

APPENDIX E  
GEOGRAPHIC COORDINATE TABLES

**Table E1: Soil Correlation Plot Locations**

<b>Sample ID</b>	<b>Latitude (North)</b>	<b>Longitude (West)</b>
SOILCORR1	42.545215	-103.270512
SOILCORR2	42.543673	-103.270735
SOILCORR3	42.541438	-103.272255
SOILCORR4	42.528583	-103.265050
SOILCORR5	42.529812	-103.271233
SOILCORR6	42.531080	-103.274623
SOILCORR7	42.492098	-103.243883
SOILCORR8	42.466478	-103.217638
SOILCORR9	42.466432	-103.221070
SOILCORR10	42.461735	-103.222565

**Table E2: Air Particulate Station Locations**

<b>Sample ID</b>	<b>Latitude (North)</b>	<b>Longitude (West)</b>
MAR1	42.495692	-103.265858
MAR2	42.480685	-103.254510
MAR4	42.459519	-103.230148
MAR3	42.459896	-103.215060
MAR5	42.451554	-103.324848

**Table E3: Radial Surface Soil Sample Locations**

<b>Sample ID</b>	<b>Latitude (North)</b>	<b>Longitude (West)</b>
C	42.500382	-103.253299
N300	42.503082	-103.253436
N600	42.505781	-103.253574
N900	42.508480	-103.253711
N1200	42.511179	-103.253848
N1500	42.513879	-103.253986
S300	42.497683	-103.253162
S600	42.494984	-103.253024
S900	42.492284	-103.252887
S1200	42.489585	-103.252750
S1500	42.486886	-103.252613
W300	42.500281	-103.256947
W600	42.500179	-103.260595
W900	42.500077	-103.264242
W1200	42.499975	-103.267890
W1500	42.499873	-103.271538
E300	42.500484	-103.249651
E600	42.500585	-103.246003
E900	42.500687	-103.242355
E1200	42.500788	-103.238708
E1500	42.500889	-103.235060
NE300	42.502363	-103.250817
NE600	42.504343	-103.248334
NE900	42.506324	-103.245851
NE1200	42.508304	-103.243369
NE1500	42.510284	-103.240886
SE300	42.498545	-103.250623
SE600	42.496709	-103.247946
SE900	42.494872	-103.245270
SE1200	42.493034	-103.242594
SE1500	42.491197	-103.239918
NW300	42.502219	-103.255976
NW600	42.504056	-103.258652
NW900	42.505893	-103.261329
NW1200	42.507729	-103.264006
NW1500	42.509566	-103.266683
SW300	42.498402	-103.255781
SW600	42.496421	-103.258263
SW900	42.494440	-103.260745
SW1200	42.492460	-103.263227
SW1500	42.490479	-103.265709

**Table E4: Radial Subsurface Soil Sample Locations**

Sample ID	Latitude (North)	Longitude (West)
C	42.500382	-103.253299
N750	42.507131	-103.253642
S750	42.493634	-103.252956
E750	42.500636	-103.244179
W750	42.500128	-103.262419

**Table E5: Direct Gamma Measurements**

Sample ID	Latitude (North)	Longitude (West)
C	42.500382	-103.253299
N150	42.501732	-103.253368
N300	42.503082	-103.253436
N450	42.504431	-103.253505
N600	42.505781	-103.253574
N750	42.507131	-103.253642
N900	42.508480	-103.253711
N1050	42.509830	-103.253780
N1200	42.511179	-103.253848
N1350	42.512529	-103.253917
N1500	42.513879	-103.253986
S150	42.499033	-103.253230
S300	42.497683	-103.253162
S450	42.496333	-103.253093
S600	42.494984	-103.253024
S750	42.493634	-103.252956
S900	42.492284	-103.252887
S1050	42.490935	-103.252818
S1200	42.489585	-103.252750
S1350	42.488235	-103.252681
S1500	42.486886	-103.252613
W150	42.500332	-103.255123
W300	42.500281	-103.256947
W450	42.500230	-103.258771
W600	42.500179	-103.260595
W750	42.500128	-103.262419
W900	42.500077	-103.264242

**Table E5: Direct Gamma Measurements (Continued)**

<b>Sample ID</b>	<b>Latitude (North)</b>	<b>Longitude (West)</b>
W1050	42.500026	-103.266066
W1200	42.499975	-103.267890
W1350	42.499924	-103.269714
W1500	42.499873	-103.271538
E150	42.500433	-103.251475
E300	42.500484	-103.249651
E450	42.500535	-103.247827
E600	42.500585	-103.246003
E750	42.500636	-103.244179
E900	42.500687	-103.242355
E1050	42.500737	-103.240532
E1200	42.500788	-103.238708
E1350	42.500838	-103.236884
E1500	42.500889	-103.235060
NE150	42.501373	-103.252058
NE300	42.502363	-103.250817
NE450	42.503353	-103.249575
NE600	42.504343	-103.248334
NE750	42.505334	-103.247093
NE900	42.506324	-103.245851
NE1050	42.507314	-103.244610
NE1200	42.508304	-103.243369
NE1350	42.509294	-103.242127
NE1500	42.510284	-103.240886
SE150	42.499464	-103.251961
SE300	42.498545	-103.250623
SE450	42.497627	-103.249284
SE600	42.496709	-103.247946
SE750	42.495790	-103.246608
SE900	42.494872	-103.245270
SE1050	42.493953	-103.243932
SE1200	42.493034	-103.242594
SE1350	42.492116	-103.241256
SE1500	42.491197	-103.239918

**Table E5: Direct Gamma Measurements (Continued)**

<b>Sample ID</b>	<b>Latitude (North)</b>	<b>Longitude (West)</b>
NW150	42.501301	-103.254637
NW300	42.502219	-103.255976
NW450	42.503138	-103.257314
NW600	42.504056	-103.258652
NW750	42.504974	-103.259991
NW900	42.505893	-103.261329
NW1050	42.506811	-103.262668
NW1200	42.507729	-103.264006
NW1350	42.508647	-103.265345
NW1500	42.509566	-103.266683
SW150	42.499392	-103.254540
SW300	42.498402	-103.255781
SW450	42.497411	-103.257022
SW600	42.496421	-103.258263
SW750	42.495431	-103.259504
SW900	42.494440	-103.260745
SW1050	42.493450	-103.261986
SW1200	42.492460	-103.263227
SW1350	42.491469	-103.264468
SW1500	42.490479	-103.265709

**Table E6: Supplemental Background Soil Sample Locations**

<b>Sample ID</b>	<b>Latitude (North)</b>	<b>Longitude (West)</b>
MARSS-01	42.546310	-103.272466
MARSS-02	42.538984	-103.266426
MARSS-03	42.538152	-103.271619
MARSS-04	42.534419	-103.267217
MARSS-05	42.534253	-103.272030
MARSS-06	42.534225	-103.275440
MARSS-07	42.526947	-103.267797
MARSS-08	42.523650	-103.269051
MARSS-09	42.523781	-103.263193
MARSS-10	42.518566	-103.264272
MARSS-11	42.508748	-103.257308
MARSS-12	42.510994	-103.259220
MARSS-13	42.514279	-103.261889
MARSS-14	42.498944	-103.255115
MARSS-15	42.498389	-103.245140
MARSS-16	42.494326	-103.239731
MARSS-17	42.487455	-103.239185
MARSS-18	42.486447	-103.235431
MARSS-19	42.483507	-103.236309
MARSS-20	42.479816	-103.233022
MARSS-21	42.482603	-103.233065
MARSS-22	42.475129	-103.231001
MARSS-23	42.459896	-103.223509

APPENDIX F  
CALCULATIONS





CLIENT: Cameco: Crow Butte Resources  
 JOB TITLE: Marsland Baseline Sampling Program

DATE: March-18-2015  
 JOB #: 114-910141

SUBJECT: Determining estimate of required number of background samples BY: DCW CHECK: \_\_\_\_\_

**From: NUREG 5849 Manual for Conducting Radiological Surveys in Support of License Termination**

**Section 6.3**

"NRC guideline values for residual activity are levels above the naturally occurring background. It is therefore necessary to determine the site background levels of direct radiation and radionuclide concentrations in soil, to enable a comparison of radiological conditions with the acceptable guideline values. "

**Section 8.6**

"The objective for background determination is that the average level should accurately represent the true background average to within ± 20% at the 95% confidence level. Selection of this criteria for defining an acceptable accuracy for background determinations is arbitrary, based on the natural variations (of background levels) occurring in the environment and the need to keep the effort and cost devoted to background determination reasonable."

**Part 1: Estimate of required number of additional samples**

The total number of background measurements needed to satisfy the objective is calculated by:

$$n_B = \left[ \frac{t_{95\%,df} \cdot S_x}{0.2 \cdot \bar{X}_B} \right]^2 \quad (8-22)$$

Where:

- $n_B$  = number of background measurements required
- $X_B$  = mean of initial background measurements
- $S_x$  = standard deviation of initial background measurements
- df = n-1 degrees of freedom, where n is the number of initial background data points
- $t_{95\%,df}$  = t statistic for 95% confidence at df

An initial 10 samples were collected in June 2014 as part of a correlation study. These samples, taken to a depth of 0-cm to 15-cm, were taken in locations such that the range of gamma exposure rates were sampled. Laboratory results of these samples and a table of t-values are provided in Attachment 1. The above equation is used, applying data from the initial 10 samples, to determine if additional samples are required to demonstrate the desired confidence of the data.

The parameters input into the above equation are provided in the table below:

Parameter	U-nat	Ra-226
$X_B$	0.41	0.69
$S_x$	0.11972	0.299814758
$t_{95\%,df}$	2.262	2.262
df	9	9

The calculated total number of background measurements required:

	U-nat	Ra-226
$n_B$ =	11	24

Subtracting the initial 10 samples from the total required number gives us an estimate of additional sampling to be performed. One additional sample is calculated as required for meeting the objective for background soil concentrations of U-nat. 14 additional samples are calculated as required for meeting the objective for background soil concentrations of RA-226



CLIENT: Cameco: Crow Butte Resources  
JOB TITLE: Marsland Baseline Sampling Program

DATE: March-18-2015  
JOB #: 114-910141

SUBJECT: Determining estimate of required number of background samples BY: DCW CHECK: \_\_\_\_\_

From: NUREG 5849 Manual for Conducting Radiological Surveys in Support of License Termination

**Part 2: Verification of background average value following supplemental sampling.**

An additional 23 supplemental soil samples were collected in November 2014 at locations evenly distributed around the site and in locations selected to account for the variability of soil types in the proposed disturbed area. The criteria used in selecting sample locations is provided in the report.

Reg. Guide 4.14 Radial grid surface samples that were located within the proposed disturbed area were also re-analyzed for U-nat concentration. These results are used in the background analysis as well.

Using the entire set of samples collected within the Marsland proposed disturbed area gives us the following parameters to be used in the equation presented on Sheet 1:

Parameter	U-nat	Ra-226
$X_B$	0.60	0.67
$S_x$	0.35	0.25
$t_{95\%,df}$	2.01575	2.016
df	45	45

The calculated total number of background measurements required:

	U-nat	Ra-226
$n_B =$	34	14

Based on this analysis the objective of determining the true background average for Ra-226 and U-nat soil concentrations to within  $\pm 20\%$  at the 95% confidence level has been met.

**ATTACHMENT 1**

**Initial Background Sample Set Laboratory Results (0-cm to 15-cm)**

Sample ID	Ra-226 (pCi/g)	U-nat (pCi/g)
SOILCORR1	1.0	0.6
SOILCORR2	0.7	0.5
SOILCORR3	1.2	0.5
SOILCORR4	1.0	0.5
SOILCORR5	0.2	0.3
SOILCORR6	0.6	0.3
SOILCORR7	0.5	0.3
SOILCORR8	0.5	0.5
SOILCORR9	0.7	0.3
SOILCORR10	0.5	0.3

**Supplemental Soil Sample Results (0-cm to 15-cm)**

Sample ID	Ra-226 (pCi/g)	Unat (pCi/g)
MARSS-01-01	0.8	0.6
MARSS-02-01	1.0	1.7
MARSS-03-01	0.4	0.7
MARSS-04-01	0.9	0.5
MARSS-05-01	0.3	0.4
MARSS-06-01	1.0	0.6
MARSS-07-01	ND	0.5
MARSS-08-01	0.8	0.6
MARSS-09-01	0.4	0.3
MARSS-10-01	0.5	0.5
MARSS-11-01	1.1	0.7
MARSS-12-01	0.7	0.4
MARSS-13-01	0.6	0.6
MARSS-14-01	0.4	0.4
MARSS-15-01	1.1	0.4
MARSS-16-01	0.5	0.3
MARSS-17-01	0.7	0.5
MARSS-18-01	0.7	0.4
MARSS-19-01	0.7	0.5
MARSS-20-01	0.6	1.3
MARSS-21-01	0.4	0.4
MARSS-22-01	1.0	0.5
MARSS-23-01	0.9	0.4

**Reg. Guide 4.14 Radial Grid Sampl Results (0-cm to 5-cm)**

Sample ID	Ra-226 (pCi/g)	Unat (pCi/g)
SE300	0.9	0.6
SE600	0.9	0.5
SE900	0.5	0.6
SE1200	0.7	1.5
SE1500	0.5	0.4
SW300	0.6	0.4
SW1200	1.0	0.6
NW900	0.3	0.4
CENTER	0.5	0.6
N300	0.8	1.1
N600	0.5	1.4
N900	0.7	0.6
NE300	0.5	0.5
NE600	0.4	0.4
NE1200	0.4	0.5
E300	1.0	1.6
E600	0.5	0.7

ATTACHMENT 1

TABLE B-1

Factors for Comparison of Survey Data  
with Guidelines and Determining Additional Data Needs

Degrees of Freedom*	t <sub>95%</sub>	t <sub>97.5%</sub>
1	6.314	12.706
2	2.920	4.303
3	2.353	3.182
4	2.132	2.776
5	2.015	2.571
6	1.943	2.447
7	1.895	2.365
8	1.860	2.306
9	1.833	2.262
10	1.812	2.228
11	1.796	2.201
12	1.782	2.179
13	1.771	2.160
14	1.761	2.145
15	1.753	2.131
16	1.746	2.120
17	1.740	2.110
18	1.734	2.101
19	1.729	2.093
20	1.725	2.086
21	1.721	2.080
22	1.717	2.074
23	1.714	2.069
24	1.711	2.064

TABLE B-1 (continued)

Factors for Comparison of Survey Data  
with Guidelines and Determining Additional Data Needs

Degrees of Freedom*	t <sub>95%</sub>	97.5%
25	1.708	2.060
26	1.706	2.056
27	1.703	2.052
28	1.701	2.048
29	1.699	2.045
30	1.697	2.042
40	1.684	2.021
60	1.671	2.000
120	1.658	1.980
400	1.649	1.966
infinite	1.645	1.960

\*Degree of freedom is the number of items of data minus 1; for values of degrees of freedom not in table, interpolate between values listed.

Reference (Gilbert 1987)