

DOE'S RADIOLOGICAL TRACEABILITY PROGRAM FOR RADIOANALYTICAL MEASUREMENTS: WORK IN PROGRESS

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ABSTRACT

DOE's Office of Environmental Management maintains two laboratory performance evaluation (PE) programs for radioanalytical and mixed waste measurement activities related to site remediation / restoration and to facility decommissioning. The programs include the Quality Assessment Program administered by DOE's Environmental Measurements Laboratory (EML) and the Mixed Analyte Performance Evaluation Program administered by DOE's Radiological and Environmental Sciences Laboratory (RESL).

During 1998, an interagency agreement was established between DOE's National Analytical Management Program (NAMP) and the National Institute of Standards and Technology (NIST) to initiate a national traceability program that would qualify the laboratories performing these PE activities to become "reference or secondary NIST laboratories" as defined by ANSI N42.23. The program has a four-year schedule for the complete exchange of performance testing (PT) matrices / radionuclide categories (48 samples) between NIST and the reference laboratories. The PT matrices include water, soil, dried vegetation and glass-fiber filters. The three categories of radionuclides include alpha, beta and gamma-ray emitting nuclides germane to the PE programs of the reference laboratories. Acceptable traceability criteria have been established to evaluate the reference laboratory's ability to prepare and radioassay PT materials. Reference laboratory traceability to NIST will be in conformance with ANSI N42.22-1995 for materials sent to NIST and with a relative percentage bias basis for materials sent by NIST.

INTRODUCTION

The US Department of Energy has an extensive history and relationship with the National Institute of Standards and Technology (NIST) for the maintenance of direct traceability to the national standard for select radioanalytical measurements and processes. In the 1970's the Department of Energy's Radiological and Environmental Sciences Laboratory (RESL) at Idaho Falls, ID established an Intercomparison Testing Program (ITP) with NIST under the Nuclear Regulatory Commission's (NRC) Confirmatory Measurements Program. The ITP with NIST has since been expanded to include the RESL *In Vitro* Radiobioassay Traceability Program in conjunction with the DOE Laboratory Accreditation Program for Radiobioassay Systems.

In 1998, the DOE National Analytical Management Program (NAMP) established a Radiological Traceability Program (RTP) with NIST that will provide a technical link with the national standard in the areas of radioanalytical measurements and processes germane to the

environmental remediation and restoration and/or facility decommissioning throughout the DOE complex. This RTP will establish NIST traceability with several qualified reference laboratories designated by DOE NAMP. As defined in ANSI N42.23-1996 (1), reference laboratories serve as “secondary” laboratories to NIST and maintain direct traceability to NIST through a defined and approved measurement assurance program. In addition, the reference laboratories are authorized, for a defined functional program, to prepare and distribute performance testing (PT) materials for the purpose of evaluating the performance of other laboratories preparing PT materials or routinely analyzing samples. The qualified DOE reference laboratories for this contract will maintain the performance evaluation programs for the DOE “monitoring” laboratories preparing PT materials and for the contract service laboratories conducting radioassays for the DOE Sample Management Offices and for the GOCO facilities / national laboratories. NIST traceability will be tiered down to the monitoring and contract service laboratories through participation in the RTP.

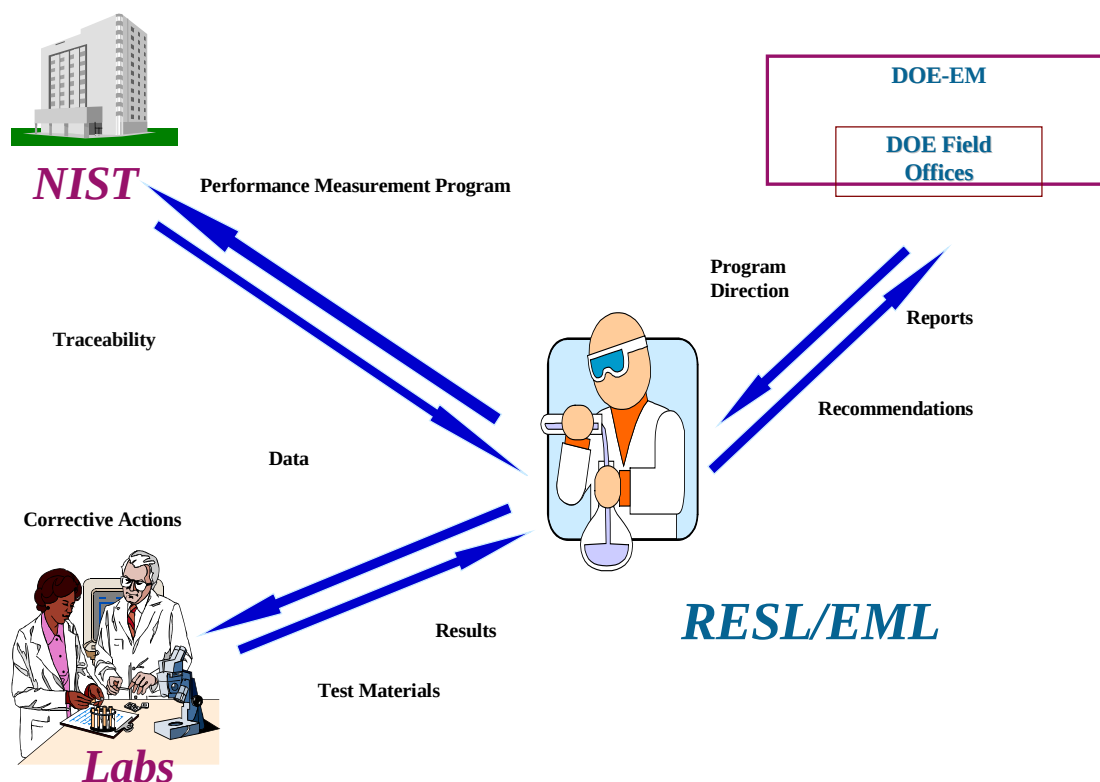


Figure 1. DOE-NAMP's NIST Radiological Traceability Program and Traceability Flow Down to Contract Service Laboratories.

The DOE performance testing programs and reference laboratories selected for this RTP include the DOE Quality Assessment Program for environmental media administered by the DOE Environmental Measurement Laboratory (DOE-EML) in New York, NY and the Mixed Analyte Performance Evaluation Program (MAPEP) for mixed wastes administered by the DOE

Radiological and Environmental Sciences Laboratory (DOE-RESL) in Idaho Falls, ID. Figure 1 provides an overview of the RTP and the relationships between DOE NAMP and the Field Offices, NIST, RESL, EML and the contract service laboratories.

PROGRAM OVERVIEW AND SCHEDULE

The RTP will consist of the exchange, in a four-year period, of samples representing four matrix types containing three nuclide categories. A sample in this context is defined as an individual sample, including replicates of the same, of a specified matrix containing multiple nuclides. The intent of the RTP is to exchange one matrix type for all nuclide categories per year between NIST and the reference laboratories. During the four-year cycle, NIST will prepare and send 24 samples (12 for each reference laboratory) to the reference laboratories. Each DOE reference laboratory will prepare 12 samples consistent with predefined specifications and forward them to NIST for analysis. The DOE reference laboratories shall follow their performance testing sample preparation protocols. The specifications outlined for the reference laboratory samples are consistent with existing DOE PE programs for environmental and mixed analyte matrices. Therefore, if a reference laboratory is conducting a PE program wherein the PT samples are consistent with the specifications outlined in this document, the reference laboratory may send to NIST PT samples prepared (from the same batch or lot) from the normal PE program sample distribution. Annually, three samples from each DOE reference laboratory and six samples from NIST (three sent to each reference lab) will be exchanged. A reference laboratory must analyze all matrix types and nuclide categories sent to them. If a reference laboratory does not provide a certain matrix type in its normal PE program, the reference laboratory may, with the concurrence on NIST, send NIST another matrix type containing all nuclide categories. Table I provides an overview of the frequency of distribution and the matrices involved on a four-year rotation basis.

Prior to the beginning of a fiscal year, the points of contact for the DOE reference laboratories and NIST shall select the matrix(ices), nuclide category(ies) and testing schedule for the year. Analytical results and corresponding uncertainties shall be submitted to NIST for statistical analysis. NIST shall evaluate the data to determine whether the reference laboratories have met the traceability acceptance criteria as outlined in this document.

The Radiological Traceability Program was initiated in FY99. NIST shall prepare a water matrix for distribution to the reference laboratories in February 1999.

PROGRAM ELEMENTS FOR NIST PREPARED MATERIALS

Preparation of Materials

Sample preparation specifications and traceability acceptance criteria for performance have been prepared for the four matrices of soil, liquids, vegetation (dried) and filter paper. Detailed specifications for the samples prepared by NIST have been outlined in Tables II through V according to matrix and nuclide category. Samples prepared by NIST shall be preserved, when applicable, to ensure maintenance of nuclide or matrix chemical form and prevention of nuclide

losses for a period of at least six months from the submittal date to the reference laboratories. This six-month sample preservation requirement is needed in case of a dispute between NIST and a reference laboratory. In all cases, the identity of the nuclides in the samples requiring quantification shall be disclosed on the sample container and sample transmittal paperwork.

The NIST traceability acceptance criteria for the nuclides / matrices prepared by NIST and sent to the DOE reference laboratories shall be based on a relative percent difference from the NIST value, without consideration of the uncertainty of the measurement process. The traceability acceptance criteria have been delineated in Tables II through V according to nuclide category.

Turnaround Time and Reporting Requirements

The NIST performance testing samples shall be preserved in such a manner that the integrity of the matrix and nuclides shall be preserved for at least six months from the date of transmittal to the reference laboratories. A sample preservation time of six months will ensure the integrity of the samples in the case that re-analysis is required by either NIST or the reference laboratories. The DOE reference laboratories shall analyze the submitted samples and report results within 90 days from the receipt of the samples.

Analytical reports shall be submitted concurrently to NIST and NAMP. The reference laboratories shall provide the best estimate of the nuclide concentration or sample content and the associated one sigma measurement combined uncertainty. For the alpha and beta-emitting nuclides, the reference laboratories shall analyze five samples per matrix / nuclide. In this case, the reference laboratories shall provide the individual sample results with associated combined uncertainty and their best estimate of the mean nuclide concentration or sample content (filter paper matrix) and combined uncertainty in the report.

Although only one sample shall be received by the DOE reference laboratories for the gamma-ray emitting nuclide category, the sample may be nondestructively analyzed numerous times. For this case, the reference laboratories shall provide the individual measurement results with associated one sigma combined uncertainty and their best estimate of the mean nuclide concentration or sample content (filter paper matrix) and combined uncertainty in the report.

The combined uncertainty shall be calculated according to normal convention (NIST Technical Note 1297 (2)) that incorporates both the systematic and random uncertainties of the measurement process. A reporting form shall be developed by NIST that is agreeable to all parties.

Traceability Acceptance Criteria

Traceability acceptance criteria for materials prepared by NIST and sent to the reference laboratories shall be based on a relative percent difference from the NIST value, without consideration of the uncertainty in the measurement process. The acceptance criteria for maintaining traceability to NIST vary according to matrix and nuclide category but ranges between eight (8) and ten (12) percent.

Report of NIST Traceability

NIST shall review their analytical results and the reported analytical data from the reference laboratories and perform the necessary statistical calculations to determine the level of compliance to the traceability acceptance criteria. Reports of traceability shall be issued within 30 calendar days from the receipt of the analytical results from the reference laboratories.

PROGRAM ELEMENTS FOR MATERIALS PREPARED BY THE REFERENCE LABORATORIES

Preparation of Materials

Sample preparation specifications and traceability acceptance criteria for materials prepared by the reference laboratories have been developed for the four matrices of soil, liquids, filter paper and dried-vegetation. Detailed specifications for the samples prepared by the reference laboratories have been outlined in Tables VI through IX. Representative samples of the performance test samples generated by the reference laboratories for their performance evaluation programs shall be sent to NIST. However, to avoid scheduler and resource conflicts with the performance evaluation programs of the reference laboratories, the submission of the test materials by the reference laboratories may be offset from their normal semiannual PT sample production schedule. When the materials are from PT sample lots previously generated, the samples shall be preserved, when applicable, to ensure maintenance of nuclide or matrix chemical form and prevention of nuclide losses for a period of at least six months from the submittal date to NIST. This six-month sample preservation requirement is needed in case of a dispute between NIST and a reference laboratory. In all cases, the identity of the nuclides in the samples requiring quantifications shall be disclosed on the sample container and sample transmittal paperwork.

A reference laboratory may not routinely generate certain PT matrices as part of their PE program. In these cases, the reference laboratory, with the concurrence of NIST, may select one of two options: 1) submittal of an alternate matrix in conformance with the specifications for that matrix / nuclides or 2) submittal of the selected matrix / nuclides under a PT sample preparation validation status. In all cases, the nuclide levels and final product matrices shall be consistent with the levels of nuclides and sample matrices provided as a final sample matrix form sent to the participants in their performance testing programs. The reference laboratories shall prepare materials for submittal to NIST according to the protocols that are used or will be used in their existing PT programs.

The reference laboratories shall provide an analytical report containing the certified values and combined uncertainties of the nuclide concentration at the same time the PT samples are submitted to NIST.

Measurement verification shall be determined using the nuclide concentration values and combined uncertainties reported by the reference laboratories and NIST and the acceptance criteria found in ANSI N42.22-1995 (3).

Turnaround Time and Reporting Requirements

NIST shall analyze the submitted samples within 90 days from the receipt of the samples. In case of difficulty, NIST may request additional samples from the same PT sample lot. Backup samples should be kept by the reference laboratories in the case of a dispute or if there is a need for re-analysis by either NIST or the reference laboratories.

The reference laboratories shall submit the test samples along with the best estimate of the nuclide concentration (or total activity estimate for the filter paper matrix), one sigma total uncertainty and with applicable homogeneity testing results. If several test samples of the same matrix type are provided to NIST, then the nuclide concentration and uncertainty of each sample must be provided, if applicable. Analytical reports from the reference laboratories shall be submitted concurrently to NAMP and NIST.

NIST shall analyze the samples and determine the nuclide concentration and measurement uncertainty. For the soil and dried vegetation matrices, the reference laboratories shall incorporate the spiked nuclide concentration and its uncertainty into the reported final nuclide concentration value and uncertainty. The reference laboratories shall incorporate the inherent/ambient nuclide concentration data of the blank matrices into their final nuclide concentration (content) and uncertainty values.

A reporting form shall be developed by NIST that is agreeable to all parties.

Traceability Acceptance Criteria

The traceability acceptance criterion for materials prepared by the reference laboratories shall be consistent with ANSI N42.22-1995. The criterion has a statistical basis that includes the uncertainty of the measurements reported by NIST and the reference laboratories.

NIST shall review their measurement results and the reported analytical data from the reference laboratories and perform the necessary statistical calculations to determine the level of compliance to the traceability criterion stated in ANSI N42.22. For materials sent to NIST the statistical test for traceability is as follows:

$$| V_{\text{NIST}} - V_{\text{Lab}} | < 3 * \sqrt{\sigma_{\text{NIST}}^2 + \sigma_{\text{Lab}}^2}$$

where:

- V_{NIST} = NIST's nuclide concentration value
- V_{Lab} = Lab's nuclide concentration value
- σ_{NIST} = 1 sigma uncertainty in V_{NIST}
- σ_{Lab} = 1 sigma uncertainty in V_{Lab}

The uncertainty shall be calculated by summing the random uncertainty for the replicate measurements and the systematic uncertainties in quadrature. The reference laboratories shall incorporate the inherent/ambient nuclide concentration data of the blank matrices into their final nuclide concentration (content) and uncertainty values.

Report of NIST Traceability

A report of traceability shall be provided within 120 days from the receipt of the test samples at NIST.

Failure to Meet Reporting Schedules by the Reference Laboratories and NIST.

Every effort shall be taken to meet the scheduled analytical processing and reporting requirements by the participants in the program. Adherence to the scheduled reporting requirements is necessary due to the limited time need to analyze additional samples from the same sample batch/lot in the event of a measurement dispute.

If a reference laboratory cannot meet the reporting schedule for samples sent by NIST, the reference laboratory shall inform NIST and NAMP within two weeks from the required report date of the delay and the reason for such delay. If the reference laboratory does not submit a report 30 days subsequent to the required submittal date, the reference laboratory shall forfeit its traceability status for the omitted nuclides / matrix category.

Additional samples shall be made available to a reference laboratory by NIST if requested within the required 90 day processing period.

RESOLUTION OF DISPUTES BETWEEN NIST AND THE REFERENCE LABORATORIES

In the event that there is a major difference in nuclide concentration results between a reference laboratory and NIST or if a reference laboratory fails to meet the traceability acceptance criteria, a mechanism has been established to resolve / verify the dispute. These disputes may arise for measurements of materials sent to and from NIST. Program details of the resolution of disputes will not be covered in this paper.

CONCLUSIONS

The National Analytical Management Program of the Department of Energy has recently initiated a Radiological Traceability Program for the radioanalytical activities conducted throughout the DOE complex in support of environmental restoration/remediation and the decommissioning of facilities and sites. Two existing well-qualified DOE laboratories have been selected to participate in this RTP as reference or secondary laboratories to NIST. The two laboratories are the DOE Environmental Measurement Laboratory and the DOE Radiological and Environmental

Sciences Laboratory. The RTP will provide the mechanism for these two laboratories to become traceable to NIST in accordance with pre-defined traceability criteria. In addition, the laboratories will demonstrate their capability to prepare and analyze performance testing materials to a high degree of quality needed for the implementation of their quality assessment programs for environmental and mixed waste media. NIST traceability shall be tiered down to the successful participants of their quality assessment programs for the radionuclides and media utilized.

This program will enhance the technical defensibility of the radioanalytical data collected throughout the DOE complex, standardize all applicable radioanalytical measurements related to DOE activities to NIST and strengthen the acceptability of radioanalytical data used in multiagency agreements such as the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) and the Multi-Agency Radiation Laboratory Protocol (MARLAP).

The Radiological Traceability Program and its protocol are considered dynamic and will evolve during the initial years of implementation. As such, the authors consider this program as a work in progress.

REFERENCES

1. ANSI N42.23-1996. Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories, 27 May, 1997.
2. B. N. Taylor and C. E. Kuyatt. Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results. NIST Technical Note 1297, 1994 Edition.
3. ANSI N42.22-1995. Traceability of Radioactive Sources to the National Institute of Standards and Technology (NIST) and Associated Instrument Quality Control, 1 November, 1995

Table I. Program Summary: Four-Year Cycle Exchange Schedule for Each DOE Reference Laboratory*.

Reference Lab Samples to NIST		NIST Samples to Reference Labs	
Soil / Nuclide	# of Samples / Lab	Soil / Nuclide	# of Samples / Lab
Gamma Emitters ^Ψ	1	Gamma Emitters	1
Alpha Emitter [@]	1	Alpha Emitters	1
Beta Emitters ^{**}	1	Beta Emitters	1
Liquids / Nuclide	# of Samples / Lab	Liquids / Nuclide	# of Samples / Lab
Gamma Emitters	1	Gamma Emitters	1
Alpha Emitter	1	Alpha Emitter	1
Beta Emitters	1	Beta Emitters	1
Filter Paper / Nuclide	# of Samples / Lab	Filter Paper / Nuclide	# of Samples / Lab
Gamma Emitters	1	Gamma Emitters	1
Alpha Emitter	1	Alpha Emitter	1
Beta Emitters	1	Beta Emitters	1
Vegetation / Nuclide	# of Samples / Lab	Vegetation / Nuclides	# of Samples / Lab
Gamma Emitters	1	Gamma Emitters	1
Alpha Emitter	1	Alpha Emitter	1
Beta Emitters	1	Beta Emitters	1
Total	12 from each lab		12 to each lab

^Ψ Select three of the following Mn-54, Co-57, Co-58, Co-60, Cs-134, Cs-137, Am-241

[@] Nuclides include Pu-239/240, Am-241 and U-234,235,238. Nuclides shall be identified.

^{*} One matrix type selected prior to each program year.

^{**} Sr-90 for solid matrices / Sr-90 or H-3 for liquids. Nuclide shall be identified.

Table II. Soil Materials Sent to the Reference Laboratories by NIST.

Nuclide	Concen. (Bq/g)	Sample Size (g)	Samples or Sample Replicates* Sent	NIST Prep	Homogeneity	NIST Certification	Traceability Acceptance Criteria
Pu & Am Combined, U Separate	0.1 - 2	1- 2	5 /Nuclide; Separate Samples Per Nuclide Category	Spike On Soil, Not Blended	N/A	<1.5% @ 1 σ	12%
Sr-90	1- 10	10	5	Spike On Soil, Not Blended	N/A	<1.5% @ 1 σ	12%
Gamma-Ray Nuclides Ψ	0.5 - 5	800	1 Sample	Spike 1 kg And Blend	3.0% @ 1 σ For 40 g	3.3% @ 1 σ	11%

Ψ Select three of the following: Co-57, Co-58, Co-60, Cs-134, Cs-137, Am-241, Mn-54

N/A - Not applicable

* Variability between replicates not to exceed 2 % (1 σ coefficient of variation)

Table III. Liquids Sent to the Reference Laboratories by NIST.

Nuclide	Concen. (Bq / g)	Sample Size (g)	Samples or Sample Replicates* Sent	NIST Prep	Variability between ampoules	NIST Certification	Traceability Acceptance Criteria
Pu & Am Combined, U Separate	0.02 - 0.4	5	5 / Nuclide; Separate Ampoules Per Nuclide Category	Sealed Glass Ampoule. Preservation: HNO ₃	<1 % of Mean	<1.5% @ 1 σ	8%
Sr-90 Or H-3	0.2 - 10	5	5	Sealed Glass Ampoule. Preservation: Sr-90 HNO ₃ , H-3 None	< 1 % of Mean	<1.5% @ 1 σ	8%
Gamma-Ray Nuclides Ψ	0.08 - 0.8 Per Nuclide	1000	1 Sample - Multiple Measurements	Sealed Glass Bottle. Preservation: HNO ₃	-	<1.5% @ 1 σ	8%

Ψ Select three of the following: Co-57, Co-58, Co-60, Cs-134, Cs-137, Am-241, Mn-54

* Variability between replicates not to exceed 2 % (1 σ coefficient of variation)

Table IV. Dried Vegetation Materials Sent to the Reference Laboratories by NIST.

Nuclide	Concen. (Bq / g)	Sample Size (g)	Samples or Sample Replicates* Sent	NIST Prep	Homogeneity	NIST Certification	Traceability Acceptance Criteria
Pu & Am Combined, U Separately	0.1 - 2	1 - 2	5 / Nuclide; Separate Samples Per Nuclide Category	Spike On Dry Vegetation, Not Blended	N/A	<1.5% @ 1 σ	12%
Sr-90	1 - 10	1 - 2	5	Spike On Dry Vegetation, Not Blended	N/A	<1.5% @ 1 σ	12%
Gamma-Ray Nuclides Ψ	0.5 - 5	800	1 Sample	Spike 1 kg of Dry Vegetation And Blend	3.0% @ 1 σ For 40 g	<3.3% @ 1 σ	11%

Ψ Select three of the following: Co-57, Co-58, Co-60, Cs-134, Cs-137, Am-241, Mn-54

N/A. Not applicable

* Variability between replicates not to exceed 2 % (1 σ coefficient of variation)

Table V. Filter Paper Matrix Sent to the Reference Laboratories by NIST.

Nuclide	Concen. (Bq / Filter)	Filter Paper Size / Type	Samples / Sample Replicates Sent	NIST Prep	Variability* between Filter Samples	NIST Certification	Traceability Acceptance Criteria
Pu & Am Combined, U Separately	0.4 - 4	7 cm Diameter; Glass Fiber	5 / Nuclide; Separate Samples Per Nuclide Category	Distributed on Filter	< 2% of Mean	<1.5% @ 1 σ	10%
Sr-90	5 - 50	7 cm Diameter; Glass Fiber	5	Distributed on filter	< 2% of Mean	<1.5% @ 1 σ	10%
Gamma-Ray Nuclides Ψ	80 - 800 Per Nuclide	7 cm Diameter; Glass Fiber	1 Sample - Multiple Measurements	Distributed Over Filter	< 2% of Mean	<1.5% @ 1 σ	10%

Ψ Select three of the following: Co-57, Co-58, Co-60, Cs-134, Cs-137, Am-241, Mn-54

* 1 σ coefficient of variation

Table VI. Soil Matrix Sent to NIST by the Reference Laboratories.

Nuclide	Concen. (Bq / g)	Sample Size(g)	Samples Sent	Reference Lab Prep	Homogeneity ϕ	Acceptance Criteria
Pu, U, Am Any Two	0.01 - 0.1	100 Final Product	1	Blended Pulverized Soil	As Quoted	N42.22
Sr-90	0.01 - 1	100 Final Product	1	Blended Pulverized Soil	As Quoted	N42.22
Gamma-Ray Nuclides Ψ	0.5 - 5	2000	1	Blended Pulverized Soil 1:10 diluent	As Quoted	N42.22

ϕ Typically a homogeneity to 3% (1 sigma) for a 40 g sample size.

Ψ Select three of the following: Co-57, Co-58, Co-60, Cs-134, Cs-137, Am-241, Mn-54.

Table VII. Aqueous Solution Matrix Sent to NIST by the Reference Laboratories.

Nuclide	Concen. (Bq / g)	Sample Size (g)	Samples Sent	Replicate Analyses	Reference Lab Prep	Variability* Between Samples	Acceptance Criteria
Pu, U, Am Any Two	0.001 - 0.01	500	2	5 / Nuclide	Sealed Glass / Poly Bottle Preservation: HNO ₃ or HCL	< 1%	N42.22
Sr-90 H-3	0.01 - 0.1 0.15 - 15	500	2	5 / Nuclide	Sealed Glass / Poly Bottle Sr Preservation: HNO ₃ or HCL	< 1%	N42.22
Gamma-Ray Nuclides Ψ	0.01 - 1	500	2	1 Sample / Multiple Measure- ments	Sealed Glass / Poly Bottle Preservation: HNO ₃ or HCL	< 1%	N42.22

Ψ Select three of the following: Co-57, Co-58, Co-60, Cs-134, Cs-137, Am-241, Mn-54.

* 1 σ coefficient of variation

Table VIII. Dried-Vegetation Matrix Sent to NIST by the Reference Laboratories.

Nuclide	Concen. (Bq / g)	Sample Size (g)	Samples Sent	Reference Lab Prep	Homogeneity ϕ	Acceptance Criteria
Pu, U, Am Any Two	0.01 - 0.1	100 Final Product	1	Spiked on Surface, Dried & Blended	As Quoted	N42.22
Sr-90	0.01 - 1	100 Final Product	1	Spiked on Surface, Dried & Blended	As Quoted	N42.22
Gamma-Ray Nuclides Ψ	0.5 - 5	2000	1	Spiked on Surface, Dried & Blended	As Quoted	N42.22

ϕ Typically a homogeneity to 3% (1 sigma) for a 40 g sample size.

Ψ Select three of the following: Co-57, Co-58, Co-60, Cs-134, Cs-137, Am-241, Mn-54.

Table IX. Filter Paper Matrix Sent to NIST by the Reference Laboratories.

Nuclide	Concen. (Bq / Filter)	Filter Paper Size / Type	Samples or sample replicates Sent	Reference Lab Prep	Variability* between Filter samples	Traceability Acceptance Criteria
Pu, U, Am Any Two	0.5 - 5	7 cm Diameter; Glass Fiber	5 / Nuclide; Separate Filter Samples per Nuclide	Distributed on Filter	< 1% of Mean	N42.22
Sr-90	5 - 50	7 cm Diameter; Glass Fiber	5	Distributed on Filter	< 1% of Mean	N42.22
Gamma-Ray Nuclides Ψ	5 - 500 per Nuclide	7 cm Diameter; Glass Fiber	1 Sample - Multiple Measurements	Distributed on Filter	-	N42.22

Ψ Select three of the following: Co-57, Co-58, Co-60, Cs-134, Cs-137, Am-241, Mn-54

* 1σ coefficient of variation