John Hickman - Responses to Emailed Comments

From: <acarson1967@comcast.net>
To: <thy@nrc.gov>, <jbh@nrc.gov>
Date: 12/12/2006 2:55 PM
Subject: Responses to Emailed Comments
CC: <babineau@yankeerowe.com>, <bourassa@cyapco.com>, <vannoordennen@cyapco.com>, <erickson@yankeerowe.com>

John/Tom,

Attached are responses to the comments provided to Yankee by John Hickman on December 7th. Also attached are supplemental documents, referenced in the response. Since there were no actual questions associated with OOL-11 and OOL-18 (report is satisfactory as is), they are not addressed in the attached responses.

If you have any questions or wish to discuss, please let me know,

Alice Carson

Mail Envelope Properties (457F0901.0DB : 11 : 61659)

Subject: Responses to Emailed Comments
Creation Date 12/12/2006 2:54:00 PM
From: <acarson1967@comcast.net>

Created By: acarson1967@comcast.net

Recipients
nrc.gov
TWGWPO04.HQGWDO01
THY (Thomas Youngblood)

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Post Office	Route
TWGWPO04.HQGWDO01	nrc.gov
OWGWPO04.HQGWDO01	nrc.gov
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Files	Size	Date & Time
MESSAGE	408	12/12/2006 2:54:00 PM
TEXT.htm	553	
nrc_answers.pdf	15702	
8871 Rev 4.pdf	676513	
YA-REPT-01-018-05.pdf	1261777	
YA-EVAL-00-001-06 (Rev0).pdf		325479
NOL-03-02-172-F-G_Recount.pdf		33664
Mime.822	3168797	

Options

Expiration Date:	None
Priority:	Standard

ReplyRequested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

Junk Mail Handling Evaluation Results
Message is eligible for Junk Mail handling
This message was not classified as Junk Mail

Junk Mail settings when this message was delivered
Junk Mail handling disabled by User
Junk Mail handling disabled by Administrator
Junk List is not enabled
Junk Mail using personal address books is not enabled
Block List is not enabled

Yankee Responses to NRC Comments/Observations on Final Status Survey Reports: NOL-03, NOL-06, and OOL-10

Final Status Survey Report NOL-03

NRC Comment #1: Page 5, Section 4.3 indicates that two discrete particles with Co-60 activity were identified by ISOCS scans and removed from the survey unit. What were the estimated activities of the hot particles identified? This question is to gauge the field detection capability of ISOCS or what a detectable hot particles looks like with ISOCS.

Yankee Response: For ISOCS #190 the assay identified Co-60 at 0.18 pCi/g. The SPA-3 reading was 14.93 kcpm. The laboratory results indicated Co-60 at 0.38 μCi. For ISOCS #161 the assay identified Co-60 at 0.14 pCi/g. The SPA-3 reading was 12.26 kcpm. This particle was also removed but was not sent to the laboratory for analysis.

NRC Comment #2: What happened in the ISOCS output report for NOL-03-02-172-F-G? This ISOCS report does not provide the measured activity or even K-40 activity? This prompts the next question...

Yankee Response: ISOCS assay NOL-03-02-172-F-G was aborted, at 20:14, 21.6 seconds into the assay. The ISOCS scan was reanalyzed with the same naming convention, at 22:31 counting for the full 600 seconds. It is Yankee's practice to include ALL assay results in the FSS report for completeness. No activity (including K-40) was measured, or subsequently included in the report for this assay, because of the very short counting time that lapsed before the assay was aborted.

NRC Comment #3: How does YR QC the ISOCS output reports? And, should not all the reports list a basic set of Identified Nuclides - for instance - K-40, Tl-208, Pb-212, Bi-214, Pb-214 and Ac-228?

Yankee Response: At the end of each ISOCS assay, the associated report is reviewed for the presence and range of K-40, and the identified and unidentified peaks are evaluated to determine if the peaks are due to the presence of naturally-occurring radionuclides such as those listed above. If anomalies are encountered, the Radiological Engineer is notified for direction (i.e. reanalysis or reconciliation of the anomaly).

The verification of the presence of K-40 and its associated appropriate peak characteristics are used as a routine response check, in accordance with DP-8871, "Operation of the Canberra Portable ISOCS Assay System." The technical basis for the decision to use K-40 is provided in Section 1.2.11 of YNPS-REPT-01-018-05, "Use Of In-Situ Gamma Spectrum Analysis To Perform Elevated Measurement Comparisons In Support Of Final Status Surveys," which is included as an appendix to the final status survey reports.

All identified nuclides for an assay are found in sections: "Nuclide identification report" (page 3 of the attached ISOCS report) and "Interference correction report" (page 4 of the attached ISOCS report).

NRC Comment #4: The sample NOL-03-02-190 results SOF = 0.9987. This appears to be a significant result, but is well below applicable release criteria. The reader can conclude that the SOF result is a fraction of Investigation level (IL) by reading the Planning Worksheet and using the activity data in ISOCS output reports. Does the FSSR clearly identify what SOF represents. SOF of IL, DCGL-W, DCGL-EMC ? The soil sample results appear to be (consistently) reported in terms of SOF of DCGL-W.

Yankee Response: Section 5.4 of the FSSR indicates that this SOF represents the SOF of the Investigation Levels. Included in Section 5.4 is an explanation of how the SOF was developed. The first formula illustrates how the Investigation Level (I_{LV}) is derived:

$$I_{LV} = DCGL_W \times AF \times \text{Adjustment Factor}$$

The SOF is derived by the following formula (also in this section): $\frac{C_1}{I_{LV_1}} + \frac{C_2}{I_{LV_2}} + \ldots + \frac{C_n}{I_{LV_n}} \leq 1$

NRC Comment #5: Page 9, Section 5.4 provides a[n] formula for Investigation Level: Investigation Level (ILV)=DCGLW X AF X Adjustment factor. What is the Adjustment Factor?

Yankee Response: The adjustment factor is the offset geometry adjustment factor derived by using the ratio of the MDC values for the 12.6 m^2 field–of-view vs. the 1 m^2 at the edge of the field-of-view. The adjustment factor for the 2 m 90 degree is discussed in YA-REPT-01-018-05 (see attached). The 1 m 180 degree adjustment factor is discussed in YA-EVAL-00-001-06 (also attached). The adjustment factor is dependant upon the detector configuration and the nuclide. The values are taken out of the technical report or the technical evaluation discussed above.

Final Status Survey Report NOL-06

NRC Comment: Page 7 indicates that survey units NOL-01-01 & NOL-06-03 and NOL-06-02 differ in the number of investigations identified. Were the areas fundamentally (radiologically) different or can the difference be attributed to the SPA-3 surveys versus ISOCS surveys?

Yankee Response: The differences are attributed to the SPA-3 surveys versus ISCOCs surveys. Because the SPA-3 is not nuclide-specific, there tends to be more investigations due to the presence of naturally-occurring radionuclides. This tendency is indicated in the NOL-06 report by the fact that, while not fundamentally radiologically different, NOL-06-02 (ISOCS survey) had no investigations, while the other two units in the survey area (SPA-3 surveys) had a number of investigations. Most of these investigations resulted in the determination that the elevated readings were due to natural occurring nuclides.

Final Status Survey Report OOL-10

NRC Comment: Table 3 for design parameters appears to indicate SPA-3 scans for survey unit OOL-10-02, but ISOCS scan results are provided in the Table 7 – ISOCS Scan Summary. This survey unit appears to surround the ISFSI and gamma scans will be affected by those radiation sources. What were the detector distance and collimation used for these ISOCS gamma scans?

Yankee Response: OOL-10-02 was scanned by ISOCS using the investigation criteria: "no plant-related nuclides identified in the assay." It was necessary to use the ISOCS, because of the logistics of moving the shielding and the very slow scan rate required to use the SPA-3. The ISOCS was positioned 2 m above the surface with a 90 degree collimator. Any report that identified a plant-related nuclide was investigated, regardless of the activity present. The investigations were performed by shielding the ISOCS area with a 1-inch thick steel plate and performing a shielded SPA-3 scan at a very slow rate in the ISOCS field-of-view. Biased soil samples were collected at the highest count rate in the investigation area as warranted.

Proc. No. DP-8871
Rev. No. 4
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OPERATION OF THE CANBERRA PORTABLE ISOCS ASSAY SYSTEM

SCOPE

This procedure governs the operation and maintenance of the Canberra portable gamma spectrum assay system. This procedure works in partnership with DP-8869 "*In-Situ* (ISOCS) Gamma Spectrum Assay System Calibration Procedure."

ENCLOSURES

DP-8871 - Pgs. 1–12

DPF-8871.1 - Pg. 1

DPF-8871.2 - Pg. 1

DPF-8871.3 - Pg. 1

DPF-8871.4 - Pg. 1

DPF-8871.5 – Pg. 1

Attachment A - Pg. 1

Attachment B - Pg. 1

Attachment C - Pg. 1

REFERENCES

1. DP-8869, "In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure"
2. Job Hazard Assessment, "Filling Detectors/Dewars with Liquid Nitrogen Activity"
3. Yankee Nuclear Power Station License Termination Plan
4. Canberra Genie-2000 V3.0 Operations Manual
5. Canberra training material for Genie-2000 Basic Operation (SU-470-4)
6. Model ISOXSHLD ISOCS Shield System Hardware Manual

7. DP-8856, "Preparation of Survey Plans"

8. DP-8872, "ISOCS Post Acquisition Processing And Data Review"

9. DP-8868, "Final Status Survey Training Program"

10. YA-REPT-00-018-05, "Use of In-Situ Gamma Spectrum Analysis to Perform Elevated Measurement Comparisons in Support of Final Status Surveys"

DEFINITIONS

Cognizant Radiological Engineer – A Radiological Engineer who has been assigned responsibility for the calibration of the detector system.

Source Certificate File – A data file used by the Canberra software which represents a radioactive source, including nuclides, energies, and activity levels.

Count – The process of collect gamma spectrum data.

DISCUSSION

This procedure provides guidance for the operation and maintenance of this system, including QC activities. The level of detail in this procedure presumes a significant degree of familiarity with the equipment and software as obtained through training and/or experience.

Operation of the portable ISOCS assay system is under the direction of qualified Radiological Engineers. Energy and efficiency calibrations are performed in accordance with procedure DP-8869, "*In Situ* (ISOCS) Gamma Spectrum Assay System Calibration Procedure." Use of the portable assay system should be under the administrative guidance of a Sample Plan or a Final Status Survey Plan. Plans provide information regarding nuclide library, acceptable MDA values, and applicable acceptance criteria.

The portable ISOCS assay system consists of a uniquely characterized HPGe detector, an InSpector2000 multi-channel analyzer, a laptop computer with Genie-2000 software installed. The system is designed to perform in situ gamma spectroscopy of large containers, surfaces, and open land areas.

PRECAUTIONS

1. Liquid nitrogen is VERY cold (approx. -200°F) and can easily cause severe frostbite. Wear eye protection when working with liquid nitrogen. Use gloves when working with cold piping and valves or where liquid nitrogen may contact the skin.

2. Nitrogen displaces oxygen and may cause asphyxiation. Do not occupy areas where an oxygen monitor is observed in the alarm state.

3. If the cryostats are being filled with LN2 in an enclosed area (room, etc.) then personnel access doors (if present) shall be open while filling unless BOTH an alarming oxygen monitor is operational in the enclosure AND the cryostats are vented to the outside of the enclosure.

4. Sources shall be controlled in accordance with Radiation Protection procedures and should be secured in locked storage when not in use or attended.

PRE-REQUISITES

1. Personnel working with liquid nitrogen shall have reviewed (and signed-off on) the associated Job Hazard Assessment for Liquid Nitrogen [2].

2. Personnel shall have received training that is applicable to the assigned task(s) in accordance with DP-8868, "Final Status Survey Training Program" [9].

3. The assay system has been set-up and an energy calibration has been performed in accordance with DP-8869, "In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure" [1].

PROCEDURE

A. GENERAL

1. If an oxygen monitor is observed in the alarm state, immediately exit the area and notify the ISFSI Shift Supervisor at x2235.

2. Guidance in this procedure generally follows a linear format. However, some steps may occasionally be determined as unnecessary or may be performed out of sequence as practical.

3. A narrative-style logbook should be maintained for purposes of documenting unique attributes of system performance or QC activities.

4. This procedure contains forms that are considered examples. Alternate or modified forms may be employed provided that information specifically required by the text of the procedure is addressed. Alternate or modified forms should be annotated with the appropriate document and revision identifier.

5. Data acquisition and analysis steps associated with FSS data are executed via Analysis Sequence Files defined by a cognizant Radiological Engineer. However, a cognizant Radiological Engineer may manually collect and analyze data without use of an ASF on a case-by-case basis.

B. FILLING CRYOSTATS WITH LIQUID NITROGEN

1. If an oxygen monitor is observed in the alarm state, immediately exit the area and notify the ISFSI Shift Supervisor at x2235.

2. The system should not be operated while a detector cryostat is being filled with liquid nitrogen because the data results will most likely be erroneous.

3. Recommended guidance concerning filling the detector cryostats with liquid nitrogen is presented in Attachment A of this procedure.

4. Notify a cognizant Radiological Engineer if any unusual conditions are encountered.

5. Attachment A may be posted for reference by personnel filling detector cryostats with liquid nitrogen.

C. QUALITY CONTROL

1. General

   a. Quality Control files shall be setup by a cognizant Radiological Engineer before QC activities can be performed.

   b. QC-related count times should be at least 600 seconds.

   c. QC reports should be maintained in a fireproof file cabinet.

2. Detector Performance Monitoring

   a. Routine QC source checks should be performed with the Eu-155 / Na-22 sources (nominally 1 μCi each) provided by Canberra.

   b. QC source checks should consist of the following attributes:

      1) The centroid channel should be tracked at 86.5 keV (± 2 channels) and 1274.5 keV (± 4 channels).

      2) The Full Width Half Max (FWHM) should be monitored at 1274.5 keV. Acceptance criteria should be selected to provide preliminary indications when the detector's specifications may be exceeded (e.g. slightly below the detector's specification).

3) Source activities at 86.5 keV and 1274.5 keV should be tracked. Acceptance criteria should be selected to flag results that exceed ±10% of the mean activity value of the source.

c. QC source counts shall be performed daily prior to use.

NOTE: Because each assay report is reviewed with respect to K-40, post shift QC source counts are not required to verify system operability.

d. Optionally, QC source counts may be performed post shift on a case-by-case basis as determined by a cognizant Radiological Engineer.

e. QC source counts shall be performed as follows:

1) Position the designated QC source in front of the detector at the prescribed position.

2) Start the Genie2000 software as described in Section E of this procedure unless the software is already running.

3) Start the QC source count via a pre-defined Analysis Sequence File (ASF). (Menu = Analyze | Execute Sequence >).

4) If an Analysis Sequence file is either not available or for some reason is not desired to be used, then a QC source count may be manually executed under the direction of a cognizant Radiological Engineer.

5) When the count is complete:

a) Review the results.

b) Annotate (check mark) the applicable Daily Checklist (DPF-8871.1) when QC activities are satisfactory. The Daily Checklists are not quality records, and are not required to be maintained; they are solely for field use if appropriate or helpful.

c) If a flagged result was encountered, notify a cognizant Radiological Engineer for resolution. Such resolutions shall be documented directly on the appropriate applicable QC report(s), including any applicable follow-up actions.

d) If the FWHM value exceeds the factory specification by less than 20%, the system may still be used. However all results should be manually reviewed for acceptability; otherwise the system should be removed from service until determined to be operational by a Cognizant Engineer.

3. Background Surveillances

a. QC surveillances for background are not performed unless background subtraction is to be applied to in-situ gamma spectroscopy results.

b. When background subtraction is applied to assay results then QC background surveillances shall be performed under the direction of a cognizant Radiological Engineer as appropriate.

c. A cognizant Radiological Engineer will establish acceptance criteria for QC background surveillances on a case-by-case basis.

d. QC background results shall be reviewed by a cognizant Radiological Engineer.

e. Flagged results for QC background surveillances used to support Final Status Survey activities shall be addressed in the applicable FSS Field Log(s).

D. SYSTEM DEPLOYMENT / STORAGE

1. Recommended guidance concerning system configuration for deployment in the field is presented in Attachment B of this procedure.

2. Notify a cognizant Radiological Engineer if any unusual conditions are encountered.

3. Attachment B should be available for reference by personnel removing the systems from the storage location.

4. Attachment C should be available by personnel when placing the systems into storage (e.g. overnight) between uses.

E. SYSTEM STARTUP

1. As necessary, start the Genie2K software (i.e. Gamma Acquisition and Analysis Module).

2. Open the appropriate detector (Menu = File | Open Datasource...)

   a. Note the distinction between the two possible types of sources: detector verses file. Select the DETECTOR radio button.

   b. Select the appropriate detector and press (click) the OPEN button. Note that the detector designations (i.e. naming convention) may include color identifiers to minimize confusion.

3. Verify that the detector high voltage is turned on. If the high voltage is not turned on, then the high voltage will need to be turned on prior to performing a count. When the high voltage has reached the prescribed set point, the system is ready for use.

F. AMPLIFIER GAIN ADJUSTMENTS

1. Amplifier gain adjustments shall be performed only as directed by a cognizant Radiological Engineer.

2. In the Genie-2000 environment, open the detector datasource requiring amplifier gain adjusting (menu = File | Open Datasource).

3. Position a QC check source at the face of the detector unless K-40 (1461 keV) is used as the reference peak.

4. Open the MCA adjust dialog box (menu = MCA | Adjust...).

   a. Verify that the detector's high (bias) voltage is turned ON.

   b. Inspect the amplifier gain settings.

5. Record the date, detector ID and as-found settings on an Amplifier Gain Log (DPF-8871.2).

6. Position the spectrum cursor at channel 5098, if a QC source is used or at channel 5843 if K-40 is used as the reference peak.

7. Start a count for approximately 300 seconds (or longer).

8. While the spectrum is being collected, adjust the super fine (& fine, if necessary) amplifier gain settings so that the centroid for the reference peak corresponds to the applicable channel.

9. Clear the spectrum (and re-start the count if necessary) after each gain adjustment, observing the influence of the gain adjustments.

10. When the reference peak's centroid is positioned at the appropriate channel, save the gain settings (Menu = File | Save) and record the "as-left" fine and super fine gain settings on an Amplifier Gain Log.

11. When the gain adjustments are satisfactory, save the gain settings and annotate the Amplifier Gain Log appropriately.

G. NUCLIDE LIBRARIES

1. For FSS activities, a nuclide library shall be developed to address the gamma-emitting radionuclides listed in the License Termination Plan.

2. For non-FSS activities, nuclide libraries may be developed on a case-by-case basis under the direction of a Radiological Engineer.

3. Libraries may include naturally occurring nuclides so as to minimize unidentified peaks.

4. Nuclide libraries should be saved with filenames that clearly denote the application of the library along with a revision identifier.

5. Nuclide libraries shall be independently reviewed with respect to the list of radionuclides and for the half-life and energy/abundance values.

H. DATA ACQUISITION

1. Before data acquisition, field personnel (e.g. RP Technician) shall verify the detector is outfitted with the correct collimator as directed by the cognizant Radiological Engineer or by the applicable FSS Plan.

2. Position the detector at the desired location, height, and orientation.

3. Verify that the detector's high (bias) voltage is turned on, if necessary.

4. If FSS data is being collected, document each acquisition either on an In-Situ Gamma Spectrum Data Collection Worksheet (DPF-8871.3), or similar, or on a report generated by a FSS database (e.g. EDMS).

a. At a minimum, the instrument identifier, date and time of acquisition, spectrum filename, and individual operating the system should be documented.

b. Remarks should be documented to describe unique conditions, configurations or other attributes that may be relevant as directed by the cognizant Radiological Engineer.

5. Initiate a count by selecting the desired analysis sequence file (Menu = Analyze | Execute Sequence >).

a. When prompted, input or edit the Sample Information in accordance with the applicable ISOCS Data Collection Worksheet (DPF-8871.3). Unique assay identifiers or descriptions, if used, should be entered as directed by the cognizant Radiological Engineer or an FSS Engineer or an FSS Supervisor.

b. When prompted, enter the filename (and path if necessary) where the spectrum's data file should be saved. The assay will automatically be saved with the specified filename at the end of the collection process.

6. If an Analysis Sequence File is either not available or for some reason is not desired to be used, then a count may be manually executed under the direction of a cognizant Radiological Engineer.

a. Set the count time (Menu = MCA | Aquire Setup).

b. Input appropriate information about the count (Menu = Edit | Sample Info...).

c. Save the data file when the count is finished (Menu = File | Save As...).

I. POST ACQUISITION PROCESSING AND DATA REVIEW

NOTE: Post acquisition processing may be applied at the time of data acquisition via Analysis Sequence Files.

1. Data analysis routines are incorporated into an ASF used to collect the data, however post acquisition processing may be manually performed.

2. After a spectrum has been collected, data analysis routines shall be applied.

a. The data file(s) should be copied to a working directory, as determined by the Radiological Engineer performing the data analysis.

b. Although data analysis routines may be selected, customized, or modified by a Radiological Engineer, the following routines are suggested:

- Peak Locate (Unidentified 2^{nd} Difference)
- Peak Area (Sum/non-Linear LSQ fit)
- Efficiency Correction (standard) – select Interpolated
- Nuclide Identification (w/ Interference Correction)
- Reports – (e.g., Header, Peak Analysis, NID, etc. as desired)

c. The following parameters should be applied to the above routines, as applicable:

- Peak locate threshold = 3.0
- Peak search range = 200 – 8000 channels
- Identification tolerance = 1.25 FWHM
- All other parameters may be selected / specified by a Radiological Engineer.

3. Directly following the completion of each assay used for FSS activities, the individual colleting the data should review the results with respect to the K-40 result, including correct centroid position (±4 channels) and the FWHM value.

4. Contact a cognizant Radiological Engineer for specific guidance or classification or if the K-40 centroid position is more than 4 channels from channel 5843.

NOTE: A "standard" efficiency calibration may be routinely and systematically applied to all spectra involving like geometries (e.g. collimator, source-to-detector distance, material, etc.). In unique cases where the assayed material is **NOT** adequately addressed by the "standard" efficiency calibration (e.g. presence of saturated soil, etc.): [10]

a. Those spectra shall be re-analyzed using an efficiency calibration suitable to the unique characteristic(s) of the subject material's matrix (e.g. density, material composition, etc.) or the physical configuration.

OR

b. Adjust investigation levels by 20%.

5. Spectrum data files may be manually analyzed or re-analyzed as follows:

   a) Open the data file to be processed (Menu = File | Open Datasource).

   b) Execute the desired analysis sequence file (Menu = Analyze | Execute Sequence >), ensuring that the efficiency calibration file applied to the data is correct.

6. Review the results. If necessary re-process the data, making any adjustments to the post acquisition processing routines. Post acquisition review/re-analysis, if necessary, shall be performed by a Radiological Engineer.

7. After post acquisition processing activities are completed, the data file shall be saved to a specific directory where FSS data is stored. Any modifications to FSS data shall be tracked on DPF-8871.5 (to include data filenames, description of modifications and Radiological Engineer making the modification).

8. Assay results may be transferred into the EDMS database for final processing and data analysis.

J. SYSTEM MAINTENANCE

1. If a component of the signal chain requires repair or non-routine maintenance, then a Maintenance Report (DPF-8871.4) shall be initiated and updated as necessary.

2. A separate Maintenance Report shall be initiated for each unique piece of equipment.

3. Maintenance Reports shall be closed out when corrective or follow-up actions are completed.

RECORDS

Spectrum data files (e.g. CAM files) used to support Final Status Surveys shall be maintained on a centralized fileserver.

Maintenance Reports (DPF-8871.4) and Amplifier Gain Logs (DPF-8871.2) "in progress" should be maintained at a central location . When the forms are completed, forward to document control in accordance with procedure AP-0223 "Document Control."

Daily checklists (DPF-8871.1) are not required to be maintained with the applicable system binder.

Required forms and assay results generated via this procedure shall be filed and processed in accordance with procedure AP-0221, "Plant Records Management."

FINAL CONDITIONS

1. The assay system is verified to be functioning properly before it is used to collect data.

2. Data is collected, reviewed and data files are saved.

PORTABLE ISOCS SYSTEM DAILY CHECKLIST

	SUN :	MON :	TUES :	WED:	THUR:	FRI:	SAT:
DIAGNOSTIC ON LN2 MONITORS:							

DETECTOR S/N:	CRYOSTAT FILL W/ LN2							
QC SOURCE DATE :	AM QC SOURCE CHECK							
CAL DUE:	PM QC SOURCE CHECK							
REMARKS:								

DETECTOR S/N:	CRYOSTAT FILL W/ LN2							
QC SOURCE DATE :	AM QC SOURCE CHECK							
CAL DUE:	PM QC SOURCE CHECK							
REMARKS:								

DETECTOR S/N:	CRYOSTAT FILL W/ LN2							
QC SOURCE DATE :	AM QC SOURCE CHECK							
CAL DUE:	PM QC SOURCE CHECK							
REMARKS:								

DETECTOR S/N:	CRYOSTAT FILL W/ LN2							
QC SOURCE DATE :	AM QC SOURCE CHECK							
CAL DUE:	PM QC SOURCE CHECK							
REMARKS:								

DETECTOR S/N:	CRYOSTAT FILL W/ LN2							
QC SOURCE DATE :	AM QC SOURCE CHECK							
CAL DUE:	PM QC SOURCE CHECK							
REMARKS:								

DETECTOR S/N:	CRYOSTAT FILL W/ LN2							
QC SOURCE DATE :	AM QC SOURCE CHECK							
CAL DUE:	PM QC SOURCE CHECK							
REMARKS:								

REVIEWED BY: ______________________________ DATE: __________

COGNIZANT RADIOLOGICAL ENGINEER

AMPLIFIER GAIN LOG

		AS-FOUND GAIN SETTINGS		AS-LEFT GAIN SETTINGS		FOLLOW-UP SATISFACTORY QC SOURCE COUNT		
DATE	DETECTOR	FINE	SUPER- FINE	FINE	SUPER- FINE		REMARKS (FLAGGED REPORT, ETC)	INITIALS

IN-SITU GAMMA SPECTRUM DATA COLLECTION WORKSHEET

SURVEY AREA OR SURVEY UNIT: ______________________________

GENERAL COMMENTS:

FSS FILENAME EXAMPLE = NOL-02-01-XXX-F-G (unless otherwise instructed), where XXX is the measurement location identifier

	DETECTOR / SYSTEM ID	DATE / TIME	DATA FILENAME OR IDENTIFIER	REMARKS	INITIALS
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					

IN-SITU GAMMA SPECTRUM ASSAY EQUIPMENT MAINTENANCE REPORT

EQUIPMENT DESCRIPTION	SERIAL NUMBER	INITIATION DATE

PROBLEM
RESOLUTION
FINAL CONDITION
REMARKS

MAINT. REPORT CLOSED: ______________________________ DATE: __________
COGNIZANT RADIOLOGICAL ENGINEER

IN-SITU GAMMA SPEC FILE MAINTENANCE TRACKING

DATE & TIME: ______________________________

SURVEY AREA /
UNIT DESIGNATION : ____

☐ FINAL SURVEY RESPONSIBLE RADIOLOGICAL ENGINEER: ____
☐ CHARACTERIZATION
☐ OTHER: ____

DATA FILENAME	ORIGINAL FILE DATE	AS-LEFT FILE DATE	DESCRIPTION OF MODIFICATION(S)

COMMENTS:

RADIOLOGICAL ENGINEER: ____ DATE: __________
RAD ENGR MAKING CHANGES

FSS MANAGER: ____ DATE: __________

ATTACHMENT A
DETECTOR CRYOSTAT FILLING WITH LIQUID NITORGEN

This attachment presents recommended guidance for filling the ISOCS HPGe detectors with liquid nitrogen (LN2).

1. Personnel filling cryostats with liquid nitrogen shall have been trained and read the Job Hazard Assessment, "Filling Detectors/Dewars with Liquid Nitrogen Activity."

2. Liquid nitrogen is VERY cold (approx. -200°F) and can easily cause severe frostbite. Wear eye protection when working with liquid nitrogen. Use gloves when working with cold piping and valves or where liquid nitrogen may contact the skin.

3. Nitrogen displaces oxygen and may cause asphyxiation. If the cryostats are filled with liquid nitrogen in an enclosed area or room, then personnel access doors (if present) shall be open while filling unless BOTH an alarming oxygen monitor is operational in the enclosure AND the cryostats are vented to the outside of the enclosure.

4. If an oxygen monitor is observed in the alarm state, immediately exit the area and notify the ISFSI Shift Supervisor at x2235.

5. Detector cryostats should be filled every 3 – 4 days while in storage without being used or daily, prior to being deployed out in the field, as practical. However, this may be relaxed to every two days for convenience.

6. Verify (test) the operability of oxygen monitors, as available, prior to filling cryostats.

7. Generally, cryostats should be filled in the horizontal position. However it may be more appropriate to fill some detector configurations in the vertical position. In such cases a cognizant Radiological Engineer will provide direction.

8. Connect the liquid nitrogen supply line to the cryostat's fill port and verify that the vent port is free from restrictions such as build-up, etc.

9. If the detector is being filled in the vertical position, install a vent line to ensure that discharging LN2 does not either create a safety concern or contact the pre-amp.

10. Verify that the pressure on the liquid nitrogen supply bottle does not exceed 50 psi.

11. Open the liquid nitrogen supply valve on the supply bottle of liquid nitrogen.

12. When the cryostat is completely filled, liquid nitrogen can be observed to be flowing from the cryostat's vent.

13. When the filling operation is completed, turn off the supply valve and remove the rubber supply line from the cryostat's fill port (when pliable).

14. After the cryostat has been filled, annotate the applicable DPF-8871.1 (Daily Checklist).

ATTACHMENT B

ISOCS SYSTEM DEPLOYMENT CONFIGURATION

This attachment is intended to serve as an informal checklist to be reviewed prior to transporting the system to a field location. If any pre-deployment configuration attributes are in question, contact a cognizant Radiological Engineer for guidance or disposition. The following not all inclusive attributes should be considered or verified:

1. Verify satisfactory performance of a QC source check by referring to the current Daily Checklist (DPF-8871.1).

2. Verify that the cryostats have been filled appropriately by referring to the current Daily Checklist (DPF-8871.1).

3. Verify that the detector, collimator, and electronics are configured as directed by the cognizant Radiological Engineer(s).

4. Remove and store the QC check source as appropriate.

5. Verify that the detector is securely seated in the collimator frame assembly.

6. Outfit the cryostat's vent port with an overflow tube to prevent liquid nitrogen from contacting the preamp when power is applied to the preamp.

7. Cap the cryostat's fill port unless otherwise directed by a cognizant Radiological Engineer.

8. Rotate the detector to the vertical position and secure.

9. Replace the battery for the InSpector unit with a fully charged battery on a daily (or shiftly) basis unless the battery had been installed on the InSpector unit AND the unit was powered ON via line supply for more than 24 hours (e.g. weekends).

10. Disconnect the (line voltage) power supply for the laptop computer and connect the power lead from the portable battery pack (located in the bottom of the electronics cabinet) to the laptop. Connect the cigarette lighter plug to the portable battery pack. Verify that connections associated with the battery pack are secure.

11. Disconnect the power cord associated with the electronics cabinet.

ATTACHMENT C

ISOCS SYSTEM STORAGE CONFIGURATION

This attachment is intended to serve as an informal, not all inclusive, checklist as reference when the system is being placed into storage (i.e. overnight). If any attributes are in question, contact a cognizant Radiological Engineer for guidance or disposition.

1. Disconnect the portable battery pack's line into the laptop computer and plug in the line voltage connection into the laptop.

2. Unplug the cigarette lighter plug from the portable battery pack

3. Plug in the line voltage supply associated with the electronics cabinet.

4. If the detectors are stored in the horizontal position, then the QC source may be set in place to facilitate source checking activities.

5. Storage facilities should be locked as necessary to ensure that sources are in a locked configuration and the electronics cabinet (i.e. laptop computer) is secured.

Use Of In-Situ Gamma Spectrum Analysis To Perform
Elevated Measurement Comparisons In Support Of Final Status Surveys

YA-REPT-01-018-05

Approvals	**(Print & Sign Name)**		
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Rev. 1

Technical Report YA-REPT-01-018-05, Rev. 1

Use Of In-Situ Gamma Spectrum Analysis To Perform Elevated Measurement Comparisons In Support Of Final Status Surveys

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1.0 REPORT

1.1 Introduction

Revision 1 was prepared to clarify and better highlight assumptions applied in the original version of this Technical Report. Minor edits in the document's text have also been made to improve readability.

This report describes the technical approach for using in-situ gamma ray spectroscopy (ISGRS) to survey for localized areas of elevated radioactivity. General methodologies are described for deriving investigation levels. Examples provided are specific to a particular detector configuration and address open land areas as well as building surfaces. This methodology is to be applied for alternate detector configurations. Implementation of this survey technique provides a quantitative evaluation as opposed to the qualitative evaluations traditionally provided via hand-held field instruments. The data produced by ISGRS is capable of accurately assaying a well-defined area so as to demonstrate that no single one-square-meter area in a survey unit exceeds the applicable $DCGL_{EMC}$.

The primary assumption made is that a potential one-square-meter of elevated radioactivity exists at the edge of the area being evaluated by a single in-situ measurement. To account for detection (i.e. efficiency) radionuclide-specific investigation levels are developed. Because the resultant investigation levels closely approximate the $DCGL_W$, assay results below investigation level(s) satisfy both the $DCGL_W$ and $DCGL_{EMC}$ criteria. The ability of ISGRS to perform radionuclide identification is also beneficial where influences from background radioactivity (e.g. ISFSI) impede survey efforts. Count times can be tailored to achieve required detection sensitivities and the detector can be collimated.

Validation of the ISOCS efficiency calibration software is beyond the scope of this report. Canberra Industries has performed extensive testing and validation on both the MCNP-based detector characterization process and the ISOCS calibration algorithms used by the software. The full MCNP method has been shown to be accurate to within 5% (typically). ISOCS results have been compared to both full MCNP and to 119 different radioactive calibration sources. In general, ISOCS is accurate to within 4-5% at high energies and 7-11% for low energies. The ISOCS technology has been independently qualified in Yankee Atomic Technical Report YA-REPT-00-022-04, "Use Of Gamma Spectrum Analysis To Evaluate Bulk Materials For Compliance With License Termination Criteria."

1.2 Discussion

1.2.1 Detector System Description

Two reverse-electrode ISOCS-characterized HPGe detectors, manufactured by Canberra Industries, have been procured. As the project progresses, other ISOCS detectors (e.g. standard electrode coaxial) may be employed. The key factor regarding the use of other ISOCS® characterized detectors is that specific efficiency calibrations will be developed and evaluated to account for each detector's unique characteristics.

The HPGe detector is mounted on a bracket designed to hold the detector / cryostat assembly and associated collimators. This bracket is mounted in a cage-like frame. This frame permits the detector to be oriented (pointed) over a full range from a horizontal to vertical orientation while being positioned above the surface being evaluated. Photographs of the frame-mounted system are presented in Attachment 1.

The InSpector (MCA) unit that drives the signal chain and the laptop computer that runs the acquisition software (Genie-2000) are mounted either in the frame or on the wheeled cart. These components are battery powered. Back-up power supplies (e.g. inverter) may be used to support the duty cycle. A wireless network has been installed so that the laptop computers used to run the systems can be controlled from any workstation at the facility. This configuration enables the use of a script to automatically write data files directly to a centralized file server following each assay. Radio communication is used to coordinate detector positioning and system operation.

1.2.2 Traditional Approach

With respect to Class 1 Survey Units, a surveillance for elevated activity is performed via scan surveys using hand-held field instruments. Acceptance criteria (i.e. $DCGL_{EMC}$) is derived by multiplying the $DCGL_W$ by the area factor associated with that area bounded by the grid used to locate soil samples. Occasionally, due to either background radioactivity or the size of the sample location grid, the detection sensitivity for these hand-held instruments exceeds the $DCGL_{EMC}$. In such instances, the survey grid is reduced so that area factors yielding higher $DCGL_{EMC}$ values can be used. This approach has a side effect of additional sampling, which impacts project schedules and costs. Additional sampling is further experienced to distinguish between natural radioactivity and plant-derived radioactivity to investigate elevated instrument responses.

1.2.3 Innovative Approach Methodology

The ISGRS supports the use of alternate area factors for determining $DCGL_{EMC}$ values because this technology, with the use of collimators, is capable of quantitatively evaluating well-defined localized areas. At the Yankee Rowe decommissioning project, area factors for a one-square-meter area are used to derive the $DCGL_{EMC}$. The application of these alternate area factors is based on the premise that the ISGRS can demonstrate that no single one-square-meter area in a survey unit exceeds the applicable $DCGL_{EMC}$. $DCGL_{EMC}$ values for a one-square-meter area are presented in Table 1 (soils) and Table 2 (building surfaces) below.

TABLE 1,
SOIL $DCGL_{EMC}$ FOR ONE-SQUARE-METER

	Soil $DCGL_W$ (pCi/g) (NOTE 1)	Soil $DCGL_W$ (pCi/g) (NOTE 2)	1 m² Area Factor (NOTE 3)	$DCGL_{EMC}$ for 1 m² (pCi/g) (NOTE 4)
Co-60	3.8	1.4	11	15
Ag-108m	6.9	2.5	9.2	23
Cs-134	4.7	1.7	16	28
Cs-137	8.2	3.0	22	66

NOTE 1 – LTP Table 6-1
NOTE 2 – Adjusted to 8.73 mRem/yr
NOTE 3 – LTP Appendix 6Q
NOTE 4 – Soil $DCGL_W$ (adjusted to 8.73 mRem/yr) for a 1 m² area

TABLE 2,
BUILDING SURFACE $DCGL_{EMC}$ FOR ONE-SQUARE-METER

	Bldg $DCGL_W$ (dpm/100m²) (NOTE 1)	Bldg $DCGL_W$ (dpm/100cm²) (NOTE 2)	1 m² Area Factor (NOTE 3)	$DCGL_{EMC}$ For 1 m² (dpm/100cm²) (NOTE 4)
Co-60	18,000	6,300	7.3	46,000
Ag-108m	25,000	8,700	7.2	62,600
Cs-134	29,000	10,000	7.4	74,000
Cs-137	63,000	22,000	7.6	167,000

NOTE 1 – LTP Table 6-1
NOTE 2 – Adjusted to 8.73 mRem/yr
NOTE 3 – LTP Appendix 6S
NOTE 4 – Building $DCGL_W$ (adjusted to 8.73 mRem/yr) for a 1 m² area

Because the detector's field-of-view is greater than one-square-meter, it is assumed that the (potential) one-square-meter of elevated radioactivity is situated at the edge of the area being evaluated. To compensate for reduced detection efficiencies associated with this assumption, an offset geometry adjustment factor is developed. The $DCGL_{EMC}$ is multiplied by this adjustment factor to derive investigation levels. When an investigation level is encountered an investigation is conducted, which may include the use of hand-held field instruments and soil sampling.

Before the offset geometry adjustment factor can be developed, the detector's field-of-view must be determined based on the detector configuration (e.g. collimator, detector height above the surface to be evaluated, etc.). For the purposes of this technical report, the detector is configured with a 90-degree collimator and the detector is positioned at 2 meters from the surface to be evaluated. For this case, the detector's field-of-view was empirically determined as presented in Attachment 2. Alternately, the field-of-view may be determined by comparing efficiency values for various diameters. For instance, considering a detector positioned at one meter above a surface, a 200-meter diameter could be considered an infinite plane. Efficiencies for this "infinite" diameter would be determined. Subsequently, efficiencies would be determined for other, much smaller, diameters (e.g. 5.5m, 6m, 7m, etc.) and then compared to the efficiencies associated with the infinite plane. The diameter that yields efficiency values at 95% that of the infinite plane would be considered the field-of-view for the detector configuration. As alternative collimator configurations are implemented specific evaluations will be conducted.

Based on the field-of-view, a grid pattern (i.e. detector spacing) convention is selected to ensure that 100% of the survey unit is evaluated. Naturally, overlapping will occur between adjacent measurements. Due to this overlapping, the area assumed to be evaluated with each assay is smaller than the field-of-view. The primary dimension of concern is the distance from the center of the grid to the corner of the grid (2.12m). This dimension (i.e. hypotenuse) is used to determine the distance the one-square-meter is offset from the center of the detector's position. The hypotenuse is reduced by the radius of a one-square-meter circle (i.e. 0.56 m). For the case of the 3-meter grid spacing example provided in this Technical Report, the offset dimension is 1.56m (2.12m – 0.56m).

Once a grid convention is selected, an adjustment factor can be derived by taking the ratio of MDA values (or efficiency values) between the following two scenarios:

- Uniformly distributed activity over the detector's field-of-view.

- Activity restricted to a one-meter-square circle offset at the edge of the grid area. The dimension for the offset is the distance from the center of the grid to the center of a one-meter-square circle situated at the edge of the area (grid) being evaluated by the assay.

This ratio, referred to as the offset geometry adjustment factor, is nuclide specific. As in the examples provided in this technical report, nuclide-specific ratios may be averaged. Investigation levels are then derived as follows:

Nuclide Investigation Level (pCi/g) = ($DCGL_{EMC}$) * CF

Where: $DCGL_{EMC}$ = ($DCGL_W$ or $DCGL_{SURR}$) * $AF_{(1\ m^2)}$, and
CF = (Mean) Offset geometry adjustment factor

1.2.4 Investigation Level Examples

For the purposes of this technical report, the detector configuration evaluated employs a 90-degree collimator with the detector positioned at 2-meters above the surface being evaluated. Separate examples are provided for open land areas (i.e. soil) and building surfaces, however the approach for both scenarios is identical. Likewise, the approach is similar for other detector configurations.

Empirical data used to determine the field-of-view for this configuration is presented in Attachment 2. As exhibited, the field-of-view has a radius of at least 2.3 meters (16.6 m^2). Considering a 3-meter grid convention, this radius exceeds the distance from the center to an outermost corner of the grid, therefore sufficient overlap will occur.

Because the one-meter-square $DCGL_{EMC}$ values listed in Table 1 and Table 2 do not account for a one-square-meter area of elevated activity positioned at the edge of the field-of-view, these $DCGL_{EMC}$ values are adjusted by the offset geometry adjustment factor. To develop this adjustment factor, a spectrum free of plant-related radioactivity was analyzed using two different efficiency calibrations (i.e. geometries). The first scenario assumes radioactivity uniformly distributed over the detector's field-of-view (i.e. 4.6 meter diameter). The second scenario assumes radioactivity localized within one-square-meter situated at the edge of the detector's field-of-view. A ratio of the resultant MDC values characterizes the difference in detection efficiencies between the two scenarios. This ratio is the offset geometry adjustment factor.

Off-set geometry adjustment factors, and the resultant investigation levels for soils, are presented in Table 3.

**TABLE 3,
SOIL INVESTIGATION LEVEL DERIVATION**

	MDC pCi/g (NOTE 1)	MDC pCi/g (NOTE 2)	RATIO (NOTE 3)	$DCGL_{EMC}$ for 1 m^2 (NOTE 4)	INVESTIGATION LEVEL pCi/g (NOTE 5)
Co-60	0.121	1.86	0.0651	15	1.0
Ag-108m	0.184	2.82	0.0652	23	1.5
Cs-134	0.189	2.90	0.0652	28	1.8
Cs-137	0.182	2.78	0.0655	66	4.3

NOTE 1 – Assumed activity distributed over the detector's field-of-view.
NOTE 2 – Efficiency calibration modeled for a 1 m^2 area situated (off-set) at the edge of the detector's field-of-view. The model assumes that all activity is distributed within the 1 m^2.
NOTE 3 – Ratio = (field-of-view MDC ÷ 1 m^2 MDC).
NOTE 4 – $DCGL_{EMC}$ values for 1 m^2 (from Table 1)
NOTE 5 – Investigation levels derived by applying of the off-set geometry adjustment factor (e.g. 0.0653) to the $DCGL_{EMC}$ for a 1 m^2 area for each radionuclide.

With respect to building surfaces, the development of the investigation level is identical to that for soil surfaces. Using the same approach, an offset geometry adjustment factor is developed. The MDC values for these two geometries were compared to characterize the difference in detection efficiencies. As expected, the condition with localized (one-square-meter) radioactivity at the edge of the detector's field-of-view yielded higher MDC values. The ratio between the reported MDC values for the two scenarios is used as the offset geometry adjustment factor. The MDC values, the associated ratios, and the derived investigation level for building surfaces are presented in Table 4.

**TABLE 4,
BUILDING SURFACE INVESTIGATION LEVEL DERIVATION**

	12.6 m^2 MDC ($dpm/100cm^2$) (NOTE 1)	1 m^2 MDC ($dpm/100cm^2$) (NOTE 2)	RATIO (NOTE 3)	$DCGL_{EMC}$ For 1 m^2 ($dpm/100cm^2$) (NOTE 4)	BUILDING SURFACE INVESTIGATION LEVEL ($dpm/100cm^2$) (NOTE 5)
Co-60	785	12,400	0.0633	46,000	2,900
Ag-108m	839	13,000	0.0645	62,600	3,900
Cs-134	900	14,200	0.0634	74,000	4,700
Cs-137	922	14,600	0.0632	167,000	10,600

NOTE 1 – Assumed activity distributed over the detector's field-of-view.
NOTE 2 – Efficiency calibration modeled for a 1 m^2 area situated (off-set) at the edge of the detector's field-of-view. The model assumes that all activity is distributed within the 1 m^2.
NOTE 3 – Ratio = (field-of-view MDC ÷ 1 m^2 MDC).
NOTE 4 – $DCGL_{EMC}$ values for 1 m^2 (from Table 3)
NOTE 5 – Investigation levels derived by applying of the off-set geometry adjustment factor (e.g. 0.0636) to the one-square meter $DCGL_{EMC}$.

In summary, suitable investigation levels for both open land areas (i.e. soils) and for building surfaces can be applied to in-situ gamma spectroscopy results. Note the MDC values associated with the detector's field-of-view were well below the derived investigation levels.

The investigation levels presented in Table 3 and Table 4 do not address the use of surrogate DCGLs. Use of surrogate DCGLs will be addressed in Final Status Survey Plans, particularly where it is necessary to evaluate non-gamma emitting radionuclides on building surfaces. When surrogate DCGLs are employed, investigation levels will be developed on a case-by-case basis using the approach outlined in this document. Similarly, the offset geometry adjustment factor presented in Table 3 and Table 4 will vary for different geometries. Where different detector configurations are employed, the offset geometry adjustment factor and applicable investigation levels will be determined using the methodology reflected in this Technical Report. Such evaluations will be documented via a Technical Evaluation, or similar.

For both open land areas and for building surfaces, when an investigation level is encountered, investigatory protocols will be initiated to evaluate the presence of elevated activity and bound the region as necessary. Such evaluations may include both hand-held field instrumentation as well as additional sampling as necessary.

1.2.5 Detector Sensitivity

For Class 1 survey units, the minimum detectable concentration is governed by the $DCGL_{EMC}$ associated with the grid area used to locate fixed-point measurements. The system's count time can be controlled to achieve the required detection sensitivity. Therefore, the grid spacing for the fixed-point measurements can be optimized thus eliminating unnecessary increases to the number of fixed-point measurements while ensuring that elevated areas between fixed measurement locations can be identified and evaluated.

Based on preliminary work, it has been determined that a count time of 900 seconds will yield an acceptable sensitivity for many areas on the site. In practice, it has been demonstrated that 600 second count times are sufficient to achieve MDAs at or below the associated investigation levels presented in Table 2 and Table 4. Count times will be adjusted as necessary where alternate detector configurations are employed or where background conditions warrant ensuring detection sensitivities are below the applicable investigation level. Since each assay report includes a report of the MDC values achieved during the assay, reviews of these reports can be used to verify that required MDC values were met.

1.2.6 Area Coverage

As discussed, based on the detector configuration's field-of-view determination, a 3-meter spacing between each survey point will result in over 100% of the survey unit to be evaluated. This spacing convention employs a grid pattern independent from the grid used to locate fixed-point measurements. An example of the grid pattern and spacing is presented in Attachment 3.

Alternate spacing conventions may be applied on a case-by-case basis. For instance, spacing may be decreased when problematic topographies are encountered. Note that decreased grid spacing in this context is not associated to the fixed-point measurements. Occasionally it may be necessary to position the detector at one meter or less from the target surface to evaluate unusual (e.g. curved) surfaces or to assist in bounding areas of elevated activity. In cases where it may be desirable to increase the field-of-view via collimator or source-to-detector distances, grid-spacing conventions (and applicable investigation levels) will be determined using the approach described in this document.

1.2.7 Moisture Content in Soil Matrix

In-situ gamma spectroscopy of open land areas is inherently subject to various environmental variables not present in laboratory analyses. Most notably is the impact that water saturation has on assay results. This impact has two components. First, the total activity result for the assay is assigned over a larger, possibly non-radioactive mass introduced by the presence of water. Secondly, water introduces a self-absorption factor.

The increase in sample mass due to the presence of water is addressed by the application of a massimetric efficiency developed by Canberra Industries. Massimetric efficiency units are defined as [counts per second]/[gammas per second per gram of sample]. Mathematically, this is the product of traditional efficiency and the mass of the sample. When the efficiency is expressed this way, the efficiency asymptotically approaches a constant value as the sample becomes very large (e.g. infinite). Under these conditions changes in sample size, including mass variations from excess moisture, have little impact on the counting efficiency. However, the massimetric efficiency does not completely address attenuation characteristics associated with water in the soil matrix.

To evaluate the extent of self-absorption, (traditional) counting efficiencies were compared for two densities. Based on empirical data associated with the monitoring wells, typical nominally dry in-situ soil is assigned a density of 1.7 g/cc. A density of 2.08 g/cc, obtained from a technical reference publication by Thomas J. Glover, represents saturated soil. A density of 2.08 g/cc accounts for a possible water content of 20%. A summary of this comparison is presented in Table 5.

TABLE 5,
COUNTING EFFICIENCY COMPARISONS

	Efficiencies		Deviation due to density
keV	1.7 g/cc	2.08 g/cc	increase (excess moisture)
434	3.3 E-6	2.7 E-6	-18.7%
661.65	2.9 E-6	2.4 E-6	-17.5%
1173.22	2.5 E-6	2.1 E-6	-15.4%
1332.49	2.4 E-6	2.1 E-6	-14.8%

In cases when the soil is observed to contain more than "typical" amounts of water, potential under-reporting may occur. In general, the presence of standing water (or ice or snow) on the surface of the soil being assayed will be not be tolerated during Final Status Survey activities. In cases where minor surface water is present, notes will be made in field logs so that associated measurement results can be reviewed and reanalyzed if necessary as prescribed in implementing procedures.

1.2.8 <u>Discrete Particles in the Soil Matrix</u>

Discrete particles are not specifically addressed in the License Termination Plan. However, an evaluation was performed assuming all the activity in the detector's field-of-view, to a depth of 15 cm, was situated in a discrete point-source configuration. A concentration of 1.0 pCi/g (Co-60), corresponding to the investigation level presented in Table 3, correlates to a discrete point-source of approximately 3.2 μCi. This activity value is considered as the discrete particle of concern. Since the presence of any discrete particles will most likely be accompanied by distributed activity, the investigation level may provide an opportunity to detect discrete particles below 3.2 μCi.

Discrete particles exceeding this magnitude would readily be detected during characterization or investigation surveys. The MDCs associated with hand-held field instruments used for scan surveys are capable of detecting very small areas of elevated radioactivity that could be present in the form of discrete point sources. The minimum detectable particle activity for these scanning instruments and methods correspond to a small fraction of the TEDE limit provided in 10CFR20 subpart E. Note that the MDC values presented in Table 3 are significantly lower than those published in Table 5-4 of the License Termination Plan.

When the investigation level in a Class 1 area is encountered, subsequent investigation surveys will be performed to include the use of hand-held detectors. The detection sensitivities of instruments used for these surveys have been previously addressed in the LTP. Furthermore, discrete point sources do not contribute to the uniformly distributed activity of the survey unit. It is not expected that such sources at this magnitude would impact a survey unit's ability to satisfy the applicable acceptance criteria.

Noting that Class 2 or Class 3 area survey designs do not employ elevated measurement comparisons, associated investigation levels are based on positive indications of licensed radioactivity above the $DCGL_W$ or above background. Because such areas are minimally impacted or disturbed, potential discrete particles would most likely be situated near the soil surface where detection efficiencies are highest.

1.2.9 Procedures And Guidance Document

General use of the portable ISOCS system is administrated by departmental implementing procedures that address the calibration and operation activities as well as analysis of the data. These procedures are listed as follows:

- DP-8869, "In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure."
- DP-8871, "Operation Of The Canberra Portable ISOCS Assay System."
- DP-8872, "ISOCS Post Acquisition Processing And Data Review."

Where the portable ISOCS® system is used for Final Status Surveys, the applicable FSS Plan will address detector and collimator configurations, applicable (surrogated) investigation levels, MDC requirements, and appropriate Data Quality Objectives, as applicable.

A secondary application of the portable ISOCS® system is to assay surfaces or bulk materials for characterization or unconditional release evaluations. Use of the portable ISOCS® system for miscellaneous evaluations will be administrated under a specific guidance document (e.g. Sample Plan, etc.). Operating parameters such as physical configuration, efficiency calibrations, count times, and MDCs will be applied so as to meet the criteria in the associated controlling documents. Such documents will also address any unique technical issues associated with the application and may provide guidance beyond that of procedure AP-0052, "Radiation Protection Release of Materials, Equipment and Vehicles."

1.2.10 Environmental Backgrounds

If background subtraction is used, an appropriate background spectrum will be collected and saved. Count times for environmental backgrounds should exceed the count time associated with the assay. In areas where the background radioactivity is particularly problematic (e.g. ISFSI), the background will be characterized to the point of identifying gradient(s) such that background subtractions are either appropriate or conservative. Documentation regarding the collection and application of environmental backgrounds will be provided as a component of the final survey plan.

1.2.11 Quality Control

Quality Control (QC) activities for the ISOCS system ensure that the energy calibration is valid and detector resolution is within specifications. A QC file will be set up for each detector system to track centroid position, FWHM, and activity. Quality Control counts will be performed on a shiftly basis prior to the system's use to verify that the system's energy calibration is valid. The Na-22 has a 1274.5 keV photon which will be the primary mechanism used for performance monitoring. If the energy calibration is found to be out of an acceptable tolerance (e.g. greater than ±4 channels), then the amplifier gain may be adjusted and a follow-up QC count performed. If the detector's resolution is found to be above the factory specification, then an evaluation will be performed to determine if the detector should be removed from service and/or if the data is impacted. Evaluations associated with QC counts shall be documented. Such documentation may be limited to a remark directly on the applicable QC report or in a logbook if the resolution does not render the system out of service. Otherwise the evaluation should be separately documented (e.g. Condition Report, etc.) so as to address the impact of any assay results obtained since the last acceptable QC surveillance.

Where it is determined that background subtraction is necessary, a baseline QC background will be determined specific to that area or region. When background subtraction is required, a QC background surveillance will be performed before a set of measurements are made to verify the applicability of the background to be subtracted. Due to the prevailing variability of the background levels across the site, the nature and extent of such surveillances will be on a case-by-case basis and should be addressed in the documentation associated with the applicable survey plan(s).

In addition to the routine QC counts, each assay report is routinely reviewed with respect to K-40 to provide indications where amplifier drift impacts nuclide identification routines. This review precludes the necessity for specific (i.e. required) after-shift QC surveillances. It also minimizes investigations of previously collected data should the system fail a before-use QC surveillance on the next day of use.

1.2.12 Data Collection

Data collection to support FSS activities will be administered by a specific Survey Plan. Survey Plans may include an index of measurement locations with associated spectrum filenames to ensure that all the required measurements are made and results appropriately managed. Personnel specifically trained to operate the system will perform data collection activities.

Data collection activities will address environmental conditions that may impact soil moisture content. Logs shall be maintained so as to provide a mechanism to annotate such conditions to ensure that efficiency calibration files address the in-situ condition(s). In extreme cases (e.g. standing water, etc.) specific conditions will be addressed to ensure that analysis results reflect the conditions. As previously discussed with respect to water, when unique environmental conditions exist that may impact analysis results, conservative compensatory factors will be applied to the analysis of the data.

1.2.13 Efficiency Calibration

The central feature of the portable ISOCS technology is to support in-situ gamma spectroscopy via the application of mathematically derived efficiency calibrations. Due to the nature of the environment and surfaces being evaluated (assayed), input parameters for the ISOCS efficiency calibrations will be reviewed on a case-by-case basis to ensure the applicability of the resultant efficiency. Material densities applied to efficiency calibrations will be documented. In practice, a single efficiency calibration file may be applied to the majority of the measurements.

The geometry most generally employed will be a circular plane assuming uniformly distributed activity. Efficiency calibrations will address a depth of 15 cm for soil and a depth up to 5 cm for concrete surfaces to account for activity embedded in cracks, etc. Other geometries (e.g. exponential circular plane, rectangular plane, etc.) will be applied if warranted by the physical attributes of the area or surface being evaluated. Efficiency calibrations are developed by radiological engineers who have received training with respect to the ISOCS® software. Efficiency calibrations will be documented in accordance with procedure DP-8869, "In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure."

1.2.14 Data Management

Data management will be implemented in various stages as follows:

- An index or log will be maintained to account for each location where evaluations for elevated activity are performed. Raw spectrum files will be written directly or copied to a central file server.

- Data Analysis – After the spectrum is collected and analyzed, a qualified Radiological Engineer will review the results. The data review process includes application of appropriate background, nuclide libraries, and efficiency calibrations. Data reviews also verify assay results with respect to the applicable investigation levels and the MDCs achieved. Data reviews may include monitoring system performance utilizing K-40. When the data analysis is completed, the analyzed data file will be archived to a unique directory located on a central file server.

- Data Reporting – The results of data files whose reviews have been completed and are deemed to be acceptable may be uploaded to a central database for subsequent reporting and statistical analysis.

- Data Archiving – Routinely (daily) the centralized file server(s) where the raw and analyzed data files are maintained will be backed up to tape.

1.3 Conclusions And Recommendations

The in-situ gamma ray spectroscopy system is a cost-effective technology well-suited to replace traditional scanning survey techniques to evaluate areas for elevated radioactivity. The static manner in which this system is operated eliminates variables and limitations inherent to hand-held detectors moving over a surface. This system provides a controllable and defendable detection sensitivity. This attribute qualifies ISGRS as an alternative survey method to that of hand-held field instruments in areas where background radiation levels make the use of such detectors problematic. The MDC to which this system will be operated satisfies (or exceeds) criteria applied to traditional scan surveys using hand-held field instruments.

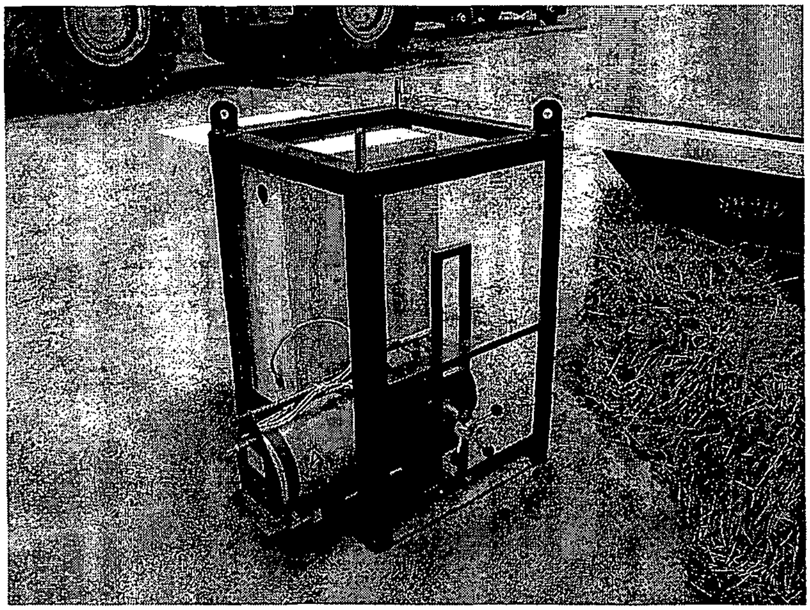
Applicable investigation levels for both open land areas (i.e. soils) and for building surfaces can be derived and applied to in-situ gamma spectroscopy results. Where surrogate DCGLs are employed, investigation levels will developed on a case-by-case basis using the approach outlined in this document.

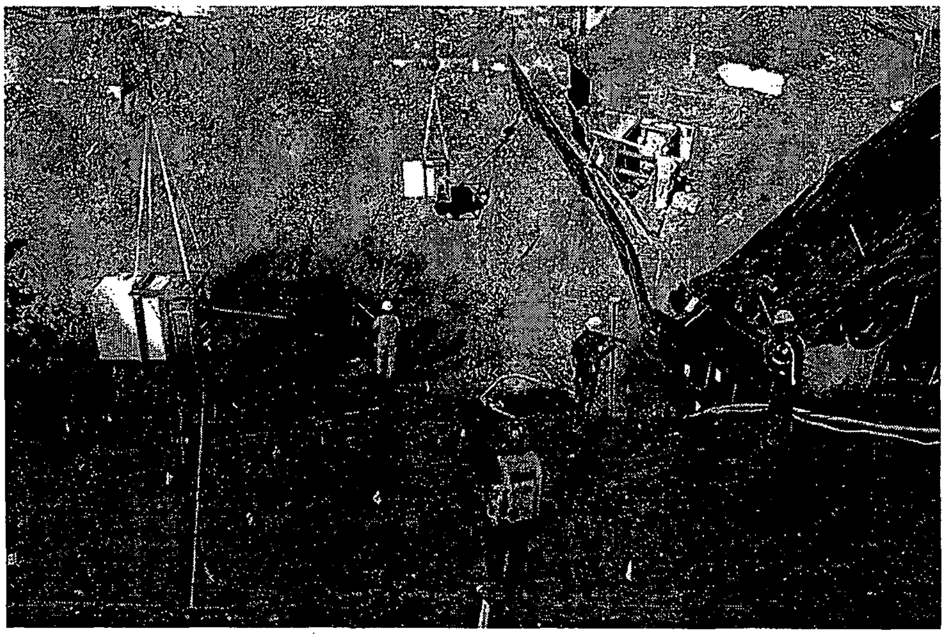
The manner in which investigation levels are derived introduces a conservative bias in that it is assumed that aside from a one-square meter, no other residual radioactivity is present in the area being evaluated. Additionally, spacing applied to in-situ measurement locations yields an overlap providing redundant opportunities to detect localized elevated activity.

1.4 References

1. YNPS License Termination Plan, Revision 1
2. Multi-Agency Radiation Survey And Site Investigation Manual (MARSSIM) Revision 1, 2000
3. Canberra User's Manual Model S573 ISOCS Calibration Software, 2002
4. Decommissioning Health Physics - A Handbook for MARSSIM Users, E.W. Abelquist, 2001
5. Canberra's Genie 2000 V3.0 Operations Manual, 2004
6. In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure DP-8869, Revision 0
7. Operation of the Canberra Portable ISOCS Assay System DP-8871 Revision 0
8. Technical Ref., by Thomas J. Glover.

Attachment 1
Portable ISOCS® Detector System Photos





Attachment 2
Field-Of-View Characterization

Generally, the HPGe detector will be outfitted with a 90-degree collimator situated at 2 meters perpendicular to the surface being evaluated. Note that characterizing the detector's field-of-view could be performed without a source by comparing ISOCS-generated efficiencies for various geometries. If a different collimator configuration is to be employed, a similar field-of-view characterization will be performed.

To qualify the field-of-view for this configuration, a series of measurements were made at various off-sets relative to the center of the reference plane. The source used for these measurements was a 1.2 μCi Co-60 point-source with a physical size of approximately 1 cm^3. Each spectrum was analyzed as a point source both with and without background subtract. It was observed that the detector responded quite well to the point source.

Figure 1 presents the results with background subtraction applied. Note that there is a good correlation with the expected nominal activity and that outside the 2-meter radius of the "working" field-of-view (i.e. at 90 inches) some detector response occurs. This validates that the correct attenuation factors are applied to the algorithms used to compute the efficiency calibration.

FIGURE 1

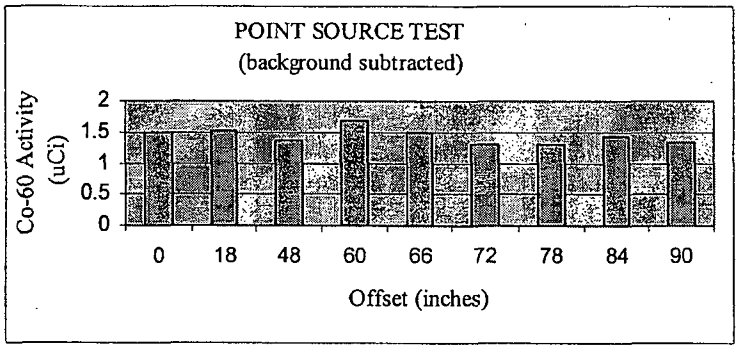
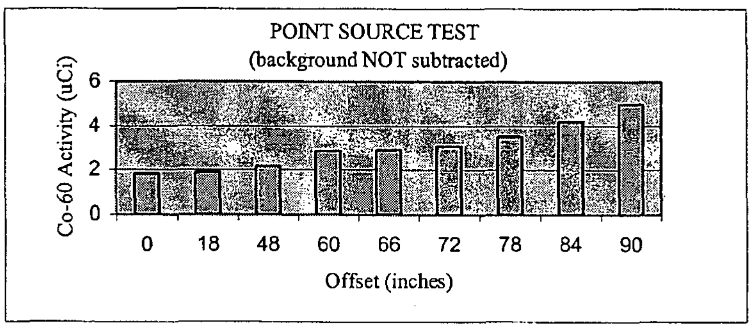
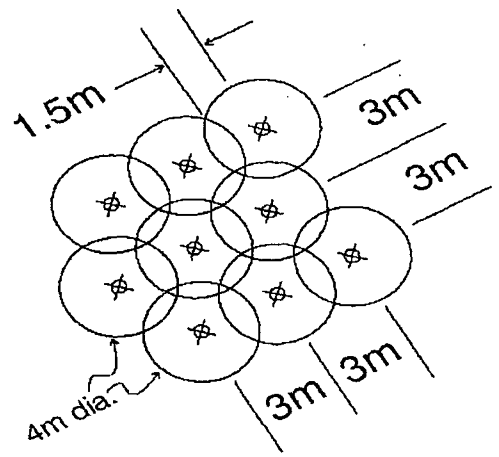


Figure 2 shows the effect of plant-derived materials present in the reference background, which indicates an increasing over-response the further the point source is moved off center. Detector response outside the assumed (i.e. 2-meter) field-of-view would yield conservative results. Normally, source term adjacent to the survey units should be reduced to eliminate background interference.

FIGURE 2



Attachment 3
Typical Grid Pattern For In-Situ Gamma Spectroscopy



Typical Scan Grid Pattern
(For 2m scan height using 90° collimator.)

=Scan Point Location
=Scan Area Footprint
(4m dia. for 2m scan height)

TECHNICAL EVALUATION TITLE PAGE

FSS Investigation Levels for In-Situ Gamma Spectroscopy
With a 1-meter, 180-Degree Configuration

YA-EVAL-00-001-06

Approvals	**(Print & Sign Name)**		
Prepares: Greg Astrauckas/	[signature]	Date:	5/16/06
Reviewer: Chris Messier/	[signature]	Date:	5-16-2006
Reviewer: Martin Erickson/	[signature]	Date:	5/17/06
Approver (Cognizant Manager): G. M. Babineau/	[signature]	Date:	5/17/06

Technical Report YA-EVAL-00-001-06, Rev. Original

FSS Investigation Levels for In-Situ Gamma Spectroscopy With a 1-meter, 180-Degree Configuration

PURPOSE

This technical evaluation addresses Investigation Levels applied to in-situ gamma spectroscopy results used to demonstrate compliance with FSS acceptance criteria. Specifically, the Investigation Levels herein are applicable only to detector configuration and grid spacing conventions described in this document. The methodologies applied to development of the Investigation Levels addressed by this document are similar to those described in YA-REPT-00-018-05, Use Of In-Situ Gamma Spectrum Analysis To Perform Elevated Measurement Comparisons In Support Of Final Status Surveys.

DISCUSSION

General

As described in the above referenced Techncial Report, the basic steps in the development of Investigation Levels are as follows:

1. Identify the collimation configuration and detector height above the surface to be evaluated.
2. Determine the field-of-view for the detector configuration.
3. Determine a suitable grid pattern.
4. Derive the offset geometry adjustment factor to account for a 1m² elevated region positioned at the edge of the detector's field-of-view (or area being evaluated).
5. Apply the offset geometry adjustment factor value to the $DCGL_{EMC}$ (DCGL for a 1m² area) to yield nuclide-specific investigation levels.

Configuration and Field-Of-View

This evaluation is for Canberra HPGe coaxial and reverse electrode detectors outfitted with 2-inch side-shields in a 180° collimation configuration. The detector is to be positioned perpendicular at one meter from a plane source. The field-of view has been evaluated for six detectors available for in-situ FSS activities. Details of this evaluation are presented in Attachment 1, which concludes that 7 meters (Radius = 3.5 meters) is the field-of-view.

Off-set Geometry Adjustment Factor

Considering the 7-meter field-of-view, a grid spacing of 4 meters in a square pattern has been selected. This spacing yields sufficient overlap to ensure that 100% of the survey unit is covered by the in-situ scan survey. Attachment 2 presents a typical scan grid pattern. The radius used to derive the off-set geometry adjustment factor is 2.264 meters. This value is derived as follows:

$$R_1 - R_2 = 2.264 \text{ meters, where:}$$

R_1 is the distance from the center of the grid to the outer corner (i.e. 2.828 m)
R_2 is the radius of a circle whose area is 1m² (i.e. 0.564 m)

The radius representing the distance from the center of the grid to the outer corner addresses the region associated with the intersection of the grids. The use of this radius differs slightly from that described in the Technical Report in that the potentially elevated $1m^2$ area is situated at the edge of the area being evaluated (i.e. the grid) rather than at the edge of the detector's field-of-view. See Attachment 2.

Off-set Geometry Adjustment Factors are calculated by a ratio of MDAs associated with two distinct scenarios. The first scenario assumes that the activity is uniformly distributed over the detector's 7-meter field-of-view. The second scenario involves application of a calibration efficiency that assumes the activity is within one-square meter situated at the edge of the area being evaluated. These ratios, referred to as Off-set Geometry Adjustment Factors, are presented in Attachment 3.

Investigation Levels

Applying the Off-set Geometry Adjustment Factors derived in Attachment 3 to the $DCGL_{EMC}$ values for one-square meter yields Investigation Levels. The resultant Investigation Levels to be applied to in-situ assay results are presented in Attachment 4.

CONCLUSION

Detector-based and nuclide-specific Investigation Levels are presented in Attachment 4. For simplicity, it is recommended that the most restrictive (minimum) nuclide-specific Investigation Level be methodically applied to all in-situ scan survey assay results. These most restrictive (minimum) nuclide-specific Investigation Levels are also presented in Attachment 4. If an Investigation Level is exceeded, associated investigations may include application of the detector-specific Investigation Level.

Investigation Levels have not been determined for two of the six detectors (7810 & 7829) because these two detectors haven't been used to collect data necessary to determine the Off-set Geometry Adjustment Factors. When this data is available, this Technical Evaluation will be revised with the Investigation Levels for these detectors.

As stated above, the Investigation Levels in Attachment 4 are predicated on a 4-meter grid spacing. Changes to the grid spacing or pattern presented in Attachment 3 will require a revision to this Technical Evaluation and may impact Investigation Levels.

Attachment 1

Field-Of-View Determination for Detector at 1 Meter with 180° Collimation

Shield set	Field-Of-View Area (m²)	Dia (m) (Note 1)	Soil Mass (g)	Eff @ 661 KeV	% Diff (Note 2)	Eff @ 1173 KeV	% Diff (Note 2)	Eff @ 1332 KeV	% Diff (Note 2)
Detector 6279 (BLUE ROVER)									
50MM-180D	31,416	200	8.01E+09	30.07		26.75		26.15	
50MM-180D	38.4	7	9.81E+06	29.40	97.76%	25.60	**95.72%**	24.85	**95.04%**
50MM-180D	28.3	6	7.21E+06	29.05	96.62%	25.17	94.12%	24.40	93.31%
50MM-180D	23.8	5.5	6.06E+06	28.63	**95.20%**	24.73	92.45%	23.94	91.57%
Detector 6264 (RED ROVER)									
50MM-180D	31,416	200	8.01E+09	30.07		26.75		26.15	
50MM-180D	38.4	7	9.81E+06	29.40	97.76%	25.60	**95.72%**	24.85	**95.04%**
50MM-180D	28.3	6	7.21E+06	29.05	96.62%	25.17	94.12%	24.40	93.31%
50MM-180D	23.8	5.5	6.06E+06	28.63	**95.21%**	24.73	92.45%	23.94	91.57%
Detector 7722 (BROWN ROVER)									
50MM-180D	31,416	200	8.01E+09	24.83		22.40		21.79	
50MM-180D	38.4	7	9.81E+06	24.29	97.83%	21.48	**95.90%**	20.74	**95.20%**
50MM-180D	28.3	6	7.21E+06	24.10	97.04%	21.22	94.74%	20.46	93.88%
50MM-180D	23.8	5.5	6.06E+06	23.60	**95.04%**	20.73	92.58%	19.96	91.62%
Detector 7780 (GREEN ROVER)									
50MM-180D	31,416	200	8.01E+09	24.05		21.73		21.10	
50MM-180D	38.4	7	9.81E+06	23.55	97.89%	20.85	**95.95%**	20.10	**95.28%**
50MM-180D	28.3	6	7.21E+06	23.31	96.92%	20.55	94.57%	19.78	93.74%
50MM-180D	23.8	5.5	6.06E+06	22.85	**95.00%**	20.08	92.43%	19.31	91.53%
Detector 7810 (ORANGE ROVER)									
50MM-180D	31,416	200	8.01E+09	23.64		20.99		20.22	
50MM-180D	38.4	7	9.81E+06	22.95	97.11%	19.98	**95.15%**	19.11	**94.47%**
50MM-180D	28.3	6	7.21E+06	22.84	96.60%	19.78	94.21%	18.88	93.35%
50MM-180D	23.8	5.5	6.06E+06	22.39	**94.70%**	19.34	92.12%	18.44	91.16%
Detector 7828 (YELLOW ROVER)									
50MM-180D	31,416	200	8.01E+09	23.45		21.00		19.99	
50MM-180D	38.4	7	9.81E+06	22.95	97.84%	20.18	**96.10%**	19.07	**95.39%**
50MM-180D	28.3	6	7.21E+06	22.18	94.56%	19.44	92.54%	18.34	91.72%
50MM-180D	23.8	5.5	6.06E+06	22.02	**93.87%**	19.24	91.62%	18.13	90.70%

Note 1: A 200 meter diameter is considered an infinite plane for purposes of this evaluation.

Note 2: Relative to an infinite (200m diameter) plane.

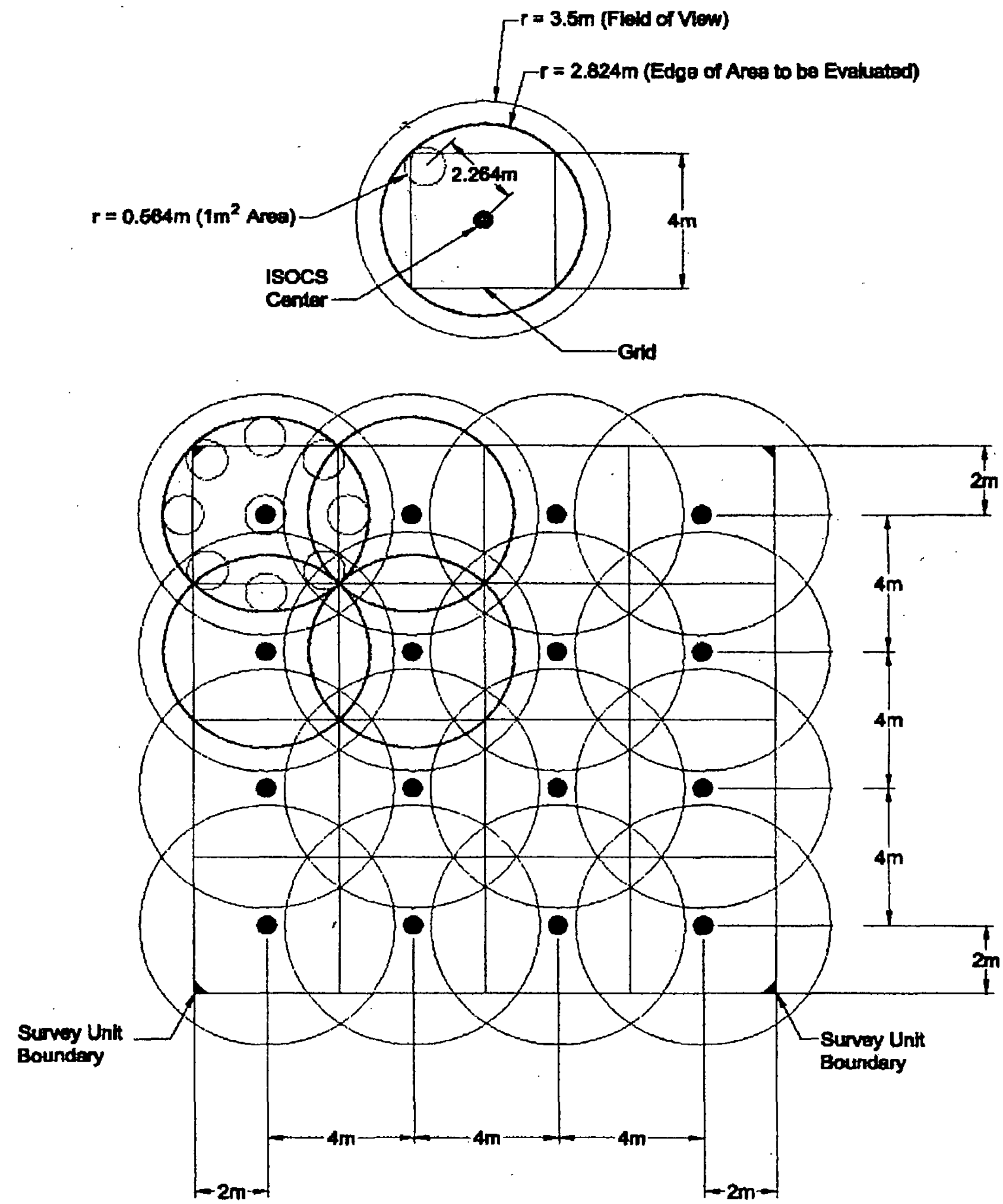
Note 3: Model Assumes 15 cm soil @ 1.7 g/cc w/detector perpendicular to reference plane.

Note 4: The 95% efficiency for Cs-137 which occurrs at 5.5 meters is listed for info only. Note that the scan survey is designed for disrete particle (Co-60) detection.

Conclusion: Assuming soil at 1.7 g/cc to a depth of 15cm, when the detector is at 1 meter above the soil surface with a 180° collimation, a field-of-view (FOV) of 7 meters yields efficiencies for Co-60 that are approximately 95% that of an infinite (200m) plane. Therefore, 7 meters is a suitable FOV (diameter) for this configuration and is applicable to all detectors in the above evaluation.

Attachment 2

Grid Spacing Convention For 1 meter 180-degree Configuration



Typical ISOCS Scan Grid Pattern

(For 1m height using 180° collimator)

Attachment 3
Off-set Geometry Adjustment Factor
For 1 meter 180-degree Configuration

	MDA Values (pCi/g) for a 600 second count										
	Co-60	Cs-137	Cs-134	Ag-108m	Eu-152	Eu-154	Eu-155	Nb-94	Am-241	Cm-243	Sb-125
6264 (RED ROVER)											
Activity distirbuted over FOV (38.5 m²)	1.07E-01	1.45E-01	1.41E-01	1.38E-01	4.06E-01	2.58E-01	1.52E+00	1.15E-01	1.94E+00	1.08E+00	4.15E-01
Activity within 1 m² off-set at 2.264 meters	8.89E+00	1.32E+01	1.26E+01	1.29E+01	3.36E+01	2.15E+01	1.19E+02	1.01E+01	1.44E+02	1.01E+02	3.92E+01
MDA RATIO (i.e. Adjustment Factors)	**1.20E-02**	**1.10E-02**	**1.12E-02**	**1.07E-02**	**1.21E-02**	**1.20E-02**	**1.28E-02**	**1.14E-02**	**1.35E-02**	**1.07E-02**	**1.06E-02**
6279 (BLUE ROVER)											
Activity distirbuted over FOV (38.5 m²)	8.36E-02	1.21E-01	1.11E-01	1.15E-01	3.08E-01	2.39E-01	9.57E-01	8.65E-02	1.17E+00	8.75E-01	3.64E-01
Activity within 1 m² off-set at 2.264 meters	7.00E+00	1.14E+01	1.02E+01	1.08E+01	2.56E+01	2.01E+01	8.83E+01	7.86E+00	9.70E+01	8.51E+01	3.54E+01
MDA RATIO (i.e. Adjustment Factors)	**1.19E-02**	**1.06E-02**	**1.09E-02**	**1.06E-02**	**1.20E-02**	**1.19E-02**	**1.08E-02**	**1.10E-02**	**1.21E-02**	**1.03E-02**	**1.03E-02**
7780 (GREEN ROVER)											
Activity distirbuted over FOV (38.5 m²)	8.41E-02	1.39E-01	1.33E-01	1.43E-01	4.31E-01	2.65E-01	1.65E+00	1.09E-01	4.29E+00	1.19E+00	4.60E-01
Activity within 1 m² off-set at 2.264 meters	6.39E+00	1.17E+01	1.08E+01	1.90E+00	3.23E+01	2.03E+01	1.46E+02	8.71E+00	4.78E+02	1.06E+02	4.05E+01
MDA RATIO (i.e. Adjustment Factors)	**1.32E-02**	**1.19E-02**	**1.23E-02**	**7.53E-02**	**1.33E-02**	**1.31E-02**	**1.13E-02**	**1.25E-02**	**8.97E-03**	**1.12E-02**	**1.14E-02**
7722 (BROWN ROVER)											
Activity distirbuted over FOV (38.5 m²)	8.35E-02	1.38E-01	1.42E-01	1.31E-01	3.86E-01	2.88E-01	1.43E+00	1.11E-01	3.07E+00	1.10E+00	4.45E-01
Activity within 1 m² off-set at 2.264 meters	6.30E+00	1.20E+01	1.21E+01	1.14E+01	3.03E+01	2.31E+01	1.46E+02	9.38E+00	3.69E+02	1.03E+02	4.11E+01
MDA RATIO (i.e. Adjustment Factors)	**1.33E-02**	**1.15E-02**	**1.17E-02**	**1.15E-02**	**1.27E-02**	**1.25E-02**	**9.79E-03**	**1.18E-02**	**8.32E-03**	**1.07E-02**	**1.08E-02**
7829 (ORANGE ROVER)											
Activity distirbuted over FOV (38.5 m²)			**NOT YET EVALUATED**								
Activity within 1 m² off-set at 2.264 meters											
MDA RATIO (i.e. Adjustment Factors)											
7810 (YELLOW ROVER)											
Activity distirbuted over FOV (38.5 m²)			**NOT YET EVALUATED**								
Activity within 1 m² off-set at 2.264 meters											
MDA RATIO (i.e. Adjustment Factors)											

	Co-60	Cs-137	Cs-134	Ag-108m	Eu-152	Eu-154	Eu-155	Nb-94	Am-241	Cm-243	Sb-125
Average	1.26E-02	1.12E-02	1.15E-02	2.70E-02	1.25E-02	1.24E-02	1.12E-02	1.17E-02	1.07E-02	1.07E-02	1.08E-02
Maximum Value	1.33E-02	1.19E-02	1.23E-02	7.53E-02	1.33E-02	1.31E-02	1.28E-02	1.25E-02	1.35E-02	1.12E-02	1.14E-02
Minimum Value	1.19E-02	1.06E-02	1.09E-02	1.06E-02	1.20E-02	1.19E-02	9.79E-03	1.10E-02	8.32E-03	1.03E-02	1.03E-02

Attachment 4
Investigation Levels For 1 meter 180-degree Configuration

	Co-60	Cs-137	Cs-134	Ag-108m	Eu-152	Eu-154	Eu-155	Nb-94	Am-241	Cm-243	Sb-125
Dose Converstion Factors - mRem/y per pCi/g (LTP Appendix 6E)	6.2E+00	2.9E+00	5.0E+00	3.4E+00	2.4E+00	2.6E+00	6.3E-02	3.5E+00	8.6E-01	7.9E-01	7.8E-01
$DCGL_w$ For 8.73 mRem	1.4E+00	3.0E+00	1.7E+00	2.5E+00	3.6E+00	3.3E+00	1.4E+02	2.5E+00	1.0E+01	1.1E+01	1.1E+01
$1m^2$ Area Factors (LTP Appendix 6Q)	1.1E+01	2.2E+01	1.6E+01	9.2E+00	9.4E+00	9.6E+00	8.0E+00	9.3E+00	1.6E+02	3.0E+01	9.1E+00
$DCGL_{EMC}$ for $1m^2$ (IAW YA-REPT-00-018-05)	**1.5E+01**	**6.6E+01**	**2.8E+01**	**2.3E+01**	**3.4E+01**	**3.2E+01**	**1.1E+03**	**2.3E+01**	**1.6E+03**	**3.3E+02**	**1.0E+02**
6264 (RED ROVER)											
Adjustment Factor (MDA Ratio) For 2.26m Offset	1.2E-02	1.1E-02	1.1E-02	1.1E-02	1.2E-02	1.2E-02	1.3E-02	1.1E-02	1.3E-02	1.1E-02	1.1E-02
Adjusted Investigation Level (pCi/g)	**1.9E-01**	**7.2E-01**	**3.1E-01**	**2.5E-01**	**4.1E-01**	**3.8E-01**	**1.4E+01**	**2.7E-01**	**2.2E+01**	**3.6E+00**	**1.1E+00**
6279 (BLUE ROVER)											
Adjustment Factor (MDA Ratio) For 2.26m Offset	1.2E-02	1.1E-02	1.1E-02	1.1E-02	1.2E-02	1.2E-02	1.1E-02	1.1E-02	1.2E-02	1.0E-02	1.0E-02
Adjusted Investigation Level (pCi/g)	**1.8E-01**	**7.0E-01**	**3.0E-01**	**2.5E-01**	**4.1E-01**	**3.8E-01**	**1.2E+01**	**2.6E-01**	**2.0E+01**	**3.4E+00**	**1.0E+00**
7780 (GREEN ROVER)											
Adjustment Factor (MDA Ratio) For 2.26m Offset	1.3E-02	1.2E-02	1.2E-02	7.5E-02	1.3E-02	1.3E-02	1.1E-02	1.3E-02	9.0E-03	1.1E-02	1.1E-02
Adjusted Investigation Level (pCi/g)	**2.0E-01**	**7.8E-01**	**3.4E-01**	**1.8E+00**	**4.5E-01**	**4.2E-01**	**1.3E+01**	**2.9E-01**	**1.5E+01**	**3.7E+00**	**1.2E+00**
7722 (BROWN ROVER)											
Adjustment Factor (MDA Ratio) For 2.26m Offset	1.3E-02	1.2E-02	1.2E-02	1.1E-02	1.3E-02	1.2E-02	9.8E-03	1.2E-02	8.3E-03	1.1E-02	1.1E-02
Adjusted Investigation Level (pCi/g)	**2.0E-01**	**7.6E-01**	**3.3E-01**	**2.7E-01**	**4.3E-01**	**4.0E-01**	**1.1E+01**	**2.8E-01**	**1.4E+01**	**3.6E+00**	**1.1E+00**
7829 (ORANGE ROVER)											
Adjustment Factor (MDA Ratio) For 2.26m Offset	**NOT YET EVALUATED**										
Adjusted Investigation Level (pCi/g)											
7810 (YELLOW ROVER)											
Adjustment Factor (MDA Ratio) For 2.26m Offset	**NOT YET EVALUATED**										
Adjusted Investigation Level (pCi/g)											

	INVESTIGATION LEVELS AT 1 METER WITH A 180° COLLIMATION										
Average Value	1.9E-01	7.4E-01	3.2E-01	6.3E-01	4.2E-01	3.9E-01	1.2E+01	2.7E-01	1.7E+01	3.6E+00	1.1E+00
Maximum Value	2.0E-01	7.8E-01	3.4E-01	1.8E+00	4.5E-01	4.2E-01	1.4E+01	2.9E-01	2.2E+01	3.7E+00	1.2E+00
Minimum Value (most conservative)	**1.8E-01**	**7.0E-01**	**3.0E-01**	**2.5E-01**	**4.1E-01**	**3.8E-01**	**1.1E+01**	**2.6E-01**	**1.4E+01**	**3.4E+00**	**1.0E+00**

NOTE 1 - The above investigation levels are applicable only for the identified ISOCS HPGe detectors outfitted with 2-inch side shields in a 180° collimation configuration. The detector is assumed to be positioned perpendicular to the source plance at a distance of 1 meter and assay points are on a 4-meter grid pattern comencing at 2 meters (or less) from the edge of the area to be assayed.

Report Generated On 6/27/2006 10:41:19 PM

YANKEE ROWE PORTABLE ISOCS

GAMMA SPECTRUM ANALYSIS

Detector ID: BLUE6279

Spectrum File: BLUE6279
Sample ID: NOL-03-02-172-F-
Sample Title: NOL-03-02-172-F-G
Description:

Sample Type:
Geometry:

Acquisition Started: 6/27/2006 10:31:16 PM
Live Time: 600.0 seconds
Real Time: 601.9 seconds

Energy Calibration Date: 3/28/2006
Eff Calibration Date: 10/4/2005
Calibration Efficiency: BLUE_1M180D_SOIL
Nuclide Library: C:\GENIE2K\CAMFILES\YAEC-FSS-OpenLand-rev1.NLB

Peak Locate Threshold: 3.00
Peak Locate Range (in channels): 200 - 8192
Identification Energy Tolerance: 1.250 FWHM

YANKEE ROWE PORTABLE ISOCS

PEAK ANALYSIS REPORT

Filename: BLUE6279
Log Number: NOL-03-02-172-F-
Title: NOL-03-02-172-F-G
Description:

Geometry:

	Peak No.	ROI start	ROI end	Peak centroid	Energy (keV)	FWHM (keV)	Net Peak Area	Net Area Uncert.	Continuum Counts
M	1	283-	305	291.18	72.62	1.02	6.39E+002	83.56	2.51E+003
m	2	283-	305	299.99	74.83	1.03	1.01E+003	96.57	2.56E+003
M	3	331-	356	339.16	84.62	1.10	3.95E+002	79.08	2.34E+003
m	4	331-	356	349.25	87.15	1.10	1.70E+002	70.01	2.41E+003
	5	834-	841	837.11	209.15	0.77	4.12E+001	46.81	2.61E+002
	6	947-	961	953.74	238.31	1.32	3.27E+002	78.48	4.42E+002
	7	1170-	1187	1180.32	294.98	0.87	7.12E+001	64.05	3.05E+002
	8	1346-	1358	1352.24	337.97	0.68	8.62E+001	45.33	1.69E+002
	9	1396-	1415	1406.16	351.45	1.16	1.28E+002	61.24	2.42E+002
	10	2031-	2052	2040.97	510.20	1.32	1.50E+002	54.79	1.68E+002
	11	2323-	2339	2329.82	582.44	1.47	2.06E+002	44.26	9.73E+001
	12	2426-	2444	2435.00	608.74	1.33	1.79E+002	46.72	1.15E+002
	13	3632-	3652	3641.44	910.44	1.33	1.65E+002	45.04	9.98E+001
	14	3866-	3882	3873.16	968.39	1.52	1.14E+002	33.90	5.93E+001
	15	4471-	4487	4477.99	1119.64	0.61	5.22E+001	28.62	5.08E+001
	16	4685-	4697	4690.92	1172.89	0.68	3.09E+001	24.00	4.51E+001
	17	5319-	5334	5327.21	1332.01	0.43	5.28E+001	19.90	1.62E+001
	18	5825-	5853	5840.18	1460.29	2.11	1.18E+003	69.59	1.83E+001
	19	6513-	6526	6519.98	1630.29	0.37	1.84E+001	9.35	1.60E+000

M = First peak in a multiplet region
m = Other peak in a multiplet region
F = Fitted singlet

Errors quoted at 1.960 sigma

YANKEE ROWE PORTABLE ISOCS

NUCLIDE IDENTIFICATION REPORT

Spectrum File: BLUE6279

Nuclide Library: C:\GENIE2K\CAMFILES\YAEC-FSS-OpenLand-rev1.NLB

IDENTIFIED NUCLIDES

Nuclide Name	Id Conf	Energy (keV)	Yield (%)	Activity (pCi/Grams)	Activity Uncertainty
ANN	0.978	511.00*	100.00	2.04037E-001	7.96634E-002
K-40	0.991	1460.81*	10.67	1.97187E+001	1.97762E+000
Co-60	0.994	1173.22*	100.00	5.26575E-002	4.11417E-002
		1332.49*	100.00	9.27603E-002	3.57251E-002
Eu-155	0.325	86.54*	30.90	6.82229E-001	3.11855E-001
		105.31	20.70		
TL-208	0.738	277.35	6.80		
		510.84*	21.60	9.44618E-001	3.76794E-001
		583.14*	84.20	3.47935E-001	8.75226E-002
		860.37	12.46		
Pb-212	0.675	74.81* @	10.70	1.44727E+001	3.15627E+000
		77.11 @	18.00		
		87.30* @	8.00	2.63511E+000	1.20454E+000
		238.63*	44.60	7.95179E-001	2.27873E-001
Bi-214	0.690	609.31*	46.30	5.57303E-001	1.61196E-001
		1120.29*	15.10	5.81670E-001	3.24910E-001
		1764.49	15.80		
PB-214	0.666	74.82* @	6.21	2.49368E+001	5.73171E+000
		77.11 @	10.50		
		87.30* @	4.67	4.51410E+000	2.09144E+000
		241.98	7.49		
		295.21*	19.20	4.27164E-001	3.90942E-001
		351.92*	37.20	4.15314E-001	2.11104E-001
Ac-228	0.987	338.32*	11.40	9.05872E-001	4.96931E-001
		911.07*	27.70	9.45573E-001	2.79805E-001
		969.11*	16.60	1.10551E+000	3.49323E-001

* = Energy line found in the spectrum.
@ = Energy line not used for Weighted Mean Activity
Energy Tolerance : 1.250 FWHM
Nuclide confidence index threshold = 0.30
Errors quoted at 1.960 sigma

Y A N K E E R O W E P O R T A B L E I S O C S

I N T E R F E R E N C E C O R R E C T E D R E P O R T

Spectrum File:BLUE6279

Nuclide Library: C:\GENIE2K\CAMFILES\YAEC-FSS-OpenLand-rev1.NLB

Nuclide Name		Nuclide Id Confidence	Wt mean Activity (pCi/Grams)	Wt mean Activity Uncertainty
ANN		0.978	1.288835E-001	8.183916E-002
K-40		0.991	1.971872E+001	1.977619E+000
Co-60		0.994	7.552091E-002	2.697467E-002
Eu-155		0.325	4.131880E-001	3.186114E-001
TL-208		0.738	3.479348E-001	8.678501E-002
Pb-212	@	0.675	7.951792E-001	2.278725E-001
Bi-214		0.690	5.621160E-001	1.444010E-001
PB-214	@	0.666	4.179714E-001	1.847199E-001
Ac-228		0.987	9.915370E-001	1.999304E-001

? = nuclide is part of an undetermined solution
X = nuclide rejected by the interference analysis
@ = nuclide contains energy lines not used in Weighted Mean Activity

Errors quoted at 1.960 sigma

U N I D E N T I F I E D   P E A K S

Peak No.	Energy (keV)	Peak Size in Counts per Second	Peak CPS % Uncertainty
M 1	72.62	1.0650E+000	13.08
M 3	84.62	6.5816E-001	20.03
5	209.15	6.8616E-002	113.70
19	1630.29	3.0667E-002	50.82

M = First peak in a multiplet region
m = Other peak in a multiplet region
F = Fitted singlet

Errors quoted at 1.960 sigma

Y A N K E E R O W E P O R T A B L E I S O C S
N U C L I D E M D A R E P O R T

Spectrum File:BLUE6279
Nuclide Library: C:\GENIE2K\CAMFILES\YAEC-FSS-OpenLand-rev1.NLB

	Nuclide Name	Energy (keV)	Yield (%)	Line MDA (pCi/Grams)	Nuclide MDA (pCi/Grams)	Activity (pCi/Grams)
+	Co-60	1173.22*	100.00	6.5844E-002	4.58E-002	5.2658E-002
		1332.49*	100.00	4.5769E-002		9.2760E-002
	Nb-94	702.63	100.00	1.1839E-001	1.02E-001	2.2014E-002
		871.10	100.00	1.0166E-001		3.0322E-002
	Ag-108m	79.20	7.10	6.0729E+000	1.29E-001	-1.3611E+001
		433.93	89.90	1.3043E-001		-7.3976E-002
		614.37	90.40	1.2853E-001		-7.4642E-002
		722.95	90.50	1.2940E-001		3.8674E-002
	Sb-125	176.33	6.89	2.4173E+000	4.03E-001	-1.3533E+000
		427.89	29.33	4.0276E-001		1.2458E-001
		463.38	10.35	1.0696E+000		-6.5114E-001
		600.56	17.80	6.2603E-001		-2.6134E-001
		606.64	5.02	2.8591E+000		4.8651E+000
		635.90	11.32	9.0850E-001		3.2577E-001
	Cs-134	563.23	8.38	1.3425E+000	1.33E-001	2.3370E-001
		569.32	15.43	7.3557E-001		6.5553E-001
		604.70	97.60	1.4440E-001		-2.5761E-002
		795.84	85.40	1.3334E-001		1.3578E-001
		801.93	8.73	1.1908E+000		9.2270E-001
	Cs-137	661.65	85.12	1.3568E-001	1.36E-001	1.1255E-001
	Eu-152	121.78	28.40	8.8223E-001	3.62E-001	2.4892E-001
		244.69	7.49	1.9678E+000		-

							5.0530E-003
		344.27	26.50	4.5822E-001			3.4678E-001
		778.89	12.74	8.2922E-001		-	1.7040E-001
		867.32	4.16	2.4415E+000		-	5.9603E-001
		964.01	14.40	9.7187E-001		-	1.5566E-001
		1085.78	10.00	1.0145E+000		-	6.4329E-001
		1112.02	13.30	7.7513E-001		-	1.0775E+000
		1407.95	20.70	3.6212E-001			1.4813E-001
	Eu-154	123.07	40.50	6.1065E-001	2.56E-001	-	1.4619E-001
		247.94	6.60	2.1571E+000			4.5644E-001
		591.81	4.83	2.3045E+000		-	8.0049E-001
		723.30	19.70	5.9893E-001			4.2368E-001
		756.87	4.33	2.4773E+000			1.3245E-001
		873.19	11.50	8.8913E-001		-	2.9207E-001
		996.32	10.30	1.0038E+000			8.5819E-001
		1004.76	17.90	5.2985E-001		-	7.6554E-001
		1274.45	35.50	2.5563E-001			6.1700E-002
+	Eu-155	86.54*	30.90	9.2998E-001	9.30E-001		6.8223E-001
		105.31	20.70	1.4676E+000			8.7608E-001
	Am-241	59.54	35.90	1.6322E+000	1.63E+000	-	1.2351E+000
	Cm-243	228.19	10.56	1.3871E+000	1.00E+000	-	2.3386E-001

Nuclide Name	Energy (keV)	Yield (%)	Line MDA (pCi/Gram)	Nuclide MDA (pCi/Gram)	Activity (pCi/Gram)
Cm-243	277.60	14.00	1.0002E+000	1.00E+000	6.4650E-001

+ = Nuclide identified during the nuclide identification
* = Energy line found in the spectrum
> = MDA value not calculated
@ = Half-life too short to be able to perform the decay correction

David W. Nelson (NMSS) - Call to discuss AAR

From: Claudia Craig
To: Claudia Craig; Jamnes Cameron; Kristina Banovac
Date: 02/01/2007
Time: 10:00 AM - 11:00 AM
Subject: Call to discuss AAR
Place: T 7 E 67

Jamnes,
You can call into my office - 301-415-7276. We'll be here.