MARSSIM Final Status Survey Design: Determining the Need for Additional Soil Samples Based on Scan MDC

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Decommissioning Section Session

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Sign Test – Co-60 and Am-241 in Soil (Class 1)

- Site contaminants: Co-60 and Am-241
- Class 1 survey unit area is 1,500 m^2
- Two strategies for determining need for additional samples based on scan MDCs
- RESRAD version 5.95 used to get DCGLs
  - 3.4 pCi/g for Co-60
  - 11.8 pCi/g for Am-241

Sign Test – DQO Inputs

- Unity rule is used for survey design
- Characterization data used for planning:

	Survey Unit
Co-60	1.1 ± 0.4 (1σ)
Am-241	3.8 ± 0.8 (1σ)

- Type I and II decision errors set at 0.05

Calculate the Relative Shift

- LBGR is set at expected concentration:

  1.1/3.4 + 3.8/11.8 = 0.65

- Standard deviations from survey unit are normalized according to MARSSIM eqn I-2:

$$\sigma^2 = \left(\frac{\sigma_{Co-60}}{DCGL_{Co-60}} \right)^2 + \left(\frac{\sigma_{Am-241}}{DCGL_{Am-241}} \right)^2$$

Calculate the Relative Shift (cont.)

- Normalized standard deviation is:

$$\sigma^2 = \left(\frac{0.4}{3.4}\right)^2 + \left(\frac{0.8}{11.8}\right)^2 = 0.0184; \quad \sigma = 0.14$$

- $\Delta/\sigma = (1 - 0.65)/0.14 = 2.5$
- MARSSIM Table 5.5 provides N = 15

Assess Data Needs for Elevated Measurement Comparison Test

- 1.25” x 1.5” NaI used for scans; scan MDC for Co-60 is 5.8 pCi/g and for Am-241 is 45 pCi/g
- Area bounded by systematic samples, a', is 1500/15 = 100 m^2
- Area factors associated with a' are:
  - 1.22 for Co-60 and 1.34 for Am-241

Area Factors for Co-60 and Am-241 (from RESRAD)

Area (m^2)	Co-60	Am-241
3000	1	1
1000	1.02	1.00
300	1.10	1.06
100	**1.22**	**1.34**
30	1.58	2.46
10	2.33	4.39
3	4.95	9.50
1	11.6	159

Assess data needs for EMC

- Determine **required** Scan MDC:

  ($DCGL_W$ ☞ Area Factor)

  Co-60: (3.4 pCi/g)(1.22) = 4.15 pCi/g

  Am-241: (11.8 pCi/g)(1.34) = 15.8 pCi/g
- Actual scan MDCs for both radionuclides are greater than the required scan MDCs – we need additional samples for EMC

Strategies for Determining Number of Additional Samples

- Determine which of the two radionuclides is the "driver" for the additional samples
  - Calculate ratio of actual-to-required scan MDC
  - Radionuclide with largest ratio is the driver
- Determine reasonable ratio (or range of ratios) between the radionuclides
  - Scan MDC, DCGL, and area factors are determined for specific radionuclide mixture

Determine "driver" for the additional samples

- Actual-to-required scan MDCs:
  - Co-60: 5.8/4.15 = 1.4
  - Am-241: 45/15.8 = 2.8
- Therefore, Am-241 is the driver
- AF = actual scan MDC/DCGL,
  AF = 45/11.8 = 3.81
- Interpolate to get area that corresponds to this AF:
  a' is 13.1 m^2; new sample size = 1500/13.1 = **115**

Determine reasonable ratio (or range of ratios) between the radionuclides

- Requires determination of the scan MDC for a specific mixture of Co-60 and Am-241

  …and modeling to determine $DCGL_W$ and area factors for this specific mixture

  (simply stated, this approach is more work!)
- Let's briefly review scan MDC calculations

Scan MDC Determination

- Minimum detectable count rate based on signal detection theory & human factors(NUREG –1507)
- Relate MDCR in cpm to minimum detectable exposure rate (MDER) based on NaI characteristics
- Microshield™ to model specific radionuclide(s) concentration and geometry – yields exposure rate
- Scan MDC = MDER/CF, where CF is the exposure rate to concentration correction factor

Scan MDCs For 1.25”x1.5” NaI Detector

Radionuclide	Scan MDC (pCi/g)
Cs-137	10.4
Am-241	44.6
Th-232	2.8
Co-60	5.8
Processed Uranium	115
Enriched Uranium (3%)	137
Ra-226	4.5

Determine Additional Sample Needs for 30% Am-241 and 70% Co-60

- Based on process knowledge and characterization, 95% confidence level on fractional amount of Am-241: 0.3 to 0.8
- Determine additional sample needs for lower bound ratio: 30% Am and 70% Co
- Calculate scan MDC – expect it to be between 5.8 pCi/g (Co-60) and 45 pCi/g (Am-241): scan MDC = 7.8 pCi/g

Determine Additional Sample Needs for 30% Am and 70% Co (cont.)

- $DCGL_W$ for 30% Am/70% Co = 4.8 pCi/g
- AFs also generated for this mixture; the AF for 100 m^2 (initial a') is 1.22
- Required scan MDC: (4.8)(1.22) = 5.9 pCi/g – need more samples
- New AF = 7.8/4.8 = 1.62; new a' is 29m^2; new sample size = 1500/29 = **52 samples**

Determine Sample Needs for Various Am-241 to Co-60 Ratios

- Scan MDC for multiple radionuclides involves Microshield™ modeling or by observation

$$scanMDC = \frac{1}{\frac{f_1}{scan\ MDC_1} + \frac{f_2}{scan\ MDC_2}}$$

- For 80% Am/20% Co: scan MDC using Microshield™ was 19.1; using eqn 19.2 pCi/g

Additional Sample Needs as a Function of Am/Co Mixture

Mixture	DCGL	Scan MDC	Add'l Samples
0%Am	3.4	5.8	62
30%Am	4.8	7.8	52
50%Am	6.6	10.3	42
65%Am	9.3	13.4	29
80%Am	14.7	19.2	0
90%Am	13.1	26.9	35
100%Am	11.8	45	115

Conclusions

- Using Am-241 as the "driver" requires **115** additional samples…no effort to get scan MDC for multiple radionuclides
- If range of ratios between Am and Co can be justified (e.g., 30 to 80% Am-241), the conservative additional sample size is **52**…but approach requires effort to get scan MDC, DCGL, and Area Factors