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DRAFT QUALITY ASSURANCE PROJECT PLAN FOR FERNALD RADON-FLUX MEASUREMENT SURVEY, PHASE I OCTOBER 1991

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Fernald Environmental Management Project

Draft Quality Assurance Project Plan for Fernald Radon-Flux Measurement Survey, Phase I

October 1991

Prepared for U.S. Department of Energy
and Westinghouse Environmental Management Project

1

Work performed under DOE Contract No. DE-AC07-86ID12584 for the **U.S. Department of Energy**
Grand Junction Projects Office

Geotech, Inc.

P-GJPO-501

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Chem-Nuclear Geotech, Inc.

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QUALITY ASSURANCE PROJECT PLAN

FOR

FERNALD RADON FLUX MEASUREMENT SURVEY

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INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been prepared to provide assurance by Chem-Nuclear Geotech, Inc. (Geotech) that the work performed at the Fernald Environmental Management Project (FEMP) will be of the quality required to satisfy the project objective and will be responsive to the requirements of the CERCLA QAPP for the RI/FS Program at FEMP. Geotech is operating contractor for the U.S. Department of Energy (DOE) Grand Junction Projects Office (GJPO). The requirements of the CERCLA QAPP, with regard to quality assurance (QA), focus on the acquisition of environmental data of known and acceptable quality. Programmatic QA requirements, such as design control, procurement document control, control of purchased items and services, and QA records, will be controlled by the requirements of the Geotech Quality Assurance Program, as described in the Geotech QA Manual (Manual 101) which was developed in response to DOE-ID Order 5700.6C and is based on ASME NQA-1, 1989 Edition "QA *Program Requirements for Nuclear Facilities.*"

The purpose of this QAPP is to provide an orderly assemblage of the detailed and specific procedures and practices that delineate how data of known and acceptable quality will be produced for the tasks specified in Geotech's Sample and Analysis Plan For The Fernald Radon Flux Measurement Survey, Phase I (SAP)[1].

This QAPP is based on the requirements set forth in *U.S. EPA Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS/005/80, December 29, 1980.* This plan is specific to the radon flux monitoring being performed by Geotech at FEMP.

Appendix A of the SAP includes the procedures to be used for this project.

To accomplish the various subtasks of this project work, a Work Readiness Review will be performed to assess the availability of adequate procedures, equipment, and properly trained, qualified, and certified personnel. These review requirements will be met prior to the start of project work to ensure that identified quality is achieved during the collection, processing, analyzing, and reporting of data.

[1]Chem-Nuclear Geotech, Inc., 1991b. *Sample and Analysis Plan for the Fernald Radon Flux Measurement Survey, Phase I*, U. S. Department of Energy, Grand Junction Projects Office, Grand Junction, Colorado.

1.0 PROJECT DESCRIPTION

The objective of this project is to develop a radon flux measurement procedure that is valid in the presence of high ambient outdoor radon concentrations and apply this procedure to each of five radium bearing waste pits located at the DOE FEMP, Fernald, Ohio. The procedure to be developed will be consistent with the requirements given in 40 CFR Part 61, Appendix B, Method 115, hereafter referred to as Method 115. The results of the flux measurements are to be compiled and the average radon flux for each of the waste pits computed and provided to the FEMP and the operating contractor, Westinghouse Environmental Management Company of Ohio (WEMCO).

1.1 SITE DESCRIPTION

Uranium production operations began at the FEMP in 1951 and continued until July, 1989 when production was halted. Over that time period, a number of different chemical and metallurgical processes occurred at the FEMP, producing a variety of waste streams. A portion of the waste produced during operations was placed into the six waste pits on the western side of the productions area. Some of the waste buried in these pits contained ^{226}Ra. Accurate records of the quantities of ^{226}Ra in the pits are not available. In 1987, a series of borings was made in the Waste Pit Area. These borings were analyzed for ^{226}Ra along with other radionuclides. Greater than background ^{226}Ra concentrations were found in Pits #1 - #5. ^{226}Ra was not detected in Pit #6 in concentrations above 20 pCi/g.

In the southwestern portion of the Waste Pit Area are four Silos, also constructed in 1951. The two southern-most Silos (also called the K-65 Silos) contain waste from the Manhattan Project, principally the residues from processing the radium-rich pitchblende ores from the Belgian Congo. These two Silos contain several thousand curies of ^{226}Ra and are a source of elevated radon concentrations in the air of the Waste Pit Area.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 PROJECT ORGANIZATION

Geotech is the operating contractor for the DOE GJPO. Table 2-1 presents key Geotech assignments for the Fernald Radon Flux project.

Table 2-1. Assignments of Key Geotech Personnel

Assignment	Name
Project Manager	Billie J. Foust
Principal Investigator	D. Tom Kendrick
Quality Assurance Coordinator	Bob Zabilka
Health and Safety Coordinator	Mike Madison
Technical Specialists	(assigned as required)

The Project Manager and the Principle Investigator are the points of contact for all project activities and will interface with the DOE GJPO and the FEMP.

2.2 PROJECT MANAGER

The Geotech Project Manager, will maintain project files which will include all project planning documents, correspondence relating to the project, training records, accident reports, and other records associated with the project. All information gathered during the course of the field work and all sample analyses and data reduction results will be forwarded to and maintained by the Project Manager.

The Project Manager is responsible for identifying the scope, schedule, budget and resources needed to achieve project objectives. The Project Manager establishes, implements and assures programmatic tasks, schedules and budgets. The Project Manger reviews and approves all project tasks, coordinates the participation of Geotech support organizations and issues all formal reports. The Project Manager is responsible for the execution of all phases of field sampling and for ensuring the collection of valid data in accordance with the procedures contained or referenced in the QAPP.

2.3 PRINCIPAL INVESTIGATOR

The Geotech Principal Investigator will maintain the project field files during the course of the field activities. These files will include the records of training for all field personnel, copies of the Chain-of-Sample-Custody forms, shipping documents, and all other miscellaneous documents relating to the conduct of the field activities. All of the field files will

be transferred to the permanent project files upon completion of the field work.

The Principal Investigator is responsible for managing site characterization activities and reporting project status to the Project Manager. The Principal Investigator has the primary responsibility for quality control activities at the site. The Principal Investigator also is responsible for the following:

- Conduct daily site status briefings prior to start of work.
- Issue work assignments.
- Verify that field personnel are qualified and trained for assigned work.
- Perform daily Quality Assurance/Quality Control (QA/QC) evaluations of field data and logbooks for completeness and accuracy to detect and correct errors in a timely manner.
- Control documents and data and maintain project files.
- Ensure chain-of-custody is maintained.

2.4 TECHNICAL SPECIALISTS

Technical Specialists from Geotech will include personnel qualified as:

- Associate Scientists
- Field Technicians

All personnel will have the education, training, technical knowledge, and experience, or a combination thereof, to perform their assigned function. Personnel records of education, experience and training will be maintained by the Geotech Human Resources Department. All field personnel will receive direction from the Principal Investigator at the FEMP Site.

2.5 QUALITY ASSURANCE COORDINATOR

The QA Coordinator will assist in planning and in the Work Readiness Review. The QA Coordinator will provide support to the Project Manager and will verify that QA requirements are included in planning documents and that QA/QC is implemented during the project activities. The QA Coordinator will work with all levels of personnel to identify and eliminate potential QA problems.

2.6 HEALTH AND SAFETY COORDINATOR

The Health and Safety Coordinator will assist in the preparation of the Site Health and Safety Plan and advise the Project Manager and the Principle Investigator on health and safety matters for the site.

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT OF DATA

The purpose of this QAPP is to detail the steps which will be implemented during the conduct of the radon flux measurements to ensure and document that the data are of known and acceptable quality. Documentation of all operations and records necessary to support the measurements and identify assignable causes in the event of measurement problems or to improve the accuracy will be kept.

3.1 DATA QUALITY OBJECTIVES

The data quality objectives of the measurements conducted during this project are to provide technically defensible measurements which meet the precision, accuracy, and completeness requirements given in Method 115. These limits are stated as follows, and apply to samples measuring greater than 1 $pCi \cdot m^{-2} \cdot sec^{-1}$.

- Precision 10%
- Accuracy ± 10%
- Completeness at least 85% of the measurements must yield useable results.

A direct measurement of the precision of the gamma ray analysis will be determined by recounting every tenth field sample collected. The precision for each replicate analysis pair will be calculated as the difference between the two count results (X_1 and X_2) divided by the mean of the two count results ($\bar{X}$), expressed as a percentage, as given in the following formula:

$$Precision = \frac{|X_1 - X_2|}{\bar{X}} \cdot 100$$

The accuracy of the gamma ray analysis will be determined by counting the two calibration standards as samples at the beginning and end of each day's counting and at a frequency of once every twenty samples throughout the day's counting. The percentage difference between the currently measured activity (X_i) and the certified activity (X_s) will be used as a point indicator of the accuracy at the time that the standard was counted. The following formula gives the computational form for this accuracy determination:

$$Accuracy = \frac{(X_i - X_s)}{X_s}$$

The best estimate of the counting system accuracy for a given day's counting results is the arithmetic mean of all of the point indicators determined for that day's counting. As per Radon Laboratory Technical Procedure RN-FLUX-U all individual analyses of the standards must yield a point estimate of the system accuracy that is 5% or less. A result in excess of 5% indicates a

problem with the counting system which must be corrected before continuing to count samples.

The samples received by the laboratory will be analyzed using the procedures detailed in the Geotech Radon Laboratory Technical Procedure entitled *Radon Flux Measurements Using the Large Area Activated Charcoal Collector Method*. The estimated detection limit for this technique, based on receiving and counting a sample within 5 days of the retrieval date, is 0.1 $pCi \cdot m^{-2} \cdot sec^{-1}$. The estimated precision of the results for a sample with a measured value of 1 $pCi \cdot m^{-2} \cdot sec^{-1}$ is approximately 8% at the 99% confidence level. This is based on a counting time of 20 minutes for the blank, and 5 minutes for the sample. The estimated precision of the results obtained by counting the standards as samples is approximately 2% at the 99% confidence level. The total uncertainty, at the 99% confidence level for this technique is estimated to range from approximately 9% at a measured value of 1 $pCi \cdot m^{-2} \cdot sec^{-1}$, to approximately 5% at the NESHAP emission limit of 20 $pCi \cdot m^{-2} \cdot sec^{-1}$. Because the NESHAP's do not state what confidence level is to be used in determining the analytical precision and accuracy, a 99 % confidence level was assumed to be conservative.

4.0 SAMPLING PROCEDURES

4.1 FIELD SAMPLING PROCEDURES

The sampling procedures which will be used are included in Appendix A of the SAP. Any deviation from these written procedures will be documented in the field notebooks, accompanied by an explanation of the reason for the deviation and the possible impact on the quality of the resulting data.

4.1.1 Types of Samples

A sample is defined as the charcoal exposed in a large area activated charcoal collector (LAACC), which has sorbed radon exhaling from the surface under investigation. The charcoal becomes a sample when the LAACC is recovered from an identified location on one of the waste pits and the sample information is recorded in the field notebook. The charcoal retains its identity as a sample for a period of 15 days (approximately 4 half-lives of the radon) following the end of the exposure. Past this period the activity remaining on the charcoal is not sufficient to meet the minimum data quality objectives and therefore the charcoal is no longer considered a valid sample. The charcoal may be recycled for future use by baking it in an oven at 110°C for four hours to remove any residual radon, as per Radon Laboratory Technical Procedure RN-FLUX-U, Section 5.

4.1.2 Radon Flux Sampling

The general procedure for collecting these samples is provided in the GJPO Radon Laboratory Technical Procedure *Radon Flux Measurements Using the Large Area Activated Charcoal Collector.*

The logistics involved with the measurement process will require that each waste pit be sampled over a separate 24 hour period. Because the temporal variations in the radon flux from these waste pits may be large, measurements at different pits, made at different times may not be directly comparable. To allow the results from one pit to be compared to another, a resampling scheme will be implemented. In this scheme, five percent (5 locations) of the locations from the first pit to be sampled will be resampled during each succeeding measurement period. Assuming Waste Pit No. 5 is the first to be selected for sampling, five of the locations would be selected for resampling. Concurrent with the measurements made at each of the remaining pits, these five locations would be resampled. This will provide a basis for comparing the results obtained from each of the pits to some common baseline. This will provide information regarding the short term temporal variability in the measured radon flux for one pit.

4.1.3 Radon Sampling

Continuous monitoring of the atmospheric radon levels will be conducted during the periods when flux measurements are made. This monitoring will be

accomplished with two Pylon AB-5 continuous radon monitors. Each of the waste pits will be roughly divided in half, and a Pylon AB-5 will be centrally located in each half. The Pylon Model AB-5 radon monitor will be operated according to the manufacturer's instruction manual[2].

4.2 SAMPLE IDENTIFICATION AND HANDLING PROCEDURES

Each sample will be assigned a unique alpha-numeric designator (Sample ID). This number will serve to both uniquely identify the sample and to provide information concerning the waste pit number, the location on the waste pit, and the date on which the LAACC was placed. The following is given as an example.

P5-036-092691
Where:

"P5"	indicates waste pit No.5
"036"	indicates sample location No. 36
"092691"	indicates the month, day, and year of placement (September 26, 1991)

Blank samples will be identified with the word "BLANK" written on the label, as well as the date and time of preparation, and the initials of the preparer. Blank samples will be prepared from the same charcoal that is being used to load the LAACC's, at the same time that the LAACC's are being loaded.

The LAACC's will be recovered from the field, the charcoal will be transferred to a sample can, and the can will be hermetically sealed. The sample ID, date and time of placement, date and time of retrieval, and the initials of the person handling the can will be written on a gummed label affixed to the can.

The information concerning the sample ID, placement and recovery times, etc. will be conveyed to the laboratory personnel by the label attached to the individual sample can.

4.3 DECONTAMINATION OF SAMPLING EQUIPMENT

To prevent the transfer of potentially contaminated soil material, each LAACC will be cleaned immediately following its recovery at the sample point. This will be accomplished by removing any soil adhering to the LAACC with a nylon brush or a clean dry cloth.

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[2]Pylon Electronic Development Company, Ltd., 1985. Pylon® Model AB-5 & Accessories Instruction Manual, Manual Number A900024.

5.0 SAMPLE CUSTODY

5.1 SAMPLE-TYPE IDENTIFICATION AND HANDLING

To maintain evidence of authenticity, the samples collected must be properly identified, and be easily distinguished from other like samples. Each of the LAACC's used will have a unique number (1 through 120) assigned to it. This number, referred to as the LAACC number, will be inscribed on the device with indelible ink. When a LAACC has been successfully exposed, the charcoal within the device becomes a sample. The identity of the sample is maintained by the entries in the field notebook data tables. The information from the notebook is used to generate a unique sample ID number, as previously described in Section 4.2. As soon as the sample has been transferred to a sample can and sealed, a label will be affixed to the can containing the sample ID, sample location, placement date and time, retrieval date and time, and the initials of the field personnel handling the sample.

5.2 TRANSFER OF CUSTODY AND SHIPMENT

The samples will be kept under custody from the point of collection to the point of analysis. Field samples will be stored prior to shipment in cardboard boxes on the FEMP site with custody seals over the opening. Chain-of-Sample-Custody forms will be used to document all transfers of possession of the samples. An example of the Chain-of-Sample-Custody form is provided in Figure 5.2-1.

While the sample is in shipment, the shipping cartons will have custody seals placed over the opening to ensure that the integrity of the samples has not been compromised. The laboratory must examine the seals on arrival and document that the seals are intact. Upon opening the container, the laboratory will note the condition of the sample containers.

A copy of the Chain-of-Sample-Custody form will be retained in the project field files for traceability in case of sample loss. The original Chain-of-Sample-Custody form signed by the GJPO Radon Laboratory personnel upon receipt of the samples at the laboratory will be filed with the project files at the GJPO Radon Laboratory.

Each set of samples (approximately 120 samples) will be shipped to the GJPO Radon Laboratory by Federal Express (using the Geotech account number) as soon as possible. For most sample sets, this will occur the day after the collectors are recovered from the waste pit. Samples recovered from the waste pits on the weekends may not be shipped until the following Monday. The samples will be packed in standard cardboard shipping boxes appropriately labeled to indicate their contents. The Chain-of-Custody form will accompany each shipment.

Shipping of the samples will be performed through the FEMP shipping department by the FEMP Certified Shipper. Because the radon flux from the waste pits remains essentially unknown at this time it is impossible to determine the

actual activity levels that the samples will exhibit. Thus there is the potential for the samples to contain sufficient radon and associated daughters to be considered radioactive materials for shipping purposes.

If the samples have an activity concentration of less than 2000 pCi/g then they are considered "not regulated material" by the DOT. Any materials with an activity concentration above 2000 pCi/g fall into the DOT classification of "Limited Quantity" radioactive materials, unless they exceed the upper limit for this category which is 0.002 Ci for Radon-222.

At the NESHAP emission limit of 20 $pCi \cdot m^{-2} \cdot sec^{-1}$, allowing a 24 hour decay period between sample collection and shipment, and a 180 g mass of charcoal for each sample, the total activity concentration is just over the 2000 pCi/g limit, when the activity of radon-222 and all of its daughters down to lead-210 are included. Because the samples are potentially above the limit it is prudent to plan to ship the samples as limited quantity radioactive materials.

The activated charcoal matrix is not considered a hazardous material. The Geotech principal investigator will provide to the FEMP Certified Shipper all known information concerning the contents of the shipments, such as: the proper shipping name, the hazard class, a conservative estimate of the total activity of the shipment, and the type of packaging for the individual samples.

5.3 LABORATORY RECEIPT AND ENTRY OF SAMPLE

The Project Manager or designee must examine the shipping container on arrival for damage and document that the custody seals are intact. If discrepancies exist, appropriate notes are made on the Chain-of-Sample-Custody form. Laboratory personnel verify that the information on the sample containers matches the information on the Chain-of-Sample-Custody form.

When sample analyses and necessary QA/QC checks have been completed in the laboratory, the charcoal may be recycled for future use since the charcoal retains its identity as a sample for a period of only 15 days (approximately 4 half-lives of radon) following the end of exposure. All identifying tags, data sheets, and laboratory records will be retained as part of the permanent documentation.

5.4 FIELD NOTEBOOKS

The Principal Investigator must maintain a bound notebook with consecutively numbered pages to provide a daily record of significant events, observations, and measurements during field investigations. The field notebook will contain information such as personnel present, site conditions, locations and sample number of samples collected, and equipment identification numbers used for sampling. All entries in the field notebooks will be made with indelible ink, and each page signed and dated to be kept as a permanent record. These notebooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the project.

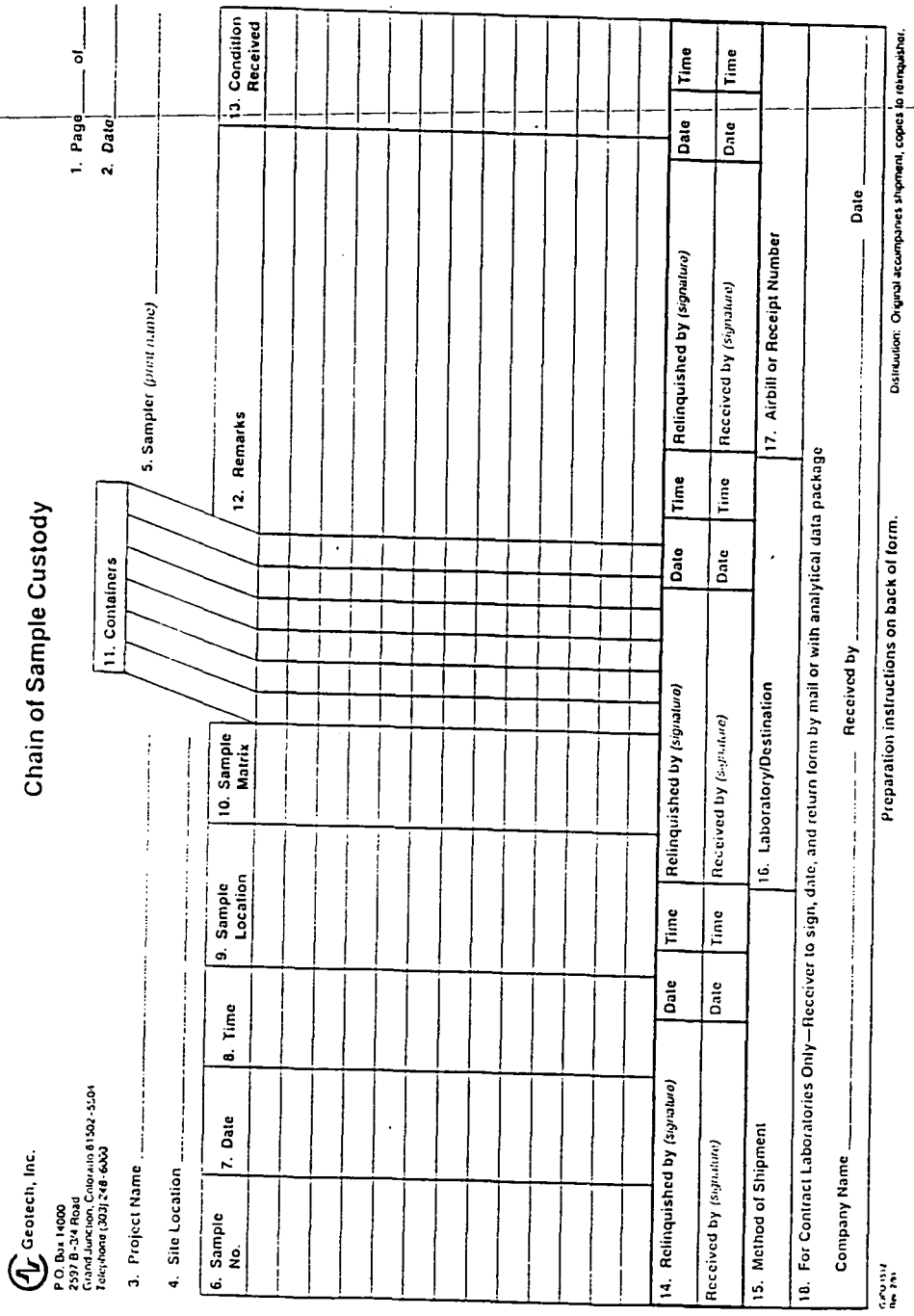

Figure 5.2-1: Chain-Of-Sample-Custody Form

6.0 CALIBRATION PROCEDURES AND FREQUENCY

6.1 FIELD AND LABORATORY EQUIPMENT

Instruments and equipment used to obtain data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the acceptable manufacturer's specifications. Calibration of instruments and equipment will be performed at approved intervals as specified by the applicable GJPO Radon Laboratory Technical Procedure or manufacturer's operating manual. Calibration standards used as reference standards will be traceable to the National Institute of Standards and Technology (NIST).

Records of calibration and maintenance will be filed and maintained by the Geotech Radon Laboratory in compliance with the procedures contained in the Geotech Radon Laboratory *Calibration and Control Program*[3].

[3]Chem-Nuclear Geotech, Inc., 1991. *Calibration and Control Program*, U. S. Department of Energy, Grand Junction Projects Office, Colorado.

7.0 ANALYTICAL PROCEDURES

The following Geotech Radon Laboratory technical procedures will be employed during the course of this project:

- *Radon Flux Measurements Using the Large Area Activated Charcoal Collector Method, (RN-FLUX-U), Rev. 0* (Appendix A of the SAP).
- *Calibration of Computer Automated Gamma Counting System for Radon Flux Measurements, (RN-FLUX-C), Rev. 0* (Appendix A of the SAP).
- *Pylon® Model AB-5 & Accessories Instruction Manual* (available upon request).

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

Data collected during the field activities will be recorded in the field notebooks, on the sample can labels, and on the requisite forms (eg. Sample-Chain-of-Custody forms). The project manager will validate critical field data (sample ID, date and time of LAACC placement and retrieval) by examining the field records for inconsistencies and omissions. A spot check of approximately 10 % of the samples will also be performed by the project manager. This spot check will include verification that the critical field data (sample ID, date and time of LAACC placement and retrieval) have been correctly transcribed from the field notes during each of the steps which resulted in an intermediate or final result.

8.1 DATA REDUCTION AND VALIDATION

As described in detail in the SAP and in the Radon Laboratory Technical Procedure RN-FLUX-U, individual radon-on-charcoal samples from each waste pit will be counted with a multi-channel analyzer to determine the net γ counts due to radon daughter activity. The counting will be performed no sooner than 4 hours following the end of the exposure period to ensure that the daughters have reached secular equilibrium with the radon. The net counts are used in the following formula to calculate the radon flux density in $pCi \cdot m^{-2} \cdot sec^{-1}$. A separate result is computed for the net counts from each of three different regions of interest (ROI's). The arithmetic mean of these three numbers is computed and used as the measured radon flux density.

$$J = \frac{C\lambda^2}{KA\,(1-e^{-\lambda T1})\,(e^{-\lambda(T2-T1)} - e^{-\lambda(T3-T1)})}$$

Where:

J = *Measured Radon Flux Density* ($pCi \cdot m^{-2} \cdot sec^{-1}$)
C = *Net Counts for the ROI* (*counts*)
λ = *Decay Constant for Rn-222* (sec^{-1})
K = *Calibration Factor for the ROI* (*cps/pCi*)
A = *Area of the Collector* (m^2)
$T1$ = *Exposure Time* (sec)
$T2$ = Δt, *Start of Exposure to Start of Counting* (sec)
$T3$ = Δt, *Start of Exposure to End of Counting* (sec)

As described in section 6.2 of the sample and analysis plan an empirical correction factor will be determined for each set of measurements (e.g. a separate correction factor for each waste pit). This correction factor will be applied to the individual results from the "standard measurements" to produce "corrected measurement results."

An average value for the radon flux density will be computed for each of the waste pits as the arithmetic mean of the individual measurements made on each waste pit. To provide a sense of the spatial variability in the radon flux,

contour maps of the measured "corrected" radon flux density will be prepared for each waste pit.

All outliers (individual measurement results which lie more than 3 standard deviations from the arithmetic mean of all results for the individual waste pit) will be examined in detail to ensure that the results are correctly computed from the field and analytical data, and that no discrepancies are observed in the field or analytical data.

The methodology given in Method 115 does not provide a mechanism for correcting results due to possible spectral interferences from thoron (^{220}Rn) daughters. Because Method 115 is the accepted method for determining radon (^{222}Rn) flux from the sources under consideration it is deemed unnecessary to consider such corrections. Moreover this is an entirely reasonable position. Because the half-life of thoron is so much shorter than that of radon the diffusion length of thoron is a factor of 77 times shorter than for radon. It is our opinion that, because of the much shorter diffusion length for thoron, the amount of thoron which reaches the charcoal in the LAACC will produce a signal which is insignificant compared to the activity of the radon daughters.

8.2 Reporting

The final report will include two separate data tables for each waste pit measured. The first table will contain the sample ID, sample location, and the uncorrected measured radon flux density for each sample location. The second table will contain the same information except that the individual measured radon flux density values will be corrected as described in Section 6.2 of the SAP.

In addition to these data tables, two tables will be prepared which list the average radon flux density computed for each of the measured waste pits. The first table will be based upon uncorrected measurements while the second will be based on the corrected values.

9.0 INTERNAL QUALITY CONTROL

9.1 LABORATORY QUALITY CONTROL

Quality control will be achieved during the laboratory activities by following the technical procedure RN-FLUX-U provided in Appendix A of the SAP. The following are specific parts of this procedure which are designed to ensure that the bias and uncertainty of results obtained from the analyses are minimized.

- Five percent of the unknown samples counted each day will be recounted. The coefficient of variation of these replicate analyses must be less than 10 % where the measured value is greater than 1 $pCi \cdot m^{-2} \cdot sec^{-1}$. The sample standard deviation computed for the two values must be multiplied by a factor of 1.253 to compensate for the small sample size of two, before the coefficient of variation is calculated[4].

- Two radon on activated charcoal standards, which are made from NIST traceable ^{226}Ra solutions, are counted at the beginning and end of each day's counting. The coefficient of variation for each of the standards must be less than 10 %, where the sample standard deviation is corrected for a small sample as above. The result computed from each count of the standards must be within 5 % of the certified value of the standard.

If either of the above conditions are not met this is an indication that the gamma ray counting system is either not functioning properly, or is in need of recalibration. The procedure for calibrating this system is provided in Appendix A of the SAP. Appropriate corrective measures will be taken and any samples which were analyzed under these conditions will be reanalyzed when the system has been restored to proper operating condition.

9.2 FIELD QUALITY CONTROL

Quality control will be achieved during the field activities by following the sampling procedures given in the SAP, which includes the use of blank charcoal samples. The blank samples are aliquots of the same charcoal which is used in the LAACC's. The blanks are hermetically sealed in a sample can at the time that the LAACC's are loaded and thus provide a measure of any contamination of the charcoal by radon prior to exposure in the LAACC.

[4]Dixon, W. J. and F. J. Massey, Jr., 1983. *Introduction to Statistical Analysis*, McGraw-Hill Book Company, page no. 145.

10.0 PERFORMANCE AND SYSTEMS AUDITS

Because of the short duration of this project, it has been determined by the Geotech QA Office that a formal audit is not required. The QA Coordinator will attend the Readiness Review and may perform surveillances on laboratory activities and records.

11.0 PREVENTATIVE MAINTENANCE

Equipment, instruments, tools, gauges, and other items required to perform work tasks both in the field and the laboratory that require preventive maintenance will be serviced in accordance with the manufacturer's recommendations and instructions. The laboratory will maintain a maintenance schedule for servicing critical items to minimize the downtime of measurement systems and to arrange for service as required.

12.0 DATA ASSESSMENT PROCEDURES

The Project Manager will assign qualified personnel to perform data-quality assessments in accordance with the applicable procedures.

Field and laboratory analytical data will be routinely reviewed and assessed to ensure the data-quality objectives listed in Section 3.1 are obtained.

Data assessment procedures used to evaluate accuracy, precision, completeness, representativeness, and comparability are described below.

- Accuracy is the nearness of a measurement of the mean ($\bar{x}$) of a set of measurements to the true value. An assessment of the accuracy will be obtained with the computer automated gamma counting system by repeated analysis of reference standards as unknowns. Each day that samples are counted two reference standards are counted a minimum of two times each. The mean ($\bar{x}$) of the certified values of the reference standards will be divided by the mean of the results for both standards. This ratio will be used to represent the accuracy for the analysis performed on that day.

- Precision is the agreement between a set of duplicate measurements without assumption or knowledge of the true value. Precision will be assessed by means of duplicate sample analysis as described in Appendix A of the SAP.

- Comparability of data is ensured through the use of standard analytical methods or methods with demonstrable equivalency in terms of method performance criteria and equivalent reported units. Comparability of the results of this investigation are ensured by using the methodology given in Method 115. The modifications made to standard Method 115 to accommodate the possible high atmospheric radon levels are made by employing additional measurements where the sampling apparatus and procedures are modified. The results from these additional measurements are used to apply a correction to the results obtained using the standard apparatus and methodology, if necessary. Both the uncorrected and corrected results will be reported so that the uncorrected results are available for comparability purposes.

- Representativeness is a term that represents the degree to which a measurement of a subject of a population, e.g., a specific sample from a specific location within a site, is characteristic of the population as a whole. Representativeness is ensured by following the sampling density as required in Method 115.

- Completeness is the measure of the amount of valid data obtained form a measurement system compared to the amount that was expected to be obtained under correct normal conditions. Sample completeness will be evaluated after the results are computed and the status of all outliers is established. The target for completeness is 85 percent.

13.0 CORRECTIVE ACTIONS

13.1 NONCONFORMANCE REPORTING

A nonconformance and corrective action program will be provided to discern, identify, and correct errors and defects at any point in the project implementation process. The data-validation activities may identify some of the key errors and deficiencies. Deficient data will be tallied, documentation of the results of corrective actions will be maintained, and causes will be eliminated prior to continuing work.

A nonconformance is defined as a malfunction, failure, deficiency, or deviation that renders the quality of an item as unacceptable or indeterminate. The nonconformance program pertains to all field equipment, measurements, and activities associated with the collection of data needed to fulfill project requirement. Any Geotech employee can originate a Nonconformance Report (Figure 13.1-1). Use of the report should be restricted to items that make data unacceptable. Minor violations or deviations for any activity will be recorded in the field logbook by the person noting the problem. The information form the Variance log will be used during data evaluation to assess the results and validity of the data.

The Nonconformance Report will be used to determine results that are out of control of established quality-control limits due to equipment malfunctions, equipment failure, operator error, or other conditions that adversely affect data quality. The originator of a Nonconformance Report will describe the findings on the form (Figure 13.1-1) and will then notify the Project Manager or QA Coordinator. All Nonconformance Reports will be reviewed by the QA Coordinator, who will then coordinate disposition of the nonconformance. The use of the equipment, item, or the activity may be temporarily stopped while the nonconformance is being investigated. If the nonconformance does not significantly affect the technical quality of the work, the work may continue pending resolution of the nonconformance.

13.2 CORRECTIVE ACTION

If corrective action is required to correct problems associated with variance or nonconformance items, the proposed corrective action will be approved by the Project Manager. The corrective action(s), once initiated, will be tracked and reviewed by the QA Coordinator for evidence that the data or activity are within the established control limits. Failure to demonstrate that the corrective action is effective will result in work stoppage until the problem is corrected.

Geotech, Inc. — Nonconformance Report

13. NCR No.:

Page 1 of ____

1. Purchase Order Number:	2. Title or Subject	3. Document No., Title, or Revision
4. Project, Program, or Activity	5. Supplier Name/Address	6. Job No. or ID No.

7. Item

8. Description of Nonconformance

9. Probable Cause of Condition

10. Recommended Action to Correct

11. Originator's Signature or Name — Date

12. QA Coordinator Signature — Date

14. Disposition/Justification Instructions

15. Design Document Change Required?	16. Reportable As an Event?	17. Corrective Action Required?
☐ Yes (Document No. _____)	☐ Yes (Report No. _____)	☐ Yes (specify _____)
☐ No	☐ No	☐ Yes (CAR No. _____)
		☐ No

18. Technical Representative	Date	Signature	Date	Signature	Date
QA Coordinator	Date	Signature	Date	Signature	Date

19. ☐ Disposition Completed As Directed

☐ Other (Specify):

_____
Originator or QA Coordinator

20. Action — Information Copies

Figure 13.1-1 Nonconformance Report (example)

(continuation sheet)

Instructions for Completion of Nonconformance Report

A Nonconformance Report can be issued by anyone. The individual (originator) identifying the nonconforming condition will enter, or provide to have entered, the following information to complete the portion of the Nonconformance Report within the heavy border (items 1 through 11).

1. The Purchase Order Number or Contract Number of the affected item or service, if applicable.
2. A brief descriptive title or name of the affected item or activity.
3. The requirements document number, title, etc., and revision.
4. The projects, program, or activity affected by or responsible for the item or activity.
5. The supplier or subcontractor name and address (when applicable).
6. A unique identification number for items, or the job number or other reference for activities.
7. Item (line) number of the condition when more than one affects a specific item or activity.
8. Description of the nonconformance condition in a "Required" and "Is" format (for an example see the Geotech Quality Assurance Manual (Manual-101), QAI 15.1, page 15.1-2).
9. When available, enter the most probable cause of the nonconforming condition.
10. When appropriate, enter the originator's recommendation of actions to correct the specific and related conditions.
11. The originator's signature (or printed name when prepared by the QA Coordinator) and the date.

Figure 13.1-1 (continued). Nonconformance Report (example)

14.0 QUALITY ASSURANCE REPORTS

Fundamental to the success of this QAPP is the active participation of management in the project. Management will be aware of project activities and will participate in the development, review, and operation of the project. Management will be informed of QA activities through the receipt, review, and/or approval of surveillance reports, nonconformance reports, and corrective action overdue notices.