U.S. Department of Energy
2597 B¾ Road
Grand Junction, CO 81503

WM-110

May 16, 2005

Mr. Myron Fliegel
Fuel Cycle Licensing Branch
Division of Fuel Cycle Safety and Safeguards
U.S. Nuclear Regulatory Commission
MS T7J8
11545 Rockville Pike
Rockville, MD 20852-2747

Subject: Transmittal of Radiological Inclusion/Exclusion and Verification Procedures, Moab, Utah Project

Dear Mr. Fliegel:

Enclosed for your review and concurrence are Radiological Inclusion/Exclusion and Verification Procedures that DOE is proposing to use during remedial action at the Moab Project site. The verification procedures will be used to demonstrate compliance with 40 CFR 192 standards.

In particular, I would like to bring your attention to Sections 4.3 and 4.6 of Attachment 2, which describes a process for verification using gamma scanning backed up by random soil sampling. The success of this process is dependent upon a field established, statistically rigorous correlation between gamma readings and opposed crystal soil sample results. It is my understanding that NRC has approved this process for the Split Rock, WY and Sherwood, WA sites regulated under Title II of the Uranium Mill Tailings Radiation Control Act.

If you have any questions please call me at (970) 248-7612 or Joel Berwick at (970) 248-6020.

Sincerely,

Donald R. Metzler
Moab Federal Project Director

Enclosure

cc w/enclosure:
Project File MOA 44.0 (Debbie Peterson)
cc w/o enclosure:
J. Berwick, DOE
J. Elmer, Stoller
B. Hopping, Stoller
T. Wright, Stoller
\DRM\MOAB\ProcedurestoNRC.doc

Field Services Procedures

for the

Radiological Excavation

Control and Radiological Verification

of the

Moab Project Site

May 2005

Work Performed by S.M. Stoller Corporation under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Environmental Management,
Grand Junction, Colorado

Overview of Field Procedures for the Moab Project

1.0 Introduction

S.M. Stoller Corp. is the Technical Assistance Contractor (TAC) for the U.S. Department of Energy (DOE), Grand Junction, Colorado, for the Moab Site Support Project. The Moab Project includes property and facilities once operated by the Uranium Reduction Co. and later by the Atlas Minerals Co. The Project Site consists of approximately 425 acres, of which 130 acres is covered by a tailings pile. The site is located north of the city of Moab, Utah, and is adjacent to the Colorado River and two state highways. In addition to the former mill site area, the potential for vicinity properties with contamination from residual radioactive material (RRM) exists.

Title I of the Uranium Mill Tailings Radiation Control Act (UMTRCA) (1978) requires DOE to establish a remedial action program and authorizes the Department to stabilize, dispose of, and control uranium mill tailings and other contaminated material at former uranium-ore processing sites and associated vicinity properties. UMTRCA also required the U.S. Environmental Protection Agency to establish standards for the remediation of RRM. Remediation of the Moab Project (millsite and vicinity properties) will comply with these standards. The Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (H.R. 4205) amended UMTRCA. This act specified that the license for the materials at the Moab site issued by the U.S. Nuclear Regulatory Commission (NRC) be terminated and the title and responsibility for cleanup be transferred to the DOE.

A preliminary Draft Environmental Impact Statement (EIS) was sent to DOE Headquarters in 2004, and underwent an extensive review process before it's release to the public. The Final EIS and Record of Decision is anticipated for release to the public in 2005.

2.0 Remedial Action

Remedial action activities for the Moab Project will be supported by the S.M. Stoller Field Services Group and will include radiological over site for the excavation of contaminated soils, building materials, and debris located on the vicinity properties and the millsite; shipment of radioactive tailings and debris; and verification of remediated areas. The radiological assessment of the non-pile areas, which excludes the actual tailings pile, will yield an estimate of the quantity including the depth and aerial extent of the RRM to be remediated at the Moab Project site.

The vicinity properties have not yet had Inclusion/Exclusion Surveys performed; therefore, the actual number of properties and scope are not yet determined. The inclusion/exclusion process, including interior and exterior gamma scans, soil sampling, and airborne radon decay-product concentrations (RDC's) will be performed using Attachment 1, "Moab Inclusion/Exclusion Surveys."

3.0 Compliance

The remediated areas will be verified for compliance with soil concentration standards and airborne criteria in structures (vicinity properties). Millsite property verification surveys will be conducted for the presence of radium-226 (Ra-226) and thorium-230 (Th-230) as compared to the soil cleanup standards; however, total uranium concentrations in soil may be addressed, on a case by case basis, for specific areas of the millsite where either historical process knowledge or a significant disequilibrium between Ra-226, Th-230, or total uranium is present. Radon-222 (Rn-222) levels, interior gamma measurements, and Ra-226 concentrations in soil will be verified for the vicinity properties. Standards for Ra-226, Rn-222, and interior gamma will be as specified in 40 CFR 192.12. Generic guidelines for Th-230 are contained in DOE Order 5400.5, and mimic Ra-226 cleanup standards; however, an UMTRA Project standard, based on a concentration relationship (sliding scale) between Ra-226 and Th-230 in soil, will be used. Uranium contaminated soils may be removed depending on its impacts as a contaminant source as it affects the long-term cleanup of the site ground water. The authorized limits and background values are summarized in Section 2 of Attachment 2, "Excavation Control and Verification Procedures."

4.0 Excavation Control

Excavation control is required to ensure that remediation and subsequent verification activities are performed safely, efficiently, and correctly. Engineering design drawings will be developed using detailed radiological assessment data for both the millsite and vicinity properties (after assessment activities are completed) showing the locations, areal extent, and depths of contamination. Prior to actual remediation activities, verification technicians will delineate (paint) the boundary of the contamination on the surface of the soil. As removal of the contaminated soil proceeds, the technicians will continuously monitor the excavation, with hand held gamma instrumentation (Appendix A, Instrumentation), noting gamma readings. A global positioning system (GPS)-based gamma scanning system incorporating a portable computer (or PDA) may also be employed to perform these surveys such that color-coded exposure rate maps of the excavation will be produced. Excavation control soil samples will be taken throughout this process to establish a correlation (excavation control value) between gamma readings observed in the excavation and Ra-226 concentrations in the soil.

The excavation control soil samples will be analyzed on site, using the Opposed Crystal System (OCS) for radium-in-soil values (detailed OCS procedures are presented in Attachment 3, "Opposed Crystal System (OCS) Soil Sample Analysis Criteria"). Periodic re-checking of the relationship between gamma measurements and radium-in-soil values will continue during the course of the excavation activities until the deposit has been removed. Detailed procedures for the excavation control process are contained in Attachment 2.

If applicable, a selected number of excavation control soil samples will be analyzed on site for uranium values (screening analysis only) using the High Purity Germanium System (HPGe) (detailed HPGe procedures are presented in Attachment 4, "Uranium Analysis"). These same samples may also be sent to an analytical laboratory for Th-230 analysis, if appropriate.

Shipment of soil samples to the off-site lab will be controlled relative to Department of Transportation (DOT) regulations through the use of procedures contained in Attachment 5, "Transportation of Radioactive Materials."

Building materials and/or debris may be encountered in the excavation area, requiring radiological surveying for determining whether it is contaminated or free-release (landfill) for disposal. This will be accomplished using beta/gamma and alpha radiation detection type instrumentation and probes. Swipes may also be collected and counted to help conduct these surveys. This survey technique (beta/gamma surveys) may also be used for excavation control purposes if process waste materials, such as uranium oxide (U_30_8), are encountered in the excavation area.

5.0 Verification

The verification technicians will begin the verification process upon completion of removal of contamination from the excavation areas. The purpose of verification is to demonstrate compliance with the appropriate cleanup standards (soil, gamma, radon, or a combination thereof) depending on the location and type of excavation area. Composite soil samples will be taken from the excavated areas to verify compliance with the appropriate soil cleanup standards. Verification soil samples will be collected using equipment and documentation described in Attachment 6, "Radiological Soil Sampling."

Two methods of soil verification may be employed depending on the size, location, depth, and depositional characteristics of the excavation. Either a Standard 100 m^2 Verification (SV) or Global Positioning System (GPS)-based gamma scanning system (GPS/GS) will be used. Both of these verification protocols are described in detail in Attachment 2, Section 4. Verification soil samples will be analyzed on site using the OCS for Ra-226 concentrations, with 10% of the samples submitted to an off site analytical lab for quality assurance/quality control (QA/QC) checks on the OCS system. (The number of samples submitted to the analytical laboratory may be reduced to 5% based on statistical confidence levels observed.) Historical statistical analysis of measuring radium-226 by the OCS method versus analytical laboratory indicates a very good correlation between the two. In general the OCS data has been slightly conservative (higher) than analytical laboratory data. Additionally, verification soil samples will be submitted to an analytical laboratory for Th-230 and total uranium analysis. Determination of the number of samples submitted for analytical laboratory analysis will be based on the stated factors and field soil conditions encountered.

If the excavation extends vertically into the river alluvium and verification sampling is required, composite samples will be collected, using the cobbly-soil sampling technique (as described in Attachments 2 and 6). Special conditions may exist, relative to excavation safety that will not allow the verification technician to enter the excavation area and perform verification activities. If the excavation area does not meet the Occupational Safety and Health Administration 29 CFR 1926, Subtitle B Regulations for sloping and personnel access, a modified scanning and sampling protocol will be followed (as described in Attachment 2, Section 4).

6.0 Instruments

All instruments (Appendix A) used by the verification technicians are bench calibrated every 12 months by either the instrument manufacturer or a qualified calibration technician, according to procedures and manufacturers specifications. A 12-month calibration sticker is placed on every instrument for QA/QC certification of the calibration. In addition, all instruments are operational checked on a daily basis with reference material or radioactive sources for a response check. Reference materials and radioactive sources will be controlled as described in Attachment 7, "Control of Radioactive Materials." The operational check provides a daily record of actual instrument response to a known specified standard. If the instrument fails the operational check, it will not be used for data acquisition, and red-tagged "Out of Service". Instrument field data will be validated on the basis of the daily operational check and specified response criteria. Similar calibrations and operational checks will be performed and documented for the OCS and HPGe soil counting systems for QA/QC purposes.

List of Attachments:

Appendix A

Instruments

Mount Sopris Portable Gamma Scintillometer, Model EL-0047A, with External Detector (modified). The Model CE-975 Detector, 3.81 cm diameter by 3.81 cm thick (1.5-inch-diameter by 1.5-inch-thick) sodium iodide crystal, was removed from the unit and mounted on a crutch with a built-in amplifier. This model is referred to as the "crutch scintillometer".

Mount Sopris Portable Gamma Scintillometer, Model EL-0047MOD with External Detector (modified). The Model CE-975 Detector, 3.81 cm diameter by 3.81 cm thick (1.5-inch-diameter by 1.5-inch-thick) sodium iodide crystal was removed from the unit, attached to a 9.14 meter (30-foot) cable and tether line, and encased in a protective PVC pipe enclosure. This model is referred to as the "soap-on-a-rope".

Delta scintillometer, 7.62 cm by 7.62 thick (3-inch- by 3-inch-thick) sodium iodide crystal, Model EL-0018B with tungsten filter.

Ludlum Model 2350/44-10 gamma detector system, 5.08 cm by 5.08 cm (2-inch by 2-inch thick) sodium iodide crystal

Ludlum Model 12 Count Rate Meter with a Ludlum 44-9 Pancake GM Beta-Gamma Detector.

Opposed Crystal System (OCS), Eberline, 3.81 cm by 3.81 cm thick (1.5-inch- by 1.5-inch-thick) sodium iodide crystal.

SPA III, Eberline, 5.08 cm by 5.08 cm thick (2-inch- by 2-inch-thick) sodium iodide crystal downhole logging device.

Bicron 1.27 cm diameter by 7.62 cm long (0.5-inch-diameter by 3-inch-long) sodium iodide crystal downhole logging device.

E-600, Eberline portable radiation monitor.

High Purity Germanium (HPGe) Detector System, ORTEC, 5.5 cm diameter by 5.5 cm length (2.16-inch-diameter by 2.16-inch-length) high purity germanium crystal, portable gamma detector.

Global Positioning System (GPS). Trimble Model TSC1.

Garmin Legend (WAAS-enabled) handheld GPS System/Garmin iQue combination handheld (WAAS-enabled) GPS and PDA unit.

Attachment 1
Moab Inclusion/Exclusion Surveys

1. Purpose

An inclusion/exclusion survey evaluates radiological contamination at a vicinity property (VP) to determine if the material is tailings derived from the millsite, and if so does it exceed the applicable standards. If conditions on the property exceed the U.S. Environmental Protection Agency (EPA) standards (40 CFR 192), the Contractor will recommend to the U.S. Department of Energy (DOE) that the property be included in the Moab Project. If it does not exceed the standards, the property will be recommended for exclusion.

The procedures for inclusion/exclusion surveys are based on the "Indoor/Outdoor Radiological Surveys" procedure contained in the *Field Services Procedures Manual* (STO 203). This procedure defines the additional data required for making an inclusion/exclusion recommendation and the report format.

2. Field Procedures

A recommendation of inclusion or exclusion begins with collecting information about the property from historical EPA gamma surveys and from homeowner interviews before performing a field investigation. The field investigation requires making measurements of one or all of the following: gamma exposure rate, radium concentration in soil, isotopic concentrations in the materials, visual characteristics, or radon decay product concentration (RDC) in air. The field investigation also requires completion of field forms to help assure that all necessary data are collected to defend the recommendation of inclusion or exclusion. Following the field investigation, a report is written to describe the survey results. Much of the report is a previously approved boilerplate that will produce reports, which are of consistent quality from investigation to investigation.

Conditions on the property will be compared to criteria for exterior deposits and interior deposits based on the EPA standards (40 CFR 192, page 2 of text) and the *UMTRA Vicinity Properties Management and Implementation Manual*, Appendix A, "Inclusion Criteria and Procedures."

The exterior parameters to be evaluated include gamma exposure-rates and radium-226 (Ra-226) concentration in soils, if it is attributed to tailings from the millsite.

1. The net area-weighted average level of gamma radiation shall not exceed the background level by more than 25 microroentgens per hour (μR/h) in land averaged over any area of 100 square meters (m^2), it will be sampled.
2. The concentration of Ra-226 in land averaged over any area of 100 m^2 shall not exceed the background level by more than:
    - 5 picocuries per gram (pCi/g), averaged over the first 15 centimeters (cm) of soil below the surface; and
    - 15 pCi/g averaged over 15 cm thick layers of soil more than 15 cm below the surface.

The interior parameters to be evaluated are gamma exposure-rates and RDC in air, if it is attributed to tailings from the millsite.

1. The net area-weighted average level of gamma radiation shall not exceed the background level by more than 20 μR/h averaged over any area of 9.3 m^2.
2. An annual average (or equivalent) RDC (including background) not to exceed 0.02 working level (WL).

2.1 Decision Tree

The following page contains the decision tree to be used to determine the basis for recommending inclusion or exclusion. The decision tree will be applied to the data gathered for the exterior, if applicable, then to the data gathered for the interior. The decision tree is designed to provide a logical decision flow through the field data to determine if there are sufficient data to recommend inclusion or exclusion of the property.

2.2 Homeowner Consent, Interview, and Photograph

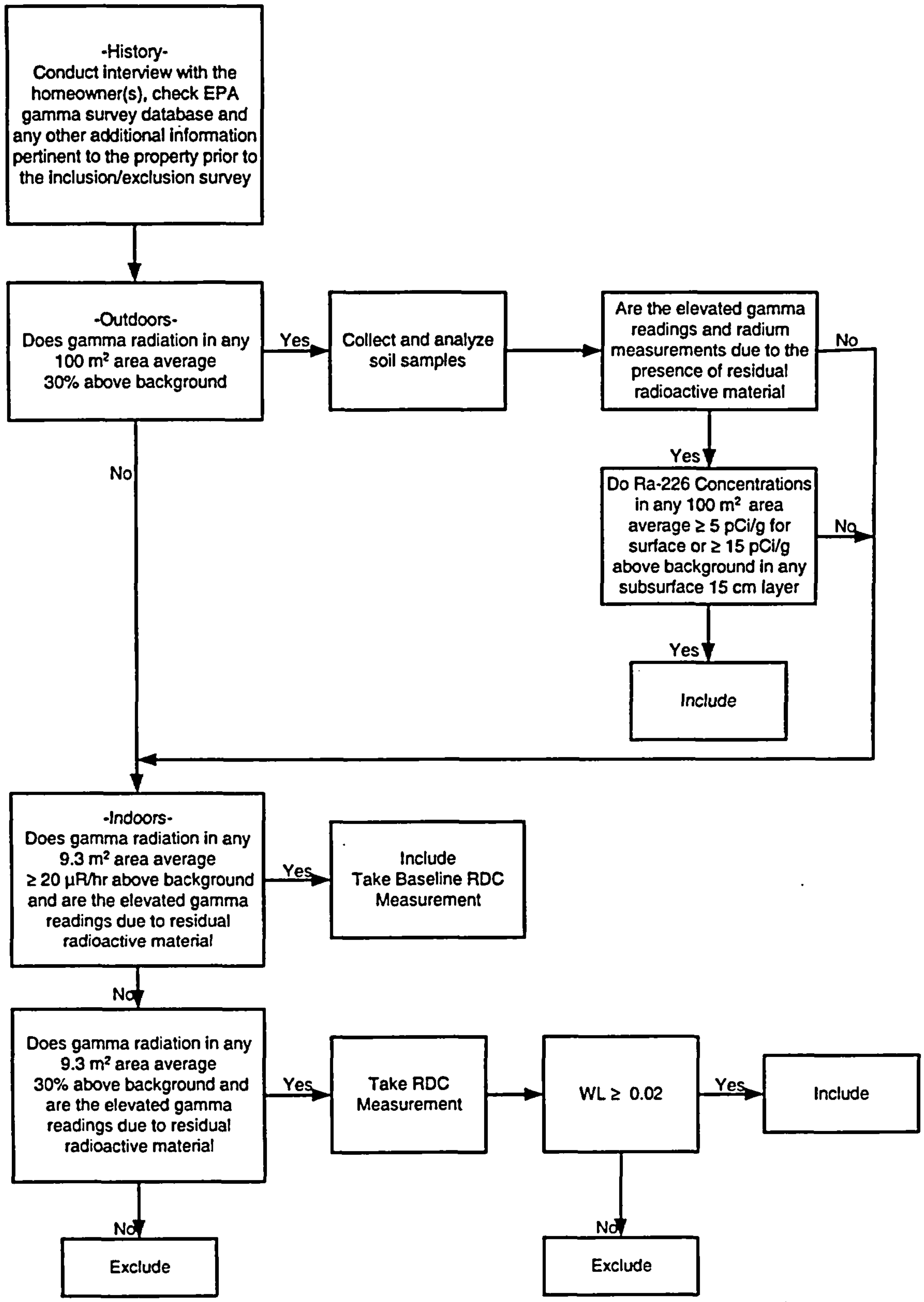
Before any radiological or land surveys are started, a consent for access must be obtained. When the location of the property, owner, and tenancy are confirmed, a Consent Form (Figure 1) must be signed by the owner(s).

The homeowner is interviewed to gather the owner data displayed in the top portion of the Survey Site Information Sheet (Figure 2); all structures are noted. A photograph of the property is taken that shows the improved portions. The photo is labeled with the property identification, date of photograph, name of photographer, and the direction the photographer was facing.

The homeowner will be asked what knowledge they have of the history of the property to try to determine whether tailings might be present on the property. In addition, the EPA gamma scan database will be checked to see what anomalies were cited. Additionally, such items as proximity to known ore-buying stations will be noted.

2.3 Exterior Gamma Scan

A land survey crew will produce a drawing of the property showing all of the major improvements and property lines on the property. The radiologic survey crew will then use this drawing as a field map. The improved portions of the property will be completely gamma scanned and elevated gamma readings greater than 30-percent above background as well as background ranges for the remainder of the property will be recorded on the field map. The areas exceeding the 30-percent above background readings will then be screened and possibly investigated to determine if any of the areas exceed EPA exterior soil criteria. If no elevated gamma exposure rates are found on the property, the property will be excluded for exterior contamination. Areas that are elevated shall be investigated further to determine if the material is tailings related. Factors to consider include history of the property, visual data (discernable color, chunks of rock), and isotopic data.



Decision Tree for Interior and Exterior

Occasional point sources may be encountered. These point sources may consist of ore, dinosaur bones, radium dial watches, or personal collectible items. These items will be evaluated for high gamma exposure rates and in-situ Ra-226 concentrations. The results of the measurements and a complete description of the items will be shown in the report; however, point sources will not affect the inclusion/exclusion decision.

2.4 Exterior Soil Samples

To determine if the EPA standard for Ra-226 in soil is exceeded, a surface (0—15 cm) and subsurface (15—30 cm) soil sample is gathered at the location of the Highest Outdoor Gamma (HOG) provided the HOG exceeds ≥ 25 μR/h above background averaged over 100 m^2. Additional soil samples are also gathered at the next highest area of exterior gamma of the same deposit at least 1 meter away from the first sample. These samples will be analyzed and the results averaged to determine the net estimated area-weighted average concentration (See Section 3.2). Samples are recorded on the Delta/Soil Sample Data Form (Figure 3) as well as the field map (Figure 4). If the 0—15 cm or the 15—30 cm soil samples exceed the EPA standard for Ra-226, no further soil samples will be collected and the property will be recommended for inclusion based on exterior criteria. If the soil samples do not exceed the EPA standard, the property will be excluded based on exterior criteria.

2.5 Interior Gamma Scan and RDC

Interior surveys are performed by scanning with gamma scintillometers at a distance of approximately 2 inches from floors and walls. The interior background value for a structure shall be the midpoint of the gamma-exposure rate range measured in an uncontaminated area of the structure. Gamma-scan data is used to identify interior areas associated with the following exposure rate ranges:

- Background to 30 percent above background,
- 30 percent above background to 20 μR/h above background, and
- Greater than 20 μR/h above background.

The boundaries of these areas are recorded on the field map of the structure with a range showing the highest and lowest gamma exposure rate measured within each area (Figure 5).

If the gamma exposure rates are elevated above background levels, but do not exceed interior gamma inclusion criteria, the property will be excluded.

If there are no gamma exposure rates that exceed 30 percent above background levels, the property will be excluded based on interior criteria.

2.6 Spillover Material

While performing inclusion/exclusion surveys, all spillover type deposits onto adjacent properties should be evaluated (with permission of the owner) to determine if the spillover material is sufficient to recommend inclusion to DOE. This evaluation may be accomplished through gamma scans and/or soil samples.

2.7 Inclusion Boundaries

Moab VP inclusion boundaries define the area where the survey is conducted. The property boundary shall be the primary basis for the inclusion boundary. The legal property boundary, if known, may be modified in the following situations:

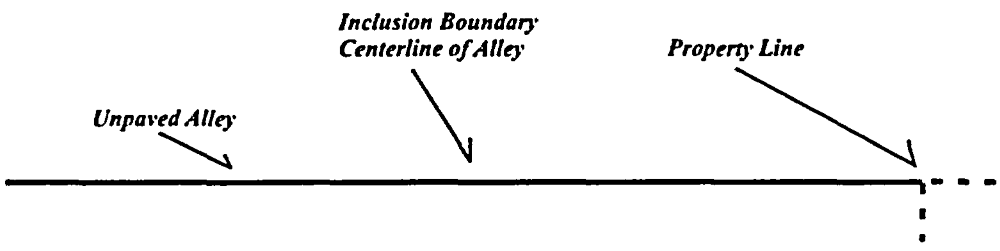
- If a common usage boundary has been established between properties, such as a fence that is different from legal property boundary, the common usage boundary shall be used.
- If the property boundary is adjacent to an unpaved road or unpaved alley, the inclusion boundary shall be extended to the edge of the road or center of an unpaved alley.

If the property boundary is contiguous to a paved road or paved alley, the inclusion boundary shall:

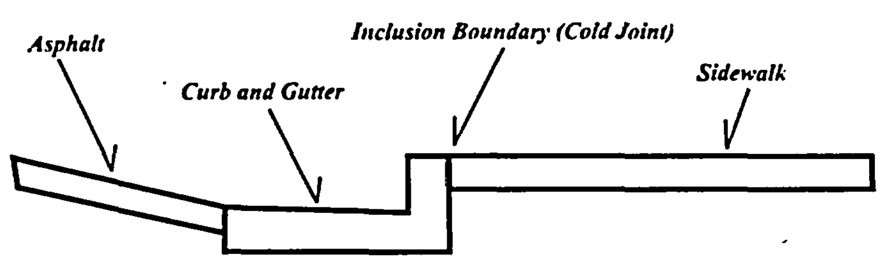
- Be extended to the asphalt if there is a monolithic sidewalk, curb, and gutter structure;
- Be extended to sidewalks detached from the paved road, curb, or gutter if the City has requested that newly installed sidewalks not be disturbed;
- Be extended to the curb if there is a sidewalk that is attached, but poured separately from the curb and gutter, and removal of the sidewalk has been approved by the City; or
- Be extended to the pavement if there is no curb or gutter and removal of any existing sidewalk has been approved by the City.

Examples of inclusion boundaries are as follows:

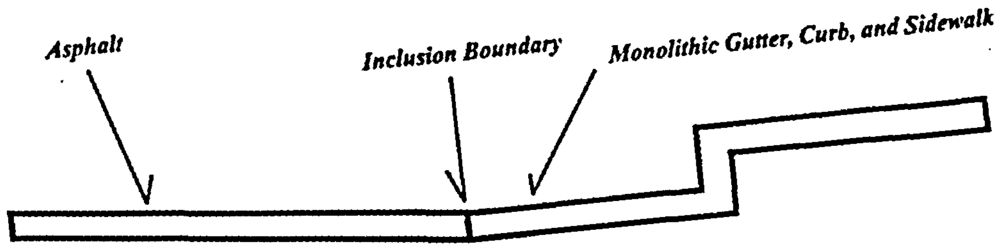
- Centerline of unpaved alleys.



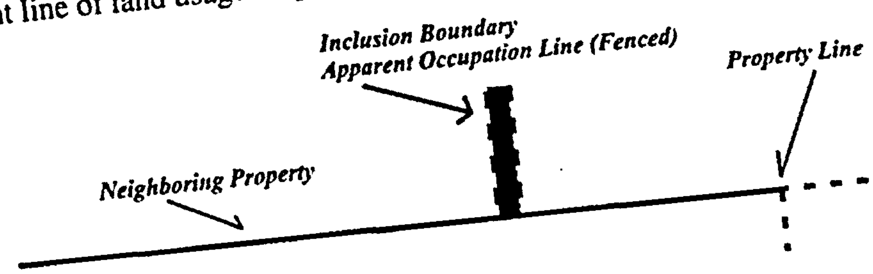
- Back of curb when sidewalk is poured separately from the curb and gutter.



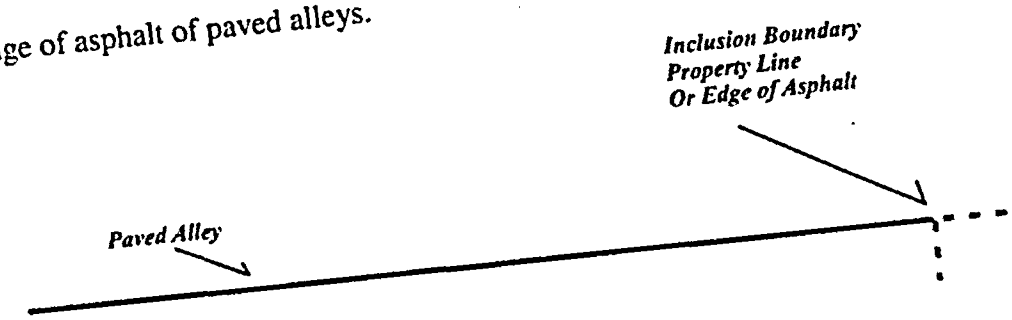
- Lip of gutter when the sidewalk, curb, and gutter are poured monolithically.



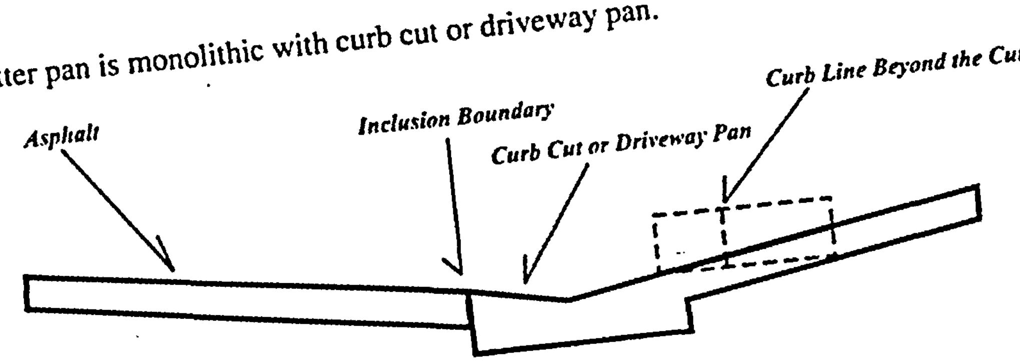
- Apparent line of land usage on property sides.



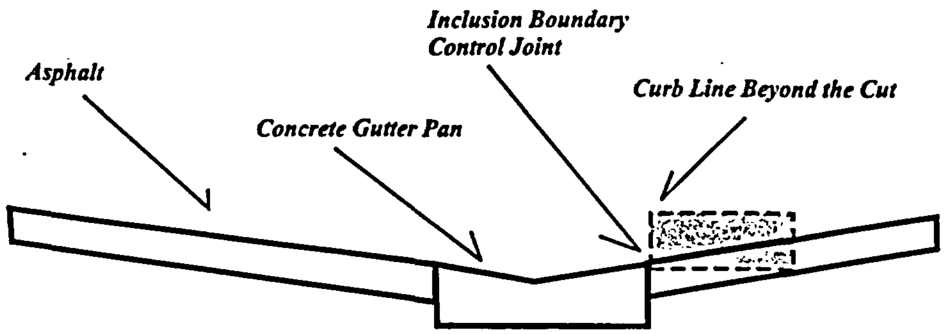
- Edge of asphalt of paved alleys.



- Gutter pan is monolithic with curb cut or driveway pan.



- Gutter pan is separate from curb cut or driveway pan.



3. Formulas Used

3.1 Gamma Exposure Rates

The formula used to calculate the net area-weighted average gamma exposure rate is:

$$G_{AW} = \sum_{i=1}^{n} \frac{G_i \times A_i}{X}$$

G_{AW} = the net area-weighted average gamma exposure rate (µR/h)
G_i = a series of average gamma exposure rates less background (µR/h)
A_i = a series of areas within regions of contamination (m^2)
X = threshold area (100 m^2 for exterior and 9.3 m^2 for interior)

Example

An interior has two areas within a 9.3 m^2 area. One area is 1.1 m^2 and has an average gamma exposure-rate of 35 µR/h. Another area is 1.9 m^2 and has an average gamma exposure-rate of 42 µR/h. The background gamma exposure-rate for the room is 15 µR/h. What is the net area-weighted average gamma exposure-rate and does the interior exceed 30-percent above background?

First find the net gamma exposure rates for the two areas by subtracting the background from both:

first area (35 µR/h – 15 µR/h) = 20 µR/h

second area (42 µR/h – 15 µR/h) = 27 µR/h

Insert the numbers into the formula:

$$G_{AW} = \frac{(20\mu R / h \times 1.1 m^2) + (27\mu R / h \times 1.9 m^2)}{9.3 m^2}$$

G_{AW}= 8 µR/h (Net area-weighted average gamma exposure-rate)

This value is less than 20 μR/h above background averaged over 9.3 m^2; however, it is greater than 30-percent above background averaged over 9.3 m^2 or (0.3 × 15 μR/h) = 4.5 μR/h. Annual average RDC measurements shall be taken to determine if the property will be recommended for inclusion or exclusion.

3.2 Exterior Net Estimated Area-Weighted Average Ra-226 Concentration

The formula used to calculate the net estimated area-weighted average Ra-226 concentration in a 0.15-meter (6-inch) soil layer is:

$$C_{AW} = \sum_{i=1}^{n} \frac{C_i \times A_i \times D_i}{100}$$

C_{AW}	=	the area-weighted average Ra-226 concentration (pCi/g)
C_i	=	a series of average Ra-226 concentrations less background (pCi/g)
A_i	=	a series of areas within regions of contamination (m^2)
D_i	=	a series of depths of samples (m)
100	=	the area used in average (m^2)

Example

Three exterior deposits were found within the trailer-house rule of 100 m^2 area. The deposits were 5 m^2, 10 m^2, and 43 m^2. The two surface soil samples were gathered from the HOG and the next highest HOG in each of the three deposits and the contamination does not appear to extend deeper than 15 cm. The average gross Ra-226 concentrations of the deposits were 44.0 pCi/g, 12.0 pCi/g, and 6.0 pCi/g, respectively. Does this 100 m^2-area exceed the net estimated area-weighted average Ra-226 concentration?

The first part of the problem will be solved using the net estimated area-weighted average Ra-226 concentration in soil formula. Background will not be subtracted through the use of the OCS system. Background will be subtracted from the Ra-226 concentrations of the deposits if the analytical laboratory is used in place of the OCS system.

$$C_{AW} = \frac{(44.0\ pCi/g \times 5\ m^2) + (12.0\ pCi/g \times 10\ m^2) + 6.0\ pCi/g \times 43\ m^2}{100}$$

$$C_{AW} = 6.0\ pCi/g$$

This value is greater than EPA standard of 5.0 pCi/g Ra-226 when averaged over 100 m^2 and the property would be recommended for inclusion.

4. Inclusion/Exclusion Report

After the field measurements are gathered, a report is written to make and support the recommendation of inclusion or exclusion. The Inclusion/Exclusion Report consists of a Summary of Evaluation/Findings (Figures 6 through 8) and a Report of Inclusion/Exclusion (Figures 9 through 14).

4.1 Table of Evaluation/Findings

The Table of Evaluation/Findings includes a summary of findings for the property, the evaluation scope, and the specific standards or guidelines that were exceeded. It consists of:

- Vicinity Property Summary Evaluation and Findings (Figure 6)
- Contractor Findings (Figure 7)
- U.S. Department of Energy Evaluation (Figure 8)

4.2 Report of Inclusion/Exclusion

The Report of Inclusion/Exclusion (Figures 9 through 14) contains Stoller's recommendation for inclusion or exclusion and discusses the basis for that recommendation. The report includes:

- Report of Radiological Survey (Figures 9 through 11)
- Property/Owner Information (Figure 12)
- Table of Radiological Screening Survey Results (Figure 13)
- Table of Extended Survey Results (Figure 14)

5. Records

Records that may be generated by this procedure include:

- Site Survey Information Sheet
- Field Measurement Data forms
- Field Maps (Procedure 2.0)
- Summary of Evaluations and Findings
- Report of Inclusion/Exclusion
- Owner Consent Form
- Property Photographs
- Table of Radiological Screening Survey Results
- Table of Exterior Radiological Survey Results and Data

All records will be placed in the property folio or forwarded to Records Management for inclusion in the property folio.

6. References

The following references contain information used in the development of this procedure.

Vicinity Properties Management and Implementation Manual, Revision B, April 29, 1985

Basic Radiation Protection Technology, 3rd Edition, Daniel A. Gollnick

Environmental Implementation Guide for Radiological Survey Procedures, Draft, November 1992, U.S. Department of Energy

7. Definitions

Contamination—The presence of unwanted radioactive material.

EPA Standards—Standards for cleanup of land and buildings contaminated with residual radioactive materials from inactive uranium processing sites (40 CFR 192, page 2 of text).

Extended Measurements—Soil samples, concrete sampling, indoor RDCs, or media sampling that requires an extended time period for analysis or data collection.

HIG—Area displaying the highest inside gamma exposure-rate measurement.

HOG—Area displaying the highest outside gamma exposure-rate measurement.

Point Source—An area that displays sharp increases in the gamma exposure-rate measurements and can be attributed to rocks (ore), dinosaur bones, radium-watch dials, or other like items.

RDC—Radon decay-product concentration expressed as a working level (WL). The formal definition of WL is any combination of short-lived radon decay-products in 1 liter of air that will result in the emission of 1.3×10^5 MeV of potential alpha energy. (It is usually easier to measure the Ra-222 and not the decay-product concentrations. The conversion is 100 picocuries per liter (pCi/L) = 1 WL for equilibrium. In Moab, an equilibrium factor of 50-percent is assumed, thus a 4.0 pCi/L Ra-222 concentration converts to 0.02 WL.)

Spillover—Contamination that is identified on the parent property and is contiguous with a deposit on one or more adjacent properties.

Trailer-House Rule—The minimum dimensions that should be used in combining deposits to evaluate a 100 m^2-area. The trailer-house rule uses an area of 15 by 70 feet, or the approximate area occupied by a residential mobile home.

CONSENT FOR ACCESS TO CONDUCT SURVEYS AND ENGINEERING STUDIES

*VICINITY PROPERTY NO.:

*PROPERTY ADDRESS:

*PROPERTY PARCEL NUMBER OR DESCRIPTION:

I (We) acknowledge that I (we) own the property described above and grant permission to employees, contractor, and subcontractor personnel and other representatives of the U.S. Department of Energy (DOE) to enter upon the property at a reasonable time during the next 26 months to conduct radiation surveys to determine the nature and extent of any radioactive material that may be present. In addition, permission is given to perform engineering assessments, if necessary, to evaluate the measures that might be taken, as well as to evaluate the extent of the work required and the cost.

I (We) understand that DOE's responsibility for any damage or disturbance to my (our) property caused by the survey and engineering activities shall be any backfilling, seeding, sodding, landscaping, rebuilding, or repair of the property required to restore it to a condition comparable to its apparent physical condition immediately prior to entry upon the property.

I (We) understand that the DOE is not obligated to perform remedial action upon the property. I (We) understand that no remedial action shall be performed until the DOE and the property owner have entered into a separate written agreement setting form the terms, conditions, and plans for remedial action.

I (We) understand that the DOE has the right to disclose to the public, in the form of technical data and reports, the results of its data gathering on the above-described property.

[ ] I grant access for the conduct of surveys and engineering studies as provided in the consent for access.

[ ] I have decided not to participate in the project.

________________________ ____________
Signature of Owner(s) Date

NAME:	__________	NAME:	__________
STREET:	__________	HOME PHONE:	__________
CITY, STATE:	__________	BUSINESS PHONE:	__________
HOME PHONE:	__________	COMMENTS:	__________
BUSINESS PHONE:	__________		__________

*To be completed by project participants.

Figure 1. Owner Consent Form

SURVEY SITE INFORMATION

Survey Date: ________________ Site Number: ________________________

Owner Data

Name: ______________________________ Location: ___________________________

Address: ______________________________

____

Phone: ______________________________

Land Use

Residential ?	Single Family ? Multi Family ?	Commercial ?	Retail Store ? Office ? Manufacture ? Hotel/Motel ?
Public Building ?	School ? Church ?	Vacant Lot ? Open Land ?	

Other __________________________ Description__________________________

Number of Structures: _______

Type of Construction (Number of levels, frame/masonry, basement/crawl space/slab on grade, etc.):

Building 1: ____

Building 2: ____

Building 3: ____

Building 4: ____

Photograph(s)

Film Roll Number: _______

		Compass Direction			Description
Frame No.	_______	Looking:	_______	At	_______________
Frame No.	_______	Looking:	_______	At	_______________
Frame No.	_______	Looking:	_______	At	_______________
Frame No.	_______	Looking:	_______	At	_______________

Spillover to Adjacent Property: [ ] Yes [ ] No

Spillover Property Address: ____

Figure 2. Survey Site Information Sheet

DELTA/SOIL SAMPLE DATA FORM

Survey Date: ________________ Site Number: ________________________

Interior ? Exterior ?

Sample Location: ______________________ Area Represented: ________________ m^2

Visible Ore: Yes ? No ? Background Sample: Yes ? No ?

Visible Tailings	Sample Number	Depth (m)	Delta pCi/g	Gamma cps	Gamma µR/h	Ra-226 pCi/g
		Surface				
		0.15				

Sample Location: ______________________ Area Represented: ________________ m^2

Visible Ore: Yes ? No ? Background Sample: Yes ? No ?

Visible Tailings	Sample Number	Depth (m)	Delta pCi/g	Gamma cps	Gamma µR/h	Ra-226 pCi/g
		Surface				
		0.15				

Sample Location: ______________________ Area Represented: ________________ m^2

Visible Ore: Yes ? No ? Background Sample: Yes ? No ?

Visible Tailings	Sample Number	Depth (m)	Delta pCi/g	Gamma cps	Gamma µR/h	Ra-226 pCi/g
		Surface				
		0.15				

Figure 3. Delta/Soil Sample Data Sheet

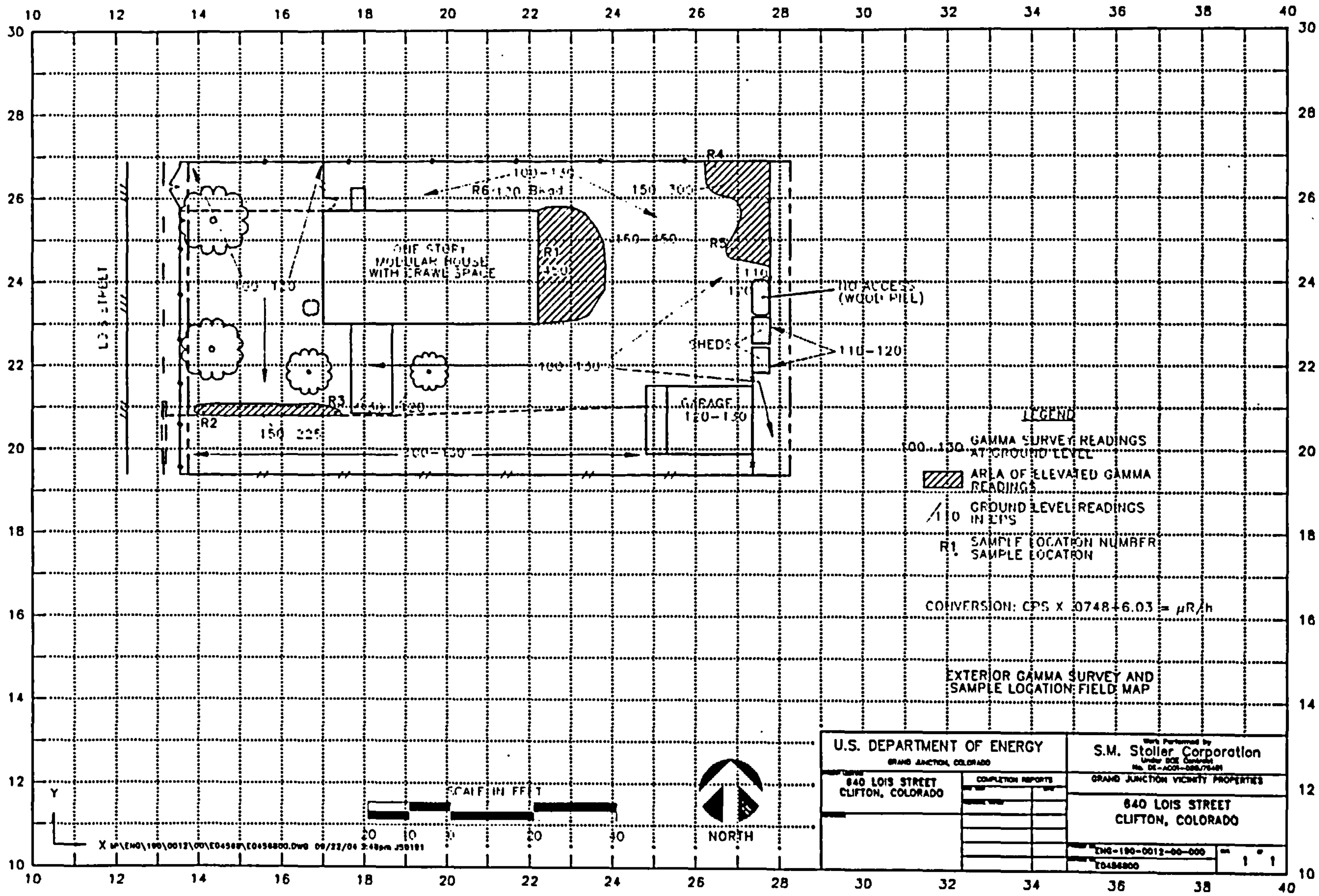


Figure 4. Exterior Gamma Scan and Sample Location Field Map

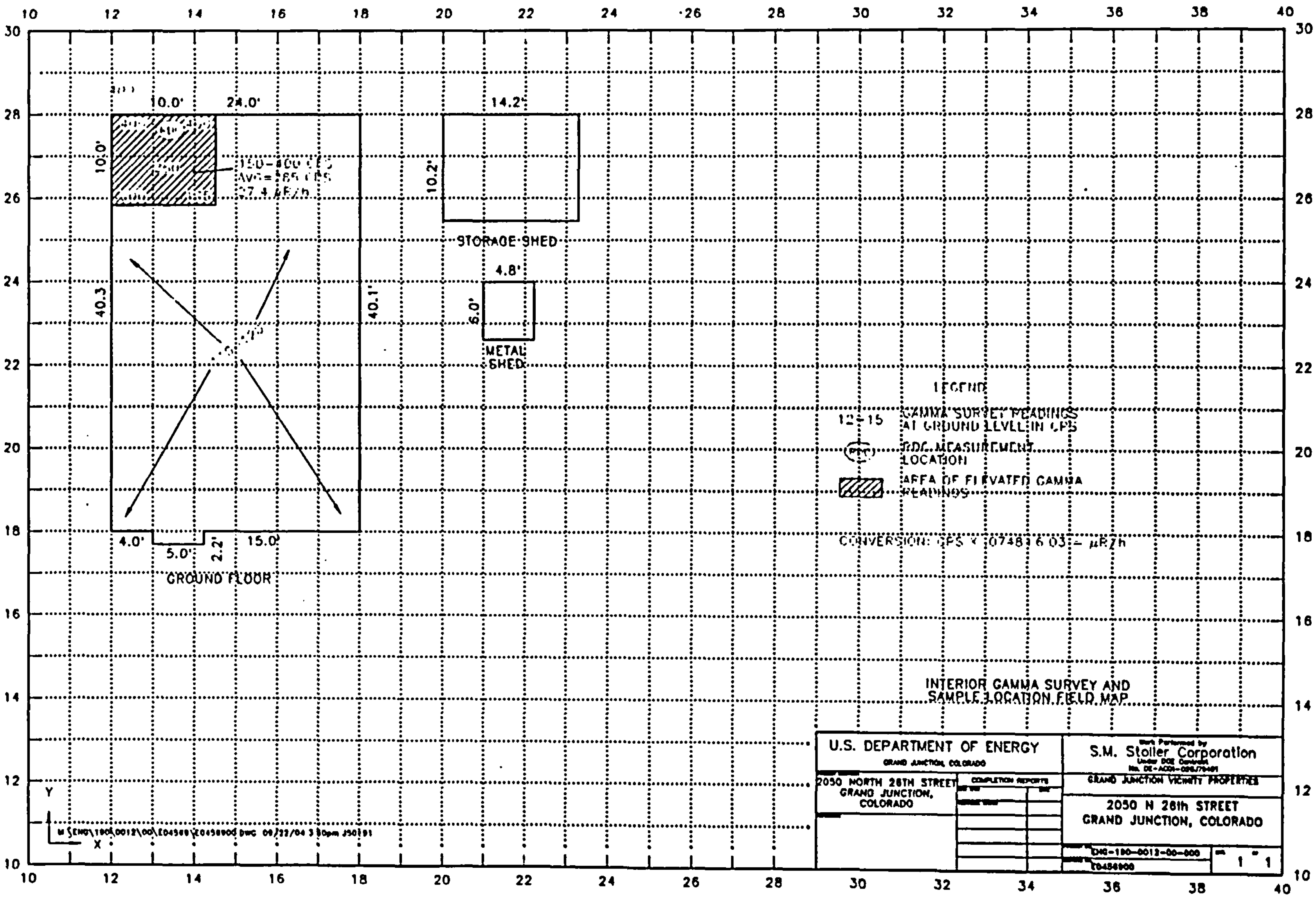


Figure 5. Interior Gamma Survey and Sample Location Field Map

DOE ID No. ____________________

Address: ________________________________

VICINITY PROPERTY SUMMARY EVALUATION AND FINDINGS

1.0 Summary Evaluation

	Inclusion Survey Contractor			U.S. Department of Energy (DOE)		
	Yes	No	Not Taken*	Yes	No	Not Taken*
1.1 Exterior Measurements						
Gamma is > 25 µR/h above background averaged over 100 m^2						
Gamma is less than 30% above background averaged over 100 m^2						
Radium-226 is > 5 pCi/g above background in top 15 cm layer averaged over 100 m^2						
Radium-226 is > 15 pCi/g above background in any subsurface 15 cm layer averaged over 100 m^2						
1.2 Interior Measurements						
Gamma is > 20 µR/h above background averaged in any room (9.3 m^2)						
Gamma is less than 30% above background in all rooms						
Annual average radon decay-product concentration is < 0.02 working level						

Other: ____

*Data was not taken because:
[ ] Data were not required to derive the findings.
[ ] Property owner did not authorize access for interior sampling.

Figure 6. Vicinity Property Summary Evaluation and Findings

DOE ID No. ________________

Address: ______________________________

2.0 Contractor Findings

The following table shows the property that was investigated by S.M. Stoller Corp. to determine whether the radiation levels exceed the guidelines specified by EPA for residual radioactive material at UMTRA vicinity properties. The table also shows S.M. Stoller Corp. evaluation and DOE's evaluation for this property.

Summary Table of Evaluation

DOE ID Number	S.M. Stoller Corp. Evaluation Exceeds Guidelines		DOE's Evaluation		
			Exceeds Guidelines		Additional Data Required
	Yes	No	Yes	No	
	[ ]	[ ]	[ ]	[ ]	[ ]

Based on S.M. Stoller Corporations evaluation:

☐ This property is recommended for inclusion.

☐ This property is recommended for exclusion.

______________________________ ______________

Toby Wright
Moab Project Manager

Date

______________________________ ______________

U.S. Department of Energy Evaluator

Date

Figure 7. Contractor Findings

DOE ID No. ____________________

Address: ________________________________

3.0 U.S. Department of Energy Evaluation

3.1 Additional Data Required:

____

____

____

____

3.2 S.M. Stoller Corp. Response to Request for Additional Data:

____

____

____

____

3.3 DOE Approval or Response:

Based on DOE's review of this evaluation, including the further information provided by S.M. Stoller in Section 3.2 above, the recommendation for the above property is listed below:

____

____

____

____

____________________________________ ____________________

U.S. Department of Energy Evaluator Date

Figure 8. U.S. Department of Energy Evaluation

FIELD ASSESSMENTS SECTION

REPORT OF INCLUSION/EXCLUSION

FOR

GJ-00410

GRAND JUNCTION, COLORADO

Submitted: June 16, 1995

Prepared for
U.S. Department of Energy

Prepared by
S.M. Stoller
Grand Junction, Colorado

<u>**CONTENTS**</u>

Figure 9. Example of Report of Inclusion/Exclusion

DOE ID NO. GJ-00410

Report of Radiological Survey

1.0 Introduction

A radiological screening survey of DOE ID number GJ-00410 was conducted by S.M. Stoller. This survey was conducted using methods, as defined in the *Vicinity Properties Management and Implementation Manual*, UMTRA-DOE/AL-050601 (March 1988) and the S.M. Stoller *Field Assessments Procedures Manual.*

The radiological survey of this property included gamma scans of the entire ground surface (interior and exterior), samples of exterior soil, and evaluation of historical data when present. An assessment also was performed on this property to determine the aeral and vertical extent of contamination. The results of the radiological assessment are shown in the Appendix A.

2.0 Summary of Recommendation

DOE ID number GJ-00410, located at 164 South Street, is recommended for inclusion based on the following:

- Radium-226 concentration is greater than 5.0 pCi/g above background in the surface 15-cm soil layer averaged over 100 m^2.

3.0 Results and Conclusions

This property was previously excluded by the DOE based on Oak Ridge National Laboratory's recommendations; however, during the assessment investigation of GJ-00222-RS, located at 252 South Street, contamination was found to spill over on to this property in sufficient concentration to recommend inclusion.

The exterior background gamma exposure rate is 13 µR/h; the interior background gamma exposure rates for the two story rock and frame house is 13 µR/h. Seven regions of exterior elevated gamma exposure rates were found and labeled Regions E1 through Regions E7 (Appendix A, Figure 1). For brevity, Region E1 was the only region used for evaluation to determine the inclusion/exclusion recommendation. This region has the greatest potential for exceeding the U.S. Environmental Protection Agency (EPA) guidelines.

Figure 10. Example of Report of Radiological Survey

Two soil samples collected from Region E1 (Location Numbers R1 and R13, Figure 1, Appendix A) yielded a net area-weighted average radium-226 concentration of 138.1 pCi/g. This value is greater than the EPA guideline of 5.0 pCi/g above background for surface soil averaged over 100 m^2. The gross radium-226 concentration results for the soil samples are shown in Table 1, Appendix A.

The soil samples and in-situ measurement results of the remaining regions and the background area are shown in Table 1 of the Appendix A.

Contamination spills over from the south (DOE ID number GJ-00222-RS), located at 252 South Street.

/ljg

Figure 11. Example of Report of Radiological Survey

PROPERTY/OWNER INFORMATION

DOE ID Number: GJ-00410

Property Location:	164 South Street, Grand Junction, Colorado 81501
Property Owner:	
Owner Address:	
Telephone Number:	
Occupant/Tenant:	
Telephone Number:	
Property Classification:	Residence
Total Area of Property:	3,897 m^2
Structures on Property:	Two story rock and frame house and a metal shed

Looking west

Figure 12. Example of Property/Owner Information

Radiological Screening Survey Results Exterior Screening		
Mean Background Exposure Rate (μR/h):	13	
Background Plus30 Percent (μR/h):	17	
Exposure-Rate Range in Contaminated Regions (μR/h):	Region E1	17-157
Region of Highest Exterior Gamma Exposure Rate (μR/h):	Region E1	157
Point Sources (Discussed in Section 3.0):	None	
Estimated Area of Exterior Contamination by Region (m^2):	Region E1	16.4
Net Estimated Area-Weighted Average Gamma Exposure Rate by Region (μR/h):	Region E1	12

Radiological Screening Survey Results Interior Screening		
Structure Description or Number:	Two story rock and frame house with basement	
Mean Background Exposure Rate (μR/h):	12	
Background Plus30 Percent (μR/h):	16	
Region of Highest Exterior Gamma Exposure Rate (μR/h):	General	13
Point Sources (Discussed in Section 3.0) :	None	
Net Estimated Area-Weighted Average (μR/h):	N/A	

Formula used to calculate the net estimated area-weighted average gamma exposure rate for interior and exterior screening:

$$G_{AW} = \sum_{i=1}^{n} \frac{G_i \times A_i}{X}$$

G_{AW} = the net area-weighted average gamma exposure rate (μR/h)
G_i = a series of average gamma exposure rates less background (μR/h)
A_i = a series of areas within regions of contamination (m^2)
X = threshold area (100 m^2 for exterior and 9.3 m^2 for interior)

Figure 13. Example of Table of Radiological Screening Survey Results

DOE ID Number GJ-00410
164 South Street

Extended Survey Results Exterior Extended Data			
Sample Location Number:	R1	R13	R9
Region Sampled:	E1		Bkgd
Sample Depth (cm):	15		
Radium-226 Concentration (pCi/g):	1,668.2	19.8	1.0
Representative (Biased) Sampling Area (m²):	16.4		0
Net Estimated Area-Weighted Average (pCi/g):	138.1		N/A

Formula used to calculate the net estimated area-weighted average radium-226 concentration in soil:

$$C_{AW} = \sum_{i=1}^{n} \frac{C_i \times A_i \times D_i}{100 \times 0.15}$$

C_{AW} = the net area-weighted average radium-226 concentration (pCi/g)
C_i = a series of average radium-226 concentrations less background (pCi/g)
A_i = a series of areas within regions of contamination (m^2)
D_i = a series of depths of samples (m)
100 = the area used in averaging (m^2)
0.15 = the depth of sample used in averaging (m)

Figure 14. Example of Table of Exterior Radiological Survey Results and Data

Attachment 2
Excavation Control and Verification Procedures

1. Purpose

The purpose of this procedure is to define the radiological release criteria and procedures used for excavation control, verification to U.S. Environmental Protection Agency (EPA) standards, and related activities during remedial action for soils contaminated with residual radioactive material (RRM) associated with the Moab site.

2. Authorized Limits and Background Values

Table 1 summarizes the authorized limits for radiological contaminants in soil for the Moab Project.

Table 1. Authorized Limits for Soils, Including Background

Contaminant	Authorized Limits, Including Background			
Ra-226 (pCi/g)	Surface		Subsurface	
	6		16	
Th-230[a] (pCi/g)	Surface		Subsurface	
	Ra-226	Th-230	Ra-226	Th-230
	1	13	1	42
	2	12	2	40
	3	10	3	38
	4	8	4	36
	5	6	5	35
	6	6	6	33
			7	31
			8	29
			9	27
			10	25
			11	23
			12	22
			13	20
			14	18
			15	16
			16	16
Total U (pCi/g)	Case by Case Basis		Case by Case Basis	

[a]The Moab millsite will be remediated and soils verified for Ra-226 and Th-230. The Moab vicinity properties will be remediated for Ra-226.

The authorization limits for the millsite are based on compliance with 40 CFR 192.12.

Authorized background radionuclide values for the projects in Table 1 are shown in Table 2.

Table 2. Authorized Background Values for Radionuclides

Program	Radium-226 (pCi/g)	Thorium-230 (pCi/g)	Uranium (pCi/g)	Source for Background Values
Moab Millsite and Vicinity Properties	1.0	0.5	1.2	Analytical laboratory values from background field samples collected

NOTE: To allow for the variability of the Opposed Crystal System (OCS) and delta-gamma instrument measurements for Ra-226, a criteria of 5 picocuries per gram (pCi/g) and 15 pCi/g, will be used for the Moab Project.

A more detailed explanation of the standards follows:

40 CFR 192 contains requirements for radium in soil, interior gamma levels, and radon in habitable buildings. These standards are:

- **Radium in Soil:** The Ra-226 concentration in soil shall not exceed 5 pCi/g above background in the first 6 inches (15 centimeters [cm]) of soil (surface standard), averaged over 1,076 square feet (ft^2) (100 square meters [m^2]); and 15 pCi/g above background in any subsequent 6-inch (15-cm) layer (subsurface standard) averaged over 1,076 ft^2 (100 m^2).

- **Interior Gamma Radiation:** In any occupied or habitable building the level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour (µR/h). The U.S. Department of Energy (DOE) will apply the EPA standard as an average over a room-sized area of 100 ft^2 (9.3 m^2).

- **Radon:** A reasonable effort shall be made to achieve an annual average (or equivalent) radon decay-product concentration (including background) not to exceed 0.02 working level (WL). In any case, the RDC (including background) shall not exceed 0.03 WL.

UMTRA Project Th-230 Protocol: Th-230 undergoes radioactive decay to produce Ra-226. During remediation of Uranium Mill Tailings Remedial Action (UMTRA) Project millsites, a thorium standard was developed which ensures that, as Th-230 decays, the Ra-226 standard will not be exceeded over a 1,000-year performance period. The allowable amount of Th-230 is dependent upon the concentration of Ra-226 left in place. Table 1 shows the relationship of Th-230 to Ra-226 left in place.

Uranium: DOE may also perform removal of uranium-contaminated soils beyond what is required for compliance with EPA standards for Ra-226. DOE would consider removal of uranium-contaminated soils if doing so would enhance the ground water compliance strategy. If removal of uranium-contaminated soils is performed, clean-up goals for the uranium will be discussed with the U.S. Nuclear Regulatory Commission.

Radioactive material (RAM): must be transported according to procedures contained in U.S. Department of Transportation (DOT) regulations (49 CFR parts 171–178) or blended on site with contaminated material of a lower activity until it falls below the cut-off criteria. Under no circumstances should a package, which is suspected to contain radioactive or hazardous material, be transported until the appropriate shipping procedures have been completed by a certified shipper.

3. Excavation Control Procedures

3.1 Purpose

Excavation control assures that applicable radiological soil standards are met prior to verification sampling. Monitoring and sampling for Th-230 and uranium soil contamination is typically performed after the Ra-226 standard has been met (if applicable).

3.2 Preconstruction Survey Procedures

Guided by the Radiological and Engineering Assessment (REA) or verification plan, gamma scintillometers are used to relocate and mark previously identified areas of surface contamination. On properties greater than half an acre, a land surveyor may also assist the team by establishing grids and by locating and marking deposits based on previous data.

3.3 General Standard Excavation Control Procedure

After contaminated soil is excavated, gamma-scan surveys, beta-gamma surveys, and soil sampling are used to define any remaining contamination in the excavation. Excavation depths and boundaries may be increased or decreased based on the data collected. This process continues until acceptable concentrations of Ra-226, Th-230, or total U, if applicable, are determined within the excavated areas. Soil samples will be analyzed using the OCS for Ra-226 concentrations and by a High Purity Germanium photon detector (HPGe) system for uranium concentrations (semi-quantitative values only), if applicable. Th-230 soil concentrations will be determined using an approved analytical laboratory.

3.4 General Global Positioning System/Gamma Scan (GPS/GS) Procedure

A GPS/GS Procedure may be used in lieu of the Standard Excavation Control Procedure described in Section 3.3. This procedure will be used to demonstrate compliance through surface gamma measurements averaged over large areas rather than point-by-point compliance. The procedure will be used primarily where windblown contamination is prevalent and depth of contamination is fairly consistent. The procedure offers less soil sampling than the "standard" procedure.

3.5 Excavation Control Definitions

Background: Typically, the scintillometer background reading is approximately 120 counts per second (cps) at the surface and 200 cps subsurface (greater than 15-cm [6 inches]). The OCS background is 1 pCi/g for Ra-226 for the Moab millsite and vicinity properties (VPs). Action levels specified in the procedures are based on these background levels.

Surface: The surface is gamma scanned and contaminated material is excavated until the 5 pCi/g radium cutoff is met as measured by the OCS. At applicable sites, isolated "hot spots" (up to 300 cps) of contaminated material may remain in place provided it is clearly documented in the Excavation Control and Verification Survey Log (Figure 1) that all relevant criteria have been met. For these areas, averaging techniques (Section 7.1) are used.

Subsurface: For subsurface layers (greater than 15-cm [6 inches]), excavation will continue until the 15 pCi/g radium cutoff is met as measured by the OCS at applicable sites. Isolated "hot spots" (up to 400 cps) of contamination may remain in place, provided it is clearly documented in the Excavation Control and Verification Survey Log (Figure 1) that all relevant criteria have been met.

An average count rate in the excavation is determined by hand scanning the excavated area and recording on the verification map the low and high gamma readings observed in the excavation. The most commonly observed gamma reading in the excavation is considered the excavation's average gamma reading. Excavation considerations may be required, taking into account various site conditions, such as excavation geometry and shine.

Anomalous areas, those with measurements 30-percent above the average count rate in the excavation, will be explored to assure that a buried tailings deposit does not exist. A 4- to 6-inch-deep shovel hole shall be made and a gamma measurement taken in the hole. A 30-percent or greater increase in the gamma count rate shows the need for further excavation. Soil samples may be taken to help determine if additional excavation is required.

Soil samples will be obtained from areas within the excavation. Those samples exceeding the applicable surface or subsurface criteria show the need for further excavation. Guidance for continued excavation will be based on the relative gamma readings within the excavation, or the OCS soil sample result, or both. (See Attachment 6, "Radiological Soil Sampling.")

Excavation Control Value: Data from the OCS are used to develop a correlation between the GPS/GS gamma exposure rates and the actual grid unit Ra-226 concentration values. The correlation data are analyzed to determine a two sigma upper limit for the gamma exposure rate (the two sigma GPS/GS limit being the exposure rate at which 95 percent of soil concentrations are expected to be below 15 pCi/g). That value, in μR/hr and called the excavation control value, is then used to control excavation. Typically, a gamma scan value equivalent to ~10.0 pCi/g Ra-226 is found to be appropriate for excavation control when applying the subsurface cleanup standard, allowing for inherent variability in the relationship between gamma exposure rate and soil Ra-226 concentrations. A gamma scan value equivalent to ~3.5 pCi/g Ra-226 will be used when applying the surface cleanup standard.

3.6 Excavation Control on Vertical Surfaces

A gamma scintillometer is used to scan the vertical faces of an excavation. If the following guidelines are exceeded, the anomaly shall be removed or soil sampling will be performed to demonstrate that the area meets the standard:

- The surface (first 6 inches) layer in the wall of the excavation shall not exceed 30-percent above the average gamma reading for the surface area of the excavation.

- Subsequent 6-inch (15-cm) layers in the walls of the excavation shall not exceed 30-percent above the average gamma reading of the excavation face.

The procedure for obtaining composite soil samples from vertical face cuts (e.g., under concrete slabs, asphalt, etc.) will be as follows:

- Composite-sample the area in 6-inch layers for each 10-foot (ft) horizontal interval. The sample aliquot should be taken at the highest gamma location in the interval. A minimum of 500 ml of material is needed.

- For surface concrete slabs that are not contaminated and are less than 6 inches (15 cm) thick, sample only the material under the slab. Then calculate the radium contamination over a full 6-inch (15-cm) interval (including the slab) and compare to the surface standard.

- The average Ra-226 concentration in the composite layer will be calculated using the following equation:

$$\frac{[A \times B] + [(6 - A) \times C]}{6}$$

Where:	A =	thickness of the interval from which soil sample was taken (inches)
	B =	concentration determined from soil sample (pCi/g)
	C =	concentration of interval not sampled (typically this is assumed to be the default background value given in Table 2)
	6 =	interval over which the EPA standard is applied in inches

Example: 4-inch-thick concrete slab with 2 inches of contaminated material under the slab. The 2-inch-thick lens contains 20 pCi/g Ra-226 and the 4-inch-thick slab is assumed to contain 2 pCi/g Ra-226.

Therefore

$$\frac{[2 \times 20] + [(6 - 2) \times 2]}{6} = 8 \ pCi/g$$

This value exceeds the surface soil standard and the slab and soil under it should be removed. Additional sampling may be required to ensure that the exposed surface is representative of the material under the entire area of the slab.

3.7 GPS/GS Excavation Control Procedure

A GPS/GS may be used to scan applicable areas of the site, as per Section 3.4, providing location and gamma exposure rate data over the areas. The vehicle-based system utilizes the Garmin

Legend (WAAS-enabled [accuracy-enhanced]) or equivalent handheld GPS unit to transmit date, time and location (latitude/longitude) data to a portable computer, at the same time exposure rate data from a Ludlum 2350/44-10, 2-inch NaI gamma detector system is recorded on the same computer. The data are jointly logged once per second, and may be plotted, color-coded for exposure rate, using ArcInfo (geographic information system) tools. An alternate system uses the Garmin iQue combination handheld WAAS-enabled GPS and PDA unit, acquiring and storing data directly from its internal GPS system, and accepting radiation data from an external Ludlum 2350/44-10 unit. (This alternate system is often used in a "backpack" configuration, allowing recording of location and exposure rate data by an individual walking over terrain difficult to navigate with a vehicle-based system.) In both systems, the gamma-detecting probe is suspended approximately 3 ft above the soil surface.

Data from the GPS/GS system are initially correlated with a set of 30 to 50 composite soil samples taken from 10 × 10 m grid units. The grid units are selected to present reasonably uniform gamma exposure rates over their surface areas, and to represent a range of average Ra-226 concentrations from background levels to concentrations exceeding 15 pCi/g. The composite soil samples are each composed of nine, 6" depth aliquots, from locations uniformly distributed over each 10 × 10 m grid unit. The composite samples are collected in accordance to procedures stated in Attachment 6, "Radiological Soil Sampling," and analyzed on-site utilizing the OCS following procedures stated in Attachment 3, "Soil Sample Analysis Using The Opposed Crystal System."

Data from the OCS are used to develop a correlation between the GPS/GS gamma exposure rates and the actual grid unit Ra-226 concentration values. The correlation data are analyzed to determine a two sigma upper limit for the gamma exposure rate (the two sigma GPS/GS limit being the exposure rate at which 95% of soil concentrations are expected to be below 15 pCi/g). That value, in μR/hr and called the excavation control value, is then used to control excavation. Typically, a gamma scan value equivalent to ~10.0 pCi/g Ra-226 is found to be appropriate for excavation control to meet the subsurface standard, allowing for inherent variability in the relationship between gamma exposure rate and soil Ra-226 concentrations. (If backfill is not used, the gamma scan value equivalent of 3.5 pCi/g Ra-226 will be used.)

Excavation control is performed by directing the excavation equipment to remove soil from areas identified during the initial GPS/GS site scan as exceeding the excavation control value. Following each soil removal pass, additional GPS/GS scanning is performed until all locations within the remediated area meet the excavation control value.

3.8 Unassessed Surface Areas Located During Construction

Anomalous areas, where surface gamma scintillometer measurements are 30-percent above the background for the property, will be explored to assure that buried tailings deposits do not exist. A 6-inch (15-cm) soil sample will be collected and a scintillometer measurement will be made in the hole. If the OCS analysis is greater than 5 pCi/g Ra-226, or if there is a 30-percent increase of the scintillometer readings in the hole, the area shall be further investigated.

4. Exterior Verification Survey

After tailings are excavated, verification surveys shall be performed in remediated areas to verify that excavated areas meet the soil standards specified in Table 1. Gamma scanning, soil samples, or both will be used to document the post-remediation radiological condition of the property, depending on the verification methodology.

4.1 Verification Mapping

The grid system for both the VP and millsite areas is based on Utah State Plane coordinates; however, a site-specific mapping and grid system will be used for the Moab Project site (millsite).

The mapping and grid system will divide the millsite property into 68 sections measuring 180 by 210 m. Each of these maps have been given a unique double letter designation from an alphabetic system based on an X, Y coordinate system. Each individual map is scaled to a 1:30 drawing with a 10- by 10-m grid. This unique system is used to set 30-m centers across the site, using wooden lath and stakes, establishing a grid system for Field Services personnel to collect radiological measurements for site verification. The 30-m centers are used to further delineate 10- by 10-m verification grids for each of the maps. There are 378 10- by 10-m grid blocks on each of the maps and the following unique numbering system will be used to identify verification areas for each map (Figure 2).

The 10- by 10-m grid blocks will be consecutively numbered beginning with the northwest grid block and moving west to east and north to south across the map. A system of letters and numbers will be used to track the location and identity of the verification soil samples.

V	=	Verification Sample
X	=	Excavation Control Sample
KJ	=	Map Designation Letter
180	=	Grid Block Number

Example: When a soil sample is submitted to the OCS operator and labeled as V-KJ-180, it can be identified as a verification sample from the 180 block of map KJ. A soil sample labeled as X-LG-165 would be identified as an excavation control sample from the 165 block of map LG. Since there is the potential to have more than 25,000 verification areas, this unique system allows the entire site to be pre-numbered and also gives the exact location of the soil sample in the identifying sample number.

A GPS will also be used to help physically locate V-areas, soil samples or gamma anomalies. This GPS may be linked to a portable computer or PDA unit for plotting V-areas/soil locations or color coded gamma exposure rate information. This system will also utilize ArcInfo(geographic information system) tools and will simultaneously be able to transmit date, time and location (latitude/longitude) data to the same portable computer or PDA.

4.2 Verification Definitions

V-areas are previously assessed areas of contamination that are excavated to remove residual radioactive materials. V-areas are documented on the vicinity property verification maps as V-1 through V-n ("n" represents the integer identifying the last verification area). The excavated portions of the property are divided into approximately 100 m^2 areas and numbered appropriately. Verification soil samples are then collected from the V-areas, as required.

Verification Soil Samples are collected to demonstrate compliance with the appropriate soil standards.

Aliquots are individual samples collected from a grid block within a V-area. The verification sample may be composited from two to twelve aliquots.

Standard Verification (SV) is a soil verification method based on subdividing a V-area of approximately 100 m^2 into 3.3 by 3.3 m grid blocks. An aliquot is taken from the center of each grid block and one to nine aliquots are combined to form the verification samples (Figure 3).

4.3 Gamma Scintillometer Scan

Scintillometers and Exposure Rate Meters used for gamma-scan surveys shall have a current calibration and daily operational check performed.

Two methods of Verification and gamma scanning protocols will be employed on the Moab Project Site, which include the SV and GPS/GS methods. The SV scanning method will involve technicians using hand held gamma instrumentation in the excavation areas obtaining gamma scan information from specific areas of removal. Mapping and documentation of these types of scans will be accomplished through the use of on-site grid systems for physical location and annotation of data onto hard copy field maps for the areas being surveyed.

The GPS/GS scanning method will involve technicians using an integrated scanning system, combining real time GPS technology for physical location. Automated gamma measurements will be taken congruently and stored electronically in either a handheld iQue or pen-top computer. This information is collected from specific excavation areas via an ATV or backpack configured system. Mapping and data management will be accomplished through the use of system software, and may be GIS enhanced, if appropriate. Hard copy gamma maps will then be generated of the scanned excavation areas.

4.3.1 For Standard Verification the excavated area shall be gamma scanned with personnel using hand held Mount Sopris SC-132 crutch scintillometers. The range and average of scintillometer readings shall be recorded on the verification map. Elevated readings from adjacent areas (spillovers) may also be recorded on the map (VPs only). The readings for the SC-132 shall be converted to exposure rates using the factor from the following equation. (The equation is based on a correlation factor that is derived from comparison of readings to a Pressurized Ion Chamber.)

$$\text{microRoentgen per hour} = (\text{cps} \times 0.0748) + 6.03$$

The range is determined by observing the high and low gamma scintillometer readings; the average is the gamma scintillometer reading most commonly observed during the scan of the excavation.

4.3.2 For GPS/GS Verification the final verification of cleanup is performed via a 100%-coverage GPS/GS scan of all remediated areas. Soil samples will be taken following completion of remedial action. The final GPS/GS scan data set for an area (including soil analysis data), demonstrating that the remediated area meets the applicable soil cleanup standard, will become the final verification record. Given the development of a defensible correlation between GPS/GS gamma scan data and correlation soil sample analyses, roughly 5% of the total number of final verification grid units will be soil sampled and analyzed as per procedures stated in Attachment 6, "Radiological Soil Sampling," for verification confirmation purposes. This GPS/GS Verification Procedure will not be used in areas where process knowledge or assessment data indicates deep deposits or the potential for significant disequilibrium between Ra-226, and Th-230 and/or U-238 soil concentrations.

Where gamma exposure interference from another source (shine) makes it difficult to use unshielded probes (see Section 4.6) to perform excavation control, a shielded probe will be used for excavation control. The shield consists of a 1 inch-wall lead cylinder covering the outside (but not the bottom) of the 44-10 cylinder and extending above the 2 inch-high NaI detector crystal located inside the 44-10 probe cylinder. Because such shielding is likely to be necessary during the project, shielded systems will be employed at the same time as unshielded systems are being employed during development of correlation data between gamma exposure rates and soil Ra-226 OCS analyses. When excavation control is performed using shielded (columnated) probes, the shielded-probe excavation control exposure rate value will be used in place of the unshielded-probe value.

The GPS/GS Verification Procedure may not be used where very high gamma exposure interference from another source (such as the tailings pile) makes it difficult to use shielded probes to perform excavation control. Standard Verification Procedures may be used to verify the soils in these areas in accordance with procedures stated in Section 4.4.

4.4 Soil Sampling Protocol

Verification sample locations are based on a grid system overlain onto the excavation. For each V-area, a composite sample is collected consisting of one aliquot from each grid block. The aliquots shall be of equal volume and represent a 6-inch (15-cm) depth interval.

For small verification areas, an individual sample may be collected.

If the sample exceeds the applicable soil standard, additional excavation will be performed, and the area will be resampled. Once sampling shows that the contaminant concentration is below the applicable standard, no further sampling is required.

Verification samples may be split (reduced in volume) following protocols contained in Attachment 6, Radiological Soil Sampling.

4.5 100-m^2 Standard Verification Method

A 100-m^2 V-area will be subdivided into nine 3.3 by 3.3 m grids (Figure 2). Each 100-m^2 V-area shall be gamma scanned, and the range and average of scintillometer readings shall be recorded on the verification field map. The gamma range of the excavated area is determined by observing the high and low gamma scintillometer readings; the average is the gamma reading most commonly observed during the scan of the excavation.

Composite soil samples will be taken from the V-area to verify compliance with soil remediation goals. Aliquots will be taken from the geometric center of each 3.3 by 3.3 m cell and sampled as above.

For both the VP and the millsite areas, verification soil samples will be analyzed on-site, for Ra-226 concentrations using the OCS. In addition, soil samples may be analyzed on-site for total uranium (for screening purposes only) by the HPGe system. For both the VPs and millsite, 10-percent of the total samples will be analyzed by an analytical laboratory for Ra-226. (For QA/QC comparison purposes relative to Lab vs: OCS analysis. The total number of samples submitted to the Lab may be reduced to 5% after a statistically valid correlation between OCS and Lab radium results is established.) Selected millsite samples may be analyzed by a subcontracted laboratory for Th-230 and total uranium. All of the samples analyzed by an analytical laboratory will use gamma spectrometry for radium, alpha spectrometry for thorium, and ICP mass spectrometry for uranium. Only OCS radium results are used for the final completion report; however, the analytical laboratory results for Th-230 and total uranium, when applicable, will also be reported for the final completion report.

4.6 Global Positioning System/Gamma Scan (GPS/GS) Verification Method

The final GPS/GS scan data set for an area (including soil analysis), demonstrating that the remediated areas meet the applicable standards, will become the final verification record. Given the development of a defensible correlation between GPS/GS gamma scan data and correlation soil sample analyses, roughly 5% of the total number of 100m^2 final verification grid units proposed will be soil sampled and analyzed as per procedures stated in Attachment 6, "Radiological Soil Sampling," for verification confirmation purposes. The composite soil samples will be taken from selected V-areas using the same protocols as those for Standard Verification Methods. The OCS radium analysis data results will be used for the final completion report.

4.7 Cobble Soil Sampling

Because of the difficulties in obtaining a representative sample from cobbly soils, this procedure is used to separate the sample into a cobbles and a fine fraction using a number, sieve (¼-inch screen). This procedure should be applied to material that contains rocks larger than 1-inch in diameter. (The NRC approved in April 14, 1992, RAC-OP-003 Procedure for "Bulk Radionuclide Determination, Excavation Control, and Site Verification for Cobbly Soils."

Aliquots will be collected from each individual grid area using a shovel. Samples should be of approximate equal volume and represent a 6-inch-depth (15-cm-depth). Rocks larger than 6-inch-diameter should be excluded from the sample. These larger cobbles contribute only background amounts of radionuclides and due to handling difficulties will be discarded. The aliquots will be combined in a clean, lined (using a standard trash bag) 5-gallon bucket to represent a composite verification sample.

The sample, liner, and bucket will be weighed and the weight recorded on the Cobbles-to-Fines Data Form (Figure 4) as total mass (M_t). The composite sample will be passed through a number 4 mesh sieve to separate the cobbles and fine fractions. The cobbles will be collected in the bucket and weighed again. The weight of the cobbles, liner, and bucket will be recorded on the form as Mass of Cobbles (M_c). The difference between the weight of the total and the weight of the cobbles is the mass of the fines or M_f. An average weight for the bucket and liner (M_b) will be determined by weighing at least ten lined buckets and averaging the results. The average bucket weight may be used for all buckets of that type.

When analyses are completed for the sample, the OCS or analytical laboratory results will be input into the following bulk concentration equation (C_B) to determine the true concentration of the sample.

$$C_B = \frac{(C_f * M_f) + (C_c * [M_c - M_b])}{M_t - M_b}$$

Where:

C_B = bulk concentration of the sample
C_f = concentration of the fine fraction
M_f = mass of the fine fraction
C_c = concentration of cobble fraction (based on previous analysis of cobbles fraction from that site)
M_c = mass of the cobble fraction, including the bucket and liner
M_b = mass of the average bucket and liner (based on previous determination)
M_t = total mass of the sample

Data may also be collected to establish a generic cobbles-to-fines correction factor for the entire site. This will be accomplished by using previously acquired data, and if necessary to ensure representative coverage, digging test pits (three to six) in the cobbly soil. The bulk samples will be sieved through a number 4 mesh screen and the weight ratios of cobbles-to-fines would be calculated for each test pit. These values will be arithmetically averaged to obtain the generic correction factor for the site. Subsequent bulk subsoil samples will be sieved to recover the fines fraction for analysis, but neither size fraction would be weighed. After analysis, the values would be corrected using the generic value to obtain the true concentration.

4.8 Verification of Deep Excavations

Verification personnel shall not enter excavations greater than 4 ft deep that have not been sloped to OSHA requirements (OSHA 29 CFR 1926, Subtitle B). For such excavations, an EL-0047 MOD scintillometer is used to scan the sides and bottom of the excavation. Any areas found to be 30-percent above the average gamma exposure rate observed in the excavation shall be removed.

The bucket of the equipment used for excavation shall be cleaned of visible dirt and then used to collect soil from the bottom and sides of the excavation. Each 10- by 10-ft area in the excavation shall be sampled and the aliquots combined into a composite sample for an excavation area of 25 to 100 m^2.

4.9 Trees and Stumps From Contaminated Areas

In contaminated areas, trees and shrubs that are cut above the soil line may be removed and disposed of as uncontaminated material.

All stumps shall be gamma scanned to determine their disposition. Gamma readings 30-percent above background indicate further decontamination is needed. Gamma ranges shall be recorded on a daily log.

Soil adhering to stumps 18 inches in diameter or smaller may be composite sampled. No more than four stumps will be sampled for each composite. The aliquots will be collected from the soil located at the highest gamma reading on each stump. Stumps greater than 18 inches in diameter shall be sampled individually.

Samples from the stumps shall be analyzed; if the OCS reading is 5 pCi/g Ra-226 or less, the stumps may be released to the landfill. If the sample exceeds 5 pCi/g Ra-226, the stumps must be further decontaminated or taken to the tailings repository. Sample results for the stumps shall be recorded on the Excavation Control and Verification Survey Log (Figure 1).

4.10 Stumps From Uncontaminated Areas

As a Best Management Practice, stumps removed from uncontaminated areas shall be scanned by gamma scintillometers. If gamma scintillometer readings do not exceed 30-percent above background, the stumps can be released to the landfill. If scintillometer readings exceed 30-percent of background, a composite soil sample shall be obtained and analyzed.

4.11 Th-230 and Total Uranium Analysis

If screening for total uranium is required (on a case-by-case basis), it will be performed by using the on-site HPGe system on samples taken in accordance with the procedure presented in Sections 3.7, 4.2, and 4.5.

Final verification analysis for Th-230 and total uranium will be performed by an analytical laboratory using analytical methods as stated in Section 4.4 and on samples taken in accordance with the procedure presented in Sections 3.7, 4.2, and 4.5.

Analytical laboratory results given in micrograms per gram (µg/g) total uranium may be multiplied by the following factors to convert to pCi/g uranium.

0.334 to convert to pCi/g Uranium-238
0.339 to convert to pCi/g Uranium-234
0.016 to convert to pCi/g Uranium-235
0.689 to convert to pCi/g Total Uranium

For uranium ore and mill tailings, Uranium-238 (U-238) and its decay product Uranium-234 (U-234) are normally in equilibrium and contribute equally to the activity of the sample. Uranium-235 (U-235) is a very minor contributor to the total activity.

5. Interior Verification Survey

5.1 Interior Gamma Survey

If elevated interior gamma readings were measured during the assessment of the property, then a post-construction gamma scan of the habitable areas shall be performed. If no elevated gamma readings were found, no interior scan is required. A separate scan range shall be documented for the areas of interior remediation.

The range of scintillometer readings will be recorded on a verification map of the structure, along with the background for the property. If the upper level of the range does not exceed background plus 30-percent or 160 cps (18 µR/h), no further measurements are required.

If the upper level of the range of scintillometer readings exceeds background plus 30-percent (160 cps), or if contaminated material was left in place, gamma readings will be taken in room-sized 9.3 m^2 (10- by 10-ft) areas of the structure where elevated readings occurred. Readings are taken at 10-ft intervals; a more frequent measurement interval may be used to adequately characterize the area. At least five readings should be taken in every 9.3 m^2(10- by 10-ft) area. Readings adjacent to a wall shall be taken at least 2 ft away from the wall.

The average of the five gamma measurements adjacent to and including the highest measurement must be less than 20 µR/h above background, averaged over a room-sized area. All scintillometer readings are converted to µR/h and recorded on the structure drawing.

If gamma readings are elevated due to contaminated materials left in place, the exposure rates shall be obtained before and after reconstruction has taken place.

5.2 Radon Survey

Where an RDC was not taken before remediation, radon measurements will be taken in habitable structures on all vicinity properties after remediation has been completed. If an RDC measurement was taken before remediation, and was less than 0.02 WL, no further RDC measurements need to be taken. The radon measurement will demonstrate compliance with EPA standards. If the RDC value exceeds 0.03 WL, DOE shall take additional efforts to either implement simple fixes, such as activating floor vents or ventilating crawlspaces, or through some additional exterior soil measurements, demonstrate that the radon level is due to an elevated background and not RRM.

Radon measurements will be taken with a track-etch device. An abbreviated method may be used to demonstrate an annual average by taking the measurement for approximately 3 to 4 months in the spring or fall.

Special attention should be taken in placement of track-etch devices to demonstrate an average annual exposure. If basement rooms are used for the measurement, a ground level room should also be used to demonstrate a true average exposure to the resident.

6. Post-Restoration Surveys

A post-restoration survey shall be performed in areas that had elevated readings (shine) due to residual RRM in adjacent areas.

These surveys may also be performed on sites where restoration requires leveling of the ground surface of previously unexcavated areas for drainage or other purposes. In this event, new ground surfaces may be exposed where the radium content does not comply with the surface soil standard of 5 pCi/g above background. For example, an area that prior to leveling was greater than 6 inches in depth and the radium content was compared to the subsurface standard of 15 pCi/g above background, is now at the surface where the radium content must be below 5 pCi/g above background.

The survey will consist of a gamma scan over the areas where leveling occurred using either hand held gamma scintillometers (SC-132's) or utilizing a GPS/GS system following procedures as stated in Section 3. Any area where gamma exposure rates exceed 30 percent above background will be sampled to assure the surface standard of 5 pCi/g above background is met.

7. Tailings Left In Place

Once it is determined that a property exceeds the applicable EPA standards, and the extent of contamination has been assessed, the UMTRA Vicinity Property Management Implementation Manual (VPMIM) directs that tailings deposits shall be removed to the greatest extent possible.

The practice of leaving tailings deposits that cover a relatively small area (such as under stoops, planters, under detached garage slabs, around utility lines extending across the property, or into the interior area) does not comply with the intent of the VPMIM. Additionally, expediting the construction schedule based on an informal cost benefit analysis does not provide appropriate justification for leaving tailings in place.

In certain instances, mill tailings may be left in place by employing mathematical averaging techniques that demonstrate compliance with EPA standards. Such techniques, however, may only be applied in the following unique situations:

- The engineering design cannot provide reasonable assurance that significant structural damage will not occur.
- The safety of workers cannot be assured.
- Mature trees or shrubbery will be permanently damaged and the owner desires to keep them.

In cases where the previously cited situations arise, and averaging shows the EPA standards have not been met, it may be necessary to apply for "Supplemental Standards" per 40 CFR 192.

7.1 Averaging of Tailings Left in Place

The soil criteria specified in Table 1 are stated in terms of a specific concentration averaged over 100 m^2 (1,076 ft^2). The average concentration for a 1,076-ft^2 area containing residual tailings is calculated using the equation:

$$C_{avg} = \frac{C_p \times A_p + (C_r \times [1{,}076 - A_p])}{1{,}076}$$

Where:	C_{avg}	=	radionuclide concentration (pCi/g) averaged over a 100-m^2 area
	C_p	=	concentration of the radionuclide in the pocket in pCi/g
	A_p	=	area of the radionuclide pocket in ft^2
	C_r	=	concentration of the remainder of the 1,076 ft^2 area, including background, in pCi/g
	1,076	=	total area (in ft^2) over which the EPA guideline is applied

Where the top 6 inches of tailings have been removed, the average concentration must be less than 15 pCi/g above background.

For example, assume that a pocket of tailings, greater than 15 cm (6 inches) deep, has an area of 25 ft^2 and a Ra-226 concentration of 150 pCi/g. Also assume that the remainder of the 1,076-ft^2 area has a Ra-226 concentration of 5 pCi/g, which includes the background of 2 pCi/g. The following calculation shows average concentration for the 1,076-ft^2 area:

$$C_{avg} = 8.4\ pCi/g$$

This value would not exceed the subsurface guideline since it does not exceed 15 pCi/g above background.

This averaging technique can be applied only when the concentration of the radionuclide pocket and the average concentration of the surrounding area are known. The concentration of the pocket can be determined by soil sampling, or for concrete, by taking an in-situ delta scintillometer measurement. The concentration of the surrounding area is determined by analyzing a composite soil sample of the area. The average background value of the radionuclide may be used if the background of the surrounding area is unknown (Table 2). Figure 5 shows an example of the form used to document average radium concentration. The form also may be used to document average Th-230 or uranium concentrations by lining out the word radium and writing in "Th-230" or "uranium".

The Explanation of Data Collection form (Figure 6) is used in conjunction with the radium averaging form to document situations which require a more detailed explanation than can be written in the Excavation Control and Verification Survey Log (Figure 1).

If two or more deposits would fit within a 15- by 70-ft rectangle or wrap around a structure, those areas shall be averaged together. The intent of this criteria is to provide a conservative estimate of radium left in place in the event the current structure expands or a new structure is built over the deposit.

7.2 Supplemental Standards

When necessary, Field Services personnel will provide project personnel with the radiological data required for supplemental standards applications. This radiological data shall include all applicable items listed in the Radiological Checklist for the Application of Supplemental Standards form (Figure 7).

8. OCS and Laboratory Soil Analysis

OCS analysis for Ra-226 is performed on all samples and these results are used for the Property Completion Report. As a QC check for OCS, laboratory analysis for Ra-226 is performed on 5 to 10 percent of the total samples analyzed using the OCS. OCS and laboratory test results shall be reviewed for comparison. If laboratory analysis of soil samples indicates that an area verified on the basis of OCS results exceeds the EPA standard, an appropriate action, which may include reassessment of the area in question and additional remedial action, may be required.

9. Backfill Surveys

Backfill material must be below the criteria for radium in soil as stated in Section 2. The radiological characteristics of the backfill will be determined by gamma scanning the area and collection of composite-soil samples of the material. The scanning may be performed using any portable handheld scintillometer that has a current calibration and daily operational check or the GPS/GS system after development of a correlation data set per Section 3.7.

Backfill may be uncontaminated material from the on-site excavation or it may be off-site material such as pit run, topsoil, or sod.

Documentation of commercial backfill verification surveys is sent to Records Management for placement in the Verification Backfill Source file. Documentation of on-site backfill surveys is placed in the property folio.

9.1 On-Site Backfill

Whenever possible, uncontaminated soil that has been removed from an excavation should be stockpiled on site and used as backfill in the original excavation. The following guidelines are used:

- Soil may be used for subsurface (below 6 inches in depth) backfill if the radium concentration is 5 pCi/g or less, as measured by the OCS.

- No on-site materials may be used as backfill for the surface 6-inch layer. (Note: On-site backfill may be used as surface cover if a variance to procedure is documented and the on-site borrow source is appropriately characterized, documenting radium-in-soil values less than or equal to 5pCi/g Ra-226).

Representative samples may also be selected for hazardous characteristics or additional radionuclide analyses.

On-site material that is to be used for backfill will be excavated in 12-inch lifts. The sampling methodology is described below:

- Each candidate area will be completely scanned for anomalous gamma readings using either hand-held gamma scintillometers (SC-132's) or the GPS/GS system. The gamma scan range will be recorded on a field map, and Excavation Control and Verification Survey Log (Figure 1), or color-coded and mapped for gamma exposure rate, using ARC/INFO GIS tools.

- Any 30- by 30-ft section of the borrow area with exposure rates in excess of 30-percent above background will be appropriately characterized and have samples collected from the borrow area. Any material found to exceed 5pCi/g Ra-226, will not be suitable for use as fill or cover.

9.2 Other Sources of Backfill Material

Personnel will perform gamma surveys on all sources of off-site backfill to verify that it is free of contamination.

Pit-run sources and sod farms used on a regular basis will be surveyed only once. Other backfill sources will be surveyed at the discretion of the site supervisor based on the size and frequency of use of the source.

Documentation of the survey will include the map showing the exposure-rate scan range, surveyor's name, survey date, instruments used, and the address or location of the backfill-source area.

Backfill from DOE-owned land or other included properties will be surveyed and used according to the procedures for on-site backfill.

10. Records

The following records may be generated by use of this procedure:

- Excavation Control and Verification Survey Log
- Calculation of Average Radium Concentration Form

- Explanation of Data Collection Form.
- Radiological Checklist for Application of Supplemental Standards
- Backfill Verification Survey Map and Memo
- Soil Sample Catalog
- OCS Data Sheet
- Verification Map

Verification records will be reviewed within two months of the final verification. A Field Supervisor or Manager reviews for accuracy, completeness, legibility, and reproducibility. All other records are forwarded to the project records coordinator.

11. References

40 CFR Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings.*

Federal Register, Volume 40, Number 205, page 56062, October 23, 1981.

U.S. DOE Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites, Revision 2, March 1987, and RESRAD Computer Code, Version 4.0, DOE/CH/8901, June 1989.

U.S. DOE Order 5400.5, *Radiation Protection of the Public and the Environment* and RESRAD Computer Code, Version 4.0, DOE/CH/8901, June 1989.

49 CFR Part 171-178, *Hazardous Material Packaging, Shipping, and Transportation.*

UMTRA Project, Generic Protocol for Thorium-230 Cleanup/Verification at UMTRA Project Sites, December 1993.

Vicinity Properties Management and Implementation Manual, Revision D, March 1988, UMTRA DOE/AL-050601.

EXCAVATION CONTROL AND VERIFICATION SURVEY LOG

PROPERTY ID NUMBER	PROPERTY ADDRESS
SURVEY DATE	CONSTRUCTION INSPECTOR
VERIFICATION TECHNICIANS	SUBCONTRACTOR

INSTRUMENTATION

INSTRUMENT NUMBER	INSTRUMENT TYPE	CALIBRATION EXPIRES	COMMENTS

AREA INFORMATION

PARTIAL VERIFICATION	FINAL VERIFICATION	EXCAVATION CONTROL

AREA UNDER EXCAVATION (INTERIOR/EXTERIOR)

SIGNATURE	DATE

EC BLANK FORMS - FEB 200[illegible]

Figure 1. Excavation Control and Verification Survey Log

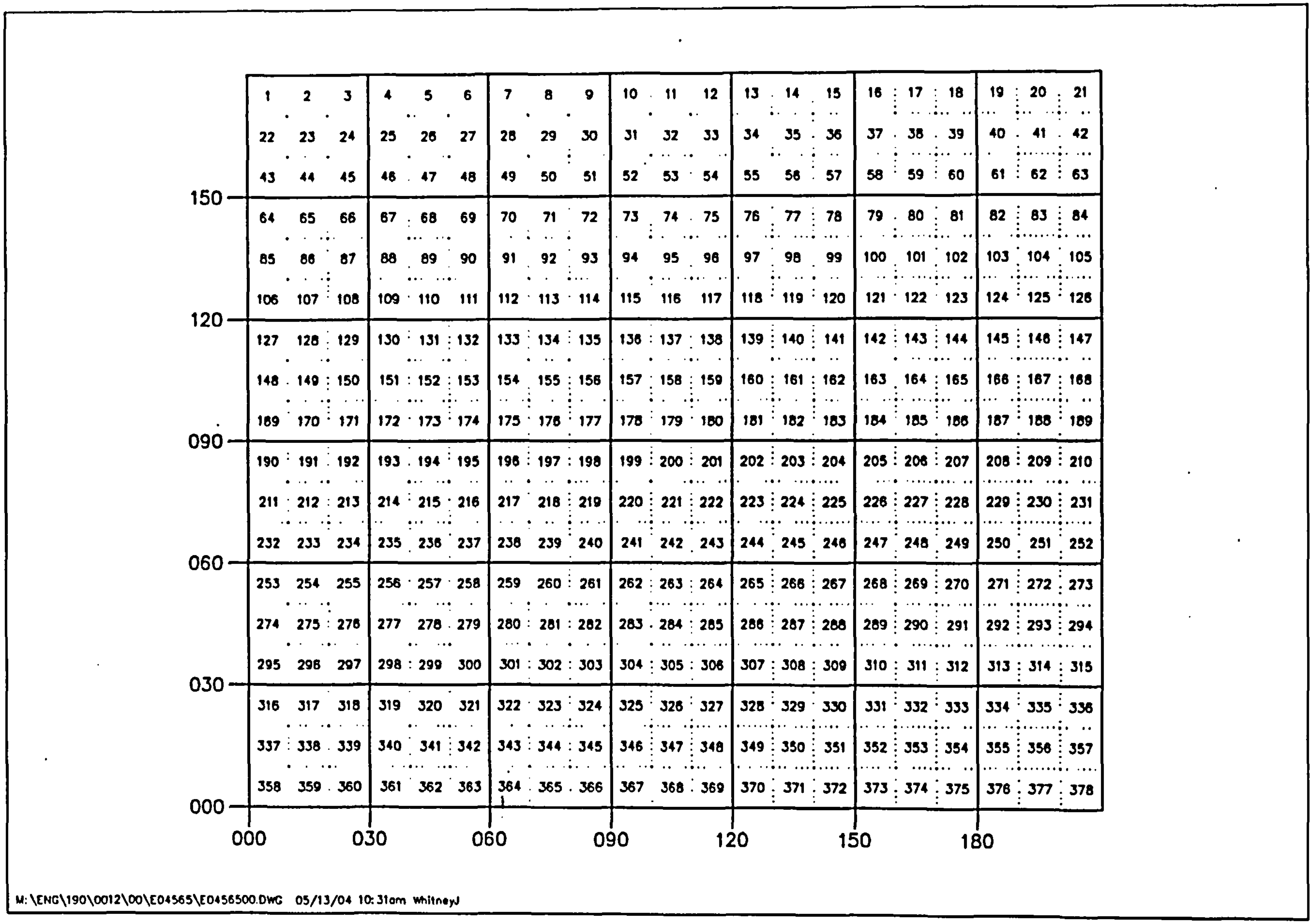
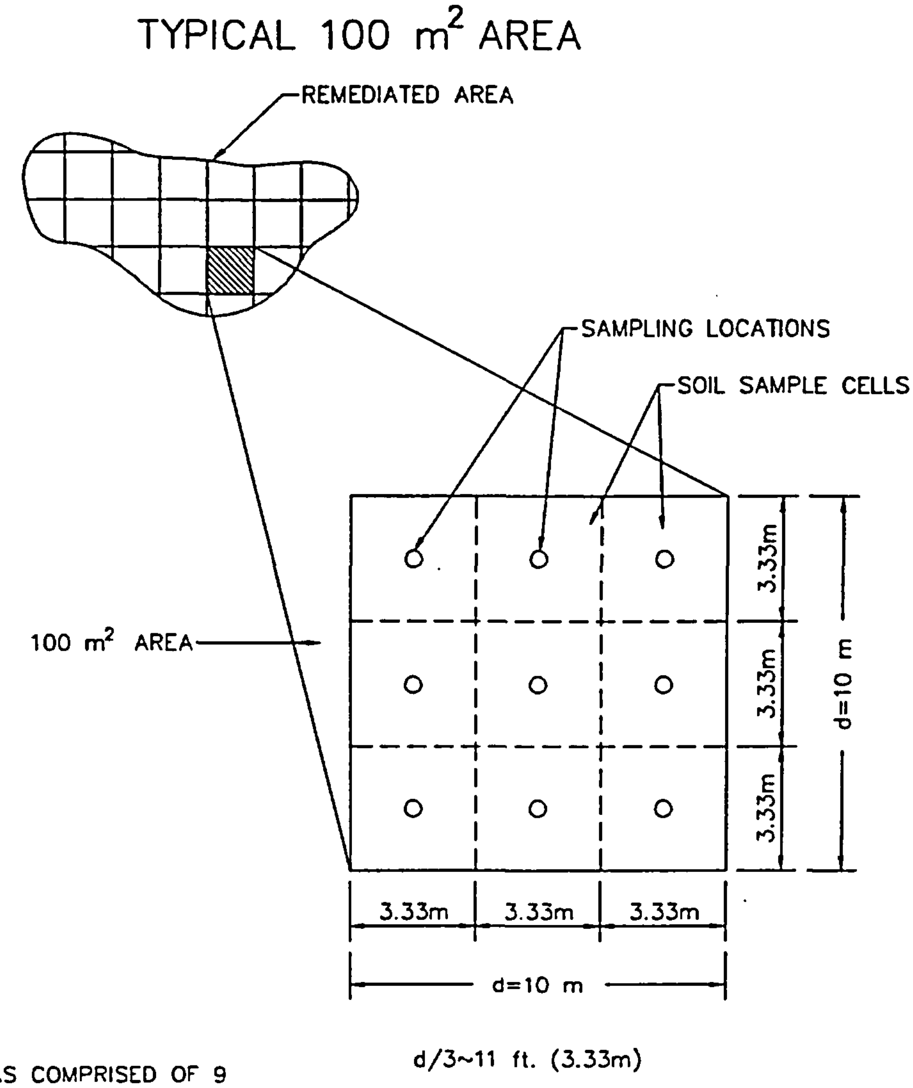


Figure 2. Grid System



- 100m² AREAS COMPRISED OF 9 CONTIGUOUS SAMPLE CELLS
- SAMPLES COLLECTED AT APPROXIMATE CENTERS OF SAMPLE CELLS
- ONE SOIL ALIQUOT COLLECTED PER SOIL SAMPLE CELL
- SOIL ALIQUOTS COMBINED TO FORM COMPOSITE SAMPLE FOR ANALYSIS

U.S. DEPARTMENT OF ENERGY GRAND JUNCTION, COLORADO	Work Performed by S.M. Stoller Corporation Under DOE Contract No. DE-AC01-02GJ79491
STANDARD VERIFICATION	
DATE PREPARED: MAY 6, 2004	FILENAME: E0456400

M:\ENG\190\0012\00\E04564\E0456400.DWG 05/06/04 10:23am J50191

Figure 3. Standard Verification 100-m² Grids

COBBLES-TO-FINES DATA FORM

Note: The average weight of the bucket and liner (M_b) = 4.1 lbs. Masses of are in decimal pounds. To convert to decimal pounds, divide the ounces by 16 and add to the pounds, for example 50 lbs 4 ounces would be 50.25 lbs.

Sample Number	Total Mass w/bucket (M_t)	Mass of Cobbles w/bucket (M_c)	Mass of Fines (Optional) $M_f = M_t - M_c$	Conc. Fines (optional) (C_f)	Conc. Cobbles (optional) (C_c)	Bulk Concentration (optional) $C_B = \frac{[C_f * M_f] + [C_c * (M_c - M_b)]}{M_t - M_b}$

VERIFIED BY: **DATE:**

H:\forms\cobbles.frm

Figure 4. Cobbles-to-Fines Data Form

CALCULATION OF AVERAGE RADIUM CONCENTRATION

PROPERTY NUMBER	PROPERTY ADDRESS
LOCATION OF AREA	

$$C_{avg} = \frac{C_p \, x \, A_p \;\; + (C_r \, x \, [1{,}076 - A_p])}{1{,}076}$$

Where:	C_{avg}	=	Radium concentration (pCi/g) averaged over 100 m^2 (1076 ft^2) area
	C_p	=	Concentration of the tailings in the pocket in pCi/g
	A_p	=	Area of the tailings pocket in ft^2
	C_r	=	Concentration of the remainder of the 100 m^2 (1076 ft^2) area.

$$C_{avg} = \frac{\_\_ x \_\_ + (\_\_ x \, [1{,}076 - \_\_])}{1{,}076}$$

$$C_{avg} = \_\_$$

☐ OCS ANALYSIS: The radium concentration does not exceed the EPA standard of 5.0 pCi/g plus background for the surface soil layers or 15 pCi/g plus background for subsurface soil layers.

☐ ANALYTICAL LABORATORY: The radium concentration does not exceed the EPA standard of 7.0 pCi/g for the surface soil layers or 17 pCi/g for subsurface soil layers.

Note: The background radium concentration for this area is approximately 2.0 pCi/g. For conservatism, the background is not added to the OCS value.

CALCULATED BY:	DATE:
VERIFIED BY:	DATE:

Figure 5. Calculation of Average Radium Concentration

EXPLANATION OF DATA COLLECTION

PROPERTY NUMBER:	PROPERTY ADDRESS
LOCATION OF AREA:	
DOES THIS AREA CONTAIN MULTIPLE DEPOSITS WITH A 70 FT X 15 FT RECTANGULAR AREA? _ YES _ NO	
DOES THIS DEPOSIT WRAP AROUND A STRUCTURE? ☐ YES ☐ NO	
MAP ATTACHED? ☐ YES ☐ NO	

TYPE OF DATA COLLECTED

SAMPLE NUMBER	☐ INDIVIDUAL ☐ COMPOSITE	SAMPLE DEPTH
SAMPLE NUMBER	☐ INDIVIDUAL ☐ COMPOSITE	SAMPLE DEPTH
SAMPLE NUMBER	☐ INDIVIDUAL ☐ COMPOSITE	SAMPLE DEPTH
COMMENTS		

EXPLANATION FOR DATA COLLECTION

CONCLUSIONS

PREPARED BY:	DATE:
VERIFIED BY:	DATE:

EXDATA.FRM (11-96)

Figure 6. Explanation of Data Collection

RADIOLOGICAL CHECKLIST FOR APPLICATION OF SUPPLEMENTAL STANDARDS

PROPERTY NUMBER	
PROPERTY ADDRESS	
DATE	INSTRUMENT NUMBERS

AREA REMAINING UNDERLAIN BY CONTAMINATION	
ESTIMATED VOLUME OF CONTAMINATED MATERIAL TO REMAIN	
RANGE OR AVERAGE RADIUM CONCENTRATION IN SOIL IN THE CONTAMINATED AREA	
IF TAILINGS ARE BELOW OR WITHIN 10 FEET OF THE STRUCTURE, RADON DECAY-PRODUCT CONCENTRATION	

RANGE AND AVERAGE EXPOSURE RATE OVER THE CONTAMINATED AREA		
RANGE AT CONTAMINATION CONTACT AVERAGE	CPS CPS	μR/hr μR/hr
RANGE 3 FEET ABOVE CONTACT AVERAGE	CPS CPS	μR/hr μR/hr
RANGE AT GROUND SURFACE AVERAGE	CPS CPS	μR/hr μR/hr

PREPARED BY:	DATE:
REVIEWED BY:	DATE:

SUPSTDS.FRM (5/1/97)

Figure 7. Radiological Checklist for Application of Supplemental Standards

BACKFILL VERIFICATION SURVEY

LOCATION:	
DATE SURVEYED	TECHNICIAN:
INSTRUMENT NUMBERS:	

DESCRIPTION OF BACKFILL (INCLUDE TYPE OF FILL, GEOLOGY AND OTHER CHARACTERISTICS OF THE DEPOSIT.

RADIOLOGICAL SURVEY RESULTS (ATTACH MAPS, DATA SHEETS, AND PHOTOGRAPH OF SITE)

VERIFICATION SUPERVISOR	DATE

BACKFILL.FRM (11-96)

Figure 8. Backfill Verification Survey

Attachment 3
Opposed Crystal System (OCS)
Soil Sample Analysis Criteria

1. System Description

The OCS consists of either a van-mounted portable or stationary gamma spectroscopy system. The van-mounted system can be driven to the field to analyze soil samples for radium. The system is used here for prompt radium concentration determination of soil samples during excavation control work and verification.

The standard method for using this system is given in "Standard Test Method for Radium-In-Soil Sample Analysis Using the Opposed Crystal System (OCS)" (Appendix A).

2. Sample Collection

The collection of soil samples to be analyzed by the OCS will be performed according to the procedure specified in the procedure "Radiological Soil Sampling" (Attachment 6).

3. Analytical Laboratory

Ten percent of all OCS samples are analyzed for Ra-226 by an analytical laboratory. The sealed OCS cans will be shipped to the analytical laboratory for analysis. Radioactive material (RAM) samples will be shipped in accordance with procedures contained in "Control of Radioactive Materials" and "Transportation of Radioactive Materials" (Attachments 7 and 5, respectively). OCS and analytical laboratory results will be statistically analyzed to determine if anomalies are reason for further evaluation of the system results.

In addition to the overall requirement that 10 percent of all OCS-analyzed samples be analyzed by an analytical laboratory, each sample type has its own analytical laboratory confirmatory analysis requirements as follows:

- **Inclusion/Exclusion Samples**—All Moab Project inclusion/exclusion survey samples that are close (±1 picocurie per gram [pCi/g] or Team Leader's judgment) to the 5 and 15 pCi/g radium standard may be submitted for confirmatory analysis.
- **Assessment Soil Samples**—The assessment soil samples do not require confirmatory analysis by the analytical laboratory, but may be analyzed at the discretion of the site supervisor.
- **Excavation Control Soil Samples**—These samples do not require confirmatory analyses by the analytical laboratory.
- **Verification Soil Samples**—Ten percent of all verification samples will be submitted to the analytical laboratory for confirmatory analysis. All remaining samples will be stored as specified by the project.

4. Disposition of Samples

- When storage is no longer required, samples will be disposed of at the disposal cell site.
- Verification samples and inclusion/exclusion samples shall be stored according to the Moab Project specified soil sample storage requirements and in accordance with the *Field Services Procedures Manual*, STO-203, Chapter 27, requirements.
- Excavation control and assessment samples will be disposed of at the disposal cell site or held at an interim repository to be located on the millsite property.

5. Control of RAM

If the true Ra-226 concentration of any sample, as measured by OCS, exceeds 24 pCi/g, it is considered RAM. Any sample that exceeds 2,000 cps should be mixed and canned in a radiologically controlled area and not in the OCS station. When preparing these types of samples, the operator should wear rubber gloves and cover the sample preparation area with a poly sheet or as designated by the Radiological Work Permit. The cans must be wiped clean before notifying a Radiological Control Technician (RCT) to survey the cans to ensure that all loose contamination has been removed from the outside of the can. Once the sample cans have been released as clean by the technician, they can then be taken to an OCS station for analysis. If a RAM sample is inadvertently prepared inside the portable or stationary OCS laboratory, the interior must be scanned by an RCT.

The OCS operator shall flag RAM samples appropriately before sending them to the analytical laboratory for analysis. This action will signify to the analytical laboratory that the sample is RAM and should be handled accordingly.

Shipment of RAM samples must be in accordance with the requirements contained in the DOT regulation, 49 CFR, Parts 171-178.

6. Records

The following records are generated using this procedure.

OCS Data Form (Appendix A, Figure 4), original data forms are returned to the person requesting the analysis for inclusion in the project file. A copy of all OCS data sheets will be retained in project specific binders for the duration of the project, after which they may be destroyed. A second copy of the OCS data forms will be given to a clerk for entry into a database which tracks sample information and storage location.

OCS Operational Check Form (Appendix A, Figure 5) will be kept in a unit specific binder for at least 1 year.

Chain of Sample Custody Form (Attachment 6, Figure 4) is used when transporting soil samples to be transferred to the subcontracted analytical laboratory or other entities. The completed forms will be retained in a 3-ring binder for the duration of the project, after which they may be destroyed. The original copy accompanies the sample until it is incorporated with the subcontracted analytical laboratory report.

Analytical laboratory reports contain analyses performed by the subcontracted analytical laboratory. After the results are entered into the database, the reports are incorporated into the project files.

Appendix A

RD–4(T) Standard Test Method for Radium-in-Soil Sample Analysis Using the Opposed Crystal System (OCS)

Standard Test Method for Radium-in-Soil Sample Analysis Using the Opposed Crystal System (OCS)

1. Scope

1.1 The Opposed Crystal System (OCS) supports radiological assessments and verification surveys for the analysis of Ra-226 in soil.

1.2 This test method describes the system components, the standardization, and the soil-sample analysis procedures for the OCS. It addresses potential interferences and hazards associated with preparing soil samples for analysis.

1.3 Use of the OCS requires that the operator be familiar with the radium-226 (Ra-226) gamma-ray spectra, including the 609-kiloelectronvolt (keV) and the 1764-keV peaks of bismuth-214 (Bi-214) as displayed using sodium-iodide (NaI) detectors (see Figure 1). Bi-214 is a daughter product of Ra-226. It has several easily recognizable peaks.

2. Hazard Analysis

2.1 *Suspected Hazardous, Toxic, or Unknown Materials*—If the OCS operator is requested to prepare and analyze a sample that is suspected to contain hazardous, toxic substances, or materials of unknown hazard, the operator shall refuse the sample and remove it from his or her immediate presence. Discolored soil, unfamiliar odors, eye irritation, or nausea may be an indication that the sample material is hazardous to a person's health.

2.2 *Suspected Radioactive Materials*—Any sample received with a reported gamma reading greater than 2,000 counts per second as measured with a portable gamma scintillometer shall be treated as radioactive material (RAM). The operator shall prepare such material outside the OCS facility. The sample container must be cleaned before analysis to avoid contamination of equipment. If, after analysis, the result for any sample meets the criteria for RAM, the sample

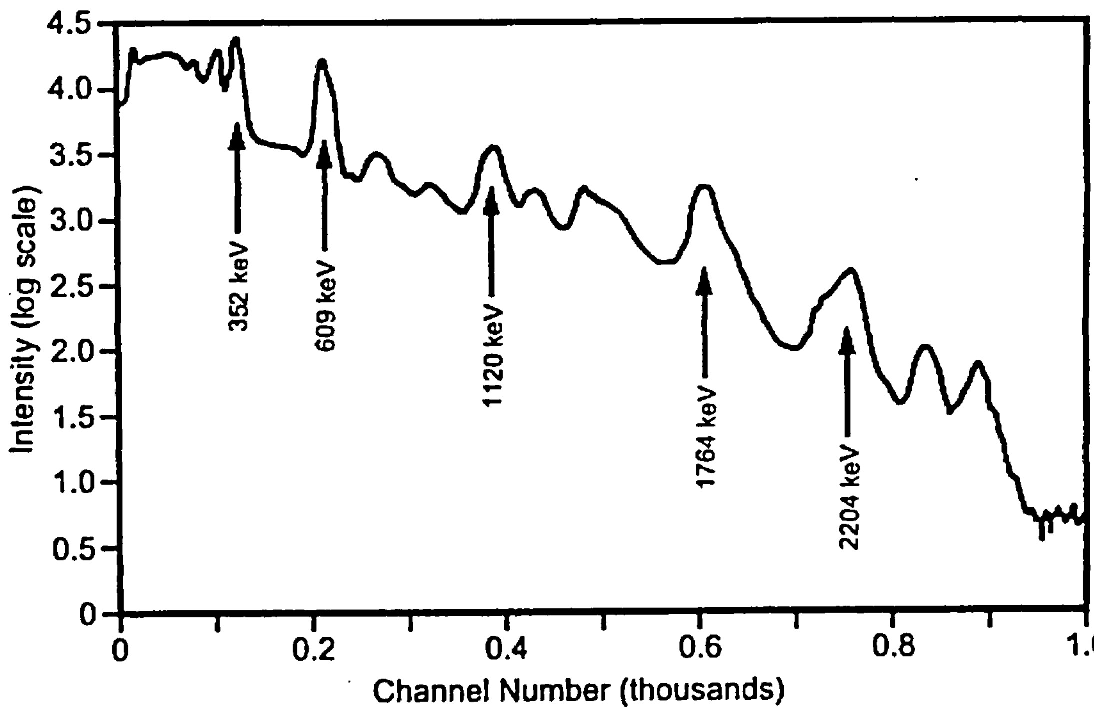


Figure 1. Typical Ra-226 Spectrum

shall be handled and stored according to procedures in the *Health and Safety Manual* (reference 3.3). Materials used to decontaminate the mixing tools shall be treated and disposed of as RAM.

3. Referenced Documents

3.1 *Code of Federal Regulations*: 40 CFR 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," Subpart B, Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

3.2 Gardner, M.J., *Performance of the Opposed Crystal System (OCS) and the Proposed UMTRAP Excavation Criteria*, U.S. Department of Energy, Grand Junction Projects Office, Grand Junction, CO, 1988

3.3 *Radiological Control Manual* (STO 3): Chapter 4, Radioactive Materials

3.4 Martz, D., *Comparison of the Opposed Crystal Method With the Chemistry Laboratory Method for Determining the Radium Concentration in Soil Samples*, U.S. Department of Energy, Grand Junction Projects Office, Grand Junction, CO, RI-0-89-1, 1989.

3.5 Ortec Maestro-32 MCA Emulator for Microsoft Windows 95, 98, 2000, and NT, A65-B32 Software User's Manual.

3.6 *Field Services Procedures Manual* (STO 203)

4. Terminology

4.1 *Lead pig*—A lead fixture that shields the NaI detectors from background radiation and encloses the material to be analyzed.

4.2 *Multichannel analyzer (MCA)*—An electronic device that sorts detected gamma-ray events by energy and accumulates a total count for each occurrence at a specific energy.

4.3 *Point source*—Typically, an ore specimen that contains one or more radioactive elements.

4.4 *RAM*—For uranium mill tailings, any material with an activity of 130 picocuries per gram (pCi/g) or greater of Ra-226 is considered RAM. For uranium ore, material with an activity of 137 pCi/g of Ra-226 or greater is considered RAM.

4.5 *Radioactive source*—Commercial- or contractor-manufactured RAM (i.e., produced by using a man-made or an enhanced radioactive nuclide) that is used exclusively for its emitted radiation.

4.6 *Reference material*—Material with radioactivity that is below the criteria for RAM.

4.7 *Region of interest* (ROI)—the part of a gamma-ray spectrum that contains the spectral peak or peaks used in analysis for a radioisotope.

4.8 *Shine*—Gamma radiation emanating from a location outside the area of concern that influences gamma measurements within that area.

5. Significance and Use

5.1 Land and buildings that have been contaminated with uranium mill tailings from inactive uranium processing sites shall be cleaned to meet the standards contained in 40 CFR Part 192.12, Standards (reference 3.1). The standards are based on the radium concentration of soils from suspected contaminated areas. The OCS provides a method to measure the radium-in-soil concentration under a variety of field conditions.

6.0 Interferences

6.1 When analyzing soils for Ra-226 content with the 609-keV peak, the gamma spectral display may be distorted by various interferences.

6.1.1 *Thorium-232 and Cesium-137 Influences*—Proper analysis of the 609-keV peak of the Ra-226 gamma-ray spectrum may be distorted by proportionately high concentrations of Cs-137 and naturally occurring Th-232, which have peaks at 583 keV and 661 keV, respectively on the Ra-226 gamma-ray spectrum (see Figure 2).

The 609-keV peak will be distorted so that it looks unusually wide in terms of absolute channel width, or the peak may appear to have a shoulder on one or both sides. If distortion is observed, the amplifier gains should be checked for coincidence and adjusted accordingly. See section 13 for the procedure to strip the Th-232 and Cs-137 interferences.

6.1.2 *Sensitivity of Equipment to Temperature Extremes*—Extremely hot or cold temperatures may affect the performance of the equipment, specifically the NaI detectors. The equipment should be operate in an area with a temperature between 60–80°F and shielded from sudden temperature changes.

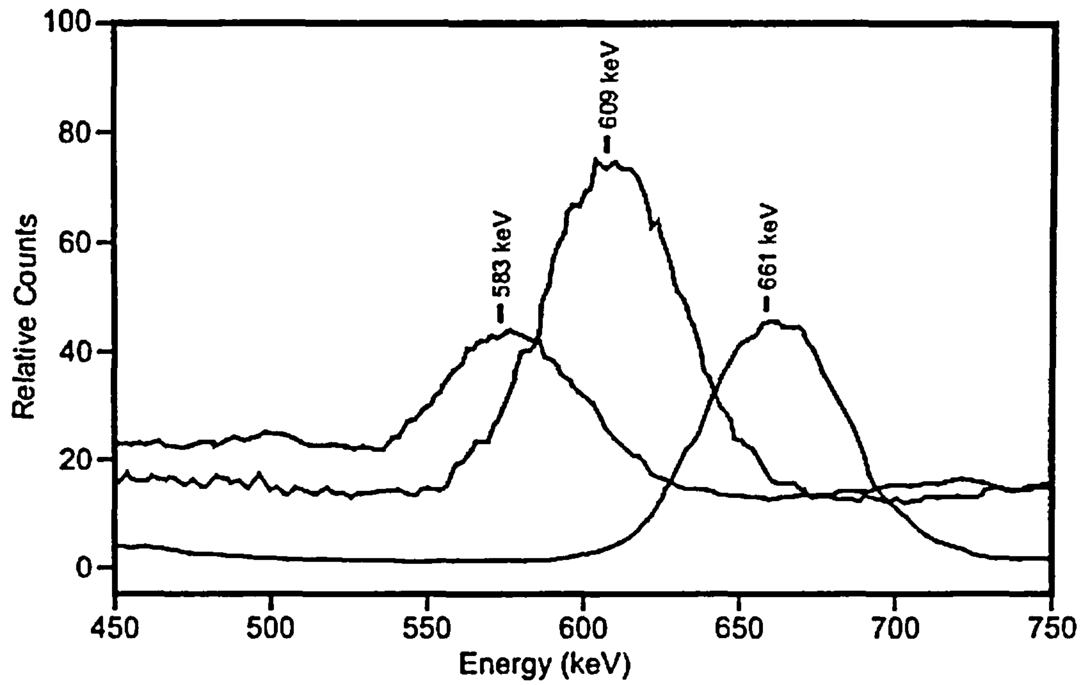


Figure 2. Example of a Gamma Spectrum Showing the Overlap of the Thallium-208 (Th-232 daughter) Peak at 583 keV with the Bi-214 (Ra-226 daughter) Peak at 609 keV and the Cs-137 Peak at 661 keV

6.1.3 *Point-Source and External Radioactive Influences*—A highly radioactive point source may result in a distorted spectrum. In this instance, the detectors are overloaded with pulse signals and physically cannot process the pulses as fast as they are received. The degree of distortion depends on the activity of the source.

6.1.3.1 There are several methods to distinguish if the distortion is from a point source (such as a small pebble of ore within the sample), from the bulk sample material itself, or possibly from external radioactive influences such as shine. The sample can be taken out of the lead pig and moved a short distance away. If a point source is in the sample, this action will improve the spectrum. Also, a scintillometer or delta reading on the sample will assist in defining bulk sample activity.

6.1.3.2 When the spectrum is distorted, a second sample representative of the same area may be prepared and analyzed.

7. Apparatus

7.1 The OCS includes the following components (shown in Figure 3). A discussion of the MCA is given in the manufacturer's instruction manual (reference 3.5).

7.1.1 Ortec Microace Amplifier and MCA Personal Computer System with integrated power supply and amplifiers.

7.1.2 Two integral 3 inch by 3 inch NaI scintillation detectors with photomultiplier tube.

7.1.3 Sentipack Model 296 photomultiplier base with preamplifier and high voltage power supply.

The switch must be modified to only turn off the HV supply.

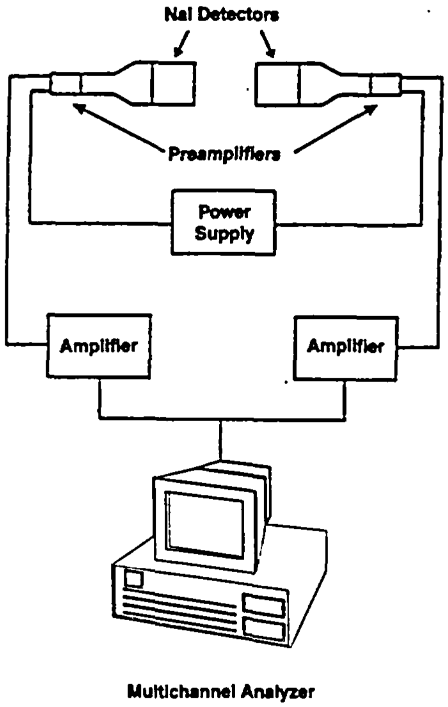


Figure 3. Schematic PC Based MicroAce MCA

7.2 *Support Equipment*

7.2.1 Reference standards with known concentrations of 15.12 ± 0.23 pCi/g and 50.2 ± 0.8 pCi/g Ra-226 and one reference material that contains higher activity tailings or uranium ore (the uranium ore is a source of Ra-226).

7.2.2 Stainless steel, round-bottom mixing bowl and hand trowel for mixing (homogenizing) the bulk sample before the sample can is filled.

7.2.3 Sample cans and lids, used to contain the sample material for analysis.

7.2.4 Canning machine for sealing the sample cans after they have been packed with soil and are ready to be analyzed.

7.2.5 Portable balance-type or electronic scales used to weigh the samples before they are analyzed.

7.2.6 Lead pig, which contains the detectors and the sample.

7.2.7 OCS Gamma Spectral Analysis Ra-226 Data Forms (Figures 4 and 5).

8. Alignment of Amplifier Gain

8.1 *Establishing Detector Coincidence*—Prior to using the OCS for soil-sample analysis, the detectors must be adjusted so that each peak location from one detector exactly overlaps the peak location of the other detector. Because of temperature variations and gain shifts, the peaks from the two detectors can become misaligned. Alignment must be performed at the beginning of each workday and any other time the peak appear to need alignment based on the appearance of the spectrum. The spectrum may appear broader than normal, show a double peak, or otherwise appear distorted. The alignment requires adjustment of the individual amplifier gains for each detector, as follows:

8.1.1 Launch the Mcb32 software. Select Services from the Menu Bar then Job Control and then MCB1align option. Place the Ra-226 op-check reference material can in the MCB1 lead pig.

8.1.2 Turn off the high voltage to either one of the ScintiPacks by depressing the On switch to the OFF (out) position.

8.1.3 Acquire a spectrum by clicking the GO button on the Toolbar. Continue acquiring until the peaks are well formed.

8.1.4 Adjust the high voltage of the active Scintipack until the center of the 609-keV peak falls in Channel 200. Clear the screen by clicking CLEAR DETECTOR/BUFFER button on the tool bar. Repeat this process until the centroid of the 609-keV peak falls in Channel 200. This process also can be performed while acquiring counts.

OCS Gamma Spectral Analysis
Ra-226 Data Form

Property Number: Moab Project Site	Date: 9-16-02 to 9-19-02
Operator: Colunga	Moab Stationary Unit: MCB 1

Ref. STD (pCi/g)	Weight (grams)	Net Peak (count)	Total Activity (pCi)		Net Countrate (cps)		Calcltd. Conc.	Within Limits?
15.00	395.4	2438	A15 =	5931.0	R15 =	4.88	14.9	Yes
50.00	419.9	8697	A50 =	20995.0	R50 =	17.39	50.0	Yes
Count Time (sec) =		500	Calibration Factor		(pCi/count second) =		1207.7	

Sample Location Number	Sample Ticket Number	Sample Depth (Inches)	Net Mass (grams)	Net Peak Area (counts)	Calcltd Conc. (pCi/g)	True Conc. (pCi/g)	Notes:
R0846	NEG 039	0 - 6	524.1	1275	5.9	9.9	S-180 H-360
R0848	NEG 040	0 - 6	499.0	705	3.4	5.4	S-195 H-180
R0850	NEG 041	0 - 6	499.7	1586	7.7	13.2	S-180 H-015
R0851	NEG 042	0 - 6	536.6	313	1.4	1.7	S-180 G-360
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	
					#DIV/0!	#DIV/0!	

GJO 2060 10/2002 gjo2060.xls Page 1

Figure 4. Example of an OCS Gamma Spectral Analysis Data Form

OCS OPERATIONAL CHECK FORM

Moab Project Site							
Count Time = 200 seconds							
MCB - 1	Op-Check Can #1			MCB - 2	Op-Check Can # 4		
Range	10% Low	10% High		Range	10% Low	10% High	
	9870	12063			10198	12464	
DATE	NAME	ROI	NET PEAK AREA	DATE	NAME	ROI	NET PEAK AREA
9/9/2002	EC	180 - 220	10083	9/9/2002	EC	180 - 220	10789
9/10/2002	EC	180 - 220	10142	9/10/2002	EC	180 - 220	11097
9/11/2002	EC	180 - 220	10658	9/11/2002	EC	180 - 220	10874
9/12/2002	lw	179 -219	10244	9/12/2002	TRU	179-220	11402
9/16/2002	EC	180 - 220	11059	9/16/2002	EC	180 - 220	11257
9/17/2002	EC	180 - 220	10658	9/17/2002	EC	180 - 220	10654
9/18/2002	EC	180 - 220	10683	9/18/2002	EC	180 - 220	11413

GJO 2061 10/2002 figure 5.xls Page 1

Figure 5. Example of an OCS Operational Check Form

8.1.5 Turn the other Scintipack off and turn the initial Scintipack on. Repeat steps 8.1.3 and 8.1.4.

8.1.6 Turn both Scintipack on and acquire a spectrum. Ensure that the centroid of the 609-keV peak falls in Channel 200. If the two spectrums do not match, repeat steps 8.1.2 through 8.1.5 until the centroids of the two peaks match. The positions for the peaks should not differ by more than two channels.

8.1.7 Remove the Ra-226 op-check reference material can from the lead pig.

8.1.8 The operator must constantly be aware of the spectrum. Any broadening or shifting of the peaks is an indication that the two detectors may no longer be in coincidence; steps 8.1.1 through 8.1.7 must be repeated to bring the peaks back into coincidence.

8.2 *Analysis of the Gamma Spectrum*—Under conditions such as poor resolution or low concentration of Ra-226, proper analysis of any given gamma spectrum can be difficult and subject to interpretation. To correct for this, operators must be consistent in the manner in which they analyze a spectrum. To properly interpret the 609-keV peak for Ra-226 analysis, the determination and placement of the ROI must be applied consistently from sample to sample. An ROI is set up around the 609-keV peak, as shown in Figure 6. The left side of the ROI should be in the lowest part of the valley immediately to the left of the peak, and the right side of the ROI should be located at the intersection of a line tangent to the spectrum and the point at which the right side of spectrum intersects that tangent line. This is often the lowest part of the right side valley.

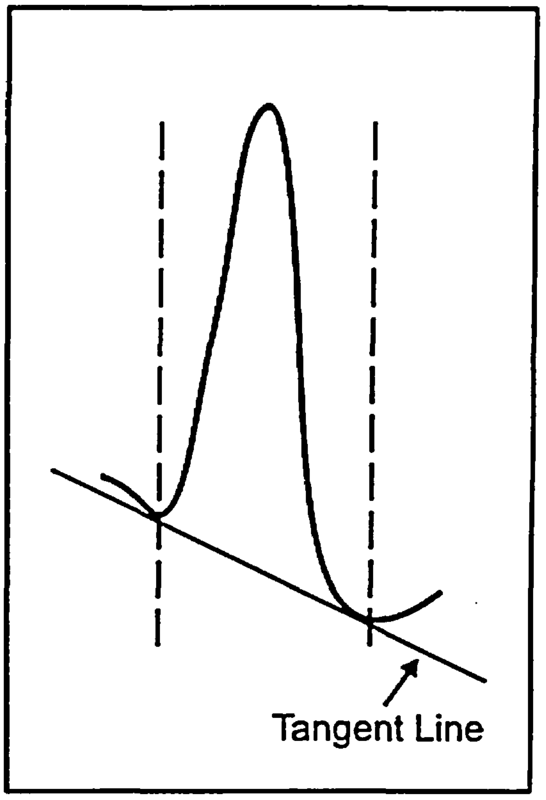


Figure 6. ROI Setup for the Bi-214 609 keV Peak

9. Daily Operational Check

9.1 Perform a daily operational check using the Ra-226 high activity reference material can as follows:

9.1.1 Select Services from the Menu Bar, then MCB1opcheck. Place the Ra-226 op-check reference material can in the lead pig.

9.1.2 Acquire a spectrum by clicking the GO button on the Toolbar. The MCA will count for 200 real time seconds.

9.1.3 At the end of the count time, establish an ROI. Selecting Calculate from the Menu Bar then Peak Search can mark the ROI menu. Referring to the channel number displayed on the monitor, move the marker to the appropriate location on the left or right side of the peak. Press F2 once to turn the Mark ROI ON. Using the directional arrows on the keyboard.

9.1.4 Move the marker to an appropriate location on the other side of the peak. Press F2 twice to turn the Mark ROI off. Using the mouse, click inside the ROI to display the integrated and NET ROI values.

9.1.5 Make sure the net ROI value falls within the acceptable range as recorded on the OCS Operational Check Form (Figure 5). If the value is acceptable, record it on the check form under "Net Peak Area"; otherwise, repeat the operational check. If the PCA fails the second operational check, the supervisor should be contacted for assistance.

9.1.6 If necessary, a new range is established by counting the Ra-226 reference material can a minimum of 10 times, computing the average, and using ± 10 percent of the average as a new check range.

10. Standardization

10.1 The OCS is standardized prior to each work week.

10.2 *Analysis of Standards*—To determine the correction factor, the net count rates for the 15 and 50 pCi/g Ra-226 reference standards are required. To obtain the net count rates, each standard will be analyzed separately as follows:

10.2.1 Select Services from the Menu Bar, then select MCB1sample.

10.2.2 Place the 15-pCi/g standard into the lead pig then click the on GO button. The standard will be counted for 500 real time seconds.

10.2.3 At the completion of the 500-second count time; press ESC to get to the ROI menu. Using steps 9.1.3 and 9.1.4, establish an ROI around the 609-keV peak.

10.2.4 Determine the Net Peak Count

10.2.5 Enter the Net peak count on the OCS Spectral Analysis Ra-226 Data Form spreadsheet.

10.2.6 Clear the spectrum. Place the 15-pCi/g standard into the lead pig then click the on GO button.

10.2.7 At the completion of the 500-second count time; establish an ROI around the 609-keV peak by following steps 9.1.3 and 9.1.4.

10.2.8 Determine the Net Peak Count

10.2.9 Enter the Net peak count on the OCS Gamma Spectral Analysis Ra-226 Data Form spreadsheet.

10.2.10 Confirm the correct weight of the standards and make corrections on the OCS Gamma Spectral Analysis Ra-226 Data Form spreadsheet if necessary.

10.2.11 The computer will display the current correction factor for the particular OCS. This information, which consists of the net ROI for the 15 and 50 pCi/g standards, the net count rate for each standard, the correction factor, and the true concentration.

10.2.12 The OCS Gamma Spectral Analysis Ra-226 Data Form spreadsheet will display the calculated concentration of the 15 and 50 pCi/g Ra-226 reference standards.

10.2.13 The calculated concentrations of the standards must be within ± 1 pCi/g of the assigned value. If not, the amplifier gain should be checked (section 8) and a new standardization performed.

10.3 *Calculation of the Calibration Factor*—The calibration factor (CF) can be calculated from the following formula:

$$CF = \frac{(A_{50} \times R_{50} + A_{15} \times R_{15})}{(R_{50}^2 + R_{15}^2)}$$

where:

A_{50} = total activity for the 50-pCi/g standard (the net weight of the standard multiplied by 50 pCi/g),

R_{50} = net count rate for the 50-pCi/g standard (the net peak area divided by the count time),

A_{15} = total activity for the 15-pCi/g standard (the net weight of the standard multiplied by 15 pCi/g), and

R_{15} = net count rate for the 15-pCi/g standard (the net peak area divided by the count time).

11. Sample Preparation

11.1 Very wet soils, such as sediment samples, may be dried prior to preparation in an oven. Very dry samples may be moistened with a spray bottle and water. An average amount of soil moisture is optimum but not required.

11.2 Prepare the sample by thoroughly mixing the soil in a mixing bowl with a hand trowel. Select the sample to be analyzed from all portions of the mixing bowl (e.g., bottom, sides, top). Wipe out the mixing bowl and wipe the trowel between samples with Kimwipes.

11.3 In instances where the sample texture is too moist (muddy) to feasibly lend itself to the mixing process, the sample may be mixed within the sample bag itself.

11.4 Select an empty can and lid from the available stock. Weigh the can and lid to determine the tare weight and zero the scale.

11.5 Pack the can with soil and level it. Clean the lip of the can, place the lid on the can, and seal the can.

11.5.1 Samples to be analyzed later for metals should be protected from contact with the can by being placed inside a plastic bag inside the OCS can.

Note 1

All samples should be analyzed within 1 hour of the time that they were canned and sealed to prevent radon in-growth from affecting the analytical results.

11.6 Weigh the filled can and record the resulting net weight of the sample and the soil sample identification number on the can and the OCS Gamma Spectral Analysis Ra-226 Data Form.

11.7 Place the sample in the lead pig and perform the analysis as described in section 12.

12. Analysis of Soil Samples

12.1 To determine the calculated concentration (CC) of the Ra-226 on the basis of the net peak area within the 609-keV ROI:

$$CC = \left(\frac{\text{Net Peak Area} \times \text{Correction Factor/Count Time}}{\text{Sample Weight}} \right)$$

12.2 To correct the Ra-226 concentration for moisture and radium-radon disequilibrium, the true concentration (TC) is determined by a correlation of the data obtained with the OCS and the analytical laboratory data as follows:

$$TC = (1.84 \times \text{OCS calculated concentration}) - 0.91$$

12.3 *Analysis of Soil Samples*

12.3.1 Select Services from the Menu Bar, then select MBC1sample.job.

12.3.2 Weigh the sample can on the electronic scale. Record the net mass (grams) on the OCS Spectral Analysis Ra-226 Data Form spreadsheet.

12.3.3 Place the sample can into the lead pig then click the on GO button. The sample will be counted for 500 real time seconds.

12.3.4 At the end of the 500-second count time, the screen will display the spectrum.

12.3.5 At the end of the 500-second count time; establish an ROI around the 609-keV peak following steps 9.1.3 and 9.1.4.

12.3.6 Determine the Net Peak Count.

12.3.7 Enter the Net peak count on the OCS Gamma Spectral Analysis Ra-226 Data Form spreadsheet.

12.3.8 The OCS Gamma Spectral Analysis Ra-226 Data Form spreadsheet will display the calculated concentration and the true radium-in-soil concentrations.

12.3.9 Save the OCS Spectral Analysis Ra-226 Data Form spreadsheet. Use file name convention

12.3.10 After analysis, dispose of the samples as directed by the program or the project-specific work plan.

13. Stripping Radionuclide Interferences

13.1 As described in step 6.1.1, the 609-keV peak may occasionally be distorted by elevated concentrations of Th-232 or Cs-137. When this distortion is observed (Figure 2), the following procedure should be used to strip the external radionuclide interference and to determine the Ra-226 concentration.

13.1.1 Using the cursor, determine the number of counts in the peak channel of the 609-keV peak (~Channel 200). Values needed: radium peak count (CNT_{radium}) and radium peak channel (CHN_{radium}).

13.1.2 Using the cursor, determine as accurately as possible the number of counts in the peak channel of the peak causing the interference. Values needed: interference peak count (CNT_{int}) and interference peak channel (CHN_{int}).

13.1.3 Determine the channel number and background count to the left and right of the 609-keV peak and the interference peak. Values needed: left background count (CNT_{left}), left background channel (CHN_{left}), right background count (CNT_{right}), and right background channel (CHN_{right}).

13.1.4 Determine the peak area for the entire area being influenced by the other Radionuclide. The peak area is determined by establishing an ROI around the entire area of radium and interference peaks. Value needed: total net peak area ($AREA_{net}$).

13.2 Once these values have been obtained, a corrected radium peak area can be obtained using the following equations. The correction assumes a Gaussian fit to the peak. The equations can be input into a spreadsheet program.

13.2.1 To obtain the corrected net radium peak area, it is necessary to calculate the slope of the background and then correct the radium peak and the interference peak for that slope. The slope will be negative.

$$m = \frac{CNT_{right} - CNT_{left}}{CHN_{right} - CHN_{left}}$$

where:

m = slope of the background,

CNT_{right} = count in the right background channel,

CNT_{left} = count in the left background channel,

CHN_{right} = channel number for the right background channel, and

CHN_{left} = channel number for the left background channel.

13.2.2 Once the slope of the background is calculated, it is used to subtract the background contribution from the radium peak and from the interference peak, respectively, using the following equations:

$$AMP_{radium} = CNT_{radium} - [CNT_{left} + m(CHN_{radium} - CHN_{left})]$$

$$AMP_{int} = CNT_{int} - [CNT_{left} + m(CHN_{int} - CHN_{left})]$$

where:

AMP_{radium} = amplitude of the radium peak (i.e., net counts in the centroid of the radium peak, approximately Channel 200);

CNT_{radium} = counts in the radium peak;

CNT_{left} = count in the left background channel;

CHN_{radium} = channel number of the radium peak, approximately Channel 200;

CHN_{left} = channel number for the left background channel;

AMP_{int} = amplitude of the interference peak (i.e., net counts in the centroid of the interference peak;

CNT_{int} = counts in the interference peak; and

CHN_{int} = channel number of the interference peak.

13.2.3 The area of the radium peak and the interference peak are then calculated using the following equations:

$$Area1_{radium} = AMP_{radium} \times FWHM_{radium} \times 1.0644$$

$$Area_{int} = AMP_{int} \times FWHM_{int} \times 1.0644$$

where:

$AREA1_{radium}$ = area of the radium peak,

$FWHM_{radium}$ = full width at half maximum of the radium peak,

$AREA_{int}$ = area of the interference peak, and

$FWHM_{int}$ = full width at half maximum of the interference peak.

13.2.4. The $FWHM_{radium}$ and the $FWHM_{int}$ are found using the OCS alignment radium can and a reference source for the material causing the interference. Each source is counted long enough to acquire a well-defined peak. The FWHM is determined using the Maestro-32 functions. Need defined

13.2.5 The amplitudes of both peaks calculated in step 13.2.3 are inaccurate because they overlap. This overlap causes the peak area to be overestimated. To correct the radium peak area, the area of the overestimated interference peak is subtracted from the net total peak area. This calculation results in a value for the radium peak that is underestimated. The overestimated and the underestimated radium peak values are averaged to obtain a corrected radium peak area. The following equations show this calculation.

$$Area2_{radium} = Area_{net} - AREA_{int}$$

$$Area_{radium} = \frac{Area1_{radium} + Area2_{radium}}{2}$$

where:

$AREA2_{radium}$ = area of the radium peak (underestimated),

$AREA_{net}$ = net area of both peaks in the ROI,

$AREA_{int}$ = area of the interference peak,

$AREA_{radium}$ = area of the corrected net radium peak, and

$AREA1_{radium}$ = of the radium peak overestimated.

13.3 A set of test data is given in Table 2 to assist in determining if the calculations have been properly set up on the calculator or spreadsheet. The correct answer, using these data, is 153,999.6676.

Table 2. Test Case

Value	Variable Name
1445	CNT_{left}
168	CHN_{left}
1217	CNT_{rigth}
250	CHN_{rigth}
9164	CNT_{radium}
202	CHN_{radium}
5604	CNT_{int}
221	CHN_{int}
244864	$AREA_{net}$
19.0	$FWHM_{radium}$
20.7	$FWHM_{int}$

Note 2

The above method can be used to correct for either Th-232 or Cs-137 interferences, but not for both simultaneously.

14. Precision and Bias

14.1 Because the nature of this test method is so different from the controlled, more precise environment of an analytical laboratory, the possibility of error in the sample results is increased. Factors such as moisture content of the soil, variable background concentrations, inconsistent methods of sample preparation, and temperature-sensitive equipment all contribute to the potential for error.

14.2 *Precision*—The error associated with the OCS system is insignificant relative to the error associated with the sample. That is, any analytical variation observed from multiple analyses of the same sample may be largely attributable to the error associated with the sample (such as sample preparation or homogeneity) as opposed to the counting or analytical error associated with the system.

14.2.1 For analytical purposes and day-to-day operations, a 5-percent error rate is considered acceptable and is consistent with error rates for other field analytical instruments.

14.2.2 The precision of the system, in terms of repeatability of data within acceptable error limits was studied using analysis of variance techniques to evaluate data obtained for identical samples that were analyzed by four different OCSs and the analytical laboratory (references 3.2 and 3.4).

14.2.3 The results of reproducibility of data between individual systems are easily in agreement with the established 5-percent error criterion. The precision of the system, however, was not subjected to, nor evaluated by, intralaboratory or interlaboratory studies.

14.2.4 Repeatability of results also may vary from one OCS operator to another. Although this procedure provides specific guidance for proper analytical techniques, professional judgment is involved for the definition of the ROI.

14.3 *Bias*—In determining the accuracy, or closeness of agreement, between the observed values of the OCS and the accepted reference values of the analytical laboratory, several biases should be noted:

14.3.1 *Analytical Laboratory Error*—It is assumed that the accepted reference value (i.e., the analytical laboratory value) is representative of the true value, or concentration. This procedure does not take into account the error associated with the analytical laboratory processes.

14.3.2 *Sample Preparation and Analysis*—The sample analyzed by the analytical laboratory is not exactly the same as the sample analyzed by the OCS. Upon receipt of the sample, the sample-receiving group of the analytical laboratory prepares the sample for analysis. The OCS sample can is opened and the sample is ground to a specified mesh. The material is dried to eliminate any moisture effects. A sample of the material is then taken from the bulk and recanned (both incorporating and excluding some material that was included in the original OCS sample). The sample is left to sit for 21 days to allow for equilibration of the radon daughters. The sample is then analyzed by gamma spectroscopy.

14.3.3 *Equipment*—Equipment differences between the gamma spectroscopy equipment in the analytical laboratory and the OCS equipment may contribute to any differences between the observed (corrected) data of the OCS and the analytical (uncorrected) data of the laboratory. The gamma spectroscopy laboratory uses high-purity germanium detectors that have much higher resolution than the NaI detectors used by the OCS and will therefore be less influenced by interferences from other isotopes.

15. Quality Assurance and Quality Control

15.1 When used to support remedial activities where U.S. Environmental Protection Agency standards or other remedial criteria have been established, a quality assurance/quality control program should be implemented to monitor the accuracy and performance of the OCS. Such a program logically consists of correlating matched data for the OCS and a controlled analytical laboratory. Data collected for the Uranium Mill Tailings Remedial Action Program were statistically analyzed through simple correlation-regression analysis and analysis of variance. All analyses were conducted at the 95-percent confidence level. For other programs or sites, the performance of the system should be periodically monitored through similar statistical analyses.

16. Records

16.1 A copy of the spreadsheet to calculate the Ra-226 values (Figure 4) is the official record for OCS soil-sample analysis. Data collected to correct the radium peak from interferences by other radionuclides are also recorded on a spreadsheet. Correction for Radionuclide Interference form (Figure 7). The OCS operator returns the completed data sheets and soil samples to the person requesting the analysis.

16.2 Daily OCS Operational Check Form spreadsheet (Figure 5).

Note: Figure 7 does not exist at this time.

Attachment 4
Uranium Analysis

1. Purpose

This procedure is used to determine the concentration of total uranium in a soil sample. It is based on spectral analysis of the 93 kiloelectron volt (keV) peak created by radioactive decay of thorium-234, the first radioactive decay product of uranium-238. Uranium-238 is assumed to be in equilibrium with uranium-234. Uranium-235 is presumed to be present at the natural abundance of 0.711 weight percent.

2. Equipment

- A Gamma Gage© portable HPGe gamma detector cooled by liquid nitrogen
- A lead shielding device (pig)
- NOMAD© 92X-P, a portable multi-channel analyzer (MCA)
- A micro computer
- Gamma Vision™ software program
- Steel cans (approximately ½ pint) and lids
- Canner
- Mixed nuclide calibration standard
- Background reference can containing pure silica sand
- Uranium reference can
- Liquid nitrogen

3. Required Training

The operator must have a basic knowledge of computers and be familiar with the software used for acquiring the spectra. The operator must also successfully complete training on this procedure.

Operators who are responsible for maintaining the system must also complete the following training:

- Filling the High Purity Germanium Detector Dewar with Liquid Nitrogen, *Field Services Procedures Manual* (STO 203).

4. Hazard Analysis

Hazards associated with the gamma spectrometry system involve handling radioactive material, as well as possible contact with the lead shielding device. Applicable portions of the *Health and*

Safety Manual (STO 2), and project-specific Health and Safety Plans and guidelines must be adhered to.

Filling the detector with liquid nitrogen also constitutes a hazard. *Field Services Procedures Manual* "Filling the High Purity Germanium Detector Dewar with Liquid Nitrogen" must be adhered to.

Handling oven-dried samples may be a hazard. Heat proof oven mitts should be used when handling hot sample containers.

5. General Operation

The HPGe system should be left on at all times (24 hours per day) to ensure the spectra are stable. Procedures for filling the detector dewar with liquid nitrogen are given in "Filling the High Purity Germanium Detector with Liquid Nitrogen".

The vertical scaling for the spectra display can be adjusted using the up and down arrows on the keyboard. As the cursor is moved within the spectrum, the bottom screen displays the channel marker number, the energy associated with that marker, and the gross counts in the marker.

The correct count times are set by selecting **Acquire** from the tool bar and then choosing **Setting** from the menu. Type the desired count time into the **Live Time** box and then click the **OK** button. Previously acquired spectra may be cleared by selecting **Acquire** from the tool bar and then choosing **Clear** from the menu. Spectrum acquisition is started by selecting **Acquire** from the tool bar and then choosing **Start** from the menu. A pop up box will appear and show the count times that have been set. If the count times are correct click the **OK** button and then another pop up box will appear and will show the file name for the spectra that is to be saved. If the file will be saved, delete the file name in the box, type the new file name, and then click the **OK** button. Counting of the sample will begin. If the file will not be saved, click the **OK** button and counting of the sample will commence.

Spectra files may be saved if desired by selecting **File** from the tool bar and then choose **Save** from the menu. Type the sample identification number into the pop-up box.

6. Calibration

6.1 Energy Calibration

Energy calibration includes the calculation of two sets of parameters: the energy versus channel number, and the full width at half maximum (FWHM) peak shape parameter versus energy. The energy calibration is performed weekly or after system startup using a spectrum obtained by counting the mixed nuclide calibration standard. Table 1 lists the singlet peaks and energies found in the calibration spectrum.

Table 1. Mixed Nuclide Calibration Standard Nuclides and Energies

Nuclide	Energy (keV)
Am-241	59.5
Cd-109	88.0
Co-57	122.1
Co-57	136.4
Ce-139	165.9
Hg-203	279.2
Sn-113	291.7
Cs-137	661.7
Y-88	898.0
Co-60	1173.2
Co-60	1332.5
Y-88	1836.0

1. Collect a spectrum of the mixed nuclide calibration standard using the "Aquire/Start" menu function of GammaVision. Acquire the spectrum for a period of time to ensure that the peaks to be used for the calibration have a minimum of 20,000 counts per peak to permit measurement of the peak positions with a precision of less than 0.2 keV.
2. Perform the energy calibration by using the "Calibrate/Energy" menu function of GammaVision. Position the cursor at the center of the corresponding to the entry in Table 1, enter the appropriate value in the "Energy" box, and click "Enter." Alternately, the peak entries can be recalled from a previous calibration using the "Table Recall" button. Delete the previous values for the peaks from the table, if present.
3. Verify the calibration by reviewing the "Energy Calibration Fit" and "FWHM Calibration Fit" data.
4. Record the channel numbers for the 59.5 keV and 1836 keV peaks on the Energy Calibration Log form (Figure 1). The energy calibration is now complete. Close the calibration box sidebar box.
5. Save the calibration data using the "Calibration/Save" menu function of GammaVision.

6.2 Efficiency Calibration

Efficiency calibration is the calculation the detector efficiency versus energy. The energy calibration must be established before the efficiency calibration is performed. The efficiency calibration is performed once per year, after system repair, or whenever the results obtained for the uranium reference can indicate a change in system performance.

1. Collect a spectrum of the mixed nuclide calibration standard using the "Aquire/Start" menu function of GammaVision. Acquire the spectrum for a period of time to ensure that the peaks to be used for the calibration have a minimum of 20,000 counts per peak to permit measurement of the peak positions with a precision of less than 0.2 keV.
2. Select the calibration library using the "Library/Select File" menu function of GammaVision.

3. Perform the efficiency calibration by using the "Calibrate/Efficiency" menu function of GammaVision. Position the cursor at the center of the corresponding to the entry in Table 1. Click "Calculate" and enter the reference date the Gamma/Sec. Emission rate for the peak from the mixed nuclide calibration standard certificate. Verify that the correct half-life is entered and click "Calculate Efficiency" and "OK". Click "Enter" to include the data for the peak in the efficiency table. Alternately, the peak entries can be recalled from a previous calibration using the "Table Recall" button. Delete the previous values for the peaks from the table, if present.
4. Verify the calibration by reviewing the "Efficiency Calibration Fit" data.
5. Save the calibration data using the "Calibration/Save" menu function of GammaVision.
6. Calculate the calibration factor as follows:

$$Factor = \left(\frac{1}{CT}\right) + (Eff) \times \left(\frac{60}{Int}\right) \times 2.05$$

Where:

Factor = Calibration factor used to calculate the uranium results in pCi/g.
CT = Count time, in seconds, used for samples (usually 900 seconds).
Eff = Detector efficiency at 88 keV from the efficiency table generated in step 3 above.
Int = The sum of the uranium peak intensities at 92.4 and 92.8 keV (0.054).
2.05 = Multiplier to include the activities of U-234 and U-235.

7. The efficiency calibration is now complete. Close the calibration box sidebar box.

7. Establishing a Region of Interest (ROI)

The uranium ROI, centered approximately 93 keV, should be checked at the beginning of each workday and established if needed. The ROI should also be checked whenever it appears the spectrum may have shifted.

1. Place the uranium reference can into the lead pig and close the door.
2. Set the live time to 100 seconds by selecting **Acquire** from the tool bar and then choose **Settings** from the main menu. Count for 100 seconds.
3. When the count is completed, move the cursor to the 93 keV peak. If necessary clear the old ROI by selecting **ROI** from the tool bar and then choose **Clear All** from the menu.
4. Center the cursor on the marker with the highest number of counts. Select **ROI** from the tool bar and then choose **Mark** from the menu. Use the left arrow to move the cursor three clicks (six markers) to the left. The markers will be highlighted. Record the left marker number on the Daily Log form (Figure 2).
5. Return the cursor to the middle marker of the peak and move the cursor three clicks (six markers) to the right of the peak. Select **ROI** from the tool bar and then choose **Off** from the menu. Record the right marker number on the Daily Log form (Figure 2).
6. The highlighted region shown on the screen will represent a 12-marker ROI centered n the 93 keV uranium peak. From the tool bar, select **ROI** and then choose **Save File**. A pop-up

box will appear. Select "uranium.roi" from the file list and click on it. When the program asks "Replace existing file?" click on **yes**. Then exit the menu.

7. Click anywhere on the highlighted ROI and the gross area in the ROI will appear on the bottom of the screen. Record the gross area on the Daily Log form (Figure 2).

8. The ROI can be recalled by selecting **ROI** from the tool bar and then choosing **Recall File** from the menu and then clicking on the ROI file named "uranium.roi".

8. Establishing Background

A 12-hour background count is performed after the energy and efficiency calibrations and the ROI are established, but prior to collecting data. This background count should be performed weekly, or whenever the system undergoes repairs or other changes.

1. Put the background reference can into the pig and close the door.
2. Change the live time to 43,200 seconds (12 hours) and start the count.
3. After the count has been completed, recall the uranium ROI and record the gross area in the ROI on the Background Log Sheet (Figure 3).
4. Calculate the average background area expected for the 15-minute sample count time by dividing the 12-hour measurement by 48, and record that value on the appropriate section of the Background Log Sheet.

The operator should be alert to a gradual or sudden increase in the background count, which could indicate contamination of the pig. If contamination is suspected, the pig should be thoroughly cleaned and a new background count should be taken as soon as possible.

9. Drying Samples

Normally, samples should first be analyzed for Ra-226 with the OCS system to determine if the sample meets the relevant Ra-226 standard. After Opposed Crystal System (OCS) analysis, the sample should be dried according to the following steps:

1. Remove the sample from the OCS can and place it in a microwave-safe dish. Put a paper towel over the dish to prevent splattering. A Pyrex beaker of water may also be set in the microwave to protect the oven from overheating.
2. Put the sample dish in a microwave oven on high power and set the microwave timer for 1 to 2 minutes, depending upon the amount of moisture in the sample.
3. After the elapsed time, stir the sample. The samples do not need to be absolutely dry; they may retain a minimum amount of moisture. If the sample is not dry enough, microwave in 1-minute increments until the sample is dry. Care should be taken not to over dry the samples as this may cause overheating of the oven.
4. After drying, obtain a new sample weight and mark it on the can. Seal the can using the canner.
5. The above protocol should not be used for soils exceeding 130 picocuries per gram (pCi/g) Ra-226.

10. Sample Analysis

To analyze the samples:

1. Record the sample identification number and the sample weight on the Uranium Analysis Form (Figure 4).
2. Change the live time to 900 seconds and begin the count.
3. When the count is completed recall the uranium ROI.
4. Click on the highlighted ROI and record the **gross area**, displayed on the bottom of the screen, on the Uranium Analysis Form (Figure 4).
5. On the Uranium Data Form subtract the 900-second average background from the gross area and record the data in the column labeled "net area".
6. Using the equation below, calculate the uranium activity.

$$uranium\ in\ pCi/g = \left(\frac{net\ counts}{sample\ weight}\right) \times Factor$$

7. Record the uranium in the appropriate column on the form.

11. Records

The records generated by this procedure and their disposition requirements are listed below.

Energy Calibration Log (Figure 1) will be retained for a minimum of 2 years. The logs will be placed in a binder by the OCS operator and kept with the HPGe system.

Daily Logs (Figure 2) will be retained for a minimum of 2 years. The logs will be kept in a binder by the OCS operator and kept with the HPGe system.

Background Logs (Figure 3) will be retained for a minimum of 2 years. The logs will be placed in a binder by the OCS operator and kept with the HPGe system.

Uranium Analysis Forms (Figure 4) will be provided for inclusion in the project records. The OCS operator will keep a copy in a binder for a minimum of 2 years.

12. References

EG&G ORTEC, *NOMAD Portable Spectroscopy System Model 92X-P Hardware Reference Manual*, Oak Ridge, Tennessee.

EG&G ORTEC, GammaVision™ Software User's Manual, Version 2.2.

S.M. Stoller *Field Services Procedures Manual* (STO 203), "Filling the High Purity Germanium Dector with Liquid Nitrogen".

S.M. Stoller *Health and Safety Manual* (STO 2).

ENERGY CALIBRATION LOG				
MCA Number		Detector Number		
DATE	OPERATOR	FINE GAIN	MARKER FOR 59.5 keV	MARKER FOR 1836 keV

h:\forms\nomad\energy.cal 27mar97

Figure 1. Energy Calibration Log

DAILY LOG FOR HPGE SYSTEM

MCA Number		Detector Number		
Date	**Operator**	**Beginning Marker**	**Ending Marker**	**Gross Area in 93 keV Peak**

h:\forms\uranium\daily.log, 27mar97

Figure 2. Daily Log

BACKGROUND LOG			
MCA Number		**Detector Number**	
Date	**12 Hour Gross Area (43,200 Second)**	**15 Minute Average Gross Area (12 hr count/48)**	**Operator**

h:\forms\uranium\back.log 6mar97 crk

Figure 3. Background Log Form

URANIUM ANALYSIS FORM

MCA NUMBER:	DETECTOR NUMBER:	COMPUTER SYSTEM:
OPERATOR:	DATE:	All samples are counted for 15 minutes (900 sec) unless noted.

This data is for informational purposes. This procedure is not an approved verification measurement. A conservative error limit of ± 12 mg/kg should be used when interpreting the data.

Sample Number	Net Wt (Grams)	Gross Area	15 Minute Average Background	Net Counts (gross area - bkg)	Calc. U (pCi/g)	Comment (optional)

H:\forms\uranium\analysis.frm 27mar97 crk

$$\text{uranium in pCi/g} = \left(\frac{\text{net counts}}{\text{sample weight}}\right) \times 48.62$$

Figure 4. Uranium Analysis Form

Attachment 5
Transportation of Radioactive Materials

1. Purpose

Transportation of radioactive material (RAM) over public roads is regulated under Department of Transportation (DOT) regulations found in 49 CFR Parts 171–178. The Department of Energy (DOE) also has requirements that must be met for shipment of RAM in DOE Order 460.2A. This procedure provides several methods for meeting these requirements.

DOT defines RAM as *any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in the table 49 CFR Part 173.436.* RAM commonly dealt with by Field Services' personnel includes samples containing uranium tailings or uranium ore, radioactive sources, and instruments containing internal radioactive sources.

This procedure applies to:

- Transportation of samples containing RAM such as uranium ore or uranium mill tailings as exempt materials or Limited Quantity RAM
- Transportation of sources
- Transportation of instruments containing internal sources

This procedure does not apply to transportation of bulk materials, waste, or other type of hazardous materials regulated by DOT.

2. References

Health and Safety Procedures Manual (STO 201), Procedure 360.1, "Movement of Radioactive Material."

Site Radiological Control Manual (STO 3), Chapter 4.0, "Radioactive Materials."

Environmental Compliance Manual (STO 11), Section 7.0, "Transportation of Hazardous and Radioactive Materials and Wastes".

Environmental Procedures Catalog (STO 6), GA-9(P), "Standard Practice for Sample Submittal to Contract Analytical Laboratories".

Field Services Procedures Manual (STO 203), Procedure 4.0, "Soil Sample Analysis Using the Opposed Crystal System."

Field Services Procedures Manual (STO 203), Procedure 16.0, "Radiological Soil Sampling."

Field Services Procedures Manual (STO 203), Procedure 20.0, "Control of Radioactive Materials."

49 CFR, including HM230, October 2004. The following sections apply to listed topics:

- Shipping Papers, 49 CFR Parts 172.200-205.
- Marking, 49 CFR Parts 172.300-301 and 172.303-310.
- Labeling, 49 CFR Parts 172.400-401, 172.403, 172.406-407, and 172.436.
- Emergency Response Information, 49 CFR Part 172.602, 172.604.
- Limited quantities of RAM, 49 CFR Parts 173.421-424.
- Radiation level limitations, 49 CFR Part 173.441.
- Contamination control, 49 CFR Part 173.443.
- Table of A1 and A2 values for radionuclides, 49 CFR Part 173.435.
- Table of Exempt material activity concentrations and exempt consignment activity limits for radionuclides, 49 CFR Part 173.436.
- Packaging, 49 CFR Part 178.

3. Definitions

Certified Shipper—A person who has received approved training in the DOT requirements for shipment of radioactive or hazardous material.

Consignment —A package or group of packages or load of radioactive material offered by a person for transport in the same shipment.

Limited Quantity—A quantity of RAM not exceeding the packaging limits specified in 49 CFR 173.421. These limits are based on the maximum activity of the RAM permitted in a Type A package as listed in 49 CFR 173.435.

Radioactive Material (RAM)—RAM is any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in the table in 49 CFR Part 173.436.

"Strong, Tight" Containers or Packages—Containers or packages that will not leak any of the material they contain during normal transportation. Plastic sample bottles and OCS cans meet this requirement. Plastic sample bags do not.

Transportation—Movement of RAM on or over a public road or highway including shipment using a commercial carrier.

4. Significance and Use

This procedure provides methods for the shipment of some common types of RAM to and from field locations. These materials include samples containing uranium tailings and ore, radioactive sources used for operational checks of field instruments, and instruments such as spectrometers and borehole logging tools that contain an internal radioactive source.

5. Training Requirements

Field personnel involved in shipment or transportation of Limited Quantity RAM must have Hazardous Materials Transportation Security Awareness (HM116), DOT Hazardous Materials Transportation General Awareness (HM100), DOT Hazardous Materials Driver's Training (Module 15) and training with this procedure. Training must be updated every 3 years or when significant changes occur to this procedure or applicable regulations.

6. Responsibilities

6.1 Environmental Services Group

Environmental Services Group is responsible for:

- Reviewing all procedures for shipment of RAM.
- Maintaining a record of all Certified Shippers and their training dates.
- Providing technical assistance on shipment of RAM as required.

6.2 Team Members

The Field Services Team Members are responsible for:

- Measuring the activity of the material to be shipped.
- Collecting and/or preparing samples, instruments, or sources for shipment as required.
- Notifying the Certified Shipper if his or her services will be required.
- Preparing and transporting Limited Quantity RAM, sources, or instruments according to this procedure.

6.3 Field Services Supervisor

The Field Services Supervisor is responsible for:

- Preparing and tracking instruments and sources for shipment.
- Working with the Environmental Services Group when shipping instruments and sources via common carrier.

7. General Requirements for Transportation of RAM

7.1 Determination of Shipment Category

The first step in preparing to ship materials that are potentially RAM is to determine the shipment category (Exempt, Limited Quantity RAM, or RAM) based on the activity concentration present and the total mass of the materials in the package. The determination of the shipment category for samples of uranium ores or uranium mill tailings containing only naturally occurring radioactive materials (NORM) is diagrammed in Figure 1 and described below. Refer to Section 7.2 for samples containing uranium oxides or non-NORM nuclides.

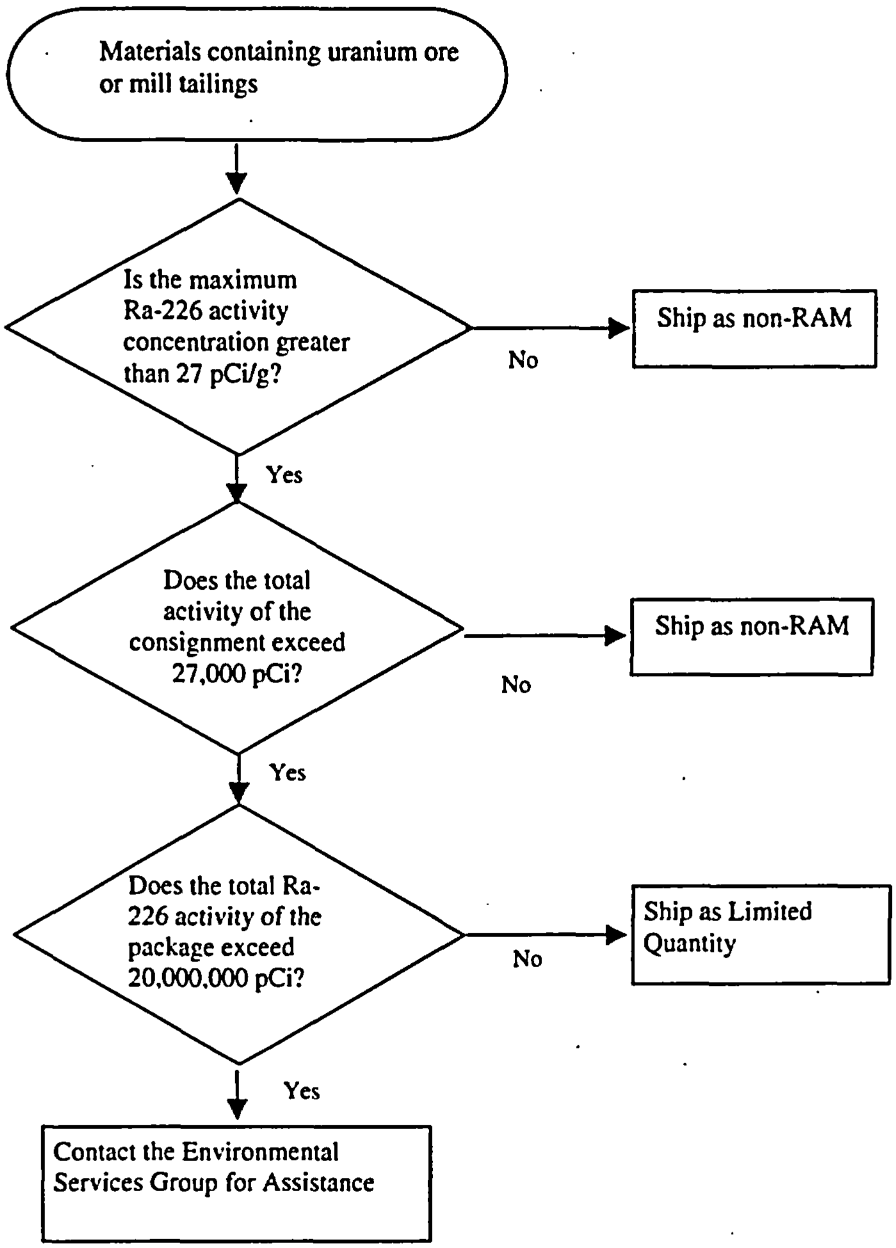


Figure 1. Shipment Category

1. Estimate the Ra-226 activity concentration of each sample using the Opposed Crystal System (OCS) or other measurement system. See the *Field Services Procedures Manual,* (STO 203) Procedure 4, "Soil Sample Analysis Using the Opposed Crystal System."

2. Measure or estimate the weight of each sample. A 1,000 milliliter (mL) plastic sample bottle full of soil will normally weigh less than 3.5 pounds. The OCS cans normally weigh less than 2 pounds when full.

3. Calculate the total Ra-226 activity in each sample by multiplying the activity concentration of each sample by its estimated weight. Sum the total activities for all samples to get the total activity of the consignment.
4. Use the maximum Ra-226 activity concentration of any sample in the consignment and the estimated total Ra-226 activity to determine the shipment category.

7.1.1 Exempt Materials

A material is exempt (non-RAM) if *either* the maximum activity concentration *or* the activity limit for exempt consignment is less than the values found in table in 49 CFR Part 173.436.

The exempt material activity concentration (from table in 49 CFR Part 173.436) for materials containing uranium ore is 27 picocuries per gram (pCi/g). This is the activity concentration of the parent nuclide (U-238) in the decay series with the assumption that secular equilibrium existing between the parent nuclide and its progeny. The Ra-226 activity concentration can be used to estimate the U-238 activity concentration when secular equilibrium exists.

The exempt material activity concentration for materials containing uranium mill tailings is also 27 pCi/g. While the activity concentration from table in 49 CFR Part 173.436 for Ra-226 is 270 pCi/g, the value for Th-230 is 27 pCi/g. If it is assumed that the Th-230 is present at an activity concentration equal to that of Ra-226, then the exempt material activity concentration is equal to that of theTh-230 value. If the maximum Ra-226 activity concentration of the samples in the consignment is less than 27 pCi/g, then the consignment may be shipped as exempt (non-RAM).

The activity limit for exempt consignment for materials containing uranium ore from table in 49 CFR Part 173.436 is 27,000 pCi. This value is also applied to uranium mill tailings under the assumption that the U-238 activity will be less than or equal to the Ra-226 activity. If any sample in a consignment has a Ra-226 activity concentration greater than 27 pCi/g but the total Ra-226 activity of the consignment is less than 27,000 pCi, then the consignment may be shipped as exempt (non-RAM). The total activity of a consignment is sum of the activities of the samples in the consignment as calculated is step 3 of 7.1.

7.1.2 Limited Quantity Materials

Sources and instruments containing sources can be shipped as "limited quantities" if the total activity of the package is less than the $A_1 \times 10^{-3}$ where A_1 is the value from table in 49 CFR Part 173.435.

Samples containing uranium or uranium mill tailings can be shipped as "limited quantities" if the total activity of the package is less than the $A_2 \times 10^{-3}$ where A_2 is the value from table in 49 CFR Part 173.435. The A_2 for uranium is unlimited. The A_2 values for Ra-226 and Th-230 are 81,000,000 pCi and 27,000,000 pCi respectively. For samples with these nuclides present, the consignment must satisfy:

$$\left(\frac{Ra226, pCi}{81{,}000{,}000}\right) + \left(\frac{Th230, pCi}{27{,}000{,}000}\right) \leq 1.0$$

If it is assumed that the concentrations of Th-230 and Ra-226 are equal in uranium ores and uranium mill tailings, then the maximum Ra-226 activity allowable for limited quantity shipment is 20,000,000 pCi. Consignments that do not meet the criteria in Section 7.1.1 for an exempt shipment, but have total Ra-226 activities less than 20,000,000 pCi are shipped as Limited Quantity Materials.

7.2 Other Sample Types

The shipment category of samples containing uranium oxides is determined by the activity concentration and total activity of U-238. These values can be estimated using the high purity germanium gamma spectrometer, see the *Field Services Procedures Manual* (STO 203) Procedure 8, "Uranium Analysis." Samples containing uranium oxides that are less than 27 pCi/g and have a total U-238 activity in the consignment of less than 27,000 are shipped as exempt (non-RAM). A consignment that exceeds both the activity concentration and the total activity values is shipped as Limited Quantity Material. There is no maximum total activity value for these types of samples.

The shipment category of samples containing non-NORM nuclides is based on the nuclides present and the values for those nuclides in tables in 49 CFR Part 173.435 and 49 CFR Part 173.436. Contact the Environmental Services Group for assistance with these types of samples.

A RAM shipment that contains other hazardous materials must be shipped in accordance with the requirements found in the *Environmental Compliance Manual* (STO 11), Section 7.0, "Transportation of Hazardous and Radioactive Materials and Wastes." A Certified Shipper must be contacted to ship this type of material.

7.3 Emergency Notification

Shipments that are not categorized as Exempt or Limited Quantity must include an emergency contact number for notification in the event a spill of the material occurs during transportation. For most shipments, this number will be the security gate extension. For shipments originating off the DOE Grand Junction site, the Certified Shipper shall fax a copy of the shipping papers to the Environmental Services Group for inclusion into the shipping information given to security gate personnel. If the transportation will occur during a single working day, local office personnel (such as the Moab Office Administrator) may be used, and the Certified Shipper will provide the shipping information to the designated responder for that shipment.

8. Procedure for the Shipment of Samples

Contact the Laboratory Coordinator prior to sample collection. The Laboratory Coordinator will notify the selected laboratory of the sample shipment and provide sample submittal documents and laboratory contact information. See the *Environmental Procedures Catalog* (STO 6), GA-9(P), "Standard Practice for Sample Submittal to Contract Analytical Laboratories."

Determine the shipment category, Section 7.1, and then proceed to Section 8.1 or Section 8.2.

8.1 Exempt (non-RAM) Shipment

Samples of uranium ores and uranium mill tailings may be shipped as non-RAM only if the Ra-226 activity concentrations are less than 27 pCi/g or the total activity of the consignment is less than 27,000 pCi. There are no special requirements for packaging and shipping samples in this category if the package does not contains other hazardous substances.

8.2 Limited Quantity Shipment

Samples of uranium ores and uranium mill tailings may be shipped as limited quantities of radioactive material if the total Ra-226 activity of the consignment is less than 20,000,000 pCi. If the consignment does not meet these criteria or contains other hazardous materials then contact the Environmental Services Group for assistance.

To ship Limited Quantity RAM the following steps must be followed:

1. Place the samples in strong, tight containers. Based on history of use, OCS cans and plastic sample jars are acceptable.
2. Clean the outside of the sample containers.
3. Attach a Caution: Radioactive Material sticker on the outside of each sample container that exceeds the Ra-226 27 pCi/g value.
4. Put the sample containers into strong, tight outer package (i.e., a cooler).
5. Contact Health and Safety to survey the outside of the package. The outside of the package must measure less than 0.5 mrem/hour and be below 220 dpm/cm^2 beta/gamma. The DOE criterion is 1,000 dpm/100cm^2 removable alpha and 10 dpm/cm^2 beta/gamma. The results shall be documented on the appropriate form by Health and Safety.
6. Fill out a chain-of-sample custody form if one does not already exist for the samples.
7. The outside of the package must be labeled with the *UN2910.*

9. Procedure for Shipment of Sources

To ship sources as Limited Quantity RAM the following steps must be followed:

1. Sources shall be transported in their appropriate locked container.
2. Attach a *Caution: Radioactive Material* sticker on the outside of each container if not already present
3. Put the containers into strong, tight outer package.
4. Contact Health and Safety to survey the outside of the package. The outside of the package must measure less than 0.5 mrem/hour and be below 220 dpm/cm^2 beta/gamma. The DOE criterion is 1,000 dpm/100cm^2 removable alpha and 10 dpm/cm^2 beta/gamma. The results shall be documented on the appropriate form by Health and Safety. To avoid unnecessary delay, allow as much lead-time as possible for completion of approval signatures and the required radiation surveys by Health and Safety.
5. The outside of the package must be labeled with the *UN2910.*

6. Transfer of sources or instruments containing sources will be documented in accordance with procedures in the *Field Services Procedures Manual* (STO 203) Procedure 20, "Control of Radioactive Materials."

10. Procedure for Shipment of Instruments Containing Internal Sources

The Mt. Sopris SC-132 scintillometer contains and internal source and requires control during transportation.

10.1 Mt. Sopris SC-132 Scintillometer

The ratemeters in the SC-132 scintillometers use a nickel-63 wire inside a sealed glass tube as part of the high voltage regulator. The nickel-63 is a beta emitter, and must be transported as limited quantity RAM, radioactive instrument or article. Voltage regulator tubes are to be inspected every 12 months during the routine instrument calibration. This inspection and the daily operational checks for the instrument verify that the sources remain intact.

10.2 Logging Tools With Internal Sources

Logging tools with internal sources shall be transported as specified in Section 9, "Procedure for Shipment of Sources".

11. Records

The project manager responsible for the shipment determines retention and classification of the documents.

11.1 Training Records

Records of training on these procedures shall be sent to the Training Group.

11.2 Shipping Records

A copy of the shipping documents and the emergency response information are to be sent to the Environmental Services Group and Security. The originals will be kept in a shipping file maintained by a project office or in a project-specific file.

Attachment 6
Radiological Soil Sampling

1. Purpose

The purpose of this procedure is to describe appropriate methods for collecting soil samples at radiologically contaminated sites. The procedure identifies responsibilities, sampling protocols, and procedures for submitting samples for analysis.

2. Soil Sampling Equipment and Overall Sampling Procedure

2.1 100-Square Meter Verification Method

A 100-square meter (m^2) verification area (V-area) will be subdivided into 3.3- by 3.3-meter grids (Figure 1). Each 100-m^2 V-area shall be gamma scanned, and the range and average of scintillometer readings shall be recorded on the verification field map. The gamma range of the excavated area is determined by observing the high and low gamma scintillometer readings; the average is the gamma reading most commonly observed during the scan of the excavation. The readings are converted to exposure rates by using factors derived from previous correlations that used a Pressurized Ion Chamber.

Composite soil samples will be taken from the V-area to verify compliance with soil remediation goals. Aliquots will be taken from the geometric center of each 3.3- by 3.3-meter cell within the V-area and blended into one composite soil sample. When analyzed, this sample will represent the average radionuclide concentration for the V-area. Areas which exceed the remediation goals will be excavated further. Afterwards a new gamma range will be documented and a new verification sample will be collected.

Some V-areas may be smaller than 100 m^2 due to topography or because the V-area overlaps a property boundary. These smaller V-areas are subdivided into 3.3- by 3.3-meter cells and sampled as above.

Soil samples will be analyzed on site for Ra-226 by the Opposed Crystal System (OCS). Ten percent of the total samples also will be analyzed by an analytical laboratory for Ra-226 by using gamma spectrometry. Sample locations are shown in Figure 1. Laboratory results for radium will be compared to OCS results for quality control purposes; however, only OCS results are used for the final property report.

2.2 Soil Sampling Equipment

Sampling equipment will be chosen based on the type of soil and the sampling objective. The following equipment is typically available, although other equipment may be used.

- T-handled bucket auger, 1.8-inch or 3-inch diameter
- T-handled screw auger
- ATV-mounted auger with modified 6-inch bit

- Square shovel marked with 6-inch depth
- Metal scoops
- Adhesive bar code sample labels and numbers (Figure 2)
- Plastic sample jars or bags (sized to accommodate 1 to 2 kilograms of soil)
- Marking pens (black, waterproof)
- Ballpoint pens (black)
- Stapler
- Request for Analytical Services form (Figure 3), Chain of Sample Custody form (Figure 4), Soil Sample Catalogue (Figure 5), or equivalent

3. General Discussion

3.1 EPA Standard

The U.S. Environmental Protection Agency standard for radium contamination (40 CFR 192) states that concentrations in soil shall be averaged over intervals that are 6-inch-deep (15 centimeters). Therefore, all samples will be collected from 6-inch intervals when possible. Deviations will be documented so that interpretation of soil analysis results will be accurate.

3.2 Sample Collection Problems

Problems in soil sampling typically occur in the following situations. If possible, the problem should be avoided by offsetting the sample location.

- Compacted gravels and soils may be too hard to sample. A breaker bar or demolition hammer may be used to loosen material. The gravel is considered part of the sample interval and is included in the sample container. Exceptions to this guideline are man-made debris such as metals, sod, large rocks, and organic debris (tree roots) that have a diameter greater than 2 inches. These should not be placed in the sample container.
- River alluviums consisting of gravel and cobbles will normally be sampled to retain all size fractions including large cobbles. This eliminates biasing the bulk composition of the sample by over representation of the fine grain sands and muds where contaminants are most likely to be trapped. (Refer to Attachment 2, "Excavation Control and Verification," for detailed procedures on alluvium sampling.)
- In dry, loose, unconsolidated material (sands and gravels), a tendency exists to collect a sample that is much wider at the top than at the bottom. A cylindrical-shaped sample with the bottom of the sample interval the same width as the top should be collected.
- For analysis of Ra-226 using the OCS and for laboratory analysis, 500 ml of sample is typically required. Guidance on the amount of sample required for other types of analyses may be obtained from the site-specific sampling plan or the analytical laboratory. In general, a 500 ml sample will also be adequate for Th-230 and U-238 analysis.

- Bedrock is typically covered with 1- to 3-inch layer of soil after remediation, because mechanical equipment cannot readily remove the last remnants of soil from the interface. Because of the difficulties in obtaining the required 6-inch deep sample for Ra-226 analysis, the following protocol will be used:

  - A representative sample of the bedrock will be obtained by chipping samples from several grid blocks in the outcrop. These samples will be combined, crushed, and analyzed by OCS for Ra-226. This will represent an average bedrock value that will be used for all grid blocks within that outcrop. Then within each 10- by 10-meter grid block, 9 aliquots of soil will be collected, composited, and analyzed for Ra-226 using the OCS. At each aliquot location the soil depth will also be measured and an average soil depth for the grid will be calculated. The verification Ra-226 concentration will be calculated using the following formula:

$$\frac{(\textit{average soil depth}) \times (\textit{soil concentration}) + (\textit{average rock depth}) \times (\textit{bedrock concentration})}{6 - \textit{inch sample interval}}$$

For example, if the average soil depth was 2 inches, the average rock depth would be the 6-inch interval – 2 inches of soil = 4 inches. If the soil concentration was 14 pCi/g and the rock concentration was 2 pCi/g, the formula would be:

$$\frac{(2\ \textit{inches soil}) \times (14\ \textit{pCi/g}) + (4\ \textit{inches rock}) \times (2\ \textit{pCi/g})}{6\text{-}\textit{inch sample interval}} = 6\ \textit{pCi/g}$$

Consequently, the verification Ra-226 value for the grid block would be 6 pCi/g. If the sample Ra-226 concentration is above the applicable standard, then further removal of loose soil material will be required and the block will need to be resampled.

3.2.1 Sampling Cleaned Bedrock

If the loose soil has been removed by high pressure washing, leaving a clean bedrock surface, the following procedure will be used to obtain a verification measurement. The outcrop will be gamma scanned and the highest gamma location within each 10- by 10-meter grid will be found and marked. A rock sample will be obtained from the high gamma location and analyzed by OCS. The rock sample does not need to be a full 6-inch deep sample.

3.3 Sample Splits

To reduce the volume of the sample, it may be necessary to perform a field split of the sample. Three methods are discussed below, but other methods may be used.

3.3.1 Conventional Sample Splitter

Follow directions of equipment manufacturer.

3.3.2 Canvas Method

A 6- by 6-ft square of canvas or tarp is placed on the ground over a broom handle. The sample is put in the middle of the tarp, flattened, and mixed with a shovel. The sample is quartered with a shovel and the quarters are separated. The individual quarters are flattened, mixed, and recombined in the center of the tarp. The broom handle under the tarp is lifted up to divide the sample and the excess half is discarded. If necessary, the remaining material may be subdivided again using the broom handle. A crease in the fabric, or other straight hard object, may be used as a substitute for the broom handle.

3.4 Handling, Shipping, and Storage

Requirements for handling, shipping, and storing soil samples depend on the contaminants likely to be found in the samples. Requirements for handling and shipping of radioactive material (RAM) samples will be in accordance with the regulations contained in 49 CFR Parts 171-178. No sample preservation (chemical preservation) is required. Sampling tools, pans, etc. should be well cleaned prior to each use, but absolute cleaning using distilled water, etc., is not necessary.

4. Sampling Objectives

4.1 Assessment

The intent of sampling is to provide evidence concerning Ra-226 concentrations and to support conclusions drawn from in-situ gamma measurements. Individual samples are collected to determine the areal extent of contamination. The results are interpreted in conjunction with gamma survey data.

4.2 Verification and Excavation Control

The intent of verification sampling is to provide evidence of remediation meeting applicable standards. Composite samples are collected for the purpose of documenting radium, thorium, or uranium concentrations over remediated areas. Excavation control samples are collected to determine the lateral and vertical extent of potentially additional contaminated soil layers.

5. Field Documentation

This procedure provides for proper documentation of samples collected for Ra-226 analysis.

5.1 Sample Identification

All samples submitted to the analytical laboratory will be identified using ASTM procedure GT-2(P), "Standard Practice for Sample Labeling" (Appendix A).

5.2 Field Procedure

Complete the Sample Label (Figure 2) information according to GT-2(P) (Appendix A). Complete a Soil Sample Catalogue (Figure 5) and Chain of Sample Custody form (Figure 4) for all samples. These documents provide a cross reference between sample location and sample number.

NOTE: A Chain of Sample Custody is also required for all samples that are transported from the Moab Project site to Grand Junction for submittal to the analytical laboratory. When custody of samples is relinquished to another person, a signature documenting receipt of the samples is required.

6. Soil Sample Analyses

6.1 OCS

The OCS is used for field radium analysis of soil samples by analyzing gamma radiation from the decay products of Rn-222, itself a decay product of Ra-226. Detailed procedures are given in the supplement to Attachment 3, *Standard Test Method for Radium-in-Soil Sample Analysis Using the Opposed Crystal System (OCS).* Regression analysis for OCS versus laboratory results has indicated a positive correlation (Martz, D.E., 1989, *Comparison of the Opposed Crystal Method with the Chemistry Laboratory Method for Determining Radium Concentrations in Soil Samples* U.S. Department of Energy, Grand Junction Projects Office, Internal Technical Report, RL-0-89-1). By using a correction equation, which accounts for moisture content and radium/radon daughter disequilibrium in OCS samples, the radium concentration can be determined quickly in the field for decision making.

6.1.1 Sample Collection

Samples for OCS analysis are typically collected in plastic sample bags and provided to the OCS operators. Samples are normally analyzed within one working day. Approximately 500 ml of sample media is required for sample analysis.

6.1.2 Sample Disposal

Samples are disposed of with other contaminated material from the collection site, or disposed of at a designated location on the pile.

6.2 Analytical Laboratory

Selected soil samples, including 10-percent of those analyzed using the OCS (for quality control purposes), are delivered to the analytical laboratory for confirmatory analysis. The results of confirmatory analysis are reported to the Field Supervisor.

The samples should be submitted by using a Request for Analytical Services form (Figure 3), and a Chain of Sample Custody form (Figure 4). The analytical charge number, project site number, and type of analysis required should be entered on the form. The name of the person who is to receive the results should also be entered onto the form, or written across the top of the form if a specific space is not provided. The results are sent to the person specified on the submittal form.

Analyses frequently requested are Ra-226, Th-232, and K-40 by gamma spectroscopy, Th-230 by alpha spectroscopy, and total uranium by ICP mass spectrometry.

6.3 Discrepancies Between the OCS and Analytical Laboratory Analyses

6.3.1 Assessment

The assessment of radium concentration normally will be based on OCS results. However, if the team leader's review of the laboratory analyses indicate that changes to the assessment are warranted, revisions shall be made by the Team Leader.

6.3.2 Verification

If the Field Supervisor finds that a sample submitted for laboratory analysis exceeds the cleanup limits for Ra-226, Th-230, or total uranium, additional remedial action, including investigation and gamma scanning of the area, will be required.

7. Records Management

All records that are generated by soil sample collection are sent to Records Management for permanent storage in the appropriate property folio or program/project files. These records include the following:

- Chain of Sample Custody form (Figure 4).
- Soil Sample Catalogue (Figure 5), or equivalent.
- OCS analysis results.
- Analytical Laboratory results.

8. Definitions

Soil—Unconsolidated material found above bedrock, including but not limited to gravel, sand, silt, and clay. Vegetation such as sod is not considered soil and is removed prior to collection of samples.

Individual Sample—A sample normally collected over a 6-inch-deep interval that is a representation of soil at a specific location. This type of sampling is used for assessment or excavation control purposes.

Composite Sample—One soil sample consisting of several smaller uniform samples (aliquots) collected at regular intervals to provide an average or biased representation of soil concentrations over a selected area (typically 100 m^2 in size).

Grab Sample—A sample collected from an unknown interval and/or depth, such as from borehole cuttings. This method is used when others are not feasible and is documented as qualitative information.

Sample Depth—Sample intervals are 6 inches. The zero (Ø) sample depth for concrete or asphalt cover is determined as follows:

The top surface of a concrete or asphalt sampling location will be at zero depth and is considered part of the 6-inch sample interval. Concrete cores may be analyzed to determine whether the concrete itself is contaminated. The activity of that interval can then be averaged with the remaining soil interval to calculate the activity of the 6-inch interval.

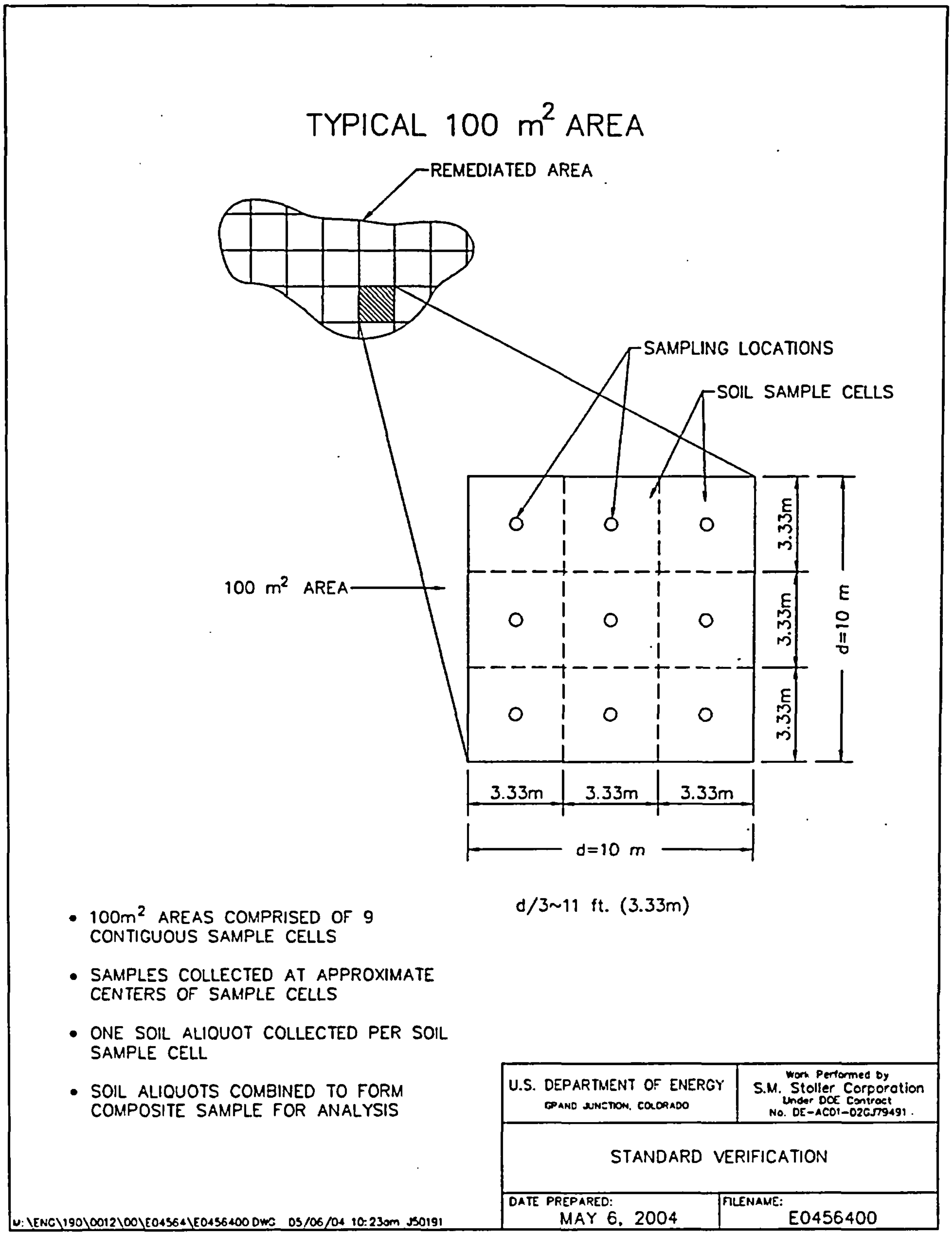
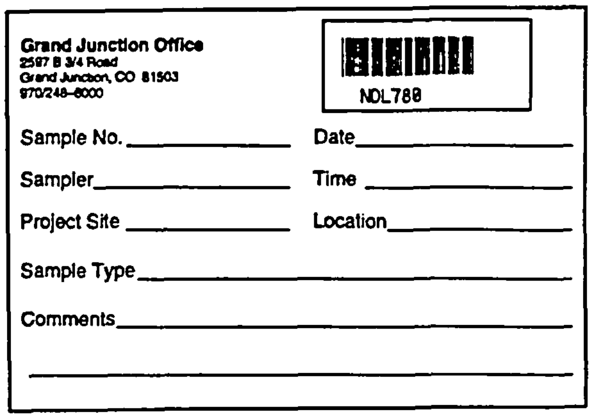


Figure 1. 100-m² Grids



Grand Junction Office
2597 B 3/4 Road
Grand Junction, CO 81503
970/248-6000

NDL788

Sample No. ______________ Date ______________

Sampler ______________ Time ______________

Project Site ______________ Location ______________

Sample Type ______________

Comments ______________

____

Figure 2. Sample Label with Stick-On Sample Number

Request for Analytical Services

For lab use
Requisition No.______
Date recieved __/__/__

Project Title: Moab
Project Number: 110403612
Date Submitted 4/11/03
Date Requiried 5/11/03
Authorized by: E Colunga
Send Final Report To: E Colunga

Sample ID	Th-230	Ra-226	Total Uranium	Soil	Water	Filter	See Inst
NAG991	X	X	X	X			
NAG992	X		X	X			
NAG993	X		X	X			
NAG994	X		X	X			

SPECIAL INSTRUCTIONS:
Return samples to E. Colunga for disposal.

Figure 3. Analytical Request Form

Grand Junction Office
2597 B 3/4 Road
Grand Junction, Colorado 81503
Telephone (970) 248-6000

Chain-of-Sample Custody

1. Page 1 of 1
2. Date 12/3/98

3. Project Name OU1
4. Site Location Grand Junction, CO
5. Sampler (print name) Sam Sampler

6. Sample No.	7. Date	8. Time	9. Sample Location	10. Sample Matrix	11. Containers: 1L Plastic	125mL Plastic	0.5L Glass	40mL Glass		12. Remarks	13. Condition Received
NAA 001	12/3/98	1:00 pm	Well 5A	Water	3					Ra-226, pH<2 HNO3	ok
"	"	"	"	"		1				metals, pH<2 HNO3 Unfiltered	"
"	"	"	"	"			3			PCB, Unfiltered, Cool	"
"	"	"	"	"				1		BOD, Cool	"

SS 12/3/98

14. Relinquished by (signature)	Date	Time	Relinquished by (signature)	Date	Time	Relinquished by (signature)	Date	Time
Sam Sampler	12/3/98	1:30p						
Received by (signature)	**Date**	**Time**	**Received by (signature)**	**Date**	**Time**	**Received by (signature)**	**Date**	**Time**
Roger Receipts	12/3/98	1:30p						

15. Method of Shipment
16. Laboratory/Destination
17. Airbill or Receipt Number

18. For Contract Laboratories Only—Receiver to sign, date, and return form by mail or with analytical data package

Company Name ______ Received by ______ Date ______

GJO 1512
5/97

Preparation instructions on back of form.

Distribution: Original accompanies shipment, copies to relinquisher.

Figure 4. Chain of Sample Custody Form

SOIL SAMPLE CATALOGUE

Property ID Number:	**Address:**
Property Start Date:	**Page ____ of ____**

Sample Number	GPS Coord.	Depth	Ticket Number	Date Sampled	Sampled By	OCS Operator	Uranium pCi/g	Ra-226 pCi/g	Comments

Figure 5. Soil Sample Catalogue

Appendix A

Standard Practice for Sample Labeling—GT-2(P)

Standard Practice for Sample Labeling

1. Scope

1.1 This procedure addresses labeling requirements and recommended practices for labeling samples that are collected in the field and intended for analysis at a later time. The materials sampled may include, but are not limited to, solids such as soils and cores, liquids and sludges, and gases.

1.1.1 This procedure does not address labeling practices for any in situ measurements.

1.2 This procedure is intended for use with a variety of sample types, including grab samples, composite samples, duplicate samples, and split samples.

1.3 All samples collected by Contractor personnel shall have a sample label and a Contractor-generated sample number.

2. Hazard Analysis

2.1 No hazards requiring controls have been identified. Site-specific controls are available in the Health and Safety Plan for a particular project.

3. Referenced Documents

3.1 *Environmental Procedures Catalog* (STO 6)

Standard Practice for Field Documentation Processes [GT–1(P)].

Standard Practice for Chain-of-Custody Control and Physical Security of Samples [GT–3(P)].

4. Terminology

4.1 *Chain-of-Custody Form*—A form used to document sample custody and receipt. It also may contain other information, such as the sample analyses required and traceability.

4.2 *Field*—Any place where the material for analyses or testing is collected.

4.3 *Duplicate samples*—More than one sample collected from the same source location, but placed in separate containers, also called multiple samples.

4.4 *In situ*—In place; not removed from the point of original deposition.

4.5 *Sample* (n)—A portion of material collected from a larger mass that represents the characteristics of that mass.

4.6 *Sample* (v)—To select and collect a sample.

4.7 *Sample label*—The documentation attached to the sample or sample container and marked with required information about the sample. An example is shown in Figure 1.

U.S. Department of Energy
2597 B 3/4 Road
Grand Junction, CO 81503
(970) 248–6000

Sample No. ____________

Project ____________

Date ____________ Time ____________

Sampler ____________ Location ____________

Analysis ____________

Filtered ☐ Cooled ☐ Other ☐ ____________

Preservative: HCl ☐ H_2SO_4 ☐ HNO_3 ☐ pH ☐

Comments ____________

Figure 1. Example of a Sample Label

4.8 *Sample log*—A document that lists all samples collected during a field visit or visits. A Chain-of-Custody form or sample ticket book are examples of sample logs.

4.9 *Sample number*—The unique identification number assigned by the Contractor to each sample and attached to, or written on, the sample label or sample container. The sample number will normally consist of three alpha and three numeric characters.

4.10 *Sample ticket book*—A soft-bound book consisting of 25 sample numbers, one number per page. Each page is backed by two duplicating no-carbon-required (NCR) sheets. For each sample number, a separate page containing 27 duplicate numbers is included. The duplicate number labels are self-adhesive.

4.11 *Split sample*—A sample that has been subdivided into two or more parts, each representative of the original sample.

5. Significance and Use

5.1 All Contractor personnel shall use this procedure for sample identification unless an approved alternate procedure is included or referenced in the official project records. Alternate procedures shall include the minimum information identified in Section 8.4.

6. Materials

6.1 Preprinted Contractor sample labels with adhesive backing.

6.2 Ballpoint pen with reproducible, waterproof ink.

6.3 Sample log or chain of custody.

7. Procedure for Obtaining Sample Numbers

7.1 Sample numbers are provided by using sample ticket booklets. These provide unique sample numbers that may be used to log various sample media.

7.2 The originator will maintain a record of sample numbers (ticked booklets) issued, the user's name, and date of issue.

8. Procedure for Using Sample Labels

8.1 Complete the sample label before or after attachment to the sample container. If labels are not available, write the required information directly onto the sample or sample container. Never write directly on a sample that is to be chemically analyzed.

8.2 Use waterproof, reproducible ink to complete the required label information.

8.3 Normally, the sampler will complete the entire label. If some of the requested information is not relevant, write "NA" for "not applicable" in that space.

8.4 The minimum information required on the sample label shall include

8.4.1 *Sample number.*

8.4.2 *Date*—The date the sample was collected.

8.4.3 *Sampler identification*—The name or initials of the person who collected the sample.

8.4.4 *Project site*—The area or property defined in project documents containing one or more sample locations. The property may be identified by a number.

8.4.5 *Sample location*—The location at which the sample was collected. Examples of sample locations include well numbers, grid locations, or surveyed coordinates.

8.5 Additional information that may be appropriate on the label includes

8.5.1 *Time*—The time at which the sample was collected.

8.5.2 *Sample type (matrix)*—One or more terms that describe the type of sample. This description may cover sample material such as soil, water, sludge, air, or core. It may also include the type of sample, such as composite, grab, or wipe.

8.6 Attach the preprinted sample number to the sample label. If the preprinted number is illegible or does not adhere to the label, the sampler may write the sample number on the sample, sample label, or sample container. The sampler also may write the number on tape and attach it to the sample.

8.7 Maintain a record of sample numbers and other pertinent information on a sample log. See Standard Practice for Field Documentation Processes [GT-1(P)] and Standard Practice for

Chain-of-Custody Control and Physical Security of Samples [GT–3(P)], reference 3.1.

8.8 When needed, protect the completed sample labels from moisture and abrasion by placing a piece of clear plastic tape over the label.

9. Procedure for Using Sample Ticket Books

9.1 Sample ticket books contain preprinted numbers for labeling multiple sample fractions (e.g., water samples from one well) or split samples. A copy of a page from a sample ticket book is shown in Figure 2.

9.2 If multiple sample fractions or duplicate samples are taken at the same location or if split samples are made in the field, the sampler shall identify each sample by removing an adhesive-backed sample number from the book and attaching it to the sample label or container. The sample number shall be identical for each sample in the entire group of duplicates or splits.

9.3 Duplicate samples or split samples each may be assigned a unique sample number for purposes of documenting the precision of the sampling and analysis process. These samples are commonly referred to as "blind duplicates" or "field duplicates."

9.4 The information required on the sample ticket is summarized on the inside flap cover of the ticket book, as shown in Figure 3. When completing the ticket, the cardboard cover should be inserted after the pink page of the current ticket to prevent copying information onto the next ticket. A ballpoint pen should be used with sufficient pressure to ensure duplication onto all copies of the NCR sheets.

9.5 Normally, the white copy of the ticket is retained by the project manager, the canary copy is forwarded to the Sample Plant or analytical laboratory with the samples, and the pink copy remains in the ticket book. This distribution may vary depending upon the needs of the project.

10. Keywords

10.1 Label, sample, sample labeling, sample log, sample number, and ticket book.

NDX 651

Project ______________________

Site ____________ Location ____________

Date ________ Time ________ Matrix ________

Interval ____________ Sampler ____________

Comments ______________________

Analyte(s)	Container Type	Number Collected	Filtered	Preservative

[illegible] White copy to Project Manager canary to laboratory pink remains in ticket book

Figure 2. Example of a Sample Ticket

Required Information

Project:	Name of Project or Project Number: "GJ–12345."
Site.	Site location: "Landfill 3," "Unit 6."
Location:	Exact location of sample such as borehole number, monitor well number, or distance to permanent landmarks: "MW–018."
Date	Date sample was collected.
Time:	Time sample was collected: "1420" or "2:20 p.m."
Interval:	Beginning and ending depth interval of sample or time duration of sample: "2 feet to 3.8 feet," or "0800 to 1622" — dependent on sample type.
Matrix:	Type of sample: soil, water, air, product, tissue, etc.
Sampler:	Name(s)/initials of sampling personnel. Initials should be listed in project file for identification.

Optional Information

Project documentation may replace optional information to avoid unnecessary writing in the field. For example, a Sampling Plan may state "all VOC samples will be collected in 40 mL glass vials" thus avoiding the need to write this for each sample. If all filtered samples use a 40 micron filter, simply put a "Y" in the filtered field. Only variances from the Sampling Plan would need to be noted on the ticket. Information duplicated on many samples may be completed on the first ticket of the series and referred to subsequently: "Same as PNN 230" or "PNN 230"

Comments:	Area weather conditions, radiation levels, composite sample/grab sample, reason for sample, additional location information, or any factors that may affect analysis. Brief location maps with a scale and north indicator are useful
Analyte	Type of analysis to be performed "KUT," "VOCs," "Metals," "Asbestos."
Type/Size.	Describe type of container: Glass, HDPE, Amber; "LDPE/500 mL," "1 L NM Glass," "WMG/250 mL."

NM	Narrow Mouth	A	Amber Glass or Plastic
WM	Wide Mouth	G	Glass
HDPE	High-Density Polyethylene	P	Plastic
LDPE	Low-Density Polyethylene		

Number Collected:	Number of containers of each analyte.
Filtered	Was sample filtered/size: Y/"0.45 micron fiber"
Preservative.	Cool, HCL, HNO_3, Frozen, etc.
Completion of Sample Label	Complete sample label as required. Remove label from ticket book and cover the "Sample Number" area on the sample label

Figure 3. Example of a Sample Ticket

Attachment 7
Control of Radioactive Materials

1. Purpose

The purpose of this procedure is to establish requirements for the handling, control, and accountability of radioactive materials (RAM) and radioactive sources within Field Services. This procedure is based upon requirements in Standard 3.1, "Radiation Protection Standard." The following areas have been identified as having potential for concern if mismanaged or left uncontrolled:

- Radioactive sources;
- Radioactive soil samples; and
- Potential spread of contamination associated with samples or sampling equipment, in vehicles, or building work areas.

2.0. Radioactive Sources

2.1 Source Control Procedures

All sources must be assigned to an individual source custodian. The assigned individuals are accountable for custody of the source.

All sources must be stored in locked containers when not in the user's personal possession or in use in an instrument.

- Custody of the source. The individual must not transfer the source to any other individual without chain-of-custody documentation. The Source Control and Inventory Log (Figure 1) must be used to document the transfer. Copies of the document should be retained by both parties relative to the transfer, if the transfer exceeds 1 day.
- When the sources are returned to their storage area, the individual source custodian will inventory all sources under his/her control by signing the Source Control and Inventory Log. The sources only need to be inventoried if they have been used or issued that day. When the inventory is performed all sources in the enclosure must be inventoried, including instruments that contain an internal source. The Source Control and Inventory Logs will be retained, by the responsible custodian, for a period of 2 years.
- The individual source custodian will lock all source boxes when the sources are returned. The main enclosure must be locked at the end of the shift. The individual source custodian will verify closure of the source cabinet by signing, dating, and recording the time on the security log (Figure 2). A second individual will verify closure and sign the log.

2.2 Off-Site Use of Sources

Sources transported off site must follow requirements in Department of Transportation (DOT) regulation 49 CFR, Parts 171–178.

When sources are necessary for an off-site project, the source custodian will issue the required source, a source container, and a container key. The Field Services Lead shall act as source custodian. The sources must be stored in the locked container when not in use. The containers shall be stored in a locked vehicle or locked office when not in use.

When possible, a second individual shall verify closure as described above. When only one person is working, he/she shall sign as both custodian and user. If a source is transferred from one field crew or individual to another, the transfer shall be documented on a chain-of-custody form.

2.3 Instruments Containing Sources

All instruments with internal radioactive sources shall be labeled and marked appropriately. All instruments that contain a removable radioactive source, such as spectrometers, shall be stored in a locked box, locked drawer, a secure storage area, or a locked vehicle during non-working hours.

Instruments containing sources shall be transported according to requirements in DOT regulation 49 CFR, Parts 171–178.

2.4 Opposed Crystal System (OCS) Reference Cans

OCS operators shall place their reference cans in a locked drawer at the end of each shift. He/she shall sign and date the log to verify closure. The keys to the drawer shall be kept locked in the individual's desk or other secured area.

2.5 Disposition of Lost, Damaged, or Retired Sources

The following circumstances required additional controls through both the Health and Safety Department and the source custodian.

- Disposition of damaged or potentially leaking sources
- Radioactive source disposal
- Retirement, excessing, or disposal of equipment containing radioactive sources
- Lost sources

In the event of lost or potentially leaking sources, the project supervisor shall be informed within 1 hour of the occurrence, and the Health and Safety Department and the source custodian within 2 hours. It is the responsibility of all personnel to provide notification of occurrences within these time constraints.

2.6 Purchase of Radioactive Sources

Purchase of radioactive sources or instruments that contain internal or fixed radioactive sources shall follow the procedures contained in the *Health and Safety Manual* (STO 2). When sources are received, they shall be checked in through Procurement, Health and Safety, and the source custodian.

3. Radioactive Soil Samples

Soil samples that exceed 1,891 picocuries per gram (pCi/g) total activity are classified as RAM and require control. For uranium mill tailings, this level of total activity is approximately equal to 174 pCi/g equivalent radium. For uranium ore samples, the approximate value is 130 pCi/g equivalent Ra-226. The stated concentrations for Ra-226, relative to RAM, are for Health and Safety contamination concerns only and do not apply to transportation of RAM. Detailed procedures for the transportation of radioactive samples and sources are contained in Attachment 5 and should be referenced when transporting RAM.

The controls necessary for RAM are:

- RAM samples shall be labeled "Caution, Radioactive Material."
- RAM samples must be canned, as previously described, and the cans wiped clean before notifying a Radiological Control Technician (RCT) to survey the cans to ensure that all loose contamination has been removed from the outside of the can. Once the sample cans have been free released by the technician, they can then be taken to an OCS station for analysis. In lieu of OCS analysis, a determination of the RAM concentration limit may be approximated by using an in-situ scintillometer reading when it is recorded on the sample container. Any sample with a scintillometer reading greater than 2,000 counts per second (cps) shall be considered RAM.
- OCS sample cans containing RAM shall not be opened at an OCS station or in an office building. If a can needs to be opened, it will be taken to a radiologically controlled area. Upon resealing the lid to the can, the can should be wiped clean and an RCT shall perform a radiologic survey to free release the sample back to the OCS operator.
- All RAM samples shall have a chain-of-custody form.
- Personnel who have been handling RAM samples shall perform a self-survey for contamination or request a contamination survey from an RCT.
- RAM samples shall be transported according to the requirements in DOT regulation 49 CFR, Parts 171–178, which are described in detail, in Attachment 5, "Transportation of Radioactive Samples and Sources."
- OCS samples that are not sent to an analytical laboratory shall be disposed of according to the *Field Services Procedures Manual*, STO 203.

4. Other RAM Material

When highly radioactive rocks, ore samples, contaminated equipment, or any RAM that exceed 2,000 cps and are encountered on vicinity properties or the millsite, personnel shall notify an

RCT. None of these items will be transported on Public Highways without complying with DOT regulation 49 CFR, Parts 171–178.

5. Cleanliness of Equipment and Buildings

5.1 Field Equipment

All equipment used in the field shall be clean and free of loose contamination before returning to the project facilities. The inside of vehicles shall be kept clean and free of loose contamination at all times. The project supervisor shall be responsible for vehicles and equipment used by their team. Individual drivers shall be responsible for vehicles assigned to them.

Equipment shall be checked by an RCT and shall be below the release limits before being shipped off site by a commercial carrier or transferred off site for repair or storage. The Radiological Survey Form (Figure 3) shall be included with the Shipping Request for off-site shipment of equipment.

5.2 Building Cleanliness

Field equipment, samples, or other items, which might accidentally transport contaminated dirt or mud, shall not be taken into any office buildings or office areas. Care shall be taken to ensure that field boots, coveralls, or other items of personnel clothing do not transport loose contamination into vehicles or office areas.

Soil samples stored at the Moab Project sample storage area shall be securely packaged and wiped clean to ensure loose contamination is not transported into the storage area. To assure stored samples meet appropriate release criteria, an RCT shall survey and release all samples to be stored.

6. Definitions

Radioactive Source—For the purpose of this procedure, a source is defined as any RAM that is manufactured and procured for the purpose of measurement or testing at any facility or project under the cognizance of Stoller or the U.S. Department of Energy located in Grand Junction, Colorado. This applies to all RAM (solid, liquid, or gaseous). Sources are typically sealed for beta/gamma emitting isotopes and electroplated for alpha emitting isotopes.

Radioactive Material—RAM is any material that contains distributed radioactivity that exceeds the exposure rate of 160 μR/h on the surface of the material, or contains total activity greater than 1,891 pCi/g, or contains activity in excess of the values listed in the DOT regulation 49 CFR, Parts 171–178, relative to transportation requirements

Reference Material—Reference material is often used to perform operational checks of instruments and analysis systems. The activity of reference material is typically below the criteria for RAM given above. Examples of reference materials are the operational check pads, OCS reference cans, and the portable operational check boxes used for out-of-town assignments. Reference material, however, may require special handling relative to DOT transportation requirements.

SOURCE CONTROL LOG FOR FIELD SERVICES SECTION

DATE:

		SOURCE CHECK OUT			SOURCE CHECK IN			COMMENTS
SOURCE NUMBER	DAILY INVENTORY INITIAL	USER NAME (OUT)	CUSTODIAN NAME (OUT)	TIME OUT	TIME IN	USER'S NAME (IN)	CUSTODIAN NAME (IN)	
U43								
TH8								
TH11								
TH12104								
TH11790								
89U23804903								

Note: Sources checked out for longer than one day shall be noted in the comments section of this log and on the Source Transfer Log form.

SECURITY LOG FIELD ASSESSMENT SOURCE CABINET OR SOURCE BOX

SOURCE CUSTODIAN NAME	TIME OF DAY SECURED	VERIFIED BY (NAME)	TIME VERIFIED	COMMENTS

source.frm 5/15/96

Figure 1. Source Control and Inventory Log

DAILY SECURITY LOG FOR FIELD SERVICE'S SOURCE CABINET

Date	Source Custodian Name	Time of Day Secured	Verified By Name	Time Verified	Comments

Figure 2. Daily Security Log for Field Service's Source Cabinet

Radiological Survey Map

Page ______ of ______

RWP No. ________ Purpose ________ Technician ________ Date ________

Address/Building No. ________ Reviewer ________ (print and sign) Date ________

Time ________ Site ID No. ________

Applicable Limits (Check one for alpha and one for beta)

Alpha (removable/total): ☐ 1000/5000 ☐ 200/1000 ☐ 20/500

Beta (removable/total): ☐ 1000/5000 ☐ 200/1000

No.	Instrument Model	Serial No.	Probe Model	Probe Serial No.	Calibration/Correction Factor
1					
2					
3					

Standarized Symbols for Surveys

- ▣ - Tape press (4"x4") (no inside)
- ○ - Smears (no inside)
- ○L - Large area smears
- △ - Air samples (no inside)
- ▭ - Neutron readings in mrem/hr unless otherwise noted
- —— - Gamma readings in μrem/hr unless otherwise noted (beta readings also)
- ★ - Contact readings (dose rate)
- HS - Hot spot
- SOP - Step off pad
- K - Reading at knee level (when sources from overhead)
- H - Reading at head level (when sources from overhead)
- ..... - Contaminated area
- XXXXX - Radiation area
- ·x·x·x· - Contaminated/radiation area
- RM - Radioactive material area
- ⊗ - Floor drain
- ccpm or ncpm - Corrected or net cpm (gross back-ground) for direct frisk, alpha or beta/gamma specified
- # - Direct frisk

Highest Dose Rates

General Area ________

Contact ________

Highest Contamination Level

Fixed ________

Loose ________

GJO 1503e
Rev 1/2000

File index no ________

Figure 3. Radiological Survey Map

Radiological Survey Map (continued)

Page ______ of ______

Item Surveyed	Location Surveyed	Direct Survey			Smear Survey			Release (Yes/No) (C/UC)[c]	Inst. No. Used	Remarks (Released to)
		Gross Count Rate (cpm)	Net Count Rate (cpm)[a]	Total Activity[b] (dpm/100 cm^2)	Gross Count Rate (cpm)	Net Count Rate (cpm)[a]	Total Activity (dpm/100 cm^2)			

Remarks ____

____

____

____

[a]Net count rate = gross count rate minus background count rate [b]See Table 2-2 of Site Radiological Control Manual (GJO 3) [c]C = conditional release; UC = unconditional release.

GJO [illegible]
Rev [illegible]

Figure 3 (continued). Radiological Survey Map