @ 10'	<0.175	0.175	0.088
SS171 @ 8'	<0.175	0.175	0.088
SS172 @ 10'	<0.175	0.175	0.088
SS173 @ 12'	<0.175	0.175	0.088
SS174 @ 8'	0.216		0.216
SS175 @ 10'	0.429		0.429
SS176 @ 12'	<0.175	0.175	0.088
SS177 @ 8'	0.230		0.230
SS178 @ 10'	<0.260	0.260	0.130
SS181 @ 12'	<0.260	0.260	0.130
SS183 @ 8'	1.15		1.150
SS184 @ 10'	0.300		0.300
SS185 @ 10'	0.521		0.521
SS186 @ 12'	<0.175	0.175	0.088
SS187 @ 12'	<0.175	0.175	0.088
SS188 @ 12'	<0.175	0.175	0.088
SS189 @ 12'	<0.175	0.175	0.088
SS190 @ 12'	<0.175	0.175	0.088
SS191 @ 12'	<0.175	0.175	0.088
SS192 @ 12'	<0.175	0.175	0.088
SS193 @ 10'	<0.175	0.175	0.088
SS194 @ 10'	<0.175	0.175	0.088
SS195 @ 12'	<0.175	0.175	0.088
SS196 @ 12'	<0.175	0.175	0.088
SS197 @ 12'	<0.175	0.175	0.088

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Selenium (Se)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

SS198 @ 12'	<0.175	0.175	0.088
SS199 @ 8'	1.28		1.280
SS200 @ 10'	<0.175	0.175	0.088
SS201 @ 12'	<0.175	0.175	0.088
SS202 @ 8'	0.214		0.214
SS203 @ 10'	<0.175	0.175	0.088
SS204 @ 8'	0.416		0.416
SS205 @ 10'	0.203		0.203
SS206 @ 12'	<0.175	0.175	0.088
SS207 @ 8'	<0.175	0.175	0.088
SS208 @ 10'	<0.175	0.175	0.09
SS209 @ 12'	0.472		0.47
SS210 @ 12'	<0.175	0.175	0.088
SS211 @ 10'	0.665		0.665
SS212 @ 12'	0.999		0.999
SS215 @ 12'	0.294		0.294
SS216 @ 10'	0.554		0.554
SS217 @ 12'	<0.175	0.175	0.088
SS218 @ 8'	0.347		0.347
SS219 @ 10'	<0.175	0.175	0.088
SS220 @ 10'	<0.175	0.175	0.088
SS221 @ 8'	<0.175	0.175	0.088
SS222 @ 10'	<0.175	0.175	0.088
SS223 @ 12'	<0.175	0.175	0.088
SS224 @ 10'	<0.175	0.175	0.09
SS225 @ 12'	<0.175	0.175	0.088
SS226 @ 10'	<0.175	0.175	0.09
SS227 @ 12'	<0.175	0.175	0.088
SS229 @ 10'	0.328		0.328
SS230 @ 12'	0.314		0.31

Site concentrations (m):	190		
bkg concentrations (n):	20		
mean-Site:	0.32	mean-bkg:	0.57
S, based on mean:	0.079	S, based on mean:	0.143
median-Site:	0.22	median-bkg:	0.57
S, based on median:	0.054	S, based on median:	0.143

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Selenium (Se)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

Computations				
Source	**Value**	**Rank**	**Site Rank**	**Bkg Rank**
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.09	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.09	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088	30.5	30.5	
Site	0.088

Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Selenium (Se)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

Site	0.130	73	73	
Site	0.130	73	73	
Site	0.13	73	73	
Site	0.13	73	73	
Site	0.130	73	73	
Site	0.18	86	86	
Site	0.188	87	87	
Site	0.191	88	88	
Site	0.197	89	89	
Site	0.198	90	90	
Site	0.203	91	91	
Site	0.205	92	92	
Site	0.210	93	93	
Site	0.211	94	94	
Site	0.214	95	95	
Site	0.216	96	96	
Site	0.225	97	97	
Site	0.229	98	98	
Site	0.23	99	99	
bkg + S	0.230	101		101
bkg + S	0.230	101		101
bkg + S	0.230	101		101
Site	0.240	103	103	
Site	0.25	104	104	
Site	0.249	105	105	
Site	0.250	106	106	
Site	0.253	107	107	
Site	0.257	108	108	
Site	0.268	109	109	
Site	0.274	110	110	
Site	0.275	111	111	
Site	0.277	112	112	
Site	0.280	113	113	
Site	0.283	115	115	
Site	0.283	115	115	
Site	0.283	115	115	
Site	0.284	117	117	
Site	0.287	118	118	
Site	0.290	119	119	
Site	0.291	120	120	
Site	0.294	121.5	121.5	
Site	0.294	121.5	121.5	
Site	0.297	123	123	
Site	0.300	124	124	
Site	0.301	125	125	
Site	0.304	126	126	
Site	0.306	127	127	
Site	0.31	128	128	
Site	0.314	129	129	
Site	0.327	130	130	
Site	0.328	131	131	
Site	0.336	132	132	
Site	0.34	133	133	
Site	0.347	134	134	
bkg + S	0.355	135		135
Site	0.355	136	136	
Site	0.359	137	137	
Site	0.367	138	138	
Site	0.374	139	139	
Site	0.38	140	140	
Site	0.383	141	141	
Site	0.402	142	142	
Site	0.412	143	143	
Site	0.416	144	144	
Site	0.423	145	145	
Site	0.428	146	146	
Site	0.43	147	147	
Site	0.431	148	148	
Site	0.436	149	149	
Site	0.437	150	150	
Site	0.448	151	151	
Site	0.453	152	152	
Site	0.459	153	153	
Site	0.463	154	154	
Site	0.468	155	155	
Site	0.471	156	156	
Site	0.47	157	157	
Site	0.475	158	158	
bkg + S	0.48	159		159

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Large Sample Wilcoxon Rank Sum Test
Werning 3, 4-2 Tank Battery - Selenium (Se)
From Box 3-34 of EPA QA/G-9S, but reformulated to match Test Form 2 in CERCLA Background Guidance

Site	0.484	160	160	
Site	0.490	161	161	
bkg + S	0.497	162		162
Site	0.499	163	163	
bkg + S	0.511	164		164
Site	0.511	165	165	
Site	0.518	166	166	
Site	0.521	167	167	
bkg + S	0.53	168		168
Site	0.533	169	169	
Site	0.546	170	170	
Site	0.553	171	171	
Site	0.554	172	172	
Site	0.567	173	173	
Site	0.584	174	174	
bkg + S	0.612	175		175
Site	0.613	176	176	
Site	0.627	177	177	
Site	0.634	178	178	
Site	0.65	179	179	
Site	0.652	180	180	
bkg + S	0.655	181		181
Site	0.665	182	182	
Site	0.715	183	183	
Site	0.737	184	184	
Site	0.768	185	185	
bkg + S	0.777	186		186
bkg + S	0.797	187		187
Site	0.799	188	188	
Site	0.806	189	189	
Site	0.828	190	190	
Site	0.829	191	191	
Site	0.834	192	192	
bkg + S	0.89	193		193
Site	0.895	194	194	
bkg + S	0.896	195.5		195.5
bkg + S	0.896	195.5		195.5
bkg + S	0.900	197		197
Site	0.922	198	198	
Site	0.999	199	199	
bkg + S	1.00	200		200
Site	1.010	201	201	
Site	1.150	202	202	
bkg + S	1.153	203		203
bkg + S	1.263	204		204
Site	1.270	205	205	
Site	1.280	206	206	
bkg + S	1.37	207		207
Site	1.440	208	208	
Site	2.040	209	209	
Site	2.110	210	210	

Raw Rank Sum (R):	18740	3415
Minimum possible value for Rank Sum:	18145	210
Adjusted Rank Sum (W_0):	595	3205

Sum of all ranks:	22155
n * m:	3800

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Werning 3, 4-2 Tank Battery - Selenium (Se)
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TASMAN

Step 1. Null Hypothesis (H_0)

H_0: μ_{site} - (1.25*μ_{bkg}) > 0
Site concentrations exceed 1.25 * background concentrations. (one-sided test)

Step 2. Alternative Hypothesis (H_A)

H_A: μ_{site} - (1.25*μ_{bkg}) ≤ 0
There is no difference between site and 1.25*background concentrations.

Step 3. Test Statistic

m and n > 20, so test statistic is:

$$z_0 = \frac{W_{bkg} - mn/2}{\sqrt{var(W_{bkg})}}$$

Where:

$$var(W_0) = \frac{mn(m+n+1)}{12} - \left\{ \frac{mn}{12(m+n)(m+n-1)} \sum_{j=1}^{g} t_j(t_j^2 - 1) \right\}$$

$$var(W_{bkg}) = Term1 - (Term2 \times SumTerm)$$

m is the sample size for Site data
n is the sample size for bkg data
g is number of tied groups

W_{bkg}:	3205	
m:	190	
n:	20	
most likely W:	1900	
var(W_0)		
tied groups (g):	6	1 group has 60 tied values, 1 group has 25 tied values, 2 groups have 3 tied values, 2 groups have 2 tied values
var(W_0) Term 1:	66817	
var(W_0) Term 2:	0.0072	
var(W_0) Sum Term:	231600	
var(W_0)	65146	

z_{bkg}	
z_{bkg} numerator:	1305
z_{bkg} denominator:	255.2
z_{bkg}:	5.11

Step 4a. Critical Value

False rejection error rate (α):	0.05	falsely conclude that Site ≤ background
False acceptance error rate (β):	0.2	falsely conclude that Site > background

Critical value ($z_{0.95}$):	1.645

Step 4b. p-value

p-value:	1.6E-07

Step 5a. Test Stat compared against Critical Value

Test Statistic (z_{bkg}):	5.11	
Critical Value ($z_{0.95}$):	1.645	
Z_{bkg} > $Z_{0.95}$:	TRUE	reject null hypothesis at 95% confidence level - Site clean

Step 5b. p-value compared against significance level

p-value:	1.6E-07	
significance level:	0.05	
p-value < significance level:	TRUE	reject null hypothesis at 95% confidence level - Site clean

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