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FINAL BASEWIDE RADIOLOGICAL MANAGEMENT PLAN NAS BRUNSWICK ME
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TETRA TECH EC INC

**DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND, ATLANTIC
REMEDIAL ACTION CONTRACT (RAC)
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**FINAL
BASEWIDE RADIOLOGICAL MANAGEMENT PLAN**

**FORMER NAVAL AIR STATION BRUNSWICK
BRUNSWICK, MAINE**

AUGUST 2014

Prepared for



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Attachment 3	Project Standard Operating Procedures

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ACRONYMS AND ABBREVIATIONS

μR/hr	microrentgens per hour
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
APP	Accident Prevention Plan
AUW	Advanced Undersea Weapons/Anti-Submarine Underwater Warfare
BRAC	Base Realignment and Closure
cm ²	square centimeter
cm/s	centimeters per second
Co-60	Cobalt 60
cpm	counts per minute
Cs-137	Cesium 137
CTO	Contract Task Order
DAC	derived air concentration
DCGL	derived concentration guideline level
DCGL _{EMC}	DCGL for elevated measurement comparison
DCGL _w	Wilcoxon Rank Sum DCGL
DoD	Department of Defense
dpm	disintegrations per minute
DQO	data quality objective
ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
FSS	Final Status Survey
GPS	Global Positioning System
G-RAM	general radioactive material
H-3	Tritium
HRA	Historical Radiological Assessment
ISO	International Organization for Standardization
LBGR	lower boundary of the gray region
m	meter
m ²	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MDCRSURVEYOR	MDCR calculated assuming a surveyor efficiency
MDER	minimum detectable exposure rate
MeV	megaelectron volt
min	minute
mrem	millirem
NaI	sodium iodide
NASB	Brunswick Naval Air Station
NEDD	Navy electronic data deliverable

NIRIS	Naval Installation Restoration Information Solution
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/mL	picocuries per milliliter
PMO	Program Management Office
PPE	personal protective equipment
PSPC	Position Sensitive Proportional Counter
Pu-239	Plutonium 239
QC	quality control
Ra-226	Radium 226
RASO	Radiological Affairs Support Office
RCT	Radiological Control Technician
RML	Radioactive Materials License
RPM	Remediation Project Manager
RPP	Radiation Protection Plan
RSO	Radiation Safety Officer
RSOR	Radiation Safety Office Representative
RSSI	Radiation Survey and Site Investigation
RWP	Radiation Work Permit
SAP	Sampling and Analysis Plan
SCM	Surface Contamination Monitor
SOP	Standard Operating Procedure
Sr-90	Strontium 90
SS	Site Supervisor
SSHP	Site Safety and Health Plan
Th-232	Thorium 232
TSP	Task Specific Plan
TtEC	Tetra Tech EC, Inc.
U-235	Uranium 235
U-238	Uranium 238
WRS	Wilcoxon Rank-Sum (test)
y	Year

1.0 INTRODUCTION

This Basewide Radiological Management Plan (Management Plan) describes survey and decontamination procedures and methodologies that will be implemented in support of radiological release of buildings, sites, structures, areas, personnel, materials and equipment at the former Naval Air Station Brunswick (NASB), Brunswick, Maine. Tetra Tech, EC (TtEC) was contracted by the United States Department of the Navy (Navy) to prepare this Management Plan for these radiological activities at NASB under Contract Task Order (CTO) WE09, Contract No. N62470-13-D-8007 for the Base Realignment and Closure (BRAC) Program Management Office (PMO) Northeast under Naval Facilities Engineering Command (NAVFAC), Atlantic. The methodologies and processes described in this Management Plan apply to operational radiological activities performed by TtEC in relation to its projects at NASB and may guide the preparation of other work plans by radiological contractors as directed by the Navy. All radiological activities identified for this project will be performed under the TtEC Nuclear Regulatory Commission Radioactive Materials License, license number 29-31396-01 (Attachment 1) or Maine Agreement State Radioactive Materials License (as required) and in accordance with the Radiation Protection Plan (RPP) which is included in Attachment 2.

The most current version of the Sampling and Analysis Plan (SAP) should be implemented during field activities.

A basic concept in radiation protection specifies that exposures to ionizing radiation and releases of radioactive material should be managed to reduce collective doses to workers and the public and ensure that exposure is as low as reasonably achievable (ALARA). The ALARA principle will be considered during the course of the radiological work carried out under the Management Plan for survey activities.

The objective of this Management Plan is to provide the radiological procedures and methodologies for:

- Evaluating impacted sites, structures, buildings, areas, material and equipment, and other items that may contain residual radioactivity above the release criteria as a result of past activities at NASB
- Removing identified radioactive contamination
- Confirming that the release criteria have been met

The radiological activities that support the objective of the Management Plan include:

- Reference (Background) surveys
- Scoping surveys
- Characterization surveys
- Remedial action support surveys
- Final Status Surveys (FSSs)

- Personnel surveys
- Equipment and material surveys
- Truck surveys
- Decontamination and dismantling

Where applicable, radiological survey activities will be conducted in accordance with the guidelines in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Nuclear Regulatory Commission (NRC) NUREG-1575 (DoD et al. 2000), as incorporated into this Management Plan. Other survey activities as well as activities not addressed by MARSSIM will be performed in accordance with this Management Plan and the Standard Operating Procedures (SOPs), which are located in Attachment 3, and applicable work instructions located at the project site office. Table 1-1 lists each of the TtEC field SOPs developed for performing radiological work at NASB. Copies of the work instructions will be available in the TtEC offices at NASB, when mobilized, and can be provided to the Navy and regulatory agencies for review upon request.

This Management Plan is organized as follows:

- **Section 1.0 Introduction** – Section 1.0 provides an overview of the project scope, work objectives, and organization of the Management Plan.
- **Section 2.0 Background** – Section 2.0 describes NASB, provides a historical summary of the Base, and includes an overview of the radiological history of NASB, including impacted sites.
- **Section 3.0 Key Radiological Personnel and Work Control Procedures** – Section 3.0 discusses the project organization, roles and responsibilities of key project personnel, personnel qualifications, and work control activities.
- **Section 4.0 Radiological Survey Types, Area Classification, and Selection** – Section 4.0 identifies the types of surveys that will be conducted, and discusses survey area classification and survey type selection.
- **Section 5.0 Survey Overview** – Section 5.0 presents an overview of survey planning, survey implementation, and data assessment.
- **Section 6.0 Release Criteria and Investigation Levels** – Section 6.0 identifies the criteria for radiological release for unrestricted use.
- **Section 7.0 Instrumentation** – Section 7.0 identifies field instrumentation that will be used to perform surveys.
- **Section 8.0 Survey Implementation** – Section 8.0 presents the approach to implementing surveys that will be conducted as well as associated sampling activities.
- **Section 9.0 Decontamination, Dismantling, and Disposition** – Section 9.0 discusses the survey and construction activities that will be implemented to perform remedial action at sites contaminated by radiation above release limits.
- **Section 10.0 Radioactive Materials Management** – Section 10.0 describes how radioactive materials will be managed, including control of samples, work areas, and wastes.

- **Section 11.0 Documentation and Records Management** – Section 11.0 presents procedures that will be used to manage records/documentation, as well as to assess, interpret, and report data.
- **Section 12.0 References** – Section 12.0 presents references cited in this Management Plan.

2.0 BACKGROUND

The following sections provide the location and description, a general site history, and a brief radiological history of NASB.

2.1 Brunswick Naval Air Station Location and Description

NASB is located in Cumberland County, Maine, about 25 miles north of Portland, Maine and 31 miles south of Augusta, Maine. The Main Station lies between the Androscoggin River to the north and Casco Bay to the south and encompasses approximately 3,200 acres. It is bordered by City of Brunswick to the east and west. The facility includes six principal areas: the Main Station, the Topsham Annex, the McKeen Street Housing Complex, the former East Brunswick Remote Radio Transmitter Site, and Rake Stations 1 and 2. The Historical Radiological Assessment (HRA) (Tetra Tech 2012) evaluated all six properties currently owned by the Navy, but all of the impacted sites were located within the Main Station.

2.2 General Site History

NASB was originally constructed on the site of a small municipal airport with two runways. The land and runways were purchased from the town of Brunswick in Cumberland County, Maine, and construction began on October 15, 1942. By January 1943, the Operations Building was in use, and the Station was commissioned on April 15, 1943. NASB was deactivated in October 1946, 14 months after the end of WWII, but was reactivated and commissioned as a Naval Air Facility on March 15, 1951. On December 1, 1951, the station's designation was officially elevated to a Naval Air Station with a mission of supporting and servicing patrol squadrons and one fleet aircraft service squadron. Its future mission was to be a master jet air station that conducted anti-submarine warfare off the Atlantic Coast.

2.3 Radiological History

Throughout its history, NASB has not had an active radiological program or mission. However, general radioactive material (G-RAM) was gradually introduced at the site. G-RAM is defined in the HRA as general radioactive materials used by the Navy or Marine Corps that are not associated with the Naval Nuclear Propulsion Program. These types of radioactive material remained the primary sources of G-RAM until NASB's closure in 2011 under the BRAC process.

Beginning in the late 1930s and continuing through the war years, radioluminescent devices and paint were widely used by the Navy. Dials and surfaces that needed to be illuminated were coated with a radioluminescent compound or paint that contained radium 226 (Ra-226) mixed

with a base. These devices constituted the first known G-RAM introduced to NASB. Areas where the use of these items is suspected include areas where radar equipment, aircraft instrumentation, and survival watches and compasses were stored, used, and/or maintained. Radioluminescent devices may have been used at NASB.

G-RAM was commonly found in other items such as: depleted uranium (uranium 238 [U-238]) counterweights; electron tubes that contained cobalt 60 (Co-60) and thorium 232 (Th-232); self-illuminating signs and aircraft lights that contained tritium (H-3); aircraft detector probes, pressure indicators, helicopter blade inspection systems, and personnel markers that contained strontium 90 (Sr-90); spark-gap irradiators that contained cesium 137 (Cs-137), uranium oxide (UO₂), or Co-60; and night vision devices, turret assemblies, and aircraft gear boxes that contained Th-232.

Additionally, it was suspected that G-RAM was disposed in landfills at the Station, and could be present in known disposal areas such as the Quarry Area of Concern, an undocumented landfill on Orion Street, and Installation Restoration Program Sites 1 (also known as 3), 2, 6, 7, 8, 9 (which contains the footprint of an old incinerator), and 18.

NASB historically supported several anti-submarine patrol squadrons and special weapons operation support functions. An Advanced Undersea Weapons (AUW) division, which had the responsibility of overseeing weapons at the Station, was added to the Weapons Department in the early 1950s. The first known AUW magazines at the Station were built in 1957. A total of 5 magazines have been impacted due to AUW storage and maintenance designation. Weapons at NASB could contain uranium (U-235), plutonium (Pu-239), or H-3.

As part of the environmental investigations being performed to facilitate transfer of NASB, the Naval Sea Systems Command prepared an HRA that documents the history of radiological materials at NASB. The HRA presents the history of G-RAM at NASB.

The HRA concluded that areas of potential radiological contamination are present at NASB and identified additional investigations to support transfer and reuse. The use and/or handling of the G-RAM may have resulted in radiological contamination at NASB. This Management Plan was prepared to address the recommendations presented in the HRA.

In accordance with MARSSIM, an “impacted site” is defined as one that has a potential for radioactive contamination based on historical information or is known to have radioactive contamination. Based on the review of historical radiological operations at NASB, the HRA concluded that 18 sites are impacted and recommended further investigation by the NAVY. Specific recommendations for surveys for each of the sites are presented in the HRA.

3.0 KEY RADIOLOGICAL PERSONNEL AND WORK CONTROL PROCEDURES

This section describes the responsibilities of key personnel necessary for management of radiological activities at NASB. In addition, this section identifies the minimum training

requirements for workers at NASB and work control procedures including Task Specific Plans (TSPs), Radiation Work Permits (RWPs), and radiological notifications.

3.1 Key Radiological Personnel

Specific personnel are essential in performing radiological activities at NASB. Qualified and experienced personnel will fulfill the necessary functions to ensure the consistent and successful implementation of radiological work activities at NASB. All key radiological personnel are expected to have the requisite skills necessary to perform these functions. The key radiological personnel include the following:

3.1.1 Radiation Safety Officer

The Radiation Safety Officer (RSO) is responsible for implementing, directing, and supervising all radiological project-related activities. The RSO has the responsibility and authority to perform the following:

- Providing oversight of implementation and ensuring compliance with the applicable NRC (or Agreement State, if applicable) Service Provider Radioactive Materials License (RML)
- Serving as contact for NRC (or Agreement State, if applicable) site inspections
- Assisting Navy representatives during site audits
- Controlling exposure conditions for site workers
- Implementing a dosimetry program for all site workers entering radiologically controlled areas
- Enforcing radiological controls
- Coordinating radiological activities with other NRC or Agreement State licensed contractors
- Ensuring all radiological work activities comply with RML requirements
- Identifying radiological analysis needs
- Providing health physics guidance on an as-needed basis
- Providing radiological control protection services, if required
- Directing and assisting radiological personnel in proper completion of radiological records
- Assisting the Radiation Safety Officer Representative (RSOR) to determine if an external dose is to be assigned to an individual who reported lost or damaged dosimetry devices
- Reviewing all changes to the SAP to ensure radiological requirements are met
- Ensuring that the required radiological safety training is provided
- Reviewing and approving project field procedures associated with the handling of radioactive materials or access to radiological areas
- Ensuring timely and thorough review of records, in accordance with the NLP-07 Radiological Records corporate SOP, prior to approval
- Approving records with verifiable signature and date once records meet the quality standards as described in the NLP-07 Radiological Records corporate SOP

- Conducting radiation incident investigations
- Conducting radiological inspections
- Conducting data assessments and evaluations

3.1.2 Radiation Safety Officer Representative

The RSOR will report directly to the RSO and will perform on-site duties as designated by the RSO. In accordance with Navy requirements, the RSO or a qualified designee will be on-site during radiological work activities conducted under this Management Plan. The RSOR has the responsibility and authority to perform the following:

- Implementing, directing, and supervising on-site radiological activities
- Assisting in identifying radiological analysis needs
- Providing health physics guidance
- Assisting in establishment of radiological controls
- Overseeing preparation and approval of radiological documents and field procedures
- Establishing personnel monitoring requirements
- Establishing, implementing, and monitoring on-site radiological training programs
- Conducting assessments of field practices and procedures
- Reviewing and approving data from radiological investigations, surveys, and remediations
- Assisting the RSO in ensuring adequate radiological controls are in place at the work site
- Assuring that specified radiological safety procedures are followed and that the radiological safety tests and inspections are complete and acceptable
- Conducting daily oversight and field safety inspections and tests required by the project technical specifications and applicable professional standards
- Attending required meetings, including weekly quality control (QC) meetings, pre- and post-construction site inspections, and other scheduled and unscheduled meetings
- Administering the on-site dosimetry program
- Verifying compliance with on-site RWPs and SOPs
- Assisting the RSO in reviewing changes to the SAP to ensure radiological requirements are met
- Approving issuance of any work document pertaining to radiological safety issues
- Providing surveillance of radiological-related activities
- Assisting the RSO in directing the production of radiological work documents and reports
- Ensuring that a Subcontract Project Manager (SPM) or designee will be on-site during radiological activities
- Conferring with radiological personnel to provide technical advice and to resolve problems
- Preparing daily project status reports
- Notifying the RSO regarding radioactive anomalies
- Managing the storage of radioactive waste in accordance with the RML

3.1.3 Subcontract Project Manager (SPM)

The SPM or designee will direct field survey personnel and health physics operations as assigned by the RSO, RSOR, or designee. The SPM position will only be filled in the event that Millenium Services, Inc. (MSI) is used as a subcontractor. In the event MSI is not used as a subcontractor, the RSOR possesses the authority and responsibilities listed for the SPM. The SPM has the responsibility and authority to perform the following:

- Overseeing task-specific radiological field activities for compliance with the RML and approved plans, work instructions, SOPs, instrument specifications, and state-of-the-art health physics practices
- Coordinating task-specific activities with the RSOR
- Preparing RWPs to outline field conditions, radiological control requirements, and personal protective equipment requirements in the field for RSO approval
- Being physically on-site when radiological operations are performed by field staff
- Ensuring all field staff are properly trained and comply with the RWP
- Supervising field staff during survey, site remediation, and decontamination activities, use of survey equipment and instrumentation, and support of other radiological activities
- Ensuring compliance with the applicable SOPs for safety program, survey, and/or remediation activities
- Interpreting and verifying task-specific data accumulated during surveys and monitoring activities
- Ensuring compliance with TSPs, as directed by the RSO and RSOR

3.1.4 Site Supervisor (SS)

The SS is responsible for organizing, scheduling, and implementing field activities. The SS has the responsibility and authority to perform the following:

- Implementing the TSPs and ensuring proper collection of radiation data for this project
- Primary on-site point of contact for other team personnel
- Ensuring the proper calibration and operation of radiological monitoring equipment and ensures that field activities are conducted in accordance with the management plan, the TSPs, and applicable procedures and regulations
- Implementing the RPP and Accident Prevention Plan (APP)/ Site Safety and Health Plan (SSHP) with regard to radiological issues including implementation of dosimetry, air sampling, surveys for radiation protection and the RWP program as necessary. The SS works with the Site Safety and Health Officer (SSHO) to ensure that safety issues are identified and addressed and that field activities are performed in a safety conscious manner.
- Implementing any site-specific radiation programs. The SS works closely with the SPM (if applicable) and Project Health Physicist (PHP) and site-specific field team members to ensure the adequacy and appropriateness of radiation safety measures, including the need for RWPs during surveys and material removal activities

- Ensuring that the survey objectives are met and to provide assistance in resolving technical issues in the field. The SS directs the day-to-day field activities of the technicians. The SS works directly with the SPM (if applicable) and PHP to ensure tasks are implemented in accordance with this management plan and the TSPs
- Maintaining schedule adherence and for reporting issues of nonconformance to the SPM (if applicable).
- Ensuring the technical defensibility of the data collected as part of this survey effort. The SS has stop work authority for all project activities.

3.1.5 Project Health Physicist (PHP)

The PHP has the responsibility and authority to perform the following:

- Assisting in the development and approval of the management plan and TSPs and in the identification of radiological data needs
- Providing technical support for field activities, health physics guidance on an as-needed basis, and radiological control protection services, if required
- Assisting project personnel in proper completion of radiological records, reviews and approves project field procedures that involve handling radioactive materials or access to radiological areas, and conducts radiation incident investigations and project inspections
- Coordinating with the analytical laboratory and data validator to assure proper implementation of SAP requirements
- Ensuring that field activities are performed in accordance with the requirements of this management plan and the TSPs
- Working with the SPM and SS for planning, coordinating, integrating, monitoring, and managing project activities
- Responsible for the review and acceptance of data in support of the determination of background and instrument efficiency
- Validating of data generated during field surveys. The RE, in conjunction with the SS, develops the survey report for each of the buildings and land area included in the scope of this management plan.

3.1.6 Site Safety and Health Officer (SSHO)

The SSHO has the responsibility and authority to perform the following:

- Implementation of the APP/SSHP, in accordance with site-specific safety protocols
- Identifying safety hazards and ensuring that they are adequately addressed prior to field activities
- Implementing the medical monitoring program for this project
- In concert with the SS and RE, the SSHO reviews field-monitoring data and authorize upgrades or downgrades in personal protective equipment (PPE)
- Performing field safety audits during sampling activities.

3.1.7 Radiological Control Technicians

Radiological Control Technicians (RCTs) will support projects in the field and have the responsibility and authority to perform the following:

- Performing radiological field activities under the direction of the SPM (as applicable) or RSOR in accordance with approved work documents and RML requirements
- Documenting field survey activities in accordance with the Management Plan, TSPs, and SOPs
- Interpreting and verifying field data gathered during survey and monitoring activities
- Supporting dose assessments, and assuring compliance with emergency plans, and procedures
- Performing effluent monitoring and radioactive material inventories
- Performing survey equipment response checks, and daily checks of the survey instruments
- Conducting safety evaluations of health physics field and laboratory equipment
- Implementing use of RWPs, including being present at active work areas to ensure compliance in the absence of the SPM

3.2 **Minimum Training Requirements**

The minimum training requirements for personnel working in the field at NASB include the following:

- Occupational Safety and Health Administration 40-Hour and Annual 8-Hour Refresher
- Radiation awareness and RWP training
- TSP training for the specific site or task
- Activity Hazard Analysis training for the specific site or task
- Training as required by the implemented APP/SSHP as identified in the project-specific Work Plan

3.3 **Work Control Procedures**

Prerequisites for the initiation of survey activities include review of the associated TSP, radiological evaluation of the designated work areas, and identification of any potential safety concerns. Work control procedures include the preparation and review of TSPs, RWPs, work instructions, and appropriate notifications of anomalies or significant radiological events.

3.3.1 Task-Specific Plan

The Management Plan provides the procedures and methodologies for performing radiological activities that will be implemented in support of radiological release of buildings, sites, structures, areas, materials and equipment, and personnel at NASB. TSPs will be prepared for surveys and remediation performed under the Management Plan and will provide supplemental information. Each TSP will provide relevant location-specific data and identify variances and/or

additions to the Management Plan. Substantial deviations from the Management Plan may result in the generation of a stand-alone, job-specific work plan. Where prepared, these stand-alone work plans will supersede this Management Plan, but may utilize certain portions of the Management Plan where indicated.

At a minimum, each TSP will include the following information:

- Task description, including the specific location history, purpose of the task, and the radionuclides of concern
- Data quality objectives (DQOs) defined to a level sufficient to ensure that the data obtained will support the goals of the task
- An activities plan consisting of a survey description and discussion of additional activities necessary to support the survey, which will include a description of applicable specific construction or decontamination and decommissioning activities (as required)
- Specific identification of variations, if any, to the Management Plan, including the requirement and variations, and the technical justification for the variations
- Specific survey figures (as required) that provide sampling and survey data points and other figures necessary to support the activity
- Attachments (as necessary) to provide further description, information, or delineation of the task activities

Each TSP will be provided to the BRAC PMO and the Radiological Affairs Support Office (RASO) for review and approval.

3.3.2 Radiological Health and Safety

SOPs and work instructions will be used to address controls necessary for radiologically safe operations and referenced as necessary in appropriate TSPs. Table 1-1 lists each of the TtEC field SOPs developed for performing radiological work at NASB. Copies of the SOPs are provided in Attachment 3. Work Instructions are available in the TtEC offices at NASB, when mobilized, and are available for review by the Navy and/or regulatory agencies upon request.

Dose rate, contamination, and air monitoring, including initial baseline sampling to determine radiological background conditions, will be performed as necessary and in accordance with the APP/SSHP. Field activities will be performed in accordance with the approved RWP and APP/SSHP as required by the project-specific Work Plan. RWPs will be prepared in accordance with the applicable RPP and SOP 002, Issue and Use of Radiation Work Permits. Personnel protective equipment (PPE) levels, dictated by radiological considerations and physical and chemical safety issues identified at each work location, will be assigned or modified, according to the approved RWP and APP/SSHP included in the approved project-specific Work Plan and SOP 022, Radiological Protective Clothing Selection, Monitoring, and Decontamination.

3.3.3 Task-Specific Work Instructions

In limited situations involving ancillary radiological activities (e.g., monitoring well installation or destruction in radiologically impacted areas, or decontamination with a vacuum system), or to further augment TSPs or SOPs, radiological work instructions may be prepared to facilitate a specific activity. These radiological work instructions, when used, will be provided to the BRAC PMO and the RASO for review and approval. Copies of the work instructions are available in the TtEC offices at NASB, when mobilized, and can be provided to the Navy and/or regulatory agencies for review upon request.

3.3.4 Notifications

During survey activities, radioactive anomalies may be identified and significant radiological events could occur. For the purposes of the Management Plan, an anomaly is described as a reading or result that appears to be an outlier in the professional judgment of the RSOR. When an anomaly is identified, the RSOR will notify the RSO and the PM, who will notify the BRAC PMO Remediation Project Manager (RPM) and the RASO. If neither the RSO nor the PM is available, the RSOR will leave a voice mail and confirmatory e-mail describing the anomaly and follow up with a call to the appointed designee, if any.

Significant events include regulatory visits (such as by the NRC or other regulatory agencies), radiological issues, injuries, and breaches in security. All significant events will be disclosed to the RPM and RASO as described above. Any radiological issues will also be reported to the RSO.

4.0 RADIOLOGICAL SURVEY TYPES, AREA CLASSIFICATION, AND SELECTION

Several types of radiological surveys will be conducted at NASB. Surveys will be used to support the release of materials, equipment, open areas, utilities and/or buildings; support remedial actions; identify radionuclides and levels of contamination present; and support unforeseen work that may be necessary.

4.1 Survey Types

This section describes the types of surveys that may be performed at NASB.

4.1.1 Reference (Background) Area Survey

The reference area is a geographical area or structure from which representative radioactivity measurements are performed for comparison with measurements performed in an impacted area. The reference area selected should have physical, chemical, radiological, and biological characteristics similar to the impacted area(s) being investigated. The reference area must not be identified as impacted by the HRA (Tetra Tech 2012). All on-site and off-site locations selected as reference areas will be approved by the RSO or RSOR. The same survey methods and equipment that will be used for conducting a survey in an impacted area will be used for the

background area survey. Reference area data will normally be provided to the RSO prior to the start of a survey.

4.1.2 Scoping Survey

Scoping surveys provide site-specific information based on limited measurements. Scoping surveys are to be conducted as indicated by the HRA with guidance from MARSSIM (DoD et al. 2000) and will consist of judgment measurements based on applicable information in the HRA and professional experience. Sufficient information will be collected to identify situations that require immediate radiological attention or to support development of other project activities.

The primary objectives of scoping surveys are to:

- Perform a preliminary contamination assessment
- Identify radionuclide contaminants
- Assess radionuclide ratios
- Assess general levels and extent of radionuclide contamination, if present
- Support classification of impacted areas
- Evaluate whether the survey strategy can be optimized for use in a characterization survey or a Final Status Survey (FSS)

4.1.3 Characterization Survey

The characterization survey is performed to determine the nature and extent of radiological contamination at the site. This includes preparing a reference grid, collecting systematic as well as judgment measurements, and performing surveys of different media (e.g., surface soils, interior and exterior surfaces of buildings). The decision as to which media will be surveyed is a site-specific decision addressed throughout this Management Plan and each TSP.

Characterization surveys are planned based on the HRA, MARSSIM guidance, and/or scoping survey results. The primary objectives of characterization surveys are to:

- Assess the nature and extent of the contamination, if present
- Collect data to support evaluation of remedial alternatives and technologies
- Evaluate whether the survey strategy can be optimized for use in the FSS
- Provide input to the FSS design

4.1.4 Remedial Action Support Survey

Remedial action support surveys are performed to assess the effectiveness of the remedial action while remediation is being conducted, and to guide the cleanup in a real-time mode. The primary objectives of remedial action support surveys are to:

- Support remediation activities
- Assess when an area is ready for the FSS
- Provide site-specific information used for planning the FSS

4.1.5 Final Status Survey

The FSS provides data to demonstrate that radiological parameters satisfy the established guideline values and conditions for radiological release. Data from other surveys conducted during the course of site investigations at NASB—such as scoping, characterization, and remedial action support surveys—can provide valuable information for planning an FSS. The primary objectives of FSSs are to:

- Verify classification
- Demonstrate that the potential dose or risk from residual activity is below the release criterion
- Demonstrate that the potential dose or risk from small areas of elevated activity is below the release criterion

4.1.6 Personnel Surveys

Surveys will be performed on personnel leaving a radiological area to ensure that individuals are free of radiological contamination as identified in the applicable RPP presented in the project-specific Work Plan.

4.1.7 Equipment and Materials Surveys

Before being put into service or leaving a radiological work area, equipment and/or materials will be surveyed in an area of low background concentrations to ensure that the equipment and materials release criteria are not exceeded, using appropriate SOPs as identified in the project-specific Work Plan.

- Equipment and/or materials being put into service in a radiological work area at NASB that exceed the release criteria will be returned to the supplier for replacement or decontamination.
- Outgoing equipment and/or materials that do not meet the release criteria will be decontaminated before leaving the radiological work area or stored for disposal.

4.2 Survey Area Classification

The HRA has identified areas at NASB that have been classified as impacted. Based on available information from previous surveys and the HRA, each area will be given a classification. Impacted areas are divided into one of three classifications as described below.

4.2.1 Class 1 Areas

Class 1 areas have (or had prior to remediation) a potential for radioactive contamination. This potential is based on site operating history or known contamination based on previous radiation surveys above the wide-area derived concentration guideline level ($DCGL_w$). Examples of Class 1 areas include:

- Site areas previously subjected to remedial actions
- Locations where leaks or spills are known to have occurred
- Former burial or disposal sites
- Waste storage sites
- Areas designated as such in the HRA

4.2.2 Class 2 Areas

Class 2 areas have (or had prior to remediation) a potential for radioactive contamination or known contamination, but are not expected to exceed the $DCGL_w$. Examples of Class 2 areas include:

- Locations where radioactive materials were present in an unsealed form
- Potentially contaminated transport routes
- Areas downwind from stack release points
- Upper walls and ceilings of buildings or rooms subjected to airborne radioactivity
- Areas handling low concentrations of radioactive materials
- Areas designated as such in the HRA
- Buffer areas on the perimeter of Class 1 areas

4.2.3 Class 3 Areas

Class 3 areas are not expected to contain residual radioactivity, or are expected to contain levels of residual radioactivity at a small fraction of the $DCGL_w$, based on site operating history and previous radiation surveys. Examples of Class 3 areas include:

- Buffer zones around Class 1 or Class 2 areas
- Areas with very low potential for residual contamination but insufficient information to justify a non-impacted classification
- Areas designated as such in the HRA

4.3 **Classification and Survey Unit Size**

A survey unit is a physical area consisting of structures or land areas of specified size and shape for which a separate decision will be made as to whether or not that area exceeds the release criterion. This decision is made as a result of the FSS. As a result, the survey unit is the primary entity for demonstrating compliance with the release criteria.

Survey units will be limited in size based on classification, exposure pathway modeling assumptions, and site-specific conditions. The limitation on survey unit size for Class 1 and Class 2 areas ensures that each area is assigned an adequate number of data points. Table 4-1 lists the survey unit sizes.

4.4 Reference Coordinate Systems

A reference coordinate system will be laid out for each survey unit to identify survey/sample locations. Two different grid systems, as specified in MARSSIM, may be used. Although the preferred method is the triangle grid, the specific TSP will specify the grid system to be used.

4.4.1 Square Grid

A square grid system may be used for Class 1 and Class 2 survey units. For Class 3 survey units, a square grid system can be used, if specified in the TSP. The length, L , of a side of the square grid is determined by the total number of samples or measurements to be taken. The length of the square will determine the distance between survey data points. The length or spacing of the grids will be calculated for each of the survey units using the following equation:

Equation 4-1

$$L = \sqrt{\frac{A}{N}}$$

Where:

- L = length of spacing (meters [m])
- A = surface area of the survey unit (square meters [m²])
- N = number of data points

Grid locations are then positioned throughout the survey unit by first randomly selecting a start point and establishing a systematic pattern. Random numbers for the square grid method, between zero and one, are determined for both the X and Y locations in each survey unit. The random number is then multiplied by the L (length of square grids) to determine both the starting X and Y locations in each survey unit. The length L is then used to determine all remaining data points based on this starting location.

4.4.2 Triangular Grid

A triangular grid system may be used for Class 1 and Class 2 survey units, but will not normally be used in Class 3 survey units. The length between triangular grid data points (L) is determined by the total number of samples or measurements to be taken, using the following equation:

Equation 4-2

$$L = \sqrt{\frac{A}{0.866 * N}}$$

Where:

- L = length of spacing (m)
- A = surface area of the survey unit (m²)
- 0.866 = constant factor from MARSSIM (sine of 60 degrees)
- N = number of data points

A second row of points is then developed, parallel to the first row, at a distance of $0.866 \times L$ from the first row. Survey points along that second row are midway (on the X-axis) between the points on the first row. This process is repeated to identify a pattern of survey locations throughout the survey unit. If identified points fall outside the survey unit or at a location that cannot be surveyed, additional points are determined using the random process described above, until the desired total number of points is identified.

The triangular grid system is generally more efficient for locating small areas of elevated activity. A more detailed discussion is provided in *Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference Based Standards for Soils and Solid Media* (EPA 1992).

4.5 SURVEY TYPE SELECTION

The type of survey selected for an area or survey unit will be specified by either the recommendations contained in the HRA or discussions and technical direction from the RASO. The exception will be remedial action support surveys, personnel surveys, equipment and material surveys, and truck surveys that will be used as necessary to assess the effectiveness of decontamination activities and to release personnel, equipment, and material.

The survey progression is reassessed typically when a survey unit fails to meet the release criterion during an FSS effort. If a Class 2 or 3 survey unit fails to meet the criterion for release, it will undergo decontamination or remedial actions, where necessary, and be reclassified as a Class 1 unit for the follow-up survey actions. If a Class 1 survey unit fails to meet the release criterion, decontamination and remedial action support surveys will be performed. A Class 1 survey will follow decontamination or remedial activities.

5.0 SURVEY OVERVIEW

This section provides an overview of survey planning, implementation, and data assessment. Survey details are given in later sections of this Management Plan. Additional details will be provided in the project-specific TSPs, as appropriate.

5.1 Data Life Cycle

Compliance demonstration is simply a decision as to whether or not a survey unit meets the release criterion. This decision is based on the results of one or more surveys. Positive actions must be taken to manage the uncertainty in the survey results so that sound, defensible decisions may be made. These actions include proper survey planning to control known causes of uncertainty, proper application of QC procedures during implementation of the survey plan to detect and control significant sources of error, and careful analysis of uncertainty before the data are used to support decision making. These actions describe the flow of data throughout each type of survey, referred to as the Data Life Cycle.

There are four phases of the Data Life Cycle:

- *Planning Phase.* The survey design is developed and documented using the data quality objective (DQO) process, which is summarized in Section 5.2.3.
- *Implementation Phase.* The survey design is carried out in accordance with the TSPs resulting in the generation of raw data. In addition, quality assurance and QC measurements will generate data and other important information that will be used during the Assessment Phase.
- *Assessment Phase.* The data generated during the Implementation Phase are first verified to ensure that the TSPs were actually followed and that the measurement systems were performed in accordance with the criteria specified in this plan. Then the data are validated to ensure that the results of data collection activities support the objectives of the survey, as documented in the applicable TSP, or permit a determination that these objectives should be modified.
- *Decision-making Phase.* A decision is made, in coordination with the responsible regulatory agency, based on the conclusions drawn from the assessment process. The ultimate objective is to make technically defensible decisions with a specified level of confidence.

5.2 Survey Planning

The Radiation Survey and Site Investigation (RSSI) process includes a series of surveys that will be used at NASB to demonstrate compliance with the release criterion. This process will be used as a framework for collecting the information required for scoping, characterization, remediation, and FSS activities. The methodology used at NASB to implement the RSSI process consists of the following six principal steps:

- Site identification
- Historical site assessment
- Scoping survey
- Characterization survey
- Remedial action support survey
- FSS

Table 5-1 provides a simplified overview of the principal steps in the RSSI process and how the Data Life Cycle can be used in an iterative fashion within the process.

Figure 2.4 of MARSSIM illustrates the RSSI process in terms of area classification and lists the major decision to be made for each type of survey. The flow chart, illustrated in Figures 2.5 through 2.8 of MARSSIM, presents the principal steps and decisions in the site investigation process and shows the relationship of the survey types to the overall assessment process.

5.2.1 Survey Design Elements

Survey and sampling process design includes, but is not limited to, the following elements:

- The *types of samples and sampling matrices* for the survey; solid samples for outdoor surveys and fixed measurements for indoor surveys
- The *measurement frequency* for direct measurement locations for each survey unit and scan percentage of each survey unit
- The *sampling frequency* for solid sample collection locations in the survey unit(s)
- The *methods* for performing remedial action support surveys and other ancillary surveys

However, before these elements can be established, a general strategy must be determined.

5.2.2 Survey Strategy

Strategies for implementing the various survey types at NASB are provided in Table 5-2. The selection of specific survey types for each area investigated under the Management Plan will be based on information in the HRA and will be identified in each corresponding TSP. For an FSS, the standard survey strategy will be based on using a MARSSIM Scenario A approach, as described in Section 5.5.3. On a case-by-case basis, as identified in a TSP, the FSS design using the Scenario B approach will be considered.

5.2.3 Data Quality Objectives

MARSSIM recommends using the seven-step DQO process in the design of radiological surveys. This process tailors the survey to the particular conditions of each survey situation. DQO elements are applicable to all the surveys to be performed under this Management Plan. Specific DQOs for each survey will be established in the relevant TSP.

The seven steps in the DQO process are as follows:

1. State the problem
2. Identify the goal of the study
3. Identify information inputs
4. Define the boundaries of the study
5. Develop the analytical approach
6. Specify performance or acceptance criteria
7. Develop the plan for obtaining data

5.3 SURVEYS

Survey implementation for each type of survey to be conducted at NASB is discussed below. While implementation requires instrumentation and survey techniques, this section will concentrate on the general approach. The instrumentation to be used is discussed in Section 7.0 and survey techniques are presented in Section 8.0. Other survey specifics will be presented in the TSP.

5.3.1 Scoping and Characterization Surveys

These surveys will be implemented as described in their individual TSPs. In practice, scoping and characterization survey data that indicate that the residual activity is below the derived concentration guideline level (DCGL) for the building/area will be used in the FSSs where possible.

5.3.2 Remedial Action Support Surveys

These surveys are implemented during the remedial activity. For example, surveys to support remediation would follow the decontamination work to assess progress.

5.3.3 Final Status Surveys

For the FSS, the data analysis framework is critical to survey development because it drives the sampling requirements. For contaminants present in background, the analysis uses the Wilcoxon Rank-Sum (WRS) test. For contaminants not present in background, the analysis uses the Sign test. In each case, the minimum number (N) of samples (or fixed measurements) is calculated as follows: the method to calculate any additional number of required data points is stated in Section 6.1, and grid spacing methods and requirements are listed in Section 4.4. The statistical tests are described in Section 5.4.

5.3.3.1 *Determination of the Relative Shift*

Using Equation 5-1, the value of the relative shift can be determined. For single radionuclide analysis, the values for the lower boundary of the gray region (LBGR) will be set at half the DCGL during the planning phase, and at the median concentration in a survey unit for the data assessment phase.

When analyzing multiple radionuclides, the values for the LBGR and σ are determined using Section 6.2

Equation 5-1

$$\frac{\Delta}{\sigma} = \frac{DCGL_w - LBGR}{\sigma}$$

Where:

$$DCGL_w = DCGL_w \text{ as appropriate}$$

LBGR = lower boundary of the gray region, as appropriate
 σ = standard deviation from the survey unit, as appropriate

The value of the relative shift is used with the appropriate random measurement probability presented in MARSSIM Tables I.2a and I.2b.

5.3.3.2 Determination of the Number of Data Points

When the contaminant is present in background, Equation 5-2 is used with the WRS test:

Equation 5-2

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2} (1.2)$$

When the contaminant is not present in background, Equation 5-3 is used with the Sign test:

Equation 5-3

$$N = \left(\frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(\text{Sign } p - 0.5)^2} \right) (1.2)$$

Where:

$Z_{1-\alpha}$ = Type I decision error level
 $Z_{1-\beta}$ = Type II decision error level
 P_r = random measurement probability
Sign p = random measurement probability
(1.2) = 20% increase in number of samples over the minimum

During the data assessment phase, the 20 percent increase of samples is omitted for statistical purposes.

5.3.4 Error Control

Actions to minimize errors will be instituted during the data collection phase of the surveys. Qualified radiation survey personnel will perform the survey and record the data. Automated recording of survey data will be used where possible to minimize errors. Data transcribing is an activity where errors may arise. To minimize data errors for manual surveys, experienced personnel will record and transcribe data.

Standard applicable quality assurance and QC measures will be implemented to control error.

The ongoing on-site analyses and evaluation of survey results provide a verification check for errors, which will be corrected if detected.

A knowledgeable individual who is not involved in the direct data collection process (e.g., SS) will review the survey data on a daily basis. This will ensure an ongoing independent review for consistency of survey data collected.

5.4 Assessment of Survey Results

A preliminary evaluation of the data set will be conducted to better understand the structure of the data and thereby identify appropriate approaches and limitations for utilization. For non-FSSs, this may be merely identifying areas of elevated contamination or reviewing the mean, median, and standard deviation of the data set. FSS evaluations include, but are not limited to, reviewing quality assurance reports, calculating statistical quantities, and graphing the data.

5.4.1 Scoping and Characterization Surveys

Basic statistical quantities (mean, maximum, standard deviation) will be calculated from the data collected. When a reference area is surveyed, the same quantities will be calculated. The focus of the data assessments will normally be the comparison of the survey data to the DCGL for the building/area. If all measurements are less than the DCGL, then the data will be used in the FSSs, where possible. Measurements above the DCGL will be assessed for further action.

5.4.2 Remedial Action Support Surveys

The focus of these data assessments will also be the comparison of the survey data to the DCGL for the building/area. If all measurements are less than the DCGL, then the remedial action can be declared complete and an FSS performed. Otherwise, measurements above the DCGL will be identified for continued remedial action.

5.4.3 Final Status Surveys

When determining compliance with FSS goals, the survey data are examined. Compliance tests are summarized as follows:

- Compare the largest measurement to the DCGL (net of background, if present in background). If all measurements are lower than the release limits (net of background, if present in background), no statistical test is necessary.
- Compare the average measurement to the DCGL (net of background, if present in background).
- Use the appropriate statistical test to determine if the survey data exceed the release limits, if necessary.
- If scan measurements are above the DCGL, then a fixed measurement will be taken to confirm the elevated reading. If the elevated reading is confirmed, then the unit would fail.

When multiple nuclides are present, each with an individual DCGL, they will be assessed in accordance with the methods described in Section 6.2.

This Management Plan will use an analysis structure incorporating three possible common statistical procedures, as well as conventional qualitative and semi-quantitative comparisons for FSS data. The statistical tests are only applied to measurements made at fixed locations. The tests are:

- **Sign test** – The Sign test is a one-sample, nonparametric test that can be used to evaluate compliance with the release limit. The Sign test is the recommended compliance evaluation procedure when the contaminant(s) under evaluation are not present at significant levels in background. Any one of the individual samples (each individual survey unit is a “sample” in this context) or any combination can be compared to the release limit with the Sign test. For example, each of the Class 1 survey units could be pooled for an overall building comparison to the release limits rather than comparing an individual survey unit to the release limit.
- **Wilcoxon Rank-Sum test** – The WRS test is a two-sample, nonparametric procedure that can be used to evaluate compliance when the contaminant is present in background. The WRS test can be used as a two-sample test to compare medians between samples (contamination concentration measured in reference background materials versus the same parameter measured in site investigative materials) when either or both sampling distributions deviate significantly from normal.
- **Normal means test** – This is the traditional two-sample t-test based on the central limit theorem (i.e., normality). It can be used to assess compliance, derive confidence intervals, and compare between samples (mean removable surface contamination concentration in one survey unit versus the same parameter measured in another survey unit) when both sample distributions are normal or do not deviate appreciably from normality.

Both scan and fixed measurements are subject to the elevated measurement comparison. The result of this comparison is not conclusive as to whether the survey unit meets or exceeds the release criterion, but is a flag or trigger for further investigation. This comparison is described in Section 6.1.

5.5 Decision Making

5.5.1 Scoping and Characterization Surveys

For a scoping survey, the decision rule is, “If the survey results meet the criteria defined in the TSPs, then design and perform an optimized FSS. If the survey results do not meet the criteria defined in the TSPs, then design and perform an optimized characterization survey.” In practice, most scoping surveys will be tested against DCGLs. If no contamination above the DCGL is found, then the survey data will be used in an FSS. If contamination is found, then a characterization survey would be performed.

For a characterization survey, the decision rule is, “If the survey results meet the criteria defined in the TSPs, then design and perform an optimized FSS. If the survey results do not meet the

criteria defined in the TSPs, then perform remedial action.” If no contamination above the DCGL is found, then the survey data would be used in an FSS.

5.5.2 Remedial Action Support Surveys

The decision rule is, “If the survey results indicate that the remediation is complete (as defined in the TSPs), then design and perform an optimized FSS. If the survey results indicate that the remediation is incomplete, then reevaluate the remedial alternative and continue remediation if necessary.”

5.5.3 Final Status Surveys

The results of the statistical testing of the data set for each survey unit will be used to evaluate whether to accept or reject the null hypothesis. Using the MARSSIM Scenario A methodology, the null hypothesis is stated as “the residual activity in the survey unit exceeds the release criterion.” Thus, in order to pass the survey unit (that is, release the area), the null hypothesis must be rejected. The objective of FSSs will be to demonstrate that residual radioactivity levels meet the release criterion. In demonstrating that the objective is met, the null hypothesis (H_0) is tested that residual contamination exceeds the release criterion; the alternative hypothesis (H_a) is then tested that residual contamination meets the release criterion.

To validate the use of a test, an evaluation will be made to determine that the data are consistent with the underlying assumptions made for the statistical procedure. Assumptions that can be made in the survey design are:

- The sample sizes determined for the tests are sufficient to achieve the DQO set for the Type I and Type II error.
- The data from the reference area or survey unit consist of independent samples from each distribution.
- The reference area and survey unit data distribution are similar, except for a possible shift in the medians.
- Whether the data represent a normal or asymmetric distribution.

Certain departures from these assumptions may be acceptable when given the actual data and other information about the study. One of the primary advantages of the nonparametric test is that it involves fewer assumptions about the data than the parametric test.

Scenario B methodology as defined in NUREG-1505 (NRC 1997a) may be used with concurrence from the RASO. If Scenario B is used, specific details will be listed in the TSP as a deviation or exception to the Management Plan.

6.0 RELEASE CRITERIA AND INVESTIGATION LEVELS

The release criteria for buildings, structures, material, and land areas at NASB are listed in Table 6-1. Release criteria for equipment and material are taken from Atomic Energy

Commission (AEC) Regulatory Guide 1.86 (AEC 1974). Criteria for structures (surfaces) are also taken from Regulatory Guide 1.86. Release criteria for soils are based on values presented in Nuclear Regulatory Commission document NUREG-1757, Consolidated Decommissioning Guidance (NRC 2006), whose limits are deemed in compliance with the 25 millirem per year (mrem/y) unrestricted dose limit in 10CFR20.1402. Listed values were developed by scaling the NUREG-1757 values to 15 mrem/y unrestricted dose. Release criteria for water have been derived from Radionuclides Notice of Data Availability Technical Document (EPA 2000) Table III, which compared the federal drinking water standards from the 1976 and 1991 Maximum Contaminant Levels. This value reflects the most conservative limit.

Release criteria organized by survey type are as follows:

- A remedial action support survey will use the release criteria for equipment, material, structures, and soil.
- An FSS will use all the release criteria in Table 6-1, and criteria for scanning surveys known as DCGLs for elevated measurement comparison (DCGL_{EMC}), discussed below.

6.1 Assessing Small Areas of Elevated Activity

Using guidance from MARSSIM, systematic measurements and sampling, in conjunction with surface scanning, are used to obtain adequate assurance that small areas of elevated radioactivity will satisfy the release criterion for small areas. Under RASO direction, this procedure may be implemented for survey units classified as Class 1.

The DCGL_W is the average concentration across the site that is equivalent to the release criterion, based on dose or risk. The general assumption is that the concentrations of the radionuclides in the source are homogeneous. The degree to which any single localized area can be elevated above the average, assuming the average is at the DCGL_W, and not invalidate the homogeneous assumption is characterized by the small area criteria (DCGL_{EMC}).

Values for the DCGL_{EMC} are obtained by modifying the DCGL_W using an area factor that accounts for the difference in area and the resulting change in dose or risk. The area factor is the magnitude by which the concentration within the small area of elevated activity can exceed the DCGL_W while maintaining compliance with the release criterion. The area factor takes into consideration how a smaller area would affect the dose or risk.

The first step in the process is to assess the scan minimum detectable concentration (MDC); this process is described in Section 7.2. The next step is to determine the “required” scan MDC. The “required” scan MDC is the product of the DCGL_W and the area factor (also known as the DCGL_{EMC}). This can be calculated using Equation 6-1:

Equation 6-1

$$\text{“required” Scan MDC} = \text{DCGL}_{\text{EMC}} = (\text{DCGL}_W) \times (\text{Area Factor})$$

The area factor is obtained from dose modeling using RESRAD or RESRAD-BUILD and is determined based on the size of the area bounded by the sample size in the survey unit. This bounded area (a') is simply the survey unit area (in m^2) divided by the number of samples determined in Section 5.3.3. Equation 6-2 is used to derive the size of the area:

Equation 6-2

$$a' = \text{Survey Unit Area (in } m^2) / \text{number of samples}$$

The “actual” scan MDC is then compared to the “required” scan MDC. If the “actual” scan MDC is less than the “required” scan MDC, then no additional samples are required. However, if the “actual” scan MDC is greater than the “required” scan MDC, an increase in the number of samples taken may be required. To determine if there is an increase in sample size, the area factor is determined using Equation 6-3:

Equation 6-3

$$\text{Area Factor} = (\text{“actual” Scan MDC}) / (DCGL_W)$$

A table of possible area factors is determined by taking the ratio of doses established by using the most current version of RESRAD for outdoor areas or RESRAD-BUILD for structures. For each radionuclide of concern, all exposure pathways are calculated assuming a concentration of radioactive contamination at the release criteria.

The area of contamination in RESRAD defaults to 10,000 m^2 . Other than changing the area (i.e., 1, 3, 10, 30, 100, 300, 1,000, or 3,000 m^2), the RESRAD exposure pathways remain constant. A table of area factors is then computed by taking the ratio of the dose or risk per unit concentration generated by RESRAD for the 10,000 m^2 to that generated for the other areas listed. If the DCGL for residual radioactivity distributed over 10,000 m^2 is multiplied by this value, the resulting concentration distributed over the specified smaller area delivers the same calculated dose.

Indoor area factors are calculated in a similar manner using the most current version of RESRAD-BUILD. As the typical maximum area of a Class 1 survey unit is 100 m^2 , this is the value that other area values will be compared to. Other than changing the area (e.g., 1, 3, 10, 25, 36, 64 m^2), the RESRAD-BUILD exposure pathways remain constant. A table of area factors is then computed by taking the ratio of the dose or risk per unit concentration generated by RESRAD for the 100 m^2 to that generated for the other areas listed. If the DCGL for residual radioactivity distributed over 100 m^2 is multiplied by this value, the resulting concentration distributed over the specified smaller area delivers the same calculated dose. Removable surface contamination is assumed to be 20 percent. No other changes to exposure pathways are to be made between iterations when calculating a table of values.

This area factor is then used to determine the new area bounded by samples a' by logarithmically interpolating from a generated table of possible area factors using Equation 6-4 below, and solving for a' :

Equation 6-4

$$\ln(a') = \frac{\ln\left(\frac{y}{z}\right) \cdot \ln\left(\frac{AF_x}{AF_z}\right)}{\ln\left(\frac{AF_y}{AF_z}\right)} + \ln(z)$$

Where:

- y = size of area with lower area factor than area factor determined
- z = size of area with higher area factor than area factor determined
- AF_x = area factor determined
- AF_y = area factor of area y
- AF_z = area factor of area z

Substituting the new bounded area *a'* into Equation 6-5 provides the increased number of samples required, if any:

Equation 6-5

$$\text{Additional number of samples required} = \text{Survey Unit Area (in } m^2) / (a')$$

The additional number of samples required, in addition to the number required for a particular statistical test from Section 5.3.3, will form the total number of samples required for a particular survey unit when using elevated measurement comparisons. This new total number of samples required will then be applied to the systematic sampling pattern described in Section 4.4 to determine the grid spacing.

6.2 Assessing Multiplier Radionuclides

When multiple radionuclides are present, either the more conservative of the individual DCGLs or a combined DCGL will be used, as directed by the RASO. A combined DCGL is calculated using Equation 6-6:

Equation 6-6

$$\text{Combined DCGL} = \frac{1}{\frac{f_1}{\text{DCGL}_1} + \frac{f_2}{\text{DCGL}_2} + \dots + \frac{f_n}{\text{DCGL}_n}}$$

Where *f_n* is the anticipated fraction of each radionuclide versus the total, and DCGL_{*n*} is the DCGL for each radionuclide present, the sum of *f₁*, *f₂*, *f_n* equals one.

6.2.1 DCGL_w for Multiple Radionuclides

As stated in MARSSIM the DCGL_w, when using multiple radionuclides, is established by definition at 1.0. The unity rule, represented in the expression below (Equation 6-7), is satisfied when the radionuclide mixture yields a combined fractional concentration limit that is less than

or equal to one. Statistical tests will be used to prove that the total sum of all radionuclides does not exceed the applicable release criterion.

6.2.2 Determination of LBGR for Multiple Radionuclides

The LBGR is the net median concentration of the contaminant in the survey unit. Since this value is unknown, MARSSIM suggests using a value for the LBGR of half the DCGL during planning purposes. However, once the median concentration activity in the survey unit is established, this value is used as a ratio to the lowest DCGL for the decay method to determine the LBGR. Equation 6-7, taken from MARSSIM, gives the method used to determine the LBGR:

Equation 6-7

$$LBGR = \frac{C_1}{DCGL_1} + \frac{C_2}{DCGL_2} + \frac{C_2}{DCGL_2} + \dots + \frac{C_i}{DCGL_i} \leq 1$$

Where:

$$\begin{aligned} C_i &= \text{median concentration of radionuclide "i"} \\ DCGL_i &= \text{DCGL of radionuclide "i"} \end{aligned}$$

6.2.3 Determination of Standard Deviation for Multiple Radionuclides

There is no estimate of the standard deviation of the contaminant in a survey unit, especially if no contaminant is initially expected or if concentrations of radionuclides are spatially unrelated. Therefore, σ is assigned the value of the standard deviation of the adjusted measurement values in the survey unit as shown in Equation 6-8 from Section 6.2.3 of Decommissioning Health Physics (Abelquist 2001):

Equation 6-8

$$\sigma = \sqrt{\left(\frac{\sigma_{C1}}{DCGL_1}\right)^2 + \left(\frac{\sigma_{C2}}{DCGL_2}\right)^2 + \dots + \left(\frac{\sigma_{Ci}}{DCGL_i}\right)^2}$$

Where:

$$\begin{aligned} \sigma_{Ci} &= \text{standard deviation from radionuclide "i"} \\ DCGL_i &= \text{DCGL of radionuclide "i"} \end{aligned}$$

6.3 **Converting DCGL Units**

At times, it may be necessary to convert the DCGL from picocuries per gram (pCi/g) to counts per minute (cpm) in order to calculate the number of samples required in a given survey unit. To perform this conversion, an arbitrary concentration of the radionuclide is divided by the associated exposure rate produced by the concentration (as identified in Section 7.2.8). The resulting number is then divided by the average net cpm per microrentgens per hour ($\mu\text{R/hr}$) for

the detector being used. Once the number is derived, the release criterion is divided by this number, as shown in Equation 6-9 on the following page:

Equation 6-9

$$cpm = \frac{DCGL}{DCGL_{AC} / M * DCGL_{AC} / \mu Rcpm}$$

Where:

- $DCGL$ = release criterion (pCi/g)
- $DCGL_{AC}$ = arbitrary concentration of radionuclide (pCi/g)
- M = exposure rate calculated by MicroShield™ (Grove Engineering 1996)
- $\mu Rcpm$ = counts per minute per $\mu R/hr$ for the detector

6.4 Investigation Levels

Investigation levels are specific levels of radioactivity used to indicate when additional investigation may be necessary. Investigation levels also serve as a QC check. For example, in addition to indicating potential contamination, a measurement that exceeds the investigation level may indicate that the survey unit has been improperly classified or may indicate a failing instrument.

When determining an investigation level using a statistical-based parameter (e.g., standard deviation), the following may be considered: survey objectives, underlying radionuclide distributions (e.g., normal, log normal, nonparametric), data population descriptors (e.g., standard deviation, mean, median), and prior survey and historical information.

When an investigation level is exceeded, the measurement will be confirmed to ensure that the initial measurement/sample actually exceeds the particular investigation level. This will involve taking further measurements to confirm the initial result, and as appropriate, to quantify the area of elevated residual radioactivity.

6.4.1 Investigation Levels for Gamma Radiation Surveys

For gamma surveys the investigation level will normally be established at the reference area mean + 3σ , where σ is the standard deviation of the gamma readings in the reference area. Other investigation levels may be implemented with prior RASO concurrence.

6.4.2 Investigation Levels for Alpha and Beta Radiation Surveys

For alpha and beta surveys, the investigation level will be the $DCGL_w$ or a statistical-based parameter, if used.

7.0 INSTRUMENTATION

Instruments will be selected that are suitable for the physical and environmental conditions at the site. The instruments and measurement methods selected will be able to detect the radionuclide of concern or radiation types of interest, and are, in relation to the survey or analytical technique, capable of measuring levels sufficient to support the DQOs. Table 7-1 identifies the instrumentation resources available to support the survey objectives.

7.1 Field Survey Instruments

Portable survey instruments will be used to perform measurements in the field. Table 7-1 lists the types of portable survey equipment expected to be used during survey activities at NASB.

7.1.1 Calibration

Portable survey instrument calibration will be completed on an annual frequency. Instrument calibration will also be performed after repairs or modifications have been performed on the instrument. The instrument will be calibrated in accordance with the manufacturer's recommended method.

7.1.2 Daily Performance

Prior to use of the portable survey instruments, calibration verification, physical inspection, battery check, and source-response check will be performed per SOP 002, Preparation of Portable Radiation and Contamination Survey Meters and Instruments for Field Use.

All portable survey instruments will have a current calibration label that will be verified daily prior to use of the instrument.

Physical inspection of the portable survey instrument will include:

- General physical condition of the instrument and detector prior to each use
- Knobs, buttons, cables, connectors
- Meter movements/displays
- Instrument cases
- Probe/probe window(s)
- Other physical properties that may affect the proper operation of the instrument or detector

Any portable survey instrument or detector having a questionable physical condition will not be used until the problems have been corrected.

A battery check will be performed to ensure that sufficient voltage is being supplied to the detector and instrument circuitry for proper operation. This check will be performed in accordance with the instrument's operations manual.

The instrument will be exposed to the appropriate (alpha, beta, gamma) check source to verify that the instrument response is within the plus or minus percent range determined during the initial response check.

The results of the daily operation checks discussed above will be documented. Instruments that do not pass the daily operation checks will be removed from service until all deficiencies have been corrected.

7.1.3 Instruments for Surface Scan Surveys for Alpha Activity

Scan surveys for alpha radiation will be performed using a Surface Contamination Monitor (SCM) , Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43 series alpha-beta gas proportional probes (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) plastic scintillation detector (or equivalent). Note: The SCM is not planned equipment for performing scans, but is available, if needed.

7.1.4 Instruments for Surface Scan Surveys for Beta Activity

Scan surveys for beta radiation will be performed using a SCM, Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43-37 alpha-beta gas proportional probes (or equivalent) or a Ludlum 43-89 or 43-93 ZnS(Ag) plastic scintillation detector (or equivalent). Note: The SCM is not planned equipment for performing scans, but is available, if needed.

7.1.5 Instruments for Direct Measurement Static Surveys for Alpha Activity

Static surveys for alpha radiation will be performed using a Ludlum Model 2221, 2241, 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43-37 alpha-beta gas proportional probes (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) plastic scintillation detector (or equivalent).

7.1.6 Instruments for Direct Measurement Static Surveys for Beta Activity

Static surveys for beta radiation will be performed using a Ludlum Model 2221, 2241, 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43-37 alpha-beta gas proportional probes (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) plastic scintillation detector (or equivalent).

7.1.7 Instruments for Scan Surveys for Gamma Activity

Scan surveys for gamma radiation will be performed using a Ludlum Model 2241, 2350-1 data logger (or equivalent) equipped with a Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) scintillation detector (or equivalent) or RASO approved towed array gamma survey system.

7.1.8 Instruments for Direct Measurement Static Surveys for Gamma Activity

Direct measurement static surveys for gamma radiation will be performed using a Ludlum Model 2241, 2350-1 (or equivalent) equipped with a Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector (or equivalent).

7.1.9 Instruments for Direct Measurement Surveys for Beta Gamma Activity

Direct measurement surveys for beta and gamma radiation will be performed using Ludlum Model 3, Model 12, Model 177 or equivalent, with a model 44-9 Geiger Mueller pancake probe (or equivalent). This instrument combination is normally used for routine surveys associated with operational aspects of decommissioning activities such as monitoring personnel and equipment exiting a radiologically controlled area.

7.1.10 Instrument for Exposure Rate Surveys

Exposure rate surveys are conducted with use of a Ludlum Model 19 MicroR meter (or equivalent). Compatible with anticipated exposure rates, the instrument is equipped with an internally mounted 1-inch by 1-inch NaI scintillation detector that is integral to the meter housing.

7.2 **Instrumentation Equations**

The following equations are used to calculate efficiencies, MDCs, and minimum detectable count rates (MDCRs).

7.2.1 Instrument Efficiency

The instrument efficiency (ϵ_i) is defined as the ratio between the net count rate, in cpm, of the instrument and the surface emission rate of the calibration source for a specified geometry. The surface emission rate is the 2π particle fluence that is affected by both the attenuation and backscatter of the radiation emitted from the calibration source.

Equation 7-1 will be used to calculate the instrument efficiency in counts per particle, although efficiency is typically reported as having no units or unitless:

Equation 7-1

$$\epsilon_i = \frac{R_{S+B} - R_B}{q_{2\pi} \left(\frac{W_A}{S_A} \right)}$$

Where:

R_{S+B} = the gross count rate of the calibration measurement (cpm)
 R_B = the background count rate in cpm

- $q_{2\pi}$ = surface emission rate of the calibration source (National Institute of Standards and Technology [NIST] traceable) in particles per minute
- W_A = active area of the detector window (square centimeters [cm^2])
- S_A = area of the source (cm^2)

The instrument efficiency procured from the instrument calibration service is determined by obtaining static counts with the detector over a calibration source that has a NIST-traceable surface emission rate. The 2π particle fluence rate is corrected for decay. Then the surface emission rate of the source must be corrected for the area subtended by the probe. Factors that can also affect instrument efficiency are discussed below:

- Efficiency Check Sources. Efficiency check sources that emit alpha or beta radiation with energies similar to those expected from the contaminant in the field (similar to the expected radionuclide[s] of concern) will be selected.
- Source Geometry Factors. Instrument efficiency will usually be determined with an efficiency check source equal to or greater than the area of the probe. If a source smaller than the probe used, no conversion factor is applied to the MDC. Conversion factors are applied if the source is larger than the probe.
- Source-to-Detector Distance. The detector efficiency will be calculated at a source-to-detector distance the same as the detector-to-surface distance used in the field.

7.2.2 Surface Activity Measurements

Surveillance measurements are used to quantify surface activity levels on concrete and other building surfaces. International Organization for Standardization (ISO) 7503-1 (ISO 1988), NUREG/CR-1507 (NRC 1997b), and Selection and Use of Portable Radiological Survey Instruments for Performing In-Situ Radiological Assessments in Support of Decommissioning (American Society for Testing and Materials 1998) are used as technical guidance to ensure accuracy in the measurement of surface activity.

Equation 7-1a is used to calculate the surface activity in units of disintegrations per minute (dpm) per 100 cm^2 :

Equation 7-1a

$$A_S = \frac{R_{S+B} - R_B}{\varepsilon_i \varepsilon_s \frac{W_A}{100 \text{ cm}^2}}$$

Where:

- A_S = total surface activity (dpm/ 100 cm^2)
- R_{S+B} = the gross count rate of the measurement in cpm
- R_B = the background count rate in cpm
- ε_i = the instrument efficiency
- ε_s = the contaminated surface efficiency

W_A = the area of the detector window (cm²)

7.2.3 Count Detection Probability for Alpha Scans (≤ 126 -cm² Probe)

Scanning for alpha emitters differs significantly from scanning for beta and gamma emitters in that the expected background response of most alpha detectors is very close to zero. The following sections cover scanning for alpha emitters.

Since the time a contaminated area is under the probe varies and the background count rate of some alpha instruments is less than 1 cpm, it is not reasonable to determine a fixed MDC for scanning. Instead, it is more practical to determine the probability of detecting an area of contamination at a predetermined DCGL for given scan rates.

For alpha survey instrumentation with backgrounds ranging from less than 1 to 3 cpm, a single count provides a surveyor sufficient cause to stop and investigate further. Assuming this to be true, the probability of detecting given levels of alpha surface contamination can be calculated by use of Poisson summation statistics.

Given a known scan rate and a surface contamination release limit, the probability of detecting a single count while passing over the contaminated area is given by Equation 7-2:

Equation 7-2

$$P(n \geq 1) = 1 - e^{-\frac{GE+B(d)}{60v}}$$

Where:

$P(n \geq 1)$ = probability of observing a single count
 G = contamination activity (dpm)
 E = ϵ_i (detector efficiency (2π)) x ϵ_s (contaminated surface efficiency)
 B = background count rate (cpm)
 d = width of detector in direction of scan (cm)
 v = scan speed (centimeters per second [cm/s])

Once a count is recorded and the guideline level of contamination is present, the surveyor should stop and wait until the probability of getting another count is at least 90 percent. This time interval can be calculated by Equation 7-3:

Equation 7-3

$$t = \frac{13,800}{CAE}$$

Where:

- t = time period for static count(s)
- C = contamination guideline (dpm/100 cm²)
- A = physical probe area (cm²)
- E = ε_i (detector efficiency (2 π)) x ε_s (contaminated surface efficiency)

7.2.4 Count Detection Probability for Alpha Scans (582-cm² Probe)

The larger (582 cm²) gas-proportional detectors have background count rates on the order of 5 to 10 cpm, and a single count will not cause a surveyor to investigate further. A counting period long enough to establish that a single count indicates an elevated contamination level would be prohibitively inefficient. For these types of instruments, the surveyor usually will need to get at least two counts while passing over the source area before stopping for further investigation.

Assuming this to be a valid assumption, the probability of getting two or more counts can be calculated by Equation 7-4:

Equation 7-4

$$P(n \geq 2) = 1 - \left[1 + \frac{(GE + B)t}{60} \right] \left[e^{-\frac{(GE+B)t}{60}} \right]$$

Where:

- $P(n \geq 2)$ = probability of getting two or more counts during the time interval t
- t = time interval (s)
- G = source activity (dpm)
- E = ε_i (detector efficiency (2 π)) x ε_s (contaminated surface efficiency)
- B = background count rate (cpm)

7.2.5 Scan detection for Alpha Scans (Surface Contamination Monitor)

The SCM is an automated scan and record system using a Position Sensitive Proportional Counter (PSPC). Scan speed is controlled by means of a DC motor. System scan speed is also computer recorded during a survey. Surface-to-detector distance is maintained by using a rigid detector mount and setting the distance prior to conducting a survey. All counts recorded by the system are computer recorded. The pulses received by the PSPC are “binned” in 5 centimeters wide areas of the detector, and are logged every 5 centimeters of system travel as determined by a precision wheel encoder feeding the computer. The result is that data is recorded in 25 cm² areas over the entire surface that is surveyed. A square meter area will have 400 individual data points recorded. As a result, the SCM scan sensitivity can be determined a priori in a fashion similar to beta survey instruments. The actual system sensitivity, or a posteriori MDC, can be determined from graphical analysis of the thousands of data points generated from even small surveys.

The low release criteria for Ra-226 requires that particle detection theory, as described in Section 6.7.2.2 and Appendix J of MARSSIM, be employed to determine an instrument's ability to detect radioactivity. To achieve the necessary detection, the SCM can be operated in a recount mode, utilizing two separate detectors hard linked to one other. Counts on a "bin" by "bin" basis on the first detector can be compared with counts in the identical "bins" on the second detector when the second detector was over the same area as the first. For each 100 cm² area, lower thresholds can be set that require counts above the threshold on both detectors to occur prior to requiring follow-up on that area. The process greatly reduces the number of false positives, the major issue when performing alpha surveys.

To achieve 95 percent probability of detection of a 100 dpm α emitting radionuclide, the system will be operated at 0.5 inch per second. The 100 dpm source will result in at least two counts in a 100 cm² area on both the primary and recount detector more than 95 percent of the time. The probability of getting two or more counts in the same 100 cm² area due to background has a low probability, less than 0.01 percent, because of the low α background associated with the SCM. Background values typically are less than 1 cpm per 100 cm² area.

The probability of detecting two counts due to a source is given by Equation 7-4 from above.

Since the detectors associated with the SCM are manufactured to the same specifications, the efficiency of each detector is similar. Therefore, the probability of obtaining 2 or more counts on each detector as they traverse the same 100 dpm source is the square of the probability for a single detector.

For areas with higher alpha backgrounds, calculations can continue to establish the probability of obtaining 3, or 4 counts from a 100 dpm source. A higher background will increase the probability of detecting a source since background is not subtracted. Using a threshold of 3 or 4 may be necessary to reduce the number of Type I errors to a manageable level while still maintaining a reasonable probability of detecting the 100 dpm source.

7.2.6 Minimal Detectable Count Rate and Minimum Detectable Concentration for Beta Scans

The minimum detectable number of net source counts in the scan interval can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in d') as shown in Equation 7-5:

Equation 7-5

$$MDCR = d' \sqrt{b_i \left(\frac{60}{i} \right)}$$

Where:

- d' = index of sensitivity (α and β errors [performance criteria])
- b_i = number of background counts in scan time interval (count)
- i = scan or observation interval(s)

The required rate of true positives will be 95 percent, and the false positives will be 5 percent. From Table 6.5 of MARSSIM, the value of d' , representing this performance goal, is 3.28. The minimum detectable number of net source counts in the interval is given by S_i . Therefore, for an ideal observer, the number of source counts required for a specified level of performance can be arrived at by multiplying the square root of the number of background counts by the detectability value associated with the desired performance (as reflected in d'), as shown in Equation 7-5a:

Equation 7-5a

$$S_i = d' \sqrt{b_i}$$

The scan MDC is determined from the MDCR by applying conversion factors that account for detector and surface characteristics and surveyor efficiency. As discussed below, the MDCR accounts for the background level, performance criteria (d'), and observation interval. The observation interval during scanning is the actual time that the detector can respond to the contamination source. This interval depends on the scan speed, detector size in the direction of the scan, and area of elevated activity.

The scan MDC for structure surfaces is calculated using Equation 7-6:

Equation 7-6

$$\text{Scan MDC} = \frac{\text{MDCR}}{\sqrt{p} \varepsilon_i \varepsilon_s \frac{W_A}{100 \text{ cm}^2}}$$

Where:

- MDCR is discussed above
- p = surveyor efficiency factor
- ε_i = instrument efficiency (count per particle)
- ε_s = contaminated surface efficiency (particle per disintegration)
- W_A = area of the detector window (cm^2) [Defaults to 100 cm^2 for probes greater than 100 cm^2]

7.2.7 MDC for Static Alpha and Beta Counts

The static MDC is the level of radioactivity practically achievable by the overall measurement process. Equation 7-7 is used to calculate instrument MDC in dpm per 100 cm^2 when the background and sample are counted for the same time intervals:

Equation 7-7

$$\text{MDC} = \frac{3 + 4.65 \sqrt{R_B T_B}}{\varepsilon_s \varepsilon_i \frac{W_A}{100} T_B}$$

Where:

- R_B = background count rate (cpm)
- T_B = background counting time (minute [min])
- ε_i = instrument efficiency (counts per particle)
- ε_s = contaminated surface efficiency (particles per disintegration)
- W_A = active area of the detector window (cm^2) [Defaults to 100 cm^2 for probes greater than 100 cm^2]

In Equation 7-7, W_A is the size of the “active” area of the detector window. If the area of the detector window (cm^2) is less than 100 cm^2 , it is necessary to convert the detector response to units of dpm per 100 cm^2 .

If the background and sample are counted for different time intervals, Equation 7-8 is used to calculate the MDC in dpm per 100 cm^2 :

Equation 7-8

$$MDC = \frac{3 + 3.29 \sqrt{R_B T_{S+B} \left(1 + \frac{T_{S+B}}{T_B} \right)}}{\varepsilon_i \varepsilon_s \frac{W_A}{100 \text{ cm}^2} T_{S+B}}$$

Where:

- R_B = background count rate (cpm)
- T_B = background counting time (min)
- T_{S+B} = sample counting time (min)
- ε_i = instrument efficiency (counts per particle)
- ε_s = contaminated surface efficiency (particles per disintegration)
- W_A = active area of the detector window (cm^2) [Defaults to 100 cm^2 for probes greater than 100 cm^2]

7.2.8 Surface Efficiency (ε_s) for Surface Activity Measurements

The surface efficiency term in the preceding equations is used to determine the 4π total efficiency for a particular surface and condition. Suitable values are based on the radiation and radiation energy, and are primarily impacted by the backscatter and self-absorption characteristics of the surface on which the contamination exists in the field. Backscatter is most affected by the energy of the radiation and the density of the surface material. Self-absorption characteristics or attenuation are also a function of the radiation’s energy and surface condition. Surfaces typically encountered in the field include concrete, asphalt, wood, drywall, plaster, carpet, and metal. Surface conditions include both physical effects, such as scabbled concrete, and the effect of surface coatings: dust, paint, rust, water, and oil.

In the absence of experimentally determined surface efficiencies, ISO-7503-1 (ISO 1988) and NUREG-1507 (NRC 1997b) provide conservative recommendations for surface efficiencies. ISO-7503-1 recommends a surface efficiency of 0.5 for maximum beta energies exceeding 0.4 megaelectron volt (MeV) and to use a surface efficiency of 0.25 for beta energies between 0.15 and 0.4 MeV and for alpha emitters (ISO 1988; NRC 1997b). NUREG-1507 provides surface efficiencies based on studies performed for the NRC. In general, NUREG-1507 indicates that the ISO rule of thumb for surface efficiencies is conservative, particularly for beta-emitting radionuclides with end-point energies between 0.25 MeV and 0.4 MeV. A surface efficiency of 0.25 will be used for alpha at NASB. A surface efficiency for beta emitters will be determined based on the least energetic beta-emitter radionuclide of concern for the particular survey unit.

7.2.9 MDC for Gamma Scans of Surface Areas

The scan MDC (in pCi/g) for land areas is based on the area of elevated activity, depth of contamination, and the radionuclide (energy and yield of gamma emissions). To establish the scan MDC, the relationship between the detector's net count rate to net exposure rate must be established first. This is accomplished by determining the MDCR using Equation 7-5 and then applying a surveyor efficiency factor p to get the $MDCR_{Surveyor}$ as show below in Equation 7-9:

Equation 7-9

$$MDCR_{Surveyor} = \frac{MDCR}{\sqrt{p}}$$

The $MDCR_{Surveyor}$ is then converted into the corresponding minimum detectable exposure rate (MDER) by use of a calibration constant specific to the detector being used and the radionuclide of concern. For example, when used with the Ludlum Model 2350-1, the calibration records for the Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector provide a calibration constant that can be used to determine the ratio of cpm to $\mu R/hr$, as shown in Equation 7-10 below:

Equation 7-10

$$MDER (\mu R / hr) = \frac{MDCR_{Surveyor} * 6 \times 10^7}{cc}$$

Where:

$$\begin{aligned} MDCR_{Surveyor} &= \text{as calculated in Equation 7-9} \\ 6 \times 10^7 &= \text{a conversion factor accounting for differences in time and} \\ &\text{activity units } ([\mu R\text{-min}]/[R\text{-hr}]) \\ cc &= \text{calibration constant } ([\text{counts}]/[R]) \end{aligned}$$

Next, the relationship between the radionuclide concentration and exposure rate is established. This is accomplished by modeling (using MicroShield) to determine the net exposure rate

produced by the radionuclide at a distance above the ground. The factors considered in modeling include:

- The dose point above the surface
- The density of material in grams per cubic centimeter
- DCGL of the radionuclide of concern in pCi/g
- The depth of detection for the DCGL
- The circular dimension of the cylindrical area of detector capability (m²)

The concentration of the radionuclide of concern (Scan MDC) necessary to yield the MDER may be calculated by taking the ratio of the MDER to the exposure rate calculated by MicroShield or Monte Carlo *N*-Particle code, as shown in Equation 7-11 below:

Equation 7-11

$$\text{Scan MDC (pCi / g)} = \frac{\text{DCGL (pCi / g)} * \text{MDER (}\mu\text{R / hr)}}{\text{Microshield Exposure Rate (}\mu\text{R / hr)}}$$

7.2.10 Minimum Detectable Count Rate for Static Gamma Counts

For gamma surveys, MDCR, rather than MDC, is calculated in cpm. If the background and sample are counted for the time intervals, Equation 7-12 is used to calculate the MDCR:

Equation 7-12

$$\text{MDCR} = \frac{3 + 4.65\sqrt{R_B T_B}}{T_B}$$

Where:

- $3 + 4.65$ = constant factor provided by MARSSIM
 R_B = background count rate (cpm)
 T_B = background counting time (min)

TSPs will not normally be designed to use different background and sample count times for gamma scan surveys; any deviation from this requires RASO approval, and notation in the TSP and final reports as an exception to the Management Plan. If the background and sample are counted for different time intervals, Equation 7-13 is used to calculate the MDC:

Equation 7-13

$$\text{MDC} = \frac{3 + 3.29\sqrt{R_B \cdot T_{S+B} \cdot \left(1 + \frac{T_{S+B}}{T_B}\right)}}{T_{S+B}}$$

Where:

$3 + 3.29$	=	constant factor provided by MARSSIM
R_B	=	background count rate (cpm)
T_{S+B}	=	background counting time (min)
T_B	=	background counting time (min)

7.3 Laboratory Instruments

Laboratory equipment will be used to analyze samples collected in the field. Worksheet 23 of the SAP lists the types of laboratory equipment expected to be used at NASB.

7.3.1 Quality Assurance Checks

Quality assurance checks shall be performed on laboratory instrumentation to ensure proper operation and to maintain calibration. The quality checks shall be documented, reviewed, and maintained. Data trends outside the tolerance limits shall be investigated to determine the cause and potential effect on measurement results.

7.3.2 Gross Alpha/Beta Loose Surface Contamination Surveys

Swipe samples will be processed using a Ludlum Model 2929 scaler or equivalent. Data are reported in units of cpm per 100 cm².

7.3.3 Gamma Spectroscopy

Gamma spectroscopy will be performed in accordance with the SAP by a Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) accredited laboratory. All results are reported in pCi/g, picocuries per milliliter (pCi/mL), or picocuries per liter (pCi/L), depending on the media analyzed. The Laboratory Manager reviews all data results, including energy spectrums, for quality assurance and to verify count integration, efficiency, and background corrections, as well as the identification of overlapping peaks. If there is any question on the analysis results, the sample is reprocessed and possibly counted for a longer interval.

7.3.4 Liquid Scintillation Analysis

Liquid scintillation counting will be performed in accordance with the SAP by a DoD ELAP accredited laboratory. The results are identified in dpm or pCi/g and grouped by energy.

7.3.5 Total Strontium/Strontium-90 Analysis

Total strontium analysis will be performed in accordance with the SAP by a DoD ELAP accredited laboratory. If the total strontium release criterion is exceeded for any sample, strontium 90 (Sr-90) analysis will be performed in accordance with the SAP by a DoD ELAP accredited laboratory. The results of ⁹⁰Sr analysis typically are reported in pCi/g, pCi/mL, or pCi/L, depending on the media analyzed.

7.3.6 Alpha Spectroscopy Analysis

Analysis of alpha-emitting radioisotopes will be performed in accordance with the SAP by a DoD ELAP accredited laboratory. The results of alpha spectroscopy analysis are reported in pCi/g, pCi/mL, or pCi/L, depending on the media analyzed.

8.0 SURVEY IMPLEMENTATION

This section discusses the types of surveys and their implementation in the field with a focus on the methods for conducting each type of survey. The survey procedures described in this section will be performed in accordance with approved SOPs or work instructions as identified in the project-specific Work Plan. Additional survey implementation details will be identified in each TSP and or project-specific Work Plan.

8.1 Reference (Background) Areas

An average background level will be determined by performing measurements at systematic or random locations within the designated background area. The detector probe will be held approximately 10 centimeters (4 inches) from the surface area for gamma radiation and 0.25 inch from the surface area for alpha/beta radiation. Instrumentation will be allowed to stabilize before background readings are taken. The average of the larger of the readings or the method detection limit or minimum detectable activity (MDA) reported by the laboratory for all of the readings taken will determine the background. Background scan ranges, swipes, and exposure rates will also be collected for reference data. In some cases, solid samples will need to be collected in the background area for comparative analyses of specific survey units. The same survey methodology and instruments used to collect the background data will be used to perform measurements within survey units.

8.2 Scan Surveys

Scan surveys are an integral part of survey programs conducted to determine contamination levels. The surveys are an evaluation technique performed by moving a detection device over a surface at a specified speed and distance above the surface to detect radiation. It will be used to identify areas that may require additional survey measurements.

8.2.1 Scan Surveys for Alpha/Beta Radiation

Surface scan surveys for alpha and beta radiation will be performed by moving the detector over the surface being surveyed at a rate to meet the required scan minimum detectable concentration for the radionuclides of concern for each specific survey unit. Details on alpha and beta scan rates will be included in individual TSPs. The detector will be held within 0.635 centimeter (0.25 inch) over the surface being surveyed.

8.2.2 Scan Surveys for Gamma Radiation

Scan measurements are obtained by traversing a path at a maximum speed (scan rate) of approximately 0.5 meter per second and slowly moving the detector assembly in a serpentine (S-shaped) pattern, while maintaining the detector approximately 10 centimeters (4 inches) above the area being surveyed. For RASO approved towed array systems, the scan rate will be a maximum of 0.5 meter per second, and at a height of 10 centimeters (4 inches), unless otherwise approved by RASO. The detector will be operated in a manner such that 100% of the area to be surveyed is scanned by the Vehicle Towed Array (VTA).

8.3 **Static Surveys**

Static contamination surveys are used to determine contamination levels on surface areas for scoping, characterization, and/or release surveys. The surveys are an evaluation technique performed by holding a detection device over a surface for a specified time at a set distance to detect radiation.

8.3.1 Static Surveys for Alpha and Beta Surface Activity

Direct measurements will be conducted with the detector within 0.635 centimeter (0.25 inch) above the surface. Count time for conducting the measurement will be dependent upon the radionuclide of concern.

8.3.2 Static Surveys for Gamma Radiation

Static gamma measurements require positioning the detector assembly approximately 10 centimeters (4 inches) above the surface and completing a stationary 60-second survey.

8.4 **Exposure Rate Measurements**

Exposure rate surveys are performed to measure ambient gamma radiation levels. These measurements are obtained by holding the detection device at the required distance from the surface being surveyed. Instrumentation will be allowed to stabilize before taking the measurement.

8.5 **Swipe Sample Measurements**

Swipe sampling will be performed to assess the presence of radioactive contamination that is readily removed from a surface. Swipe samples will be taken to evaluate the presence of alpha and beta surface activity. As called for in individual TSPs, swipe samples may be collected to evaluate tritium contamination. The procedures for collecting swipe samples are discussed in the SAP.

8.6 **Survey and Sample Locations**

Static measurements, swipe samples, exposure rate measurements, and media samples will be taken from the same predetermined locations within each survey unit to obtain data for use in

FSSs. Section 4.4, Reference Coordinate Systems, and Section 6.1, Assessing Small Areas of Elevated Activity, provide further discussion of survey and sample locations for FSSs. Static measurement locations for equipment and material surveys are given in TSPs and/or; SOP 006, Radiation and Contamination Surveys; SOP 012, Release of Materials and Equipment from Radiologically Controlled Areas; and other work instructions. Table 1-1 lists each of the TtEC field SOPs developed for performing radiological work at NASB. Copies of the SOPs are provided in Attachment 3. Work Instructions are available in the TtEC offices, when mobilized, at NASB and can be provided to the Navy and/or regulatory agencies for review upon request.

8.7 Equipment and Material Surveys

Equipment and materials surveys will be performed in accordance with SOPs as identified in the project-specific Work Plan. Table 6-1 lists acceptable levels of contamination based on the AEC Regulatory Guide 1.86 limits. In the event that survey results indicate levels of contamination exceeding the limits listed in Table 6-1 (for surfaces), appropriate decontamination methods will be performed using methods described in these SOP 016, Decontamination of Equipment and Tools.

8.8 Personnel Surveys

Properly trained staff will perform personnel surveys in a predesignated low-background area before leaving a radiologically controlled area, as specified in the RWP or when deemed necessary by the RCT. Personnel who are not qualified to administer a self-survey will be monitored by a qualified technician. Personnel surveys will be performed using the appropriate survey methods described above and in accordance with appropriate SOP 006, Radiation and Contamination Surveys.

8.9 Media Sampling

Various samples may be collected for radiological analysis, including soil, water, brick, porcelain, wood, and others. The SAP provided in the project-specific Work Plan will describe the methods for collecting samples, sample numbering, sample labeling, sample shipment, and completion of the associated chain-of-custody and other required documentation.

8.10 Air Sampling

As specified in the RWP, airborne activity monitoring (continuous or grab samples) and engineering controls will be necessary during the course of work. To control occupational exposures, establish PPE, and determine respiratory-protection requirements, monitoring and trending for airborne radioactive material will be performed as necessary. Engineered controls will be implemented if required to maintain airborne concentrations below 10 percent of the applicable derived air concentration (DAC) value for the radionuclides of concern (Table 8-1).

If, during the course of work, an airborne concentration exceeds 10 percent of the DAC, ongoing activities will cease and the affected location will be posted until the source of the airborne concentration is eliminated and levels are confirmed to be below 10 percent of the DAC.

Air monitoring will be performed using the methods described in SOP 008, Air Sampling and Sample Analysis.

8.11 Truck Surveys

During the course of work at NASB, soils and debris will be transported via truck to recycling centers, landfills, and other licensed disposal sites. Most of these items and materials will require radiological surveys prior to leaving the site. However, some stockpiles of soil, debris, and miscellaneous materials may not be surveyed because the likelihood of contamination is very low. As an added measure against inadvertently sending radioactive materials to a landfill or disposal site, trucks carrying material from potentially impacted sites will be surveyed for gamma radiation. Truck surveys will be performed using SOP 011, Gamma Screening of Trucks Using the Stationary Portal Monitor and Using Portable Survey Instrumentation. The RSO, RSOR, and PM will be immediately notified of any truck rejected at the portal monitor or using portable survey instrumentation.

8.12 Global Positioning System Measurements

As specified in TSPs, Global Positioning System (GPS) units may be used while performing outdoor area field surveys. For example, during an outdoor gamma scan survey, a GPS unit may be carried adjacent to the gamma detector. The GPS output will be logged along with the gamma count rates, so that each gamma reading will have an associated location point. After the survey, gamma data may be color coded and plotted on a survey map.

In addition, outdoor survey units may be mapped by walking the perimeter with a GPS unit. Once the outline is digitized, static reading locations for that survey unit can be generated in latitude and longitude, using Visual Sample Plan software (Gilbert et al. 2001). These points can be located using the GPS unit followed by the collection of static readings and samples, as appropriate.

9.0 DECONTAMINATION, DISMANTLING, AND DISPOSITION

Decontamination, dismantling, and disposition activities will be performed, as identified in a TSP and/or project-specific Work Plan, as part of radiological remedial action activities performed at NASB. Decontamination is the removal, by chemical or physical means, of radioactive material from various types of internal and external surfaces including equipment, materials, components, systems, and structures. Dismantling is the removal, as applicable, of furniture, equipment, and walls or similar structural outworks and components for the purpose of permanently breaking down, removing, and eliminating such materials. This would also include conducting work in open land areas to support the removal of contaminated material or devices. To assess the extent and type of contaminants identified during the course of ongoing fieldwork, various remedial activity support surveys will be necessary.

9.1 Decontamination

To support ongoing work at NASB, decontamination of materials, equipment, and structures may be necessary. There are numerous decontamination methods available for use. If practical, manual decontamination methods should be used. Abrasive methods may be necessary if areas of fixed contamination are identified. Chemical decontamination can also be advantageous by using detergents for nonporous surfaces with contamination present. Chemicals should be selected for decontamination that will minimize the creation of mixed waste.

Decontamination activities will be conducted using SOP 007, Decontamination of Equipment and Tools.

9.2 Dismantling and Remediation

To support the release of buildings, structures, equipment, materials, and land areas, remedial support activities will need to be conducted. These activities include, but are not limited to, soil removal, and dismantling, disassembling, and/or removal of various systems, components, and structures. The following is a list of expected remedial support activities that may be performed at NASB:

- Piping and associated pumping system removal
- Ventilation system removal
- Equipment, furniture, and material removal
- Soil, asphalt, or concrete removal
- Building demolition
- Structure removal

Specific control methods and more detailed information will be provided in the TSP and/or project-specific Work Plan.

9.3 Disposition

Disposition is the methodology of identifying the radiological status of equipment, materials, and structures for its end use. Disposition will be conducted after the decontamination and/or dismantling activities have been completed. This will include the following key elements:

- Control of equipment and materials
- Free release
- Decontaminate for free release
- Off-site disposal

Controlling equipment and materials is essential to ensure that contaminated items are not used in uncontrolled areas to prevent the inadvertent spread of contamination. If decontamination methods are unsuccessful, some materials and equipment may be stored for future use in

radiologically controlled areas. If it is not feasible or cost-effective to control contaminated equipment and materials, they will be disposed of off-site in accordance with RASO guidance.

10.0 RADIOACTIVE MATERIALS MANAGEMENT

Planned site activities could potentially involve the presence of radioactive materials. Activities involving the presence of radioactive material, including handling, storage, packaging, will be performed under the requirements of NRC license #29-31396-01, issued to TtEC or Maine Agreement State RML, as required. A copy of the license is included as Attachment 1. Copies of supporting SOPs are included as Attachment 3. The activities will be conducted by personnel who are trained and qualified to apply management and control measures as required by regulatory agencies. The license requires that the provisions of 10 CFR Part 19 and 10 CFR Part 20 be implemented for activities involving radioactive materials.

The RSOR or the SPM will delegate the daily operating responsibility for related activities with the use of defined directives that comply with applicable regulatory requirements. Actions necessary to carry out related decisions and policy include:

- Specific oversight of radioactive materials that result from site activities
- Acting as a primary point of contact for site-specific activities involving radioactive materials
- Establishing administrative controls to manage radioactive materials according to regulatory requirements
- Acting as a primary point of contact with the NRC or Maine Agreement State on radioactive materials present such as point sources, soil contaminants, naturally occurring radioactive material (NORM)
- Coordinating activities with subcontractors performing activities under this management plan

10.1 Managing Radioactive Materials

The day-to-day management of radioactive material is governed by NRC License #29-31396-01 or Maine Agreement State RML which requires compliance with the requirements of Title 10 CFR Part 19 and Title 10 CFR Part 20. Existing materials that require the implementation of radioactive materials management include:

- Sealed radioactive sources used for radiation-detection instrument checks
- Devices and contaminants from past operations at NASB
- Control of radioactive and mixed waste generated during current site operations

Activities involving radioactive materials will be controlled by the SOPs provided in Attachment 3. An SOP will be implemented if field conditions meet the procedural requirements. If required by SOP 010, a RWP will be issued. The RWP will establish radiation protection requirements for performing specific tasks. The requirements may include dosimetry, air

sampling, protective clothing requirements and limitations on the performance of the work. Radioactive material will be managed by the RSOR or designee. Off-site organizations and contractors who plan to use radioactive materials in support of project activities must obtain approval. Approval can be obtained by directing a request, in writing, through the RSOR or designee. Requests must include:

- A detailed description of proposed radioactive material use
- A copy of the appropriate NRC or Maine Agreement State License with a completed NRC Form 241, Navy Radioactive Material Permit (NRMP) or exemption, if the material is licensed
- Name and address of the responsible local representative and contact information
- A copy of contract documentation describing the work to be done and inclusive dates
- Documentation acknowledging that the RSOR or designated appointee can perform periodic checks to ensure that the user is complying with applicable requirements

10.2 Radioactive Material Handling

There should be no contact with radioactive material or exposure to ionizing radiation where an expected benefit is not realized. Exposures should be ALARA and consistent with technology, cost, and operational requirements.

10.2.1 Limitations

Designees responsible for the control of radioactive materials are required to limit its accessibility and use. Material management policies (that performed by the contractor and its subcontractors) require an inventory accountability process. Clearly defined radiological safety requirements shall be established for (1) operating, changing, and repairing systems containing, or designed to operate with radioactive material; and (2) control of waste materials resulting from investigative processes.

10.2.2 Authorizations

Work involving the handling and storage of radioactive materials will be performed under NRC License #29-31396-01 or Maine Agreement State RML, as required, which requires compliance with the requirements of Title 10 CFR Part 19 and Title 10 CFR Part 20 and with authorization for such work from the RSOR.

In order to minimize unauthorized access to or removal of radioactive materials, application of appropriate security-protection measures will be exercised (for example, combination or key lock safes for source storage, Conex boxes with padlocked doors for sample storage, or “clam shell” casings for drums). Licensed radioactive sources and devices, as well as non-exempt quantities of radioactive materials in non-permitted sources, must be routinely inventoried and documented as such. Identification of locations where radioactive materials are present will be accomplished with the use of conspicuous posting compliant with Title 10 CFR Part 20.

The SOP will be periodically assessed for accuracy and applicability by the RSOR or designee appointee to ensure that necessary requirements are in place to manage radioactive material. The degree of required management is dependent on the quantity and type of material on hand, where the material is generated, and the location and configuration of available storage.

Only pre-authorized areas will be used to store radioactive materials. These areas will be selected with concurrence from the Navy. Security measures for these areas will be coordinated with the Caretaker Site Office.

Radioactive material handling activities must be performed in a manner to ensure that:

- Access to areas or rooms is restricted where radioactive materials are known to be present
- Surveys of areas where sealed radioactive materials are stored are completed at least weekly
- Surveys of areas where unsealed radioactive materials are used are completed according to a RWP.

11.0 DOCUMENTATION AND RECORDS MANAGEMENT

The purpose of this section is to define standards for the maintenance and retention of radiological records. Radiological records provide historical data, document radiological conditions, and record personnel exposure.

Project electronic data will be downloaded from its collection device (such as laptop computers and data loggers) on a daily basis. At the conclusion of each day's survey activities, electronic data collected that day will be backed up to appropriate removable media (for example, compact disk, zip disk, or equivalent) and the backup will be removed from the site. The backup will not be stored in the same building in which the original project electronic data is stored.

Sample collection, field measurements, and laboratory data will be recorded both electronically and on paper, to the extent practicable. Data and information recorded on paper will be recorded using indelible ink. Both electronic and paper records of field-generated data will be reviewed by the RSOR or a designee knowledgeable in the measurement method for completeness, consistency, and accuracy. Data manually transposed to paper from electronic data collection devices will be compared to the original data sets to ensure consistency and to resolve noted discrepancies. Electronic copies of original electronic data sets will be preserved on a nonmagnetic retrievable data storage device. No data reduction, filtering, or manipulation will be performed on the original electronic versions of data sets.

Project data will be recorded in project data logbooks or on approved forms. Multiple survey teams may use individual project data logbooks during the field effort. Sample collection forms, direct measurement forms, and photographic log sheets will be provided as needed to sampling teams in the field. All actions taken to review, approve, transfer, copy, duplicate, backup, store or secure project data will be noted in a project data logbook.

Project data logbooks, individual team member logbooks, field data forms, COC forms, and copies of all electronic data files will be filled out and collected at completion of fieldwork associated with each building or land area.

The data will be entered and reviewed for accuracy and completeness by the RSOR, SPM or designee. Following review, the RSOR, or designee will certify accuracy of information in the project data logbooks.

Data logbooks and approved forms are considered legal records. Logbooks will be permanently bound and the pages will be numbered. Pages may not be removed from logbooks under any circumstances. Logbook entries will be in ink, legible, factual, detailed, and complete and will be signed and dated by the individuals making the entries. Completed forms will be in ink, legible, detailed, factual, and signed and dated by the individual completing the form. If a mistake is made in a log or on a form, placing a single line through the erroneous entry and initialing and dating the correction will denote the error. Under no circumstances will any previously entered information be completely obliterated. Use of whiteout in data logbooks or on forms is not permitted for any reason. Project documents will be transferred to Navy personnel at the end of the project to be maintained as specified in the RML.

Photographs of sample collection and direct measurement activities taken during the field operations will be documented in a project logbook or using approved forms. Electronic photos will be saved as Joint Photographic Experts Group (JPEG) format files. Descriptions of photographs will include the building and room number or area description; direction photographer is facing, and any measurement location information relevant to the photograph to correlate location.

11.1 Requirements

Records resulting from implementation of this Management Plan shall meet the quality standards as outlined herein. All records must be retrievable and maintained for their prescribed retention time defined in the Project Quality Control Plan as included with each project-specific Work Plan. Working copies of records used for reference will be stored separately from the original. Completed records awaiting transfer to long-term storage shall be stored in an appropriate manner to minimize loss and damage that could result from exposure to weather, fire, or other conditions.

Principal personnel who create, review, and approve radiological records must sign and date the record and follow quality standards specified in the Project Quality Control Plan presented in the project-specific Work Plan.

11.2 Document Quality Standards

Records shall be legible and completed with an indelible ink that provides reproducible and legible copies. Records shall be dated and contain a verifiable signature of the originator. Errors shall be corrected by marking a single line through the error and by initialing and dating the

correction. Radiological records shall not be corrected using an opaque substance. Shorthand or nonstandardized terms may not be used.

To ensure traceability, each record shall clearly indicate:

- Identification of the facility
- Specific location
- Function and process
- Date
- Document number (if applicable)

The quantities used in records shall be clearly indicated in standard units (curie, rad, rem, dpm, becquerel), including multiples and subdivisions of these units.

11.3 Documentation

The four types of documentation that will be maintained and assessed are field operation records, laboratory records, data handling records, and work support documents. The majority of the data produced will be entered into the electronic data management system to produce quality data for inclusion in reports, documents, and presentations.

11.3.1 Data Management System

Supportable and definitive data must be produced and managed to achieve the removal action objectives. The TtEC team developed a unique “cradle-to-grave” data management system that seamlessly integrates all phases of the radiological and construction work process from initial survey, excavation, remediation, and FSS activities through backfill of survey units and site restoration. Acquiring, evaluating, and managing data are the principal tasks involved in every aspect of the removal action activities. The resulting survey data are easily uploaded to the Navy electronic data deliverable (NEDD) Naval Installation Restoration Information Solution (NIRIS) database.

11.3.2 Field Operation Records

The information contained in field operation records will document overall field operations and may consist of the following:

- Field measurement records – At a minimum, this documentation will identify the names of the persons conducting the activity, measurement identification, measurement locations, measurement results, maps and diagrams, equipment, and unusual observations. Data record forms, bound field notebooks, and electronic data loggers will be used to record raw data and make references to prescribed procedures and changes in planned activities.
- Sample tracking records – These records will be documented as identified in the SAP presented in the project-specific Work Plan.

- QC records – QC records will be prepared as indicated in the SAP.
- Personnel files – Personnel files record the names and training certificates of the staff collecting data and will be maintained in accordance with the SAP.
- Deficiency and problem identification reports – The SS documents any work not performed in accordance with Management Plan, TSPs or procedural requirements on a Nonconformance Report (NCR). The NCR will detail the nonconforming condition, the recommended corrective action(s) and the disposition of the corrective action(s). The NCR shall remain open until the nonconforming condition has been satisfactorily resolved and verified by the project PQCM

11.3.3 Laboratory Records

Laboratory records will be prepared as indicated in the SAP included in the approved project-specific Work Plan.

11.3.4 Data Handling Records

Data-handling records document protocols used in data reduction, verification, and validation (as applicable). Data reduction involves data transformation processes such as converting raw data into reportable quantities and units, using significant figures, and calculating measurement uncertainties. Data verification involves reviewing reports of data entered into the electronic data management systems by the appropriate supervisory personnel knowledgeable of and with access to the original data to verify data transcription accuracy in accordance with SOPs. Data comparison and evaluation will be done on radiological samples as discussed in the SAP presented in the project-specific Work Plan. Record copies of surveys, sampling, and analytical data (and their supporting data) will be protected and maintained in project record files as indicated in the project-specific Work Plan. Table 1-1 lists each of the current TtEC field SOPs developed for use at NASB. Copies of these SOPs are provided in Attachment 3. Work instructions are available in the TtEC offices, when mobilized, at NASB and can be provided to the Navy and/or regulatory agencies upon request.

11.3.5 Work Support Documents

Work support documents may include RWPs, TSPs, reports, and work instructions that will be prepared, reviewed, and approved in accordance with the project-specific Work Plan.

12.0 REFERENCES

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TABLES

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**TABLE 1-1
NAVAL AIR STATION BRUNSWICK STANDARD OPERATING PROCEDURES ^a**

Standard Operating Procedures	
SOP Number	SOP Title
SOP 001	Radiation and Contamination Surveys
SOP 002	Preparation of Portable Radiation and Contamination Survey Meters and Instruments for Field Use
SOP 003	Release of Materials and Equipment from Radiologically Controlled Areas
SOP 004	Radiological Records
SOP 005	Radiological Protective Clothing Selection, Monitoring, and Decontamination
SOP 006	Sampling Procedures for Radiological Surveys
SOP 007	Decontamination of Equipment and Tools
SOP 008	Control of Radioactive Material
SOP 009	Air Sampling and Sample Analysis
SOP 010	Issue and Use of Radiation Work Permits
SOP 011	Gamma Screening Of Trucks Using the Stationary Portal Monitor and Using Portable Survey Instrumentation
SOP 012	Radiologically Controlled Area Posting and Access Control
SOP 013	Vehicle Towed Array (VTA)
SOP 014	Transfer of Low Level Radioactive Waste to Another Contractor for Waste Disposal
SOP 015	Use of the Berkeley Nucleonics Corporation SAM-940-30 Radioisotope Identifier
RP-OP-017	Operation of the Ludlum Model 2929 Dual Scaler
RP-OP-025	Operation of the Ludlum Model 2221
RP-OP-026	Operation of the Ludlum Model 19
SCM-OPS-01	Position Sensitive Proportional Counters Purging
SCM-OPS-02	Position Sensitive Proportional Counters Plateau Determination
SCM-OPS-03	Position Sensitive Proportional Counters Position Calibration
SCM-OPS-04	Encoder Calibration
SCM-OPS-05	Position Sensitive Proportional Counters Efficiency Calibration
SCM-OPS-06	Position Sensitive Proportional Counters Quality Assurance
SCM-SETUP-01	Position Sensitive Proportional Counters Repair
SCM-SETUP-02	Hardware Setup
SCM-SETUP-03	Quality Assurance Testing of SCM

^a The most current version of each controlled SOP and Work Instruction is available in the Tt offices at NASB and can be provided to the Navy and regulatory agencies upon request.

NASB Naval Air Station Brunswick
SCM Surface Contamination Monitor

SOP Standard Operating Procedure
TtEC Tetra Tech EC, Inc.

TABLE 4-1
SURVEY UNIT SIZE

Area Classification	Survey Unit Size
Class 1 Structure	Up to 100 m ² floor area
Class 1 Land area	Up to 2,000 m ²
Class 2 Structure	100 to 1,000 m ²
Class 2 Land area	2,000 to 10,000 m ²
Class 3 Structure	No limit
Class 3 Land area	No limit

Abbreviations and Acronyms:
m² – square meter

**TABLE 5-1
DATA LIFE CYCLE USED TO SUPPORT THE
RADIATION SURVEY AND SITE INVESTIGATION PROCESS**

RSSI Process	Data Life Cycle	Phases	MARSSIM Guidance
Site Identification	N/A	N/A	Provides information on identifying potential radiation sites (Section 3.3) ^a
Historical Site Assessment	Historical Site Assessment Data Life Cycle	Plan Implement Assess Decide	Provides information on collecting and assessing existing site data (Sections 3.4 through 3.9) and potential sources of information (Appendix G)
Scoping Survey	Scoping Data Life Cycle	Plan Implement Assess Decide	Discusses the purpose and general approach for performing scoping surveys, especially as sources of information when planning FSSs (Section 5.2)
Characterization Survey	Characterization Data Life Cycle	Plan Implement Assess Decide	Discusses the purpose and general approach for performing characterization surveys, especially as sources of information when planning FSSs (Section 5.3)
Remedial Action Support Survey	Remedial Action Data Life Cycle	Plan Implement Assess Decide	Discusses the purpose and general approach for performing remedial action support surveys, especially as sources of information when planning FSSs (Section 5.4)
FSS	Final Status Data Life Cycle	Plan Implement Assess Decide	Provides detailed guidance for planning FSSs (Chapter 4 and Section 5.5), selecting measurement techniques (Chapters 6 and 7, and Appendix H), and assessing the data collected during FSSs (Chapters 8 and 9)

Notes:

a Section numbers refer to chapters in MARSSIM (DoD et al. 2000).

Abbreviations and Acronyms:

FSS – Final Status Survey

MARSSIM – Multi-Agency Radiation Survey and Site Investigation Manual

N/A – not applicable

RSSI – Radiation Survey and Site Investigation

**TABLE 5-2
SURVEY STRATEGIES**

Survey Type	Minimum Survey Requirement	Sampling and/or Direct Measurements ^a	Minimum Scanning Requirements	Static Measurements	Surface Scans	Exposure Rates	Swipes ^b	Media Samples ^c	General Operational Surveys ^d
Scoping	N/A	Random and Additional Biased	Judgmental	X	X	X	I	O	
Characterization	N/A	Systematic and Additional Biased	Judgmental	X	X	X	I	O	
Remedial Action Support	N/A	Random and Biased	Judgmental						X
Final Status	Class 1	Systematic with Random Start	100% Coverage	X	X	X	I	O	
	Class 2	Systematic with Random Start	50% Coverage	X	X	X	I	O	
	Class 3	Random	25% Coverage	X	X	X	I	O	

Notes:

I = indoor surveys; O = outdoor surveys; X = both

a Additional locations will be chosen based on history and the judgment of the radiological technician. The minimum number of sample points will be calculated as in Section 5.3.3.

b In addition to the swipes taken at each randomly or systematically determined sampling point, swipe sampling will be performed on floor drains, exhaust fans, work benches, sinks, and other suspect locations.

c Indoor locations may be chosen based on scanning results and the judgment of the radiological technician.

d General operation surveys may include static measurements, surface samples, exposure rates, swipes, and media samples.

e Reference the HRA for NASB (Tetra Tech 2014).

Abbreviations and Acronyms:

HRA – Historical Radiological Assessment

NASB – Naval Air Station Brunswick

N/A – not applicable

**TABLE 6-1
RELEASE CRITERIA**

Radionuclides	CAS Number	SURFACES	SOILS ^b	WATER ^d	Laboratory Specific	
		Structures, M&E, Waste (dpm/100 cm ²) ^a	pCi/g ^c	pCi/L	QL pCi/g	MDA pCi/g
Cesium-137/Barium-137m	10045-97-3	5,000	6.6	119	0.070	0.070
Cobalt-60	10198-40-0	5,000	2.28	100	0.070	0.070
Radium-226	13982-63-3	100	1.0	5 ^e	0.7	0.33
Total Strontium	7440-24-6	1,000	1.02	8	0.32	0.32
Thorium-232	7440-29-1	1,000	0.66	15	0.5	0.5
Tritium (H-3)	10028-17-8	5,000	66	20,000	10 pCi/sample	10 pCi/sample
Uranium-238	7440-61-1	5,000	8.4	30	0.5	0.5

Notes:

Criteria for other nuclides will be listed in TSPs, if needed.

a These limits are based on AEC Regulatory Guide 1.86 (USAEC 1974). Values indicate the measured value above background as determined from the reference area. Limits for removable surface activity are 20 percent of these values.

b These limits are based on Nuclear Regulatory Commission document NUREG-1757, Consolidated Decommissioning Guidance (NRC 2006), whose limits are deemed in compliance with the 25 mrem/y unrestricted dose limit in 10CFR20.1402. Listed values were developed by scaling the NUREG-1757 values to 15 mrem/y unrestricted dose.

c Criteria is above background for those radionuclides found in background soils.

d Release criteria for water have been derived from *Radionuclides Notice of Data Availability Technical Document* (EPA 2000) Table III, which compared the federal drinking water standards from the 1976 and 1991 Maximum Contaminant Levels. This value reflects the most conservative limit.

e Limit is for total Radium Concentration.

Abbreviations and Acronyms:

pCi/g picocurie per gram
pCi/L picocuries per liter
dpm disintegration per minute

**TABLE 7-1
PORTABLE SURVEY INSTRUMENTS**

Measurement/ Technique	Type of Instrument			Typical Background	Typical Total Efficiency (%)	Typical Minimum Detectable Concentration
	Detector	Detector Size and Dimension	Meter Description			
Surface Alpha Scan	Gas Proportional Ludlum 43-68	126 cm ² 7.9 cm x 16 cm	Ludlum 2221, 2241, or data logger 2350-1, 2360	0-2 cpm α	~ 25 α	0.969 probability of detection (Note 1)
Surface Alpha Scan	Position Sensitive Proportional Counter	100 cm ² 10 cm x 10 cm	Surface Contamination Monitor	1 cpm/100 cm ²	~ 35 α	0.998 probability of detection (Note 2)
Surface Beta Scan	Gas Proportional Ludlum 43-68	126 cm ² 7.9 cm x 16 cm	Ludlum 2221, 2241, or data logger 2350-1, 2360	150-250 cpm	~ 25 β	~2,000 dpm/100 cm ² (Note 3)
Surface Beta Scan	Position Sensitive Proportional Counter	100 cm ² 10 cm x 10 cm	Surface Contamination Monitor	350-400 cpm/ 100 cm ²	~ 25 β	~2,100 dpm/100 cm ² (Note 3)
Static Alpha Measurement	Gas Proportional Ludlum 43-68	126 cm ² 7.9 cm x 16 cm	Ludlum 2221, 2241, or data logger 2350-1, 2360	0-2 cpm α	~ 25 α	~ 80 dpm/100 cm ² (Note 4)
Static Alpha Measurement	Position Sensitive Proportional Counter	100 cm ² 10 cm x 10 cm	Surface Contamination Monitor	1 cpm/100 cm ²	~ 35 α	~ 60 dpm/100 cm ² (Note 4)
Static Beta Measurement	Gas Proportional Ludlum 43-68	126 cm ² 7.9 cm x 16 cm	Ludlum 2221, 2241, or data logger 2350-1, 2360	150-250 cpm	~ 25 β	~1100 dpm/100 cm ² (Note 5)
Static Beta Measurement	Position Sensitive Proportional Counter	100 cm ² 10 cm x 10 cm	Surface Contamination Monitor	350-400 cpm/ 100 cm ²	~ 25 β	~1250 dpm/100 cm ² (Note 5)
Static Beta Measurement	Geiger-Mueller Model 44-9	15 cm ² 4.37 cm diameter	Ludlum 2221 or Ludlum 2241	50-100 cpm	~ 10 β	350 dpm/100 cm ²

**TABLE 7-1 (CONTINUED)
PORTABLE SURVEY INSTRUMENTS**

Measurement/ Technique	Type of Instrument			Typical Background	Typical Total Efficiency (%)	Typical Minimum Detectable Concentration
	Detector	Detector Size and Dimension	Meter Description			
Swipe Analyzer	Ludlum 43-10-1 Scintillation Probe	20.3 cm ² 5.05 cm diameter	Ludlum Model 2929	3 cpm α 80 cpm β	38% α 26% β	16 dpm α, 325 dpm β
Gamma Exposure Rate	Micro R meter Ludlum Model 19	N/A	Sodium Iodide	5 – 7 μR/hr	N/A	N/A
Gamma	Ludlum 44-10 NaI (tl) probe	2 in. x 2 in.	Ludlum 2241 or 2360	9750 cpm	N/A	900 cpm/μR/hr

Notes:

α Alpha

β Beta

cm² Centimeters squared

cpm Counts per minute

dpm Disintegrations per minute

mrR/hr millirems per hour

Note 1 Probability of Detection is based on a 100 dpm point source; 0.5 inch/sec scan speed, 1 cpm background, and a detection threshold value of 2 counts per detector width.

Note 2 Probability of Detection is based operation of the SCM in the recount mode (two detectors, as described in Section 5.2.2), a 100 dpm point source, 0.5 inch/sec scan speed, 1 cpm background, and a detection threshold value of 2 counts per 100 cm² area. The Probability of Detection is based on both detectors observing the threshold value or greater in the same 100 cm² area.

Note 3 Scan MDC values are based on 95% false negative and 5% false positive at a survey speed of 2 inches per second. The scan MDC is based on typical efficiencies for Cs-137.

Note 4 Alpha static measurement MDC is based on a 1 minute count with the 43-68 detector and an 8-second count with the SCM

Note 5 Beta Static Measurement MDC is based on a 1 minute count with the 43-68 detector and an 8-second count with the SCM. The static MDC is based on typical efficiencies for Cs-137

TABLE 8-1
DERIVED AIR CONCENTRATION

Radionuclide	Radiation	DAC ($\mu\text{Ci/mL}$)	10% DAC ($\mu\text{Ci/mL}$)
Radium-226	Alpha (α)	3.0×10^{-10}	3.0×10^{-11}
Thorium-232		5.0×10^{-13}	5.0×10^{-14}
Strontium-90	Beta (β^-)	8.0×10^{-9}	8.0×10^{-10}
Tritium-3		2.0×10^{-5}	2.0×10^{-6}
Cobalt-60	Beta/gamma (β^-, γ)	7.0×10^{-8}	7.0×10^{-9}
Uranium-238		6.0×10^{-10}	6.0×10^{-11}
Cesium-137		6.0×10^{-8}	6.0×10^{-9}

Abbreviations and Acronyms:

$\mu\text{Ci/mL}$ – microcuries per milliliter

CFR – *Code of Federal Regulations*

DAC – derived air concentration (10 CFR 20 Appendix B)

ATTACHMENT 1

TETRA TECH EC, INC. NRC RADIOACTIVE MATERIALS LICENSE, 29-31396-01

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PENNSYLVANIA 19406-1415

March 2, 2010

Docket No. 03038199
Control No. 144333

License No. 29-31396-01

Philip Bartley
Vice President, ESQ
Tetra Tech EC, Inc.
1000 The American Road
Morris Plains, NJ 07950

SUBJECT: TETRA TECH EC, INC., NEW LICENSE, CONTROL NO. 144333

Dear Mr. Bartley:

This refers to your request for an NRC license. Enclosed with this letter is the license. Please review the enclosed document carefully and be sure that you understand all conditions. Please be informed that your license is assigned the program code 03219, Decontamination Services. If there are any errors or questions, please notify the U.S. Nuclear Regulatory Commission, Region I Office, Licensing Assistance Team, (610) 337-5239, so that we can provide appropriate corrections and answers.

When submitting future license amendments, please have the document signed by a management representative rather than the Radiation Safety Officer. The NRC views a letter signed by a management representative as indication that management has reviewed the application and concurs in the statements and representations contained therein. In addition, please note that NRC Form 313 requires the applicant, by signature, to verify that the applicant understands that all statements contained in the application are true and correct to the best of the applicant's knowledge. The signatory for the application should be the licensee or a certifying official of the licensee rather than a consultant.

The NRC expects licensees to conduct their programs with meticulous attention to detail and high standards of safety and compliance. Because of the serious consequences to employees and the public that can result from failure to comply with NRC requirements, you must conduct your program according to NRC regulations, the conditions of your NRC license, and the representations made in your application. In particular, note that you must:

1. Operate in accordance with NRC regulations 10 CFR Part 19, "Notices, Instructions and Reports to Workers; Inspections," 10 CFR Part 20, "Standards for Protection Against Radiation," and other applicable regulations.
2. Notify the NRC in writing of any change in mailing address.

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P. Bartley

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3. In accordance with 10 CFR 30.36(d), notify the NRC, promptly, in writing, and request termination of the license
 - a) when you decide to terminate all activities involving materials authorized under the license; or
 - b) if you decide not to acquire or possess and use authorized material.
4. Request and obtain a license amendment before you:
 - a) change Radiation Safety Officers;
 - b) order byproduct material in excess of the amount, or radionuclide, or form different than authorized on the license;
 - c) add or change the areas of use, or addresses of use identified in the license application or on the license; or
 - d) change the name or ownership of your organization.
5. Submit a complete renewal application or termination request at least 30 days before the expiration date of your license. You will receive a reminder notice approximately 90 days before the expiration date. Possession of byproduct material after your license expires is a violation of NRC regulations.

You will be periodically inspected by the NRC. Failure to conduct your program safely and in accordance with NRC regulations, license conditions, and the representations made in your license application and supplemental correspondence with NRC will result in enforcement action against you. This could include issuance of a notice of violation, imposition of a civil penalty, or an order suspending, modifying or revoking your license.

An environmental assessment for this action is not required, since this action is categorically excluded under 10 CFR 51.22(c)(14).

Current NRC regulations and guidance are included on the NRC's website at www.nrc.gov; select **Nuclear Materials; Medical, Academic, and Industrial Uses of Nuclear Material**; then **Regulations, Guidance, and Communications**. You may also obtain these documents by contacting the Government Printing Office (GPO) toll-free at 1-866-512-1800. The GPO is open from 7:00 a.m. to 6:30 p.m. EST, Monday through Friday (except Federal holidays).

P. Bartley

3

Thank you for your cooperation.

Sincerely,



Kathy Modes
Senior Health Physicist
Decommissioning Branch
Division of Nuclear Materials Safety

Enclosure:
License No. 29-31396-01

cc w/enclosure:
Erik Abkemeier, Radiation Safety Officer

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NRC FORM 374

PAGE 1 OF 6 PAGES

U.S. NUCLEAR REGULATORY COMMISSION

MATERIALS LICENSE

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 36, 39, 40, and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations, and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

<p style="text-align: center;">Licensee</p> <p>1. Tetra Tech EC, Inc.</p> <p>2. 1000 The American Road Morris Plains, New Jersey 07950</p>	<p>3. License number 29-31396-01</p> <p>4. Expiration date March 31, 2020</p> <p>5. Docket No. 030-38199 Reference No. 46-27767-01/03036414</p>
--	---

<p>6. Byproduct, source, and/or special nuclear material</p> <p>A. Any byproduct material with atomic numbers 1 through 83</p> <p>B. Any byproduct material with atomic numbers 84 through 103</p> <p>C. Radium 226</p> <p>D. Source Material</p> <p>E. Any Special Nuclear Material</p>	<p>7. Chemical and/or physical form</p> <p>A. Any</p> <p>B. Any</p> <p>C. Any</p> <p>D. Any</p> <p>E. Any</p>	<p>8. Maximum amount that licensee may possess at any one time under this license</p> <p>A. 100 curies per radionuclide and 100 curies total</p> <p>B. 1 curie per radionuclide and 1 curie total</p> <p>C. 5 curies total</p> <p>D. 10,000 kilograms</p> <p>E. Not to exceed 200 grams uranium-233, or 350 grams uranium-235, or 200 grams plutonium, or any combination of these provided the sum of the ratios does not exceed unity</p>
--	---	---

9. Authorized use:

A. through E. Receipt, storage, use, and/or possession incident to the following activities:

- (1) Decontamination, decommissioning, and remediation of contaminated structures, materials, groundwater, soils and soil-like material;
- (2) Site characterization;
- (3) Solidification and treatment of wastes;
- (4) Packaging for transport;
- (5) Transport in packages or containers approved for use under the provisions of 10 CFR Part 71, for transfer to licensees authorized to receive the materials, in accordance with the terms and conditions of licenses issued by the NRC or an Agreement States.

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**MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License Number
29-31396-01

Docket or Reference Number
030-38199

CONDITIONS

10. Licensed material may be used only at temporary job sites of the licensee anywhere in the United States where the U.S. Nuclear Regulatory Commission maintains jurisdiction for regulating the use of licensed material, including areas of exclusive Federal jurisdiction within Agreement States.
- If the jurisdiction status of a Federal facility within an Agreement State is unknown, the licensee should contact the Federal agency controlling the job site in question to determine whether the proposed job site is an area of exclusive Federal jurisdiction. Authorization for use of radioactive materials at job sites in Agreement States not under exclusive Federal jurisdiction shall be obtained from the appropriate state regulatory agency.
11. Licensed material shall be used by, or under the supervision of, individuals who have received the training described in the letter dated February 22, 2010.
12. The Radiation Safety Officer for this license is Erik Abkemeier.
13. This license does not authorize the use of licensed material at temporary job sites for uses already specifically authorized by the customer's license. If a customer also holds a license issued by the NRC or an Agreement State, the licensee shall establish a written agreement between the licensee and the customer specifying which licensed activities shall be performed under the customer's license and supervision, and which licensed activities shall be performed under the licensee's supervision pursuant to this license. The agreement shall include a commitment by the licensee and customer to ensure safety, and any commitments by the licensee to help the customer clean up the temporary job site if there is an accident. A copy of this agreement shall be included in the notification required by Condition 18.A. of this license.
14. Pursuant to 10 CFR Parts 30.11, 40.14, 70.14, and Condition 10 of this license, the licensee is exempted from the requirements of 10 CFR Parts 30.35, 40.36 and 70.25 to establish decommissioning financial assurance.
15. Except for calibration sources and reference standards, possession of licensed material at each temporary job site shall be limited to material originating from each site. This material must either be transferred to an authorized recipient or remain at the site after activities authorized by this license are completed.
16. Notwithstanding the requirements in 10 CFR Parts 30.32(i), 40.31(j), and 70.22(i), the licensee is not required to establish an emergency plan. Before taking possession of licensed material at a temporary job site in quantities requiring an emergency plan, the licensee shall either:
- (1) Obtain NRC approval of an evaluation demonstrating that an emergency plan is not required pursuant to 10 CFR Parts 30.32(i), 40.31(j), and 70.22(i); or

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**MATERIALS LICENSE
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Docket or Reference Number
030-38199

- (2) Submit written confirmation to the Regional Administrator, U.S. Nuclear Regulatory Commission, Region I, ATTN: Director, Division of Nuclear Materials Safety, 475 Allendale Road, King of Prussia, Pennsylvania 19406, that the licensee personnel have been trained and will follow the provisions of an existing emergency plan approved by the NRC or an Agreement State for the temporary job site.
17. If approved by the Radiation Safety Officer specifically identified in this license, the licensee may take reasonable action in an emergency that departs from conditions in this license when action is immediately needed to protect public health and safety and no action consistent with all license conditions that can provide adequate or equivalent protection is immediately apparent. The licensee shall notify the NRC before, if practicable, and in any case, immediately after taking such emergency action using reporting procedure specified in 10 CFR Part 30.50(c).
18. A. At least 14 days before initiating activities at a temporary job site, the licensee shall notify, in writing, the Regional Administrator, U.S. Nuclear Regulatory Commission, Region I, ATTN: Director, Division of Nuclear Materials Safety, 475 Allendale Road, King of Prussia, Pennsylvania 19406. The notification shall include the following information:
- (1) Estimated type, quantity, and physical/chemical form(s) of material;
 - (2) Specification of site location;
 - (3) Description of project activities including waste management and disposition;
 - (4) Estimated project start date and duration; and
 - (5) Identification of, and information on how to contact, key project personnel.
- B. Within 30 days of completing activities at each job site location, the licensee shall notify, in writing, the Regional Administrator, U.S. Nuclear Regulatory Commission, Region I, ATTN: Director, Division of Nuclear Materials Safety, 475 Allendale Road, King of Prussia, Pennsylvania 19406, of the temporary job site status and disposition of any licensed material used.
19. The licensee shall maintain records of information important to decommissioning each temporary job site at the applicable job site pursuant to 10 CFR Parts 30.35(g), 40.36(f), and 70.25(g). The records shall be made available to the customer upon request. At the completion of activities at a temporary job site, the licensee shall transfer these records to the customer for retention.
20. The licensee shall not use licensed material in or on human beings.
21. The licensee shall conduct a physical inventory every six months, or at other intervals approved by the U.S. Nuclear Regulatory Commission, to account for all sources and/or devices received and possessed under the license. Records of inventories shall be maintained for 5 years from the date of each inventory and shall include the radionuclides, quantities, manufacturer's name and model numbers, and the date of the inventory.

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22. A. Sealed sources shall be tested for leakage and/or contamination at intervals not to exceed six months or at the intervals specified in the certificate of registration issued by the U.S. Nuclear Regulatory Commission under 10 CFR 32.210 or under equivalent regulations of an Agreement State.
- B. Notwithstanding Paragraph A of this Condition, sealed sources designed to primarily emit alpha particles shall be tested for leakage and/or contamination at intervals not to exceed 3 months.
- C. In the absence of a certificate from a transferor indicating that a leak test has been made within the intervals specified in the certificate of registration issued by the U.S. Nuclear Regulatory Commission under 10 CFR 32.210 or under equivalent regulations of an Agreement State, prior to the transfer, a sealed source received from another person shall not be put into use until tested and the test results received.
- D. Sealed sources need not be tested if they contain only hydrogen-3; or they contain only a radioactive gas; or the half-life of the isotope is 30 days or less; or they contain not more than 100 microcuries of beta- and/or gamma-emitting material or not more than 10 microcuries of alpha-emitting material.
- E. Sealed sources need not be tested if they are in storage and are not being used; however, when they are removed from storage for use or transferred to another person and have not been tested within the required leak test interval, they shall be tested before use or transfer. No sealed source shall be stored for a period of more than 10 years without being tested for leakage and/or contamination.
- F. The leak test shall be capable of detecting the presence of 0.005 microcurie (185 becquerels) of radioactive material on the test sample. If the test reveals the presence of 0.005 microcurie (185 becquerels) or more of removable contamination, a report shall be filed with the U.S. Nuclear Regulatory Commission in accordance with 10 CFR 30.50(c)(2), and the source shall be removed immediately from service and decontaminated, repaired, or disposed of in accordance with Commission regulations.
- G. Tests for leakage and/or contamination, including leak test sample collection and analysis, shall be performed by the licensee or by other persons specifically licensed by the U.S. Nuclear Regulatory Commission or an Agreement State to perform such services.
- H. Records of leak test results shall be kept in units of microcuries and shall be maintained for 5 years.
23. Sealed sources or detector cells containing licensed material shall not be opened or sources removed from source holders by the licensee.

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Docket or Reference Number
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24. The licensee is authorized to transport licensed material in accordance with the provisions of 10 CFR Part 71, "Packaging and Transportation of Radioactive Material."
25. Notwithstanding the requirements of License Condition 27 the licensee is authorized to make program changes and changes to procedures specifically identified in the condition, which were previously approved by the U.S. Nuclear Regulatory Commission and incorporated into the license without prior Commission approval as long as:
- A. The proposed revision is documented, reviewed, and approved in accordance with the letter dated February 22, 2010.
 - B. The revised program is in accordance with regulatory requirements, will not change the license conditions, and will not decrease the effectiveness of the Radiation Safety Program.
 - C. The licensee's staff is trained in the revised procedures prior to implementation.
 - D. The licensee's audit program evaluates the effectiveness of the change and its implementation.
26. The licensee will comply with the requirements for the "Order Imposing Increased Controls" (ADAMS Accession No. (ML053130183) published in the Federal Register on December 1, 2005 (70 FR 72128); and with the "Order Imposing Fingerprinting and Criminal History Records Check Requirements for Unescorted Access to Certain Radioactive Materials" (fingerprinting Order) (ADAMS Accession No. (ML073230738) published in the Federal Register on December 13, 2007 (72 FR 70901). The licensee will complete implementation of said requirements by the first day that radionuclides in quantities of concern are possessed at or above the limits specified in "Table 1: Radionuclides of Concern" contained within the fingerprinting Order. Notwithstanding any provisions of the Commission's regulations to the contrary, all measures implemented or actions taken in response to these Orders shall be maintained until the Commission orders otherwise, or until the Commission explicitly modifies its regulations to reflect the increased controls and fingerprinting requirements, and states in modifying its regulations, that the revisions are to supersede these Orders. The licensee shall notify the Director, Office of Federal and State Materials and Environmental Management Programs, U. S. NRC, Washington, DC, 20555, in writing, within 25 days after it has completed the requirements of this condition. In addition, licensee responses applicable to this license condition shall be marked as "Withhold From Public Disclosure Under 10 CFR 2.390."

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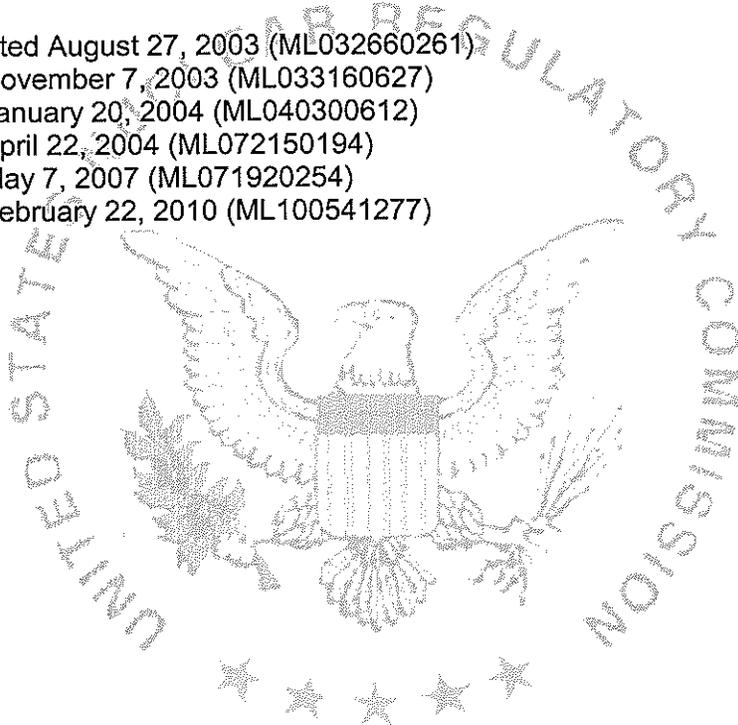
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**MATERIALS LICENSE
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Docket or Reference Number
030-38199

27. Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents, including any enclosures, listed below. The U.S. Nuclear Regulatory Commission's regulations shall govern unless the statements, representations, and procedures in the licensee's application and correspondence are more restrictive than the regulations.
- A. Application dated August 27, 2003 (ML032660261)
 - B. Letter dated November 7, 2003 (ML033160627)
 - C. Letter dated January 20, 2004 (ML040300612)
 - D. Letter dated April 22, 2004 (ML072150194)
 - E. Letter dated May 7, 2007 (ML071920254)
 - F. Letter dated February 22, 2010 (ML100541277)



For the U.S. Nuclear Regulatory Commission

Date March 2, 2010

By

Kathy Modes
Decommissioning Branch
Division of Nuclear Materials Safety
Region I
King of Prussia, Pennsylvania 19406

Tuesday, March 2, 2010 08:15:24



UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PENNSYLVANIA 19406-1415

March 2, 2010

Docket No. 03036414
Control No. 144332

License No. 46-27767-01

Philip Bartley
Vice President, ESQ
Tetra Tech EC, Inc.
1000 The American Road
Morris Plains, NJ 07950

SUBJECT: TETRA TECH EC, INC., LICENSE TERMINATION, CONTROL NO. 144332

Dear Mr. Bartley:

Please find enclosed Amendment No. 7 terminating License No. 46-27767-01 as requested by your letter dated August 7, 2009. This termination is being issued in accordance with the requirements of the applicable NRC License Termination Rule (10 CFR 30.36, 10 CFR 40.42, and 10 CFR 70.38).

Current NRC regulations and guidance are included on the NRC's website at www.nrc.gov; select **Nuclear Materials; Medical, Academic, and Industrial Uses of Nuclear Material**; then **Regulations, Guidance, and Communications**. You may also obtain these documents by contacting the Government Printing Office (GPO) toll-free at 1-866-512-1800. The GPO is open from 7:00 a.m. to 6:30 p.m. EST, Monday through Friday (except Federal holidays).

Your cooperation with us is appreciated.

Sincerely,

A handwritten signature in black ink that reads "Kathy Modes".

Kathy Modes
Senior Health Physicist
Decommissioning Branch
Division of Nuclear Materials Safety

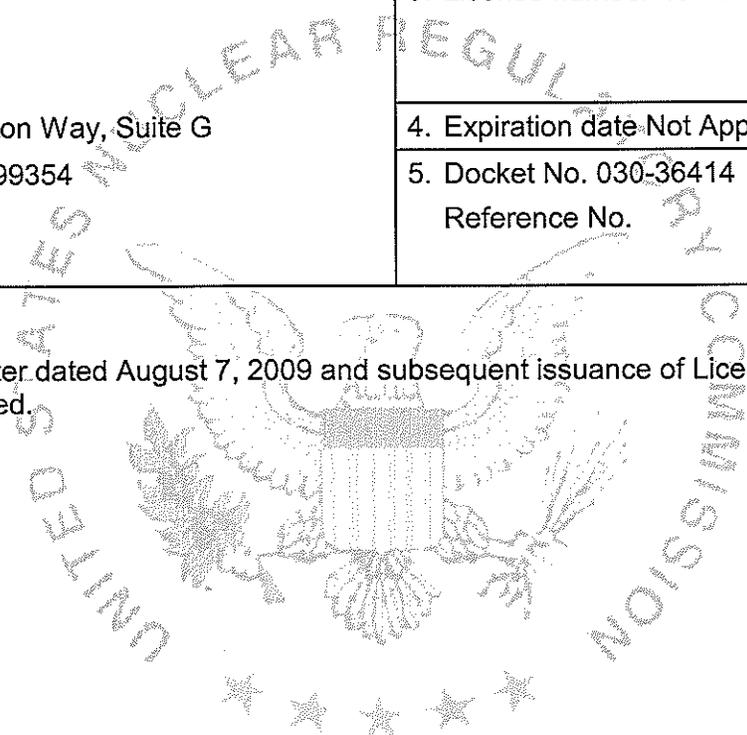
Enclosure:
Amendment No. 7

cc w/enclosure:
Erik Abkemeier, Radiation Safety Officer

MATERIALS LICENSE

<p style="text-align: center;">Licensee</p> <p>1. Tetra Tech EC, Inc.</p> <p>2. 3200 George Washington Way, Suite G Richland, Washington 99354</p>	<p>3. License number 46-27767-01</p> <p>4. Expiration date Not Applicable</p> <p>5. Docket No. 030-36414 Reference No.</p>
--	--

In accordance with the letter dated August 7, 2009 and subsequent issuance of License No. 29-31396-01, this license is hereby terminated.



For the U.S. Nuclear Regulatory Commission

Date March 2, 2010

By

Kathy Modes

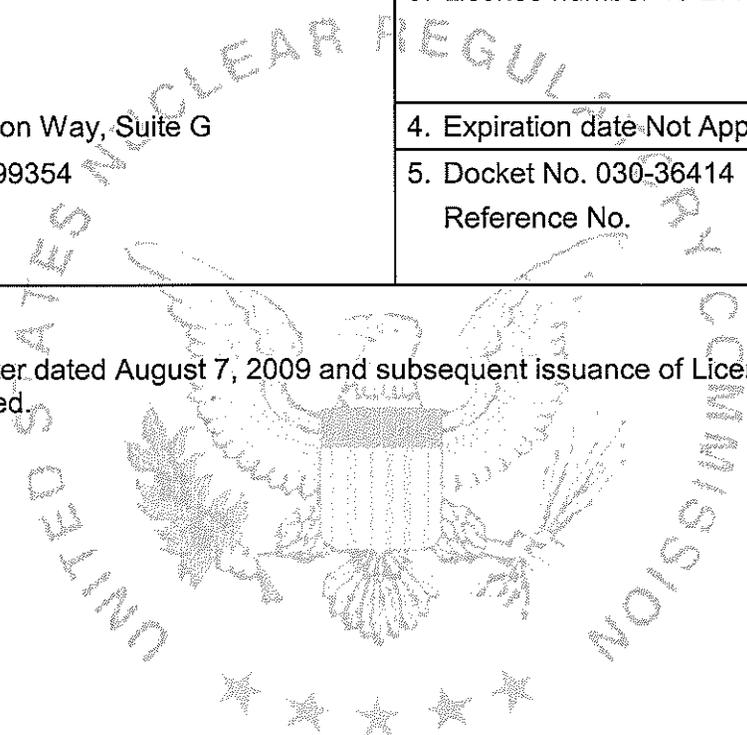
Kathy Modes
Decommissioning Branch
Division of Nuclear Materials Safety
Region I
King of Prussia, Pennsylvania 19406

Tuesday, March 2, 2010 07:58:12

U.S. NUCLEAR REGULATORY COMMISSION
MATERIALS LICENSE

Licensee	
1. Tetra Tech EC, Inc.	3. License number 46-27767-01
2. 3200 George Washington Way, Suite G Richland, Washington 99354	4. Expiration date Not Applicable
	5. Docket No. 030-36414 Reference No.

In accordance with the letter dated August 7, 2009 and subsequent issuance of License No. 29-31396-01, this license is hereby terminated.



For the U.S. Nuclear Regulatory Commission

Date March 2, 2010

By

Original signed by Kathy Modes

Kathy Modes
Decommissioning Branch
Division of Nuclear Materials Safety
Region I
King of Prussia, Pennsylvania 19406

Tuesday, March 2, 2010 07:58:12

ATTACHMENT 2

TETRA TECH EC, INC. RADIATION PROTECTION PLAN

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RADIATION PROTECTION PLAN

October 2013

Prepared by:



TETRA TECH EC, INC.

Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

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APPENDICES

Appendix A Radiation Protection Plan Acknowledgment Form

ABBREVIATIONS AND ACRONYMS

ALARA	as low as reasonably achievable
APP	Accident Prevention Plan
CFR	<i>Code of Federal Regulations</i>
CHPM	Corporate Health Physics Manager
DAC	derived air concentration
DOT	U.S. Department of Transportation
EHS	environmental health and safety
HRA	Historical Radiological Assessment
MOU	Memorandum of Understanding
NRC	U.S. Nuclear Regulatory Commission
PjM	Project Manager
PPE	personal protective equipment
QC	quality control
226-Ra	radium-226
RASO	Radiological Affairs Support Office
RCA	Radiologically Controlled Area
RCT	Radiological Control Technician
RMA	Radioactive Materials Area
RML	Radioactive Material License
RPG	Radiation Protection Guidance
RPP	Radiation Protection Plan
RSO	Radiation Safety Officer
RSOR	Radiation Safety Officer Representative
RWP	Radiation Work Permit
SOP	Standard Operating Procedure
SS	Site Supervisor
SSHP	Site Safety and Health Plan
TEDE	total effective dose equivalent
TIP	Task Initiation Procedure
TtEC	Tetra Tech EC, Inc.
VPESQ	Vice President for Environmental Safety and Quality Services

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1. PURPOSE/INTRODUCTION

The purpose of this Radiation Protection Plan (RPP) is to detail Tetra Tech EC, Inc's. (TtEC's) requirements for activities conducted under Radioactive Material License (RML) No. 29-31396-01 or Maine Agreement State RML, as applicable, issued and subject to regulatory enforcement by the United States Nuclear Regulatory Commission (NRC). The following activities are subject to this RPP:

- Project activities that involve the use and/or handling of licensed by-product, source, and/or special nuclear material (hereafter referred to as radioactive material)
- Tasks with the potential for radioactive material to be present based on available data and historical record
- Work in locations posted and controlled because of radioactive material

Project activities will incorporate the requirements within to maintain compliance in parallel with the current version of corporate procedure RP1-1, Radiological Protection Program.

Project activity performance steps are detailed in site-specific Work Plans, Standard Operating Procedures (SOPs), Work Instructions, Task-Specific Plans, etc. (Agencies that may have jurisdiction or an interest in project activities are also identified in such documents.) Project staff tasked to perform assignments involving the presence of radioactive material (e.g., those identified in the applicable portions of Section 2.0) will complete a review of this document and indicate an understanding of all requirements by completing a Radiation Protection Plan Acknowledgment Form (Appendix A).

1.1 Policy

It is TtEC's policy that work with radioactive material be purposeful and performed in a manner that protects project staff, members of the general public, and the environment. Radiologically oriented work may not begin unless it can be performed in a safe and reliable manner that is compliant with the exposure reduction rules, regulations, and principles described in Section 1.3.

1.2 Project-Specific Radiation Protection Plan

Corporate procedure RP1-1, Radiological Protection Program, provides the foundation for the RPP and its use for any project or activity that involves the possession or use of radioactive materials, including the subsequent potential for exposure to ionizing radiation. Content provided within this RPP reflects corporate policy and provides the guidance needed for project management to execute the scope of work in a safe manner. Site-specific guidance for radiological safety and control is further detailed in SOPs. SOPs are subject to approval by the Radiation Safety Officer (RSO) or designee. The RSO is also the company's Corporate Health Physics Manager (CHPM).

1.3 As Low as Reasonably Achievable

Work involving radioactive material and any corresponding exposure to ionizing radiation must be purposeful and performed in a manner sufficient to ensure the protection of staff, members of the

public, and the environment. TtEC applies industry-recognized principles to radiological work so that exposure to ionizing radiation is maintained in accordance with corporate procedure NLP-01, As Low As Reasonably Achievable (ALARA) Program.

1.4 Authorization to Stop Work

In accordance with corporate procedure RP1-1, Radiological Protection Program, and as detailed in Section 2.9, employees are authorized to stop work if an unsafe condition exists or safety protocol is being violated, and immediately report the condition to project management.

Work performed under a Radiation Work Permit (RWP) will stop, and the Radiological Affairs Support Office (RASO) will be notified if any of the following atypical work site conditions are encountered:

- An individual total effective dose equivalent (TEDE) exceeding 500 millirems
- The collective TEDE for the job exceeding 1 rem
- Individual airborne exposures exceeding 10 derived air concentration (DAC) hours in a 7-day period
- General area exposure rates exceeding the limits of the current radiological posting
- Contamination levels exceeding 100 times the limits, requiring classification of an area as a Contaminated Area

In cases where the RASO must be notified, the license RSO, with concurrence from the RASO, must approve the RWP before restarting work.

1.5 Scope of Work

The project-specific scope of work involves the following activities:

- Task-specific training of personnel
- Site controls and establishment of work zones at sites with, or having the potential for, radioactive commodities or contaminants
- Handling and management of collected radioactive commodities, radiologically contaminated soil, or other radiologically contaminated material
- Site investigation and remediation including characterization surveys and sampling, excavation, screening for and removal of commodities, and surveys and sampling to document final conditions

1.6 Quality Control and Auditing

To maintain continued compliance and evaluate overall RPP effectiveness, quality control (QC) measures including self-assessment and management reviews will be used. Formal audits, including

those conducted at field projects, will be coordinated and tracked to completion by the RSO as will any need for adjustments to audit frequencies.

1.6.1 Self-Assessment, Management Reviews, and Audits

A self-assessment and management review of RPP use, as detailed in corporate procedure NLP-08, Radiation Protection Program Audits, will be conducted. Project personnel including the Project Manager (PM), project Radiation Safety Officer Representative (RSOR), and on-site personnel will support and cooperate with any audit conducted.

1.6.2 Responses and Corrective Actions

Radiological deficiencies must be responded to in a timely fashion. Deficiencies that represent an imminent threat to radiological control or safety (e.g., compromise of procedural protocol) will be immediately reported to the RSOR, RSO, and PM or designee(s). Subsequent corrective actions will be tracked to completion by the RSO or designee. Radiological deficiencies, including corrective actions, will be promptly reported by the RSO to the project client (e.g., the Navy; for the purposes of this RPP, Navy means U.S. Department of the Navy, Naval Facilities Engineering Command Atlantic; U.S. Department of the Navy, Base Realignment and Closure, Program Management Office East; and Naval Sea Systems Command Detachment, RASO). Responses to findings will be submitted to the RSO or designee for review, approval, and final disposition.

1.6.3 Daily Instrumentation Check

As addressed in Section 3.16, survey instruments procured for field use will have proof of current calibrations in accordance with the manufacturers' procedures, employing applicable standards and sources traceable to the National Institute of Standards and Technology. Copies of instrument calibration certificates will be maintained on-site for reference. Instruments will be response-checked daily in accordance with applicable SOPs.

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2. RADIATION PROTECTION PERSONNEL

This section details the radiological safety responsibilities vested with key personnel within the project. (Nonradiological safety responsibilities will be detailed in a separate project-specific Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP). Reporting relationships between TtEC support personnel and the client (e.g., the Navy) will be referenced in a site-specific controlling document as well (e.g., a Site-Specific Radiological Work Plan).

2.1 Vice President for Environmental Safety and Quality Services

The Vice President for Environmental Safety and Quality Services (VPESQ) or the acting representative has overall responsibility for TtEC's safety operations. The VPESQ is responsible for:

- Ensuring proper maintenance of the RPP consistent with applicable regulatory mandates, TtEC corporate policy, and recognized industry practice
- Establishing and maintaining all necessary management oversight specific to the RPP
- Implementing a management review process to ensure applicable use of RPP requirements

2.2 License Radiation Safety Officer (Corporate Health Physics Manager)

The CHPM (also referred to as the RSO) is appointed by the VPESQ as the senior health physicist and the Health Physics Resource Manager for TtEC. The CHPM is responsible for:

- Reviewing and making recommended revisions to:
 - The RPP, RML procedures, radiation protection guidelines, and supporting documents
 - Project plans involving the use or handling of radioactive materials, or access to areas of radiological concern to ensure compliance with RPP requirements and supporting guidelines
- Acting as the Health Physics Resource Manager, also referred to as the corporate-level or license RSO
- Designating a Project Health Physicist, also referred to as the project-level RSOR, to provide day-to-day guidance on radiological protection issues
- Compliance as the license RSO, with RML No. 29-31396-01 or Maine Agreement State RML, as applicable, including:
 - Primary point of contact for all communications to the NRC or Maine regulatory agencies
 - Identification and training of RML authorized users

- Assignment of project RSORs
 - Coordination of investigations involving radiological occurrences to include review and approval of a resulting Corrective Action Plan
 - Advance NRC or Maine Agreement State notification in writing at least 14 days before initiating at a temporary job site under TtEC RML jurisdiction any activity, or change to scope involving new activities, in areas of radiological concern (excluding routine packaging or repackaging for purposes of transporting and not requiring a job- or site-specific work package, and characterization and/or final surveys where radioactive materials and/or radiation are not likely to be detected)
 - Refrain from taking ownership of licensed materials in excess of possession limits without prior notification and written NRC/Maine Agreement State approval
 - Advance NRC/Maine Agreement State notification in writing within 30 days of the temporary job site completion status involving decontamination and decommissioning activities, and disposition of any licensed material as related to RML jurisdiction
 - Placement of reciprocity request with applicable Agreement States when necessary
 - Maintenance of radiological exposure records
 - Development and/or approval of radiation safety training materials and/or courses
 - Performance of program audits as detailed in corporate procedure NLP-08, Radiation Protection Program Audits
 - Providing guidance on radiological protection issues
 - Identification of appropriate project staffing needs to implement RPP requirements
 - Assistance with the development of site Environmental Health and Safety (EHS) plans and approval of EHS plans for projects that involve the use or handling of radioactive materials or access to areas of radiological concern
 - Resource Specialist review for Task Initiation Procedures (TIPs) for proposed projects involving exposure to radiation or radioactive materials
- Delegating project responsibilities to other company health physicists (also referred to as RSORs), as necessary

2.3 Project Radiation Safety Officer Representative (Project Health Physicist)

The project RSOR, also referred to as the Project Health Physicist, is assigned by the RSO and vested with corporate-level authority to implement the RPP and the TtEC RML at a project site. Whenever radiological work is actively ongoing under the TtEC RML, the RSOR or designee identified as an authorized user will be present at the project site. The RSOR is vested with the following responsibilities at projects subject to jurisdiction involving the TtEC RML:

-
- Providing health physics guidance on an as-needed basis
 - Conducting required radiological safety training
 - Reviewing and approving project field procedures that involve the handling of radioactive materials or access to areas of radiological concern
 - Conducting radiation incident investigations and project inspections
 - Maintaining a project site file that details radiological protection training provided, dosimetry records generated, radiological surveys performed, and other documentation pertinent to the RPP, RML procedures, radiation protection guidelines, and supporting documents; copies of these will be provided to the CHPM at the conclusion of the project
 - Arranging for and assisting in program radiation protection audits as detailed in the most current version of corporate procedure NLP-08, Radiation Protection Program Audits
 - Assisting in the development and approval of the site EHS plan
 - Helping in the identification of project radiological analysis needs and selection of analytical support contractors
 - Coordinating required ALARA reviews
 - Ensuring appropriate staff work practices are employed to maintain occupational radiation exposures ALARA
 - Ensuring items needed to perform work in accordance with the RPP, RML, and supporting documents are available, such as appropriate instrumentation, protective devices, dosimetry, etc.
 - Directing the preparation of, and performing the review and approval of, RWPs
 - Stopping work if necessary to ensure radiological safety
 - Communicating with the PM and RSO as needed to ensure the RPP is implemented correctly
 - Ensuring proper operation of radiation-measuring equipment, including the performance of daily function and QC tests, and removing out-of-compliance instruments from service
 - Maintaining radiation-measuring equipment in accordance with manufacturers' recommendations
 - Directing and supervising the performance of radiological surveys and sampling in accordance with the most current version of this RPP and supporting TtEC SOPs

- Reviewing survey reports and instrument performance data for accuracy, completeness, and compliance with project, procedural, and regulatory requirements
- Ensuring work is performed in accordance with current versions of project plans, procedures, and the RPP

The project RSOR reports to and receives technical direction from the RSO, advises the PM on radiation protection and radiological operation matters, coordinates with the PM on day-to-day project activities, and communicates and coordinates radiation protection and radiological operation activities with the RSO and the client. Company Health Physicists (also referred to as RSORs) may delegate project responsibilities to other staff members deemed qualified for the task assigned.

2.4 Project Manager

The PM is responsible for:

- Ensuring implementation of and compliance with the RPP requirements and current versions of the following support documents applicable to the project:
 - TtEC RML procedures (i.e., applicable NRC License Procedures or applicable Maine Agreement State Procedures)
 - TtEC Radiation Protection Guidance (RPG) documents
- Forwarding any TIP or modified TIP involving exposure to ionizing radiation or radioactive material to the RSO or designee for input and review (involvement includes the use of subcontractors who may use radioactive materials or radiation-generating devices in the course of corresponding work such as field radiography, soil density gauges, well logging, etc.)
- Determining with the assistance of the RSO or designee whether the project is required to use the TtEC RML or whether activities will fall under a Department of Energy, NRC, Agreement State, or other license
- Working with the license RSO in accordance with corporate procedure RP1-1, Radiological Protection Program, to identify applicable NRC and Agreement State requirements for projects that will not use the TtEC RML
- The safe conduct of work in compliance with all permits, client contracts, and other controlling documents that apply
- Exposure to radiation ALARA by project staff
- Adequate resources and staffing to develop and implement this RPP in compliance with applicable regulations and requirements
- The PM reports to the TtEC Program Manager.

2.5 Construction Manager/Project Superintendent

Responsibilities for the Construction Manager/Project Superintendent include:

- Ensuring assigned personnel comply with radiological requirements
- Supplying relevant information to the RSOR on planned work activities and proposed applications necessary to maintain occupational radiation exposures ALARA
- Timely RSOR and PM notification of radiological problems or issues encountered
- Verifying staff is sufficiently prepared for assigned tasks (e.g., appropriate tools and equipment needed to minimize the time spent in areas of radiological concern)
- Confirming that escorted visitors accessing areas of radiological concern are properly supervised and exhibiting safe work practices in accordance with RPP protocol

The Project Superintendent/Construction Manager reports to the PM.

2.6 Site Supervisor

The Site Supervisor (SS) is the TtEC representative responsible for Radiological Control Technician (RCT) oversight and corresponding field operations conducted in areas of radiological concern. Designated as an authorized user at projects subject to jurisdiction under the TtEC RML, the SS is vested with the following responsibilities:

- Supporting required ALARA reviews
- Coordinating plans for field activities with the Construction Manager/Project Superintendent to ensure exposure to radiation is maintained ALARA and in accordance with corresponding RWPs
- Supervising the preparation of, and performing review of, RWPs
- Stopping work if necessary to ensure radiation safety
- Maintaining communication with the RSO, RSOR, PM, Construction Manager, and Project Superintendent as needed to ensure the RPP is fully implemented
- Confirming proper operation of radiation survey instruments, including the validation of daily function and QC checks, and removing noncompliant instruments from service
- Ensuring radiation survey instruments are maintained in a way that complies with manufacturer instructions and recommendations
- Directing and supervising the performance of radiological survey and sampling practices in accordance with the RPP, current versions of applicable SOPs, and corresponding RWPs
- Validating field survey reports and instrument performance data for accuracy, completeness, and compliance with the RPP, applicable SOPs, and corresponding RWPs

- Participating in periodic internal and external reviews of RPP content and implementation
- Supporting self-assessments and management reviews as needed and correcting identified deficiencies within the allotted time frame

The SS reports to and receives technical direction from the RSOR. Note that on projects of limited complexity and personnel, the RSOR may act as the SS.

2.7 Radiological Control Technicians

The RCTs are responsible for:

- Ensuring occupational exposure to radiation is maintained ALARA
- Preparing, using, and adhering to the RWP
- Stopping work if necessary to ensure radiological safety
- Performing radiation surveys and other radiological safety tasks in accordance with the RPP, applicable SOPs, and corresponding RWPs
- Confirming proper operation of assigned radiation survey instruments prior to field use to include verification of daily function and QC performance checks, and removing noncompliant instruments from service
- Using radiation survey instruments in accordance with the RPP, applicable SOPs, and corresponding RWPs and maintaining the instruments in a way that complies with manufacturers' instructions and recommendations

The RCTs report to and receive technical direction from the SS.

2.8 Radiation Workers (Field Personnel)

Project staff (including the general labor force associated with TtEC and its subcontractors) who have the potential to receive occupational exposure to radiation while on the job site, and who are expected to work under the requirements of this RPP as radiation workers, will:

- Receive sufficient training, prior to beginning work, in accordance with the most current version of corporate document RPG 2-5, Radiation Safety Training.
- Report to the SS or RCT any nonoccupational radiation exposures that result from the use of medical or dental applications more aggressive than a standard X-ray.
- Comply with requirements of all procedures and guidelines applicable to the project.
- As required, exercise stop work authority and report radiological safety issues or concerns, including incidents and unplanned events, immediately to project management and Environmental Safety and Quality staff in writing, verbally, or with a Zero Incident Performance[®] slip; respond promptly to any stop-work and/or evacuate orders.

- Display use of industry recognized radiological work practices when inside areas of radiological concern, and conform promptly to instructions when provided by RCTs.
- Strictly adhere to radiological control procedures, guidelines, and postings including information provided in RWPs.
- Immediately report lost dosimetry devices to the RCT.
- Report planned medical radiation treatments in advance to supervision and the project RSOR and prior to entering areas of radiological concern or wearing dosimetry.
- Periodically confirm personal radiation exposure status and ensure that administrative dose guidelines are not exceeded.
- Notify the RCT of faulty or alarming radiological protection equipment.

When in areas of radiological concern, workers report to the SS.

2.9 Stop Work Authority

Company and subcontractor personnel will have the responsibility and authority to stop work when controls are inadequate or imminent danger exists. In any situation in which stop work authority is used, the following requirements will apply:

- Exercise stop work authority in a justifiable and responsible manner.
- Once work is stopped, do NOT resume until proper controls have been established.
- Resumption of work will require concurrence by the PM or designee.

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3. TASK-SPECIFIC HAZARD ANALYSIS/CONTROLS

A task-specific hazard analysis is performed on a daily basis to allow for risk identification associated with site work, including physical, chemical, and radiological components. (Radiation exposures that result from naturally occurring background sources and medical applications conducted under the care of a physician are examples of dose that is independent of occupational monitoring requirements but considered when planning task assignments. In instances of verifiable therapeutic applications, employee-furnished notifications will be used as an informational reference and included as part of a corresponding radiation exposure file.)

Risk-based hazards and controls are defined in a site-specific Activity Hazard Analysis. Anticipated physical and chemical risks are described in detail in the project-specific APP/SSHP. Radiological risk controls are categorized in the sections to follow, and protective measures apply as defined in task-specific RWPs and corresponding SOPs.

3.1 Identification of Radiation Risks

Project tasks subject to RPP protocol indicate a known or suspected likelihood of activities occurring in radiologically impacted areas (e.g., locations with sources of radium-226 [226-Ra], areas with similar radionuclides of concern as identified in a site-specific Historical Radiological Assessment [HRA]).

3.2 Controlling Documents

Unless indicated otherwise in Section 1.0, work conducted under the RPP will be subject to requirements detailed in TtEC RML No. 29-31396-01 or Maine Agreement State RML, as applicable, and in accordance with any project-specific Memorandum of Understanding (MOU) criteria and applicable radiological control work documents (e.g., site-specific Basewide Radiological Plan, SOPs). TtEC will incorporate site-specific versions of SOPs as needed to implement and satisfy license commitments. Title 10 of the *Code of Federal Regulations* (CFR) Section 20 applies to the RPP standards used. In parallel, industrial safety requirements and U.S. Environmental Protection Agency regulations detailed in 29 and 40 CFR also have applicability for a variety of regulatory subjects including Comprehensive Environmental Response, Compensation, and Liability Act; the Resource Conservation and Recovery Act; and the National Emission Standards for Hazardous Air Pollutants.

3.3 Evaluation of Potential Exposure to Workers

RPP dose limits for the control of occupational exposure to ionizing radiation are listed in 10 CFR 20.1201–1208. Dose limits for individual members of the public are detailed in 10 CFR 20.1301–1302. In accordance with TtEC policy, all exposures will be minimized to the extent practical. Administrative guidelines, established below the federal limits, will be used as detailed in the current version of corporate procedure NLP-01, As Low As Reasonably Achievable Program. Occupational exposures for project personnel will be maintained below TtEC administrative values for annual TEDE.

Occupational dose, if any, is expected to originate from external sources (e.g., 226-Ra, cesium-137, or strontium-90 or similar known radionuclides of concern as listed in a site-specific reference

document [e.g., HRA]). Dose resulting from internal exposures is not anticipated. External exposure controls are addressed in Section 3.8, and controls to prevent or limit internal exposures are detailed in Section 3.9. Dose rates for general area work sites are expected to reflect naturally occurring background values.

3.4 Evaluation of Public Dose

Based on the scope of planned work, the limited activity of radionuclides expected, and low concentration of naturally occurring radioactive material anticipated, public dose associated with tasks performed under this RPP is not projected. To validate the maintenance of public dose goals, TtEC will implement necessary survey and sampling protocol in areas of intrusive work, conspicuously post and restrict access to intrusive work locations that require monitoring (e.g., areas where soil excavations and/or handling, etc., may disturb sources of radioactive material), and validate survey and sampling results and frequencies with the client (e.g., RASO), RSO, RSOR, and SS representatives to ensure established controls are effective.

3.5 Training Program

Site personnel tasked to conduct project-oriented activities must satisfy corresponding APP/SSHP training requirements. Persons subject to assignments involving a known or suspected potential for occupational radiation dose will receive additional training commensurate with radiological awareness requirements as defined in 10 CFR 19.12, Instructions to Workers. Visitors and escorted persons must receive a site briefing and will be assigned to a qualified radiation worker aide when in an area of radiological concern.

3.5.1 Site Briefing

An RPP site briefing is designed for an escorted person and is presented when access is needed to radiologically impacted locations. Specific to the area(s) of concern where access is needed, the RPP brief will cover at a minimum:

- Applicable portions of 10 CFR 19, 10 CFR 20, the RPP, RWPs, site-specific reference documents (e.g., HRA), and supporting SOPs
- A description of radiation exposure risks and monitoring requirements
- Access and egress protocol specific to the radiologically impacted location(s) requiring entry
- Radiation exposure reduction techniques for an embryo/fetus
- Completion of applicable briefing/exposure monitoring documentation
- Notification of contacts as needed to complete training requirements

3.5.2 Radiation Worker Training

RPP training for the radiation worker is provided when unescorted access is needed to impacted site locations subject to radiological control. Inclusive of material that may be required by project-specific Work Plans and documents (e.g., APP/SSHP, Task-Specific Plans), training may be

presented in the form of a group overview, video presentation, or other format, with use of printed handouts approved by the RSOR. Training will address at a minimum:

- Applicable portions of 10 CFR 19, 10 CFR 20, the RPP, site-specific reference documents, and supporting SOPs specific to task performance
- A description of radiation exposure risks, monitoring requirements, and techniques
- Access and egress protocol specific to radiologically impacted locations
- Required contacts and expected actions in the event of an emergency (in accordance with the current version of corporate procedure NLP-06, Managing Radiological Emergencies)
- Expected actions and contacts if radioactive material is discovered in an area where it is not expected
- Understanding “hands and feet” and “whole body” monitoring requirements
- Risks with radioactive material and radiation-producing devices unique to the site
- ALARA work principles and techniques
- Understanding the requirements for and compliance with RWPs including protocol for dosimetry and personal protective equipment (PPE)
- Radiation exposure reduction techniques for the embryo/fetus
- Completion of applicable training and exposure monitoring documentation
- Notification of contacts as needed to complete training requirements

3.5.3 Radiological Control Technician Training Qualification

As coordinated between the RSO and RSOR, TtEC will evaluate and ensure acceptable qualification of RCTs. When selected for project assignment, RCT qualifications are evaluated between the RSO and RSOR in accordance with the requirements detailed in NRC License No. 29-31396-01. Project-specific training is provided to RCTs commensurate with anticipated duties and assignments.

3.6 Declared Pregnant Female Worker

To maintain embryo/fetus radiation exposure ALARA, female employees who are pregnant or attempting to become pregnant are encouraged to declare this information to project management in writing to allow for criteria to be exercised as detailed in:

- 10 CFR 20.1208, Dose Equivalent to an Embryo/Fetus
- NRC Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure, Revision 3, Washington, DC (NRC 1999)

- NRC Regulatory Guide 8.29, Instruction Concerning Risks from Occupational Radiation Exposure, Revision 1, Washington, DC (NRC 1996)

Because of the small anticipated annual dose for workers associated with project activities (i.e., less than 10 millirems/year), it is unlikely in instances of pregnancy that separate dose tracking for the embryo/fetus will be necessary. Managing occupational exposures for all staff within annual TtEC administrative TEDE guidelines is expected to satisfy parallel maintenance of less than 500 millirems total dose for any pregnant female worker over the course of an entire gestation period.

3.7 As Low as Reasonably Achievable Program

TtEC is committed to maintaining radiation exposure to workers and the public as far below company guidelines and regulatory limits as practical. RPP requirements are established for field operations in an effort to meet that commitment in accordance with the current version of corporate procedure NLP-01, As Low As Reasonably Achievable Program.

3.8 External Exposure Control

The following steps will be taken to control external radiation exposure to levels that are ALARA:

- Employ basic dose reduction strategies as detailed in corporate procedures and site-specific SOPs using the ALARA concepts of time, distance, and shielding.
- Use instruments at frequencies sufficient to accurately determine the level and extent of radiation fields.
- Present adequate staff training to ensure the ability to recognize situations involving objects that might be radioactive, to be wary of objects that are unfamiliar, and to rely on valid instrument readings to limit and safely manage external exposure.

3.9 Internal Exposure Control

Internal exposure is expected to be below all the recognized DAC values as specified in 10 CFR 20. Should the potential for internal dose be confirmed during fieldwork (e.g., due to the nature of the planned activity such as remediation efforts), the activity will be temporarily suspended and the work area secured pending determination and use of corrective protocol as decided among the RSO, RSOR, and PM.

3.10 Monitoring and Measuring External Exposure

A vendor accredited by the National Voluntary Laboratory Accreditation Program will be used to provide project-related dosimetry services. Dosimetry applications and considerations will apply to field staff designated as radiation workers (i.e., personnel needing unescorted access to impacted site locations subject to radiological control). Prior to dosimetry issue, a radiation worker will have satisfactorily completed requirements as detailed in Section 3.5.2.

3.11 Monitoring and Measuring Internal Exposure

The monitoring of work practices conducted in areas of radiological concern will be coordinated among the RCTs, SSs, and members of project management designated as radiation workers using

frequencies necessary to confirm the application of correct techniques and PPE to minimize potential transfer of external contaminants inside the body.

Air sampling will be performed during intrusive activities conducted in areas of radiological concern. Air sample results will be reviewed and tracked among the RSO, RSOR, SS, and designated RCTs to determine whether trends (e.g., concentrations greater than 10 percent of DAC) exist that require work stoppage and/or re-engineering of task-specific contamination controls.

3.12 Surveys and Monitoring

A project-based summary of historic survey and monitoring information is typically available in site-specific documentation (e.g., an HRA manual or Basewide Radiological Work Plan). Protection of workers, the public, and the environment depends on accurate assessment and interpretation of past historical information as compared to present-day survey data collected in accordance with prescribed procedures and project support documents.

In situations subject to this RPP, guidance for determining survey frequency and technique is detailed in applicable portions of corporate procedures NLP-04, Radiological Entry Control Program; NLP-05, Radioactive Contamination Control; and RPG 2-9, Radiological Surveys and Operational Checks; and SOP 001, Radiation and Contamination Surveys.

3.12.1 Surveys of Equipment and Materials

Equipment and material passing through areas controlled for radiological concern will be subject to survey criteria and techniques detailed in applicable portions of corporate procedure NLP-05, Radioactive Contamination Control, and SOP 003, Release of Materials and Equipment from Radiologically Controlled Areas.

3.13 Action Levels

Action levels represent transition points at which concentrations of radioactivity require additional response and/or investigation (e.g., PPE upgrades or increased work technique controls). Action levels for radiological controls are detailed in corporate procedure NLP-01, As Low As Reasonably Achievable Program; NLP-04, Radiological Entry Control Program; and SOP 012, Radiologically Controlled Area Posting and Access Control. Modification to project-specific action levels requires client (e.g., Navy) concurrence.

3.14 Radiologically Controlled Areas and Posting

Site structures, outdoor locations, and/or perimeter boundaries posted with yellow and magenta markings are established to identify areas designated for radiological control, prevent (to the extent practical) access by unauthorized persons, and protect members of the public from exposure to radiation. A detailed description of scenarios and postings used for control purposes is provided in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program and SOP 012, Radiologically Controlled Area Posting and Access Control.

3.14.1 Controlled Area

A Controlled Area may be established where access to impacted portions of a work site requires specialized qualification and approval. A Controlled Area (which may also be called a Restricted Area) is intended to serve as the outermost boundary around planned and established work zones.

Controlled Area access requires prior authorization and use of PPE as defined in a project specific APP/SSHP. Visitors must have requisite training as specified in an SSHP. Personnel who enter a Controlled Area may not cross into more restrictive areas posted within unless prior authorization is obtained.

Where the perimeter to a Controlled Area is first encountered for radiological purposes, posting applications will have the wording “Caution Controlled Area” (or Restricted Area) and provide a contact phone number. (Supplemental information as specified by the RSOR or designee may also be included as magenta [preferred], purple, or black markings on a yellow [preferred] or white background). A minimum of one sign will be posted on each straight run of the Controlled Area (or Restricted Area) boundary. Note that areas not typically accessed by pedestrians (e.g., windows) need not be posted. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.2 Access Control Point

When used, an Access Control Point is part of a Controlled Area (or Restricted Area) boundary. Intended to serve as a transition corridor, an Access Control Point allows for the accountability of personnel, tools, and equipment that pass through. When established as a radiological control mechanism, an Access Control Point RCT will be present any time activities within are ongoing. During periods of inactivity, control point gates (part of the contiguous area boundary) are closed and locked.

3.14.3 Radiologically Controlled Area

A Radiologically Controlled Area (RCA) represents an area in which a person who works for 1 year might receive a whole body dose in excess of 100 millirems from all pathways (excluding natural background and medical exposures). For external sources, the RCA is typically posted when the dose rate of 30 centimeters exceeds 50 microrems per hour, although this may be modified at the discretion of the licensed RSO based on accurately assessed occupancy factors. Intended to include (for posting purposes) the nearest boundary or perimeter associated with the affected area, RCA restrictions and corresponding access protocol can be found in SOP 012, Radiologically Controlled Area Posting and Access Control.

When used, a minimum of one sign will be posted on each straight run of the RCA boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary. For waterfront areas, signs should be posted at areas accessible by watercraft.

3.14.4 Radioactive Materials Area

A Radioactive Materials Area (RMA) identifies any area or room in which there is used or stored an amount of licensed material exceeding 10 times the quantity of such material specified in Appendix C, Title 10, Part 20 of the CFR. Intended to warn of the potential for occupational dose, a description of RMA scenarios and postings used for control purposes can be found in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program and SOP 012, Radiologically Controlled Area Posting and Access Control.

When used, a minimum of one sign will be posted on each straight run of the RMA boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.5 Contaminated Area

A Contaminated Area is any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors (AEC 1974), but do not exceed 100 times those values. Contamination is radioactive material that is deposited on a surface where it is unwanted. Subject to license control, a description of Contaminated Area scenarios and postings used for control purposes can be found in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and SOP 012, Radiologically Controlled Area Posting and Access Control. When used, a minimum of one sign will be posted on each straight run of the RCA boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.6 High Contamination Area

A High Contamination Area is any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in Regulatory Guide 1.86 (AEC 1974). High Contamination Area scenarios and postings used for control purposes are detailed in applicable portions of supplemental site-specific documentation (e.g., Department of Energy Procedures for Radiologically Restricted Areas – Posting and Access Control per 10 CFR 835) and may be authorized by the RSO.

When used, a minimum of one sign will be posted on each straight run of the High Contamination Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.7 Radiation Area

A Radiation Area means any area accessible to individuals in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 millisievert) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates. A description of Radiation Area scenarios and postings used for control purposes can be found in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and SOP 012, Radiologically Controlled Area Posting and Access Control. When used, a minimum of one sign will be posted on each straight run of the Radiation Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.8 High Radiation Area

A High Radiation Area means any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem (0.001 sievert) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. A description of High Radiation Area scenarios and postings used for control purposes can be found in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program and SOP 012, Radiologically Controlled Area Posting and Access Control. When used, a minimum of one sign will be posted on each straight run of the High Radiation Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.9 Airborne Radioactivity Area

An Airborne Radioactivity Area is a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations:

- In excess of the DACs specified in Appendix B to 10 CFR 20.1001–20.2401, or
- To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake or 12 DAC hours.

As an example, for 226-Ra, the most likely airborne contaminant at Navy radiological remediation projects, the applicable DAC value is 3.0E-10 microcuries/milliliter. A description of Airborne Radioactivity Area scenarios and postings used for control purposes can be found in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and SOP 012, Radiologically Controlled Area Posting and Access Control. When used, a minimum of one sign will be posted on each straight run of the Airborne Radioactivity Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.15 Contamination Control

Contamination control practices are established to preclude the spread of contaminants into uncontrolled areas. Recognized applications are detailed in corporate procedure NLP-05, Radioactive Contamination Control.

3.15.1 Physical Boundary

A physical boundary will be established using criteria referenced in Section 3.14.4 to fully enclose a location established as a Contaminated Area.

3.15.2 Entry

Entry into a Contaminated Area will be compliant with pre-established requirements as detailed on a job-specific RWP. In such instances, an RCT will be present to assist in radiological control and support. (See Section 3.17.1 for details related to RWP use.)

3.15.3 Exit

Exit from a Contaminated Area will be compliant with pre-established requirements as detailed on a job-specific RWP. In such instances, an RCT will be present to assist in radiological control and support. (See Section 3.17.1 for details related to RWP use.)

3.15.4 Limitations on Entry

Personnel with open wounds or sores are not generally granted access into a Contaminated Area. Entry may be authorized by the RSOR or designee, on a case-by-case basis, if appropriate protection of the wound or sore is verified, planned work activities are unlikely to compromise the protection, and there is no other medical reason to restrict entry.

Jewelry and personal items are not allowed in Contaminated Areas; only project furnished tools, materials, and equipment necessary to accomplish the planned task are acceptable. Container wrappings, packing, and similar materials must be segregated from essential items prior to entry.

3.15.5 Control of Items

Items such as equipment and tools to be removed from a Contaminated Area must meet unconditional release criteria as detailed in applicable portions of corporate procedure NLP-05, Radioactive Contamination Control, and SOP 003, Release of Materials and Equipment from Radiologically Controlled Areas.

3.16 Instrumentation

As detailed in applicable portions of corporate procedure RPG 2-9, Radiological Surveys and Operational Checks, field survey instruments will be calibrated annually at a minimum in accordance with the manufacturers' specifications. Instruments will be removed from service on or before calibration due dates and returned to the supplier for recalibration.

3.17 Control of Radiological Work

All radiological work activities will be planned in consultation with the RSOR, the PM, and other project personnel tasked with oversight responsibilities. Work performed in areas of radiological concern require establishment of an RWP, which details radiologically based requirements and protective measures.

3.17.1 Radiation Work Permits

RWPs detail the protective measures and controls needed to perform tasks in areas of radiological concern. Information considered during RWP development is detailed in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and SOP 010, Issue and Use of Radiation Work Permits.

3.17.2 Task-specific Work Instructions

Task-specific work instructions are used to supplement RWP requirements and address in greater detail corresponding activities planned while personnel are inside areas of radiological concern. These instructions are required for tasks scheduled to occur in locations as determined by the PM, RSO, RSOR, or the Construction Manager. The RSO or designee will finalize, control, and issue radiologically based work instructions.

3.18 Credentialing of Staff

Qualification and training requirements for RCTs are provided in TtEC NRC License No. 29-31396-01 and are detailed in applicable portions of corporate procedure RPG 2-5, Radiation Safety Training. The RSO verifies qualifications and conducts required license-specific training with any RSOR designated on the license as an authorized user.

To supplement and validate the correct use and implementation of this RPP and TtEC NRC License No. 29-31396-01, a Health Physicist certified by the American Board of Health Physicists provides support to active field projects.

3.19 Procurement, Receipt, and Inventory OF SEALED RADIOACTIVE SOURCES

It is not anticipated that field projects will receive radioactive material shipments other than exempt-quantity radioactive check sources. As detailed in corporate procedures NLP-02, Radioactive

Material Accountability, and NLP-03, Sealed Radioactive Source Control, check sources are controlled, stored, posted, and managed as radioactive material.

3.19.1 Leak Testing

Radioactive sealed sources with quantities exceeding the licensable threshold will be leak-tested as detailed in applicable portions of corporate procedures NLP-02, Radioactive Material Accountability, and NLP-03, Sealed Radioactive Source Control.

3.19.2 Transport of Sources

Check sources will be used on field projects only for the period of time necessary to execute planned work, will not be introduced onto a project location prior to project initiation, and will be returned to the provider immediately following the completion of planned field activities.

Check sources will be maintained as detailed in applicable portions of corporate procedures NLP-02, Radioactive Material Accountability, and NLP-03, Sealed Radioactive Source Control.

3.19.3 Reporting Lost, Damaged, or Stolen Sources

As detailed in applicable portions of corporate procedures NLP-02, Radioactive Material Accountability and NLP-03, Sealed Radioactive Source Control, if a check source is lost, damaged, or stolen, the event will be reported immediately to the RSOR or designee. The RSOR will immediately notify the RSO, the PM, and the client (e.g., the Navy) and initiate appropriate recovery actions. In consultation with the client, a report will be filed by the RSO or designee with the appropriate law enforcement agency if it is determined that radioactive material was stolen. The RSO will make any necessary notifications to the NRC and Maine regulatory agencies, as applicable.

3.20 Shipping and Transportation of Radioactive Materials

Off-site shipment of radioactive materials other than exempt-quantity radioactive check sources by TtEC is not anticipated. Information pertinent to an authorized shipper for a field project is provided in Section 6.0.

3.21 Control of Radioactive Waste

Radioactive waste will be minimized by compliance with contamination control practices (Section 3.15) combined with segregation and survey practices. A waste shipment provider contracted to the client (e.g., the Navy through the Army Joint Munitions Command) will provide brokerage services including waste characterization sampling, waste containers, and transportation of radioactive materials/waste generated from a field project. Soil and used PPE will typically be processed for final disposition in disposal bins. When filled, bins will be transferred to the custody and control of the authorized shipper. As detailed in corporate procedure NLP-02, Radioactive Material Accountability, and SOP 008, Control of Radioactive Material, commodities are stored in a locked radioactive materials storage area, are controlled by the RSOR or designee, and will periodically be packaged and transferred to the authorized shipper for disposal. Radioactive material will be packaged, stored, shipped, and disposed of as required by U.S. Department of Transportation (DOT) regulations.

3.22 Radiation Protection Records

As detailed in the applicable portions of corporate procedure NLP-07, Radiological Protection Records, the RSO or designee is responsible for ensuring that airborne monitoring, contamination surveys, and exposure/dose rate surveys are reviewed for accuracy and completeness as an on-going process. Individual exposure records including dosimetry and bioassay reports for personnel are reviewed for results as generated.

3.23 Reports and Notifications

Workers who have previous occupational work history with radiological environments will supply the RSO or designee with prior estimated or reported dose histories on an NRC Form 4 or equivalent as defined in 10 CFR 20.2104.

Records of radiation exposures to workers who have been issued external dosimetry monitoring devices will be maintained. Dosimetry monitoring results for workers will be reported to the RSO annually at a minimum. Annual occupational exposure greater than or equal to 100 millirems for the previous calendar year, or otherwise when requested, requires a summary of individual exposure to be reported to the employee monitored.

3.24 Licenses

Entities subject to the use of this RPP will conduct radiological-based tasks with use of TtEC NRC License No. 29-31396-01 or a Maine Agreement State RML, as applicable. TtEC will ensure that the Radiological Control Program and work practices are implemented and performed in accordance with the NRC or Maine Agreement State license requirements and the RPP. (Any client-designated waste shipment provider may implement their NRC-issued license to conduct waste characterization sampling of waste material in support of low-level radioactive waste shipment and disposal. An MOU between TtEC and a waste shipment provider will be developed, identifying interfaces and commitments for the transfer of radioactive materials. Active MOUs will be maintained by the RSO or designee.)

3.25 Review and Approvals of Radiation Protection Plans

The RSO or designee will prepare the RPP, which will then be reviewed for approval with subject matter experts (e.g., the PM, RSOR). In addition, the client (e.g., the Navy) will have an opportunity to review the draft content, provide input, and indicate acceptance of the plan. Changes to the RPP will be reviewed and accepted following the same process.

3.26 Planned Special Exposures

No anticipated event within work scopes subject to this RPP will require use of a planned special exposure. In the event it is necessary to initiate such a need, an activity-specific work instruction including a formal ALARA review and an RWP will be prepared and submitted for acceptance following the same process as the RPP submittal in Section 3.25.

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4. PERSONAL PROTECTIVE EQUIPMENT

Minimum PPE requirements based on chemical contaminants are established by the Health and Safety Manager (in a project-/task-specific APP/SSHP). This primary level of PPE, Level D, is historically sufficient for radiological work activities and is supplemented by activity-specific RWPs based on the radiological conditions and field tasks required to perform planned activities. Information considered for PPE during RWP development is detailed in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program; SOP 002, Issue and Use of Radiation Work Permits; and SOP 012, Radiologically Controlled Area Posting and Access Control.

4.1 Selection of Personal Protective Equipment

Personnel must wear PPE commensurate with contamination hazards associated with both the work area and the planned activity. Activities that require heavy physical effort or that have an increased potential for damage to PPE may require additional layers or different PPE materials, even in areas of low contamination. Site- or task-specific PPE requirements beyond the minimum traditionally used will be detailed in a corresponding RWP and SOP 005, Radiological Protective Clothing Selection, Monitoring, and Decontamination.

4.2 Donning and Doffing Personal Protective Equipment

To prevent contamination of personnel or the spread of contamination, PPE must be donned and doffed in a specific manner. Directions for donning and doffing standard PPE ensembles are provided in the applicable sections of corporate procedure NLP-05, Radioactive Contamination Control, and SOP 005, Radiological Protective Clothing Selection, Monitoring and Decontamination. Additional instructions for non-standard site- or task-specific PPE requirements will be provided in the applicable RWP.

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5. DECONTAMINATION PROCEDURES

Decontamination will be performed at a dedicated location (e.g., decontamination pad, room) according to steps detailed in applicable portions of corporate procedure NLP-05, Radioactive Contamination Control, and SOP 007, Decontamination of Equipment and Tools.

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6. SHIPPING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

Field projects subject to the use of this RPP will conduct radiological-based activities with use of TtEC NRC License No. 29-31396-01 or Maine Agreement State license, as applicable. The client-designated waste shipment provider) may implement their NRC-issued or Maine Agreement State license to conduct waste characterization sampling of waste material in support of low-level radioactive waste shipment and disposal. An MOU between TtEC and a waste shipment provider will be used, identifying interfaces and commitments for the transfer of radioactive materials. In such instances, a current MOU will be maintained by the project RSOR for projects subject to the requirements of the RPP.

Environmental samples shipped for off-site analysis and exempt-quantity radioactive check sources are packaged and shipped in accordance with DOT regulations via commercial carriers.

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7. REFERENCES

AEC (Atomic Energy Commission). 1974. Regulatory Guide 1.86. Termination of Operating Licenses for Nuclear Reactors. June.

NRC (U.S. Nuclear Regulatory Commission). 1996. Regulatory Guide 8.29, *Instruction Concerning Risks from Occupational Radiation Exposure*, Revision 1, Washington, DC. February.

———. 1999. Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure*, Revision 3, Washington, DC. June.

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Appendix A
Radiation Protection Plan
Acknowledgment Form

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ATTACHMENT 3

PROJECT STANDARD OPERATING PROCEDURES

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Standard Operating Procedure

RADIATION AND CONTAMINATION SURVEYS

SOP-001

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

11/9/12

Date

REVISION HISTORY

<i>Revision (Date)</i>	<i>Rev. No</i>	<i>Prepared By</i>	<i>Description of Changes</i>	<i>Affected Pages</i>
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1.0 PURPOSE

The purpose of this procedure is to specify methods and requirements for radiological surveys, and to provide documentation of acquired data.

Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results. This guidance for control of radiation exposures provided in this procedure is in accordance with the as low as reasonably achievable (ALARA) philosophy.

2.0 SCOPE

This procedure shall be implemented by Tetra Tech EC, Inc. (TtEC) staff and subcontractor personnel when conducting radiation or contamination surveys.

3.0 DEFINITIONS AND ABBREVIATIONS

Activity – The rate of disintegration (transformation) or decay of radioactive material. The units of activity for the purpose of this procedure are disintegrations per minute (dpm) for loose and fixed surface contamination, picocuries per gram (pCi/g) for soil, or microcuries per milliliter (μ Ci/mL) for airborne contamination.

Contamination – Deposition of radioactive material in any place is not desired. Contamination may be due to the presence of alpha particle, beta particle, or gamma-ray-emitting radionuclides.

Exposure/Dose Rate – The amount of radiation (exposure or dose) delivered at a given point per unit time. Typical units for exposure are microroentgen per hour (microR/hr) while typical units for dose are micro Rem per hour (microRem/hr).

Fixed Contamination – Radioactive contamination that is not readily removed from a surface by applying light to moderate pressure when wiping with a paper or cloth disk swipe, or masslin.

Minimum Detectable Activity (MDA) – For purposes of this procedure, MDA for removable radioactive contamination is defined as the smallest amount of sample activity that will yield a net count with a 95 percent confidence level based upon the background count rate of the laboratory counting instrument used.

Minimum Detectable Concentration (MDC) – For purposes of this procedure, MDC is the *a priori* activity level that a specific instrument and technique can be expected to detect 95 percent of the time for portable survey instruments.

Removable Surface Contamination – Radioactive contamination that is readily removed from a surface by applying light-to-moderate pressure when wiping with a paper or cloth disk swipe, or masslin.

4.0 PROCEDURE DETAILS

4.1 General

Radiation surveys are performed to identify radiation areas, measure the exposure and or dose rate, and assess the intensity and shape of those areas to determine control requirements at the worksite.

Contamination surveys are conducted to detect loose surface contamination and fixed contamination. Loose surface contamination is normally detected indirectly by a swipe sample or wipe performed on the item or surface of interest. Fixed contamination levels are measured directly.

Survey results, locations, and any unusual conditions shall be documented and described on survey forms like Attachments 1 and 2, Radiation/Contamination Survey Form, and Radiation/Contamination Survey Supplement, respectively.

When performing surveys, express readings as the actual observed number. Do not report "<MDA" or "<Bkg." When background corrections are made, results may be expressed as negative numbers as applicable.

Field backgrounds will be checked and MDC calculations verified each work day.

4.1.1 Discussion

Radiation and contamination surveys shall be performed on an as-needed basis. The need for performing a survey is identified by, but not limited to, the following conditions:

- A condition exists where radiological data are needed.
- An investigation is required due to abnormal conditions or indications.
- An ongoing job requires a survey to update radiological postings.
- A routine survey is required to meet TtEC's Nuclear Regulatory Commission Radioactive Materials License or Agreement State Radioactive Materials License.
- As required to support Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM; NUREG-1575) based survey activities.

4.1.2 Planning and Prerequisites

Instruments used to perform radiation and contamination surveys shall be operated in accordance with their operation procedure. Steps to be completed during the planning phase include the following:

- Obtain appropriate survey instruments and prepare the instruments for use.
- Obtain the necessary forms, swipes, and applicable protective clothing that will be used during the survey.

Prior to entering an area to perform a survey, each radiation detection instrument shall be:

- Checked to make sure battery is charged.
- Checked for obvious physical damage.
- Quantitatively response-checked daily, prior to use.

Radiation and Contamination Surveys

- Checked to ensure that the instrument calibration is current.

If any of the above conditions are unsatisfactory, the instrument shall be tagged “out of service” and not used.

4.2 Procedure Process**4.2.1 Exposure/Dose Rate Surveys**

Always survey a sufficient number of locations to determine the average and maximum general area and contact radiation levels.

A Ludlum Model-19, Bicron MicroREM, or equivalent meter, should be used for performing exposure or dose rate surveys for radiation. The instrument should be operated in accordance with the manufacturer-supplied operations manual and any applicable requirements from work-specific documents. Care should be taken to ensure that the instrument has been allowed to stabilize between individual measurements.

When performing general area exposure/dose rate surveys, the Radiological Control Technician (RCT) should:

- Attempt to determine the source of radiation fields.
- Record the highest level as the general area exposure/dose rate.
- Perform contact exposure/dose rate measurements with the detector within 1 inch of the surface to be surveyed.
- Perform surveys at approximately 1 meter (waist level) from the surface to establish posting requirements for the area.
- Verify the exposure/dose rates of known elevated exposure/dose rate locations.

4.2.2 Removable Contamination Surveys**4.2.2.1 Removable Contamination Swipe**

The following guidance shall be used unless an approved site-specific survey/work instruction directs otherwise.

4.2.2.2 Swipe Surveys

1. Label or number swipes, as necessary, to identify each swipe.
2. Wipe the swipes over approximately 100 square centimeters (cm²) (16 square inches) of the surface to be sampled.
3. Apply moderate pressure.
4. Exercise care on rough surfaces so as not to tear the swipes.
5. Exercise care on wet surfaces so as not to degrade the swipes. Ensure that surfaces are not submerged in water and that cloth swipes, or similar, are used on wet/damp surfaces.

When surveying an area:

Radiation and Contamination Surveys

1. Obtain swipes from sample points, which are representative of the average and maximum contamination levels in the area, as identified during preliminary surveys. These areas could include:
 - a. Areas of high traffic
 - b. On and under benches or tables
 - c. Beneath piping and components
 - d. On accessible wall surfaces
 - e. On piping and significant components
 - f. Near drains, sumps, and low spots
2. Swipe floor and component surfaces which display evidence of (potentially) contaminated water leakage.
3. Ensure that contamination is not spread to clean areas when obtaining swipes.

When surveying equipment:

1. Obtain swipes on large surfaces.
2. Obtain swipes in cracks or crevices where contamination may have settled.
3. Obtain swipes on openings to internal surfaces.
4. Handle swipes in a manner that will prevent cross-contamination.

4.2.2.3 Counting Swipes

A Ludlum Model-2929 scaler with a Model 43-10-1 ZnS(Ag) scintillation probe (or equivalent) or Protean Alpha/Beta Gas Flow Proportional Counter (or equivalent) may be used.

1. Count the swipes in accordance with the operating procedure for the instrument.
2. Record swipe results in dpm/100 cm².
3. Store/archive used swipes as radioactive material until disposal is approved by the Radiological Affairs Support Office (RASO).

4.2.2.4 Removable Contamination Surveys Using Large-area Wipes (LAWs)

Large-area contamination surveys using LAWs are appropriate for monitoring the radiological cleanliness of non-contaminated areas or equipment, to track area decontamination progress, or for initially verifying that surfaces are free from contamination.

There are no specific requirements concerning the amount of area to be wiped when performing LAWs. The area wiped should be determined based on the use of the survey data and the dust loading of the LAW material.

4.2.2.5 Performing LAWs

Use masslin, oil-impregnated cloths, or equivalent media to perform LAWs. Select an appropriate collection material and method based upon the survey conditions such as wet surfaces, rough surfaces, heavily soiled areas, and oily and greasy surfaces.

1. Label or number the cloths, as necessary, to assist in determining the location of the sample.

Radiation and Contamination Surveys

2. Determine the size of the area to be sampled based on the survey requirements.
3. Wipe the collection media over the surface using moderate pressure by hand, with a masslin mop, or other approved techniques.

4.2.2.6 Evaluating LAWs

1. Allow wet LAW to dry prior to counting.
2. Scan the LAW with an appropriate field instrument (Ludlum Model-2360 meter with a 43-89 probe, or equivalent), in an area with a low background.
3. Hold the detector within a quarter inch of the swipe and move the detector over the swipe at a maximum rate of 1 inch per second.
4. If any indication of an increased count rate is noted, pause to allow the meter reading to stabilize.
5. If the swipe reading is indistinguishable from background, consider the surveyed surface to be free from contamination. If the LAW reading is greater, conduct further surveys to isolate the boundaries of the contamination.

4.2.3 Surveys for Fixed Alpha/Beta Contamination

Fixed contamination surveys are used to obtain indications of fixed contamination levels on surface areas, pieces of equipment, or tools for characterization and/or release surveys. Fixed contamination surveys are also performed to assess if residual contamination is present greater than the release criteria for the radionuclide(s) of concern.

A Ludlum Model-2360 meter with a 43-68 probe, or equivalent, should be used for performing fixed contamination surveys for alpha and beta radiation.

4.2.3.1 Scans

1. When surveying for fixed alpha/beta contamination, the probe should be held within a quarter inch or less from the surface being surveyed. The movement rate of the detector probe should be 1 inch per second or slower.
2. When performing direct scan surveys of objects, surfaces, materials, equipment, etc., static measurements should be performed frequently to ensure the detection of residual activity.
3. Whenever practical, 100 percent of accessible areas being surveyed should be direct-scan surveyed, unless the applicable work planning document indicates otherwise.
4. Scan ranges are documented as the range from the lowest measurement to the highest measurement observed.

4.2.3.2 Static

1. Count time for conducting static measurements will be dependent upon the isotope of concern and the MDA for the instrument being used.
2. Static measurements should be performed as required by a work-specific document, or frequently enough to ensure the detection of residual activity.

3. When taking a static measurement for fixed alpha/beta contamination, the probe should be held within a quarter inch or less from the surface being surveyed.
4. Results should be reported in units of net counts per minute (cpm) above background or dpm/100 cm².

The following formula should be used for converting direct probe readings in cpm to dpm/100 cm²:

$$A_S = \frac{R_{S+B} - R_B}{\varepsilon_i \varepsilon_s \frac{W_A}{100 \text{ cm}^2}}$$

where

A_S	= total surface activity (dpm/100 cm ²)
R_{S+B}	= the gross count rate of the measurement in cpm
R_B	= the background count rate in cpm
ε_i	= the instrument efficiency (counts per particle)
ε_s	= the contaminated surface efficiency (particles per disintegration)
W_A	= the physical area of the detector window (cm ²)

In the absence of experimentally determined surface efficiencies, ISO-7503-1 and NUREG-1507 provide conservative recommendations for surface efficiencies. ISO-7503-1 recommends a surface efficiency of 0.25 for alpha emitters. NUREG-1507 provides surface efficiencies based on studies performed primarily at Oak Ridge Institute for Science and Education. A surface efficiency of 0.25 will be used for alpha/beta emitters.

4.2.4 Gamma Surveys

A Ludlum Model-2350-1 meter with a 44-10 probe, or equivalent, should be used for gamma radiation surveys. For large areas, a RASO-approved vehicle towed array system may be used in accordance with *SOP 013, Vehicle Towed Array*.

4.2.4.1 Scans

1. Set the audio response switch to the "on" position.
2. If a single detector is used, traverse a path at a maximum speed of approximately 0.5 meters per second and slowly move the detector assembly in a serpentine (S-shaped) pattern, while maintaining the detector approximately 10 centimeters (cm) (4 inches) from the area being surveyed.
3. If a detector array is used, it will be pushed or pulled in a straight line with the detector centers positioned approximately 30 cm apart.
4. Scan ranges should be recorded from the lowest reading to the highest reading noted.
5. If data logging is being performed, the scan data will be collected at the time interval necessary to obtain the measurements required for the survey.

Radiation and Contamination Surveys

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6. Locations of radiation levels greater than 3 standard deviations above background shall be marked and identified for further investigations.
7. Measurement results are recorded in cpm.

4.2.4.2 Static

1. Static gamma measurements require positioning the detector assembly approximately 10 cm (4 inches) above the surface and completing a stationary 60-second survey.
2. Static measurements should be performed as required in the applicable work planning document, or frequently enough to ensure the detection of residual activity.
3. Record results in cpm.

5.0 RECORDS

Radiation/Contamination Survey Form

Radiation/Contamination Survey Supplement

6.0 REFERENCES

<i>Number</i>	<i>Title</i>
NUREG-1575	Multi-Agency Radiation Survey and Site Investigation Manual

7.0 ATTACHMENTS

Forms provided in this section illustrate the minimum requirements for their respective subject matter. Alternative documents or electronic data logging may be used providing the information is presented in a clear and concise manner and the content meets or exceeds the information required to complete these documents.

Attachment 1, Radiation/Contamination Survey Form

Attachment 2, Radiation/Contamination Survey Supplement

ATTACHMENT 1 – RADIATION/CONTAMINATION SURVEY FORM

DATE:	TIME:	INSTRUMENTATION USED				
SURVEY NUMBER:	Model Inst/Det.	Serial Number	Calibration Due Date	% Efficiency	MDC/MDA (dpm/100cm²)	Background (dpm/100cm²)
LOCATION:						
SURVEYOR:						
REVIEWED BY:						
RSOR:						
Isotopes of Concern:						
Description or drawing:						
Routine (Daily / Weekly / Monthly) <input type="checkbox"/>				Non-routine <input type="checkbox"/>		
All radiation readings in µr/hr unless otherwise noted. ⊕denotes swipe location or fixed α/β readings. #denotes G/A radiation readings. # / #denotes contact / 1 meter radiation readings. *denotes highest radiation reading on contact. Δdenotes static location.						

ATTACHMENT 2 - RADIATION/CONTAMINATION SURVEY SUPPLEMENT

SURVEY NUMBER:								
SURVEYOR:					LOCATION:			
Location	Exposure Rate (µR/hr)		Fixed + Removable			Removable		Comments
	Contact	1 Meter	Gamma (cpm)	Alpha dpm/probe	Beta/Gamma dpm/probe	Alpha dpm/100cm ²	Beta/Gamma dpm/100cm ²	
1								
2								
3								
4								
5								
6								
7								
8								
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Reviewer			Date/Time:		RSOR		Date/Time:	

Standard Operating Procedure

PREPARATION OF PORTABLE RADIATION AND CONTAMINATION SURVEY METERS AND INSTRUMENTS FOR FIELD USE

SOP-002

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

11/9/12

Date

**PREPARATION OF PORTABLE RADIATION AND
CONTAMINATION SURVEY METERS AND INSTRUMENTS
FOR FIELD USE**

REVISION HISTORY

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11/9/12	0	E. Abkemeier	Original	All

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**PREPARATION OF PORTABLE RADIATION AND
CONTAMINATION SURVEY METERS AND INSTRUMENTS
FOR FIELD USE****1.0 PURPOSE**

This procedure is used to specify the general requirements for preparing portable radiation and contamination survey meters and instruments for use at field locations. The procedures presented below will be supplemented by the specific instrument operation manuals, Tetra Tech EC, Inc. (TtEC)-approved subcontractor procedures, and specific work documents (i.e., Task-specific Plans (TSPs), work instructions, and other Work Plan documents).

2.0 SCOPE

This procedure will be used by TtEC personnel and its subcontractors for preparation of portable radiation and contamination survey meters and instruments used on site. This procedure is intended to provide general instructions for preparing radiation and contamination survey meters and instruments for field operations. Development of specific procedures for the implementation of the requirements of this procedure is the responsibility of the end users.

In certain instances the requirements of this procedure may need to be added to or modified for specific field operations. Additional requirements and guidance for these cases will be provided in work-specific documents (i.e., Time Critical Removal Action Work Plan, etc.), will be subject to the same review process as this document, and will have precedence over the guidelines in this document as appropriate.

3.0 DEFINITIONS AND ABBREVIATIONS

Acceptance Range – A range of values that describes an acceptable instrument check result. An acceptance range is typically determined by adding ± 20 percent or $\pm 2\sigma$ to the expected value.

Calibration Sticker – A label affixed to a properly calibrated instrument. The calibration sticker may be applied by the calibration facility or the end user. The calibration sticker should indicate the date through which the calibration is valid.

Chi-Square Test – A probability density function that gives the distribution of the sum of the squares of a number of independent random variables, each with a normal distribution with zero mean and unit variance, that has the property that the sum of two or more random variables with such a distribution also has one, and that is widely used in testing statistical hypotheses, especially about the theoretical and observed values of a quantity and about population variances and standard deviations. This test is used to evaluate the operation of an instrument, generally upon return from calibration.

Check Log – A form, or series of forms, used to document that an instrument was checked prior to usage in the field. Check logs can consist of multiple pages and must contain at least one page identifying the instrument. At least one page must also specify the parameters (source, geometry, etc.) used for the daily check. Space shall be provided to document the daily tests in the log. The log should be designed so as to clearly associate the required verifications with the signature or initials of the individual performing the check and date of each check.

Instrument Efficiency – A measure of the response (counts) obtained with a particular instrument when exposed to a known fluence of radioactive particles. Instrument efficiency has units of counts per disintegration though are typically recorded as a unitless value.

4.0 PROCEDURE DETAILS

4.1 Calibration

Instrument calibrations shall be performed using measuring and test equipment and National Institute of Standards and Technology (NIST) traceable sources. Calibrations will be performed at an accredited calibration laboratory. Calibration will be performed in accordance with the equipment manufacturers' manuals or a subcontractor's TtEC-approved procedure. Properly calibrated instruments shall be marked with a calibration sticker and include an accompanying calibration certificate.

Calibration shall be performed annually (± 15 days) or on a schedule consistent with the manufacturer's recommendation if more restrictive. The routine frequency may be extended by up to one additional month with written approval of the Radiation Safety Officer Representative (RSOR), or designee. However, the frequency of calibration may not be extended when instruments are being used for surveys of record (i.e., Final Status Surveys, Characterization Surveys, etc.) In addition to the routine frequency of performance, calibration shall be performed under the following conditions:

- Prior to placing a new instrument into service.
- After any major repair or alteration to the instrument or detector.

4.2 General Considerations

Upon receipt of survey equipment from an offsite vendor, and prior to shipment to an offsite vendor, the survey equipment shall be surveyed for alpha/beta fixed and loose contamination in accordance with *SOP 003, Release of Materials and Equipment from Radiologically Controlled Areas*. If any contamination limits are exceeded, notify the RSOR immediately.

Determination of instrument background, chi-square testing and instrument efficiency should be conducted in a controlled environment. This typically will consist of a secured office or lab area located in a non-impacted area and which is known to be free of contamination. Testing jigs or apparatus may be employed as necessary to ensure that consistent, reproducible geometries are used, particularly during repeated measurements.

In the event that any instrument and detector combination fails a chi-square test or daily operation check or has exceeded its annual calibration date without RSO approval, the instrument shall be put in an "out of service" condition by placing an "out of service" tag or equivalent on the instrument and detector combination, and securing in a separate area such that the instrument and detector combination cannot be issued for use. The RTS shall be notified immediately when any survey instrumentation has been placed "out of service".

Any instrument and detector combinations that have not had a daily operation check performed because daily plans do not include their use shall be secured in an area to prevent their use until operation checks have been performed.

Table 4-1 gives suggested geometries to use for the most common instrument types to be used. Alternate geometries can be used provided that they are more appropriate for the intended usage of the instrument.

**PREPARATION OF PORTABLE RADIATION AND
CONTAMINATION SURVEY METERS AND INSTRUMENTS
FOR FIELD USE**

4.3 Determination of Instrument Background

The determination of an instrument specific background is an optional procedure which may be employed at the discretion of the RSOR. There is no regulatory requirement that necessitates the determination of background for each instrument. Instrument background determination is typically performed in a controlled environment and usually consists of a series of repeated background measurements that are statistically analyzed to obtain an expected range of valid background values. The established instrument background range can be used as a means of performing daily operation checks.

Instrument background determinations, when necessary, are considered valid for as long as the instrument has been properly maintained per the requirements of this procedure. If instrument backgrounds are required, a new background determination should be performed following each calibration.

TABLE 4-1

**SUGGESTED GEOMETRIES FOR BACKGROUND MEASUREMENTS
AND SOURCE CHECKS**

Measurement	Instrument/Detector Combinations	Probe Location
Exposure/Dose Rate	Ludlum Model 19, RO-20, Bicron MicroREM, or equivalent meter with integral tissue equivalent plastic or sodium iodide (NaI) 1"x1" detector	contact ^a
Gamma	Ludlum Model 2221, 2350-1 or 2360 portable survey meter or equivalent with a Ludlum Model 44-10, FIDLER or equivalent detector	4 inches above ground surface/source
Beta/Gamma	Ludlum Model 2360 portable survey meter or equivalent with a Ludlum Model 43-37, 43-68, 43-89 or equivalent detector; Ludlum Model 3 portable survey meter with a Ludlum Model 44-9 G-M probe or equivalent	¼ inch above ground surface/source
Alpha/Beta	Ludlum 2360 portable survey meter or equivalent with a Ludlum 43-37, 43-68, 43-89 or equivalent detector	¼ inch from surface/source

Notes:

^a Field readings with exposure/dose rate instruments are conducted at 1 meter; background determination, chi-square test and operational checks are typically performed at a more convenient distance. Geometry should be documented as appropriate on the relevant data forms and logs.

When required, background determinations will be documented on Attachment A or equivalent as specified in the work-specific procedures. The form should include the following information at a minimum:

- Identification information (i.e., model and serial numbers) for the instrument and detector
- Conditions used for determination (geometry, radiation type, operating voltage, etc.)
- Date and time of determination
- Identification and signature, or initials, of technician
- Identification and signature of reviewer

The end result of a background determination should be to obtain an acceptance range for subsequent background checks.

4.4 Chi-Square Test

When chi-square tests are required by work-specific documents, this procedure shall be followed; however, any specific instructions for chi-square testing in governing work specific documents shall have precedence. When required, chi-square tests shall be performed annually (± 15 days), following calibration, or if there is reason to suspect that the instrument calibration may no longer be valid (i.e., inability to obtain a valid range of chi-square values). Chi square testing is not required to be performed on exposure rate instruments (e.g., Ludlum Model 19 or RO-20) or personnel contamination "frisking" instrument/detector combinations (e.g., Ludlum Model 3 or 177 with 44-9) unless specified in work-specific documents.

Chi-square tests shall be performed with NIST traceable sources with isotopic content appropriate to the detector being evaluated and the anticipated contaminants in the survey area. The source should be of sufficient activity to yield a counting rate of 1,000 to 50,000 counts per minute (cpm). The source should not exceed 50,000 cpm.

When required, chi-square tests should be documented in Attachment B or equivalent, or as specified in the work-specific documents. The form should include the following information at a minimum:

- Identification information (i.e., model and serial numbers) for the instrument and detector
- Conditions used for the test (geometry, radiation type, operating voltage, etc.)
- Source ID number
- Date and time of determination
- Identification and signature, or initials, of technician
- Identification and signature of reviewer

The chi-square test procedure will produce a chi-squared value (χ^2), which should be between 10.11 and 30.14 for a test using 20 counts. Failure to obtain a chi-squared value in this range indicates a problem with either the instrument or the methodology used to perform the chi-square test and requires further investigation. The RSOR should be notified of the failure to assist in planning a course of action.

4.5 Instrument Efficiency for Portable Instruments

The instrument efficiency (ϵ) is the ratio between the net count rate (in cpm) of the instrument and the surface emission rate of the efficiency check source for a specified geometry. The surface emission rate is the 2π particle fluence that is affected by both the attenuation and backscatter of the radiation emitted from the efficiency check source.

The following equation is used to calculate the instrument efficiency in counts per particle:

**PREPARATION OF PORTABLE RADIATION AND
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$$\varepsilon_i = \frac{R_{S+B} - R_B}{q_{2\pi} \left(\frac{W_A}{S_A} \right)}$$

Where,

- E_i = the instrument efficiency (counts per disintegration)
 R_{S+B} = the gross count rate of the efficiency check source, measured in cpm
 R_B = the background count rate in cpm
 $q_{2\pi}$ = the 2 π surface emission rate of the calibration source (NIST traceable)
 W_A = the active area of the probe window in square centimeters (cm²)
 S_A = the area of the source in cm²

Note: This equation assumes that the dimensions of the efficiency check source are sufficient to cover the window of the instrument detector. If the dimensions of the efficiency check source are smaller than the detector's window, set W_A equal to the dimensions of the efficiency source (i.e., set the quotient of W_A and S_A equal to 1).

Instrument efficiency shall be determined for all instruments and radiation and contamination survey meters that are to be used for alpha and beta surveys prior to use for field operations. Instrument efficiency is dependent upon energy of the incident radiation. Multiple energy-specific instrument efficiencies may be determined when isotopes with significantly varying energies are analyzed.

The equipment manufacturer's procedures shall be followed to determine the instrument efficiency for those instruments for which it is required. In instances where governing work-specific documents specify a means or expanded scope of inclusion for instrument efficiency determination, they shall have precedence.

All instrument efficiency determinations should be documented on an approved subcontractor form, or as specified in the work-specific documents. The form should include the following information at a minimum:

- Identification information (i.e., model and serial numbers) for the instrument and detector
- Conditions used for determination (geometry, radiation type, operating voltage, etc.)
- Source-specific information (ID number, surface emission rate, area)
- Detector window area
- Date and time of determination
- Identification and signature, or initials, of technician
- Identification and signature of reviewer (typically the RSOR)

The resulting efficiency should be reported in units of counts per disintegration.

**PREPARATION OF PORTABLE RADIATION AND
CONTAMINATION SURVEY METERS AND INSTRUMENTS
FOR FIELD USE****4.6 Operation Check**

An operation check for each instrument should be performed at the beginning of each workday that a particular instrument is used. The operations check should include the following checks at a minimum:

- Check that instrument calibration is still valid (date on sticker not yet passed)
- Check the instrument (including the probe) for physical defects (knobs, displays, cables, connectors, Mylar windows, etc.)
- Check of instrument battery (per manufacturers' instructions)
- Source check (should give consistently reproducible results with same source)

Instructions for performing operation checks for specific instruments and detectors are included in Attachment C of this procedure. Failure of any of the above checks shall result in the instrument being removed from active service until the condition can be addressed. The RSOR should be notified of any instrument failing an operations check for reasons other than failure of a battery check. In cases of battery check failure, the battery should be replaced and the check repeated.

The specified checks should each be performed every day and documented. A separate check log shall be maintained for each instrument type. The check log shall contain the following information at a minimum:

- Identification information (i.e., model and serial numbers) for the instrument and detector
- Conditions used for the check (geometry, radiation type, etc.)
- Source ID number
- Source check readings in appropriate measurements
- Verification of current calibration
- Verification of physical condition
- Verification of battery check
- Verification that source check is in acceptance range
- Date of operational check
- Signature or initials of technician
- Identification and signature of reviewer

Of the required information given above, only the verifications, date and signature or initials need to be completed on a daily basis. The remaining information can be completed once and kept in the check log with the additional pages for daily checks, provided that none of the information changes. If the information changes, then a new check log should be started.

A sticker annotating that daily operation checks have been completed satisfactorily shall be affixed to each instrument. The sticker shall contain the following information at a minimum:

- Initials of technician

**PREPARATION OF PORTABLE RADIATION AND
CONTAMINATION SURVEY METERS AND INSTRUMENTS
FOR FIELD USE**

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- Date of operational check

4.7 Maintenance

Instruments shall be stored in areas which prevent damage by movement, accumulation of moisture or dust. Detector covers shall be used for storage when practical.

Instrument maintenance (except external adjustments and cable or Mylar window replacements) shall be performed by the manufacturer or an approved vendor.

5.0 RECORDS

Records that result from this procedure may include forms that document background determinations, chi-square tests, instrument efficiency, instrument calibration and check logs. Record forms shall be obtained from the attachments of this procedure or equivalent electronic versions or as specified in work-specific procedures.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A, Instrument/Detector Background Form

Attachment B, Chi Square Form

Attachment C, Instrument and Detector Operational Check Procedures

Standard Operating Procedure

RELEASE OF MATERIALS AND EQUIPMENT FROM RADIOLOGICALLY CONTROLLED AREAS

SOP-003

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

11/15/12

Date

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1.0 PURPOSE

The purpose of this procedure is to specify the radiological survey requirements for releasing materials and equipment from radiologically controlled areas (RCAs).

2.0 SCOPE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors to release materials from RCAs.

3.0 DEFINITIONS AND ABBREVIATIONS

Contamination – Radioactive material in any place it is not desired. Contamination may be due to the presence of alpha particle, beta particle, or gamma-ray-emitting radionuclides.

Fixed Surface Contamination – Contamination that is not readily removed from a surface by applying light-to-moderate pressure when wiping with a paper or cloth disk swipe or masslin.

Radiologically Controlled Area (RCA) – An area to which access is controlled in order to protect individuals from exposure to radiation and radioactive materials and/or to prevent the release of radioactive materials to the uncontrolled areas.

Release for Unrestricted Use – The authorization to remove or reuse equipment and/or material from an RCA. Such authorization will be based on review of survey data confirming that the material and/or equipment being released does not exhibit radiation levels exceeding those in Table 4-1.

Removable Surface Contamination – Contamination that is readily removed from a surface by applying light to moderate pressure when wiping with a paper or cloth disk swipe or masslin.

4.0 PROCEDURE DETAILS

4.1 General

Surveys for fixed and removable surface contamination shall be conducted and documented in accordance with *SOP 001, Radiation and Contamination Surveys*.

Items presented for release shall be surveyed in an area of relatively low background.

4.2 Limitations

This procedure shall not be used for personnel surveys. Personnel will be surveyed in accordance with *SOP 005, Radiological Protective Clothing Selection, Monitoring, and Decontamination*.

4.3 Release Procedure

4.3.1 Material History

Upon receipt of an item presented for release from RCAs, the history of the item should be determined. This determination should include, if possible:

- The current and past use of the item.
- The location(s) in which the item was used or stored.
- If the item was in an area where radioactive material was used or stored.

This history will be used, if applicable, to evaluate the potential for contamination to be present on inaccessible surfaces of the item.

4.3.2 Contamination Surveys

All accessible surfaces will be surveyed for removable and fixed surface contamination in accordance with *SOP 001, Radiation and Contamination Surveys*.

Swipes collected for removable surface contamination shall be analyzed with a Ludlum Model 2929 scaler with a Model 43-10-1 ZnS(Ag) scintillation probe (or equivalent) or Protean Alpha/Beta Gas Flow Proportional Counter (or equivalent).

Scan surveys will be conducted on all accessible surfaces of the material or equipment that may have come in direct contact with radioactively contaminated material. Whenever practical, 100 percent of these areas will be scanned for alpha and beta contamination.

Following the scan survey, the number of static survey measurements to be collected shall be determined by:

- Size and history of the item.
- Preliminary results of the swipe and scan surveys.
- If an increase in the audible and/or digital/analog count rate was detected.
- If, during the survey, the Radiological Control Technician determines that there may be fixed activity present.

4.3.3 Inaccessible Surfaces

If items have inaccessible surfaces that may have been exposed to contamination, or if it is unknown if they have been exposed to contamination, the items should be disassembled as completely as possible to facilitate release surveys. Items with inaccessible surfaces will not be released from an RCA unless evaluated and documented by the Radiation Safety Officer Representative (RSOR), or designee, in conjunction with the Radiological Affairs Support Office.

4.3.4 Release of Material and Equipment

The following steps shall be taken for release of material and equipment:

**RELEASE OF MATERIALS AND EQUIPMENT
FROM RADIOLOGICALLY CONTROLLED AREAS**

1. If the results of the swipe, scan, and static surveys do not exceed the limits of Table 4-1, then the material may be released for unrestricted use.
2. If the swipe, scan, or static survey results indicate contamination which exceeds the limits of Table 4-1, the material shall not be released for unrestricted use. Material and equipment that cannot be released for unrestricted use will be evaluated for decontamination in accordance with *SOP 007, Decontamination of Equipment and Tools*, or packaged for disposal.
3. Results of the swipe, scan, and static surveys shall be documented in accordance with *SOP 001, Radiation and Contamination Surveys*.
4. If the equipment and/or materials are being returned to a vendor or removed from the site, a completed Attachment 1 – Unconditional Release of Equipment or Materials Form – or copy of the Radiation/Contamination Survey and Supplement form (Attachments 1 and 2 from *SOP 001, Radiation and Contamination Surveys*) with the statement “Equipment or materials have been surveyed and found to be within acceptable surface contamination levels for unconditional release as required by AEC Guide 1.86” written or stamped on the Radiation/Contamination Survey Form or equivalent will accompany the equipment and/or material .

**TABLE 4-1
RELEASE LIMITS FOR MATERIALS AND EQUIPMENT**

Radiation Type	Release Limits ¹ (Fixed) (dpm per 100 cm ²)	Release Limits ¹ (Removable) (dpm per 100 cm ²)
Alpha (α) Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	20
Beta (β -) Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000	200
Beta-Gamma (β - γ) Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	1,000

Notes:
¹ These limits are based on AEC Regulatory Guide 1.86 (AEC, 1974)

**RELEASE OF MATERIALS AND EQUIPMENT
FROM RADIOLOGICALLY CONTROLLED AREAS**

AEC – Atomic Energy Commission
cm² – square centimeters
dpm – disintegrations per minute

5.0 REFERENCES

<i>Number</i>	<i>Title</i>
AEC Regulatory Guide 1.86	<i>Termination of Operating Licenses for Nuclear Reactors</i>
SOP 001	<i>Radiation and Contamination Surveys</i>
SOP 005	<i>Radiological Protective Clothing Selection, Monitoring, and Decontamination</i>
SOP 007	<i>Decontamination of Equipment and Tools</i>

6.0 ATTACHMENTS

Attachment 1 – Unconditional Release of Equipment or Materials Form

RELEASE OF MATERIALS AND EQUIPMENT
FROM RADIOLOGICALLY CONTROLLED AREAS

ATTACHMENT 1

UNCONDITIONAL RELEASE OF EQUIPMENT OR MATERIALS FORM

Survey #:		Date:		
Description of equipment or materials:				
SURVEY EQUIPMENT:				
Model No:	S/N:	Background:	Eff:	Cal Due Date:
Model No:	S/N:	Background:	Eff:	Cal Due Date:
Model No:	S/N:	Background:	Eff:	Cal Due Date:
CONTAMINATION LEVELS:				
	dpm/100 cm ² βγ	Removable		
	dpm/100 cm ² α	Removable		
	dpm/100 cm βγ	Fixed		
	dpm/100 cm ² α	Fixed		
This is to certify that the above described equipment or materials have been surveyed and found to be within acceptable surface contamination levels for unconditional release as required by AEC Regulatory Guide 1.86.				
Radiological Control Technician:			Date/Time:	
Disposition of equipment or materials:				
Reviewed By:			Date:	

Standard Operating Procedure

RADIOLOGICAL RECORDS

SOP-004

Revision 0

Approved By:



11/15/12

Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

Date

REVISION HISTORY

<i>Revision (Date)</i>	<i>Rev. No</i>	<i>Prepared By</i>	<i>Description of Changes</i>	<i>Affected Pages</i>
11/15/12	0	E. Abkemeier	Original	All

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1.0 PURPOSE

The purpose of this procedure is to define Tetra Tech EC, Inc. (TtEC) standards for the maintenance and retention of radiological records, including personal protection.

2.0 OVERVIEW

Radiological records provide valuable historical data, radiological conditions, and exposure for use in future site operations, health studies, and litigation support. The following types of radiological records are required to be maintained:

- Radiological control procedures
- Radiological control (RadCon) Personnel Training (course records and individual records)
- Radiological instrumentation test, repair, and calibration records
- Radiological surveys
- Dosimetry results
- Dose to Members of the general public
- Radiological work permits
- Radiological incident reports
- The results of internal audits and other reviews of program content and implementation
- Written declarations of pregnancy, including the estimated date of conception
- Records for release of material from radiologically controlled areas
- Records of Waste Disposal

Radiological records are transferred to the project file located in San Diego following completion for projects completed under California Agreement State Radioactive Material License (RML) number 7909-01, and to the Corporate Headquarters in New Jersey for projects completed under Nuclear Regulatory Commission (NRC) RML number 32-31396-01.

3.0 RESPONSIBILITIES

3.1 Radiation Safety Officer

The Radiation Safety Officer is responsible for:

- Ensuring effective implementation of the RadCon records management program and that the program is in compliance with regulatory requirements.

3.2 Radiation Safety Officer Representative

The Radiation Safety Officer Representative:

- Directs and assists Radiological Control Technicians and project personnel in proper completion of radiological records.
- Ensures that records are in compliance with the quality standards outlined in this procedure.
- Ensures timely and thorough review of records in accordance with this procedure, prior to approval.

RADIOLOGICAL RECORDS

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- Approves records with verifiable signature and date once the records meet the quality standards.
- Ensures that records are transferred or transmitted to the San Diego office following completion.

3.3 Other Project Personnel

Other project personnel will:

- Create, review, or transmit radiological records for retention.
- Ensure that all document quality standards are met.

4.0 REQUIREMENTS

All records must be retrievable and maintained for their prescribed retention time.

Completed records awaiting transfer to storage shall be stored in an appropriate manner to minimize loss and damage that could result from exposure to weather, fire, or other conditions.

All personnel who create, review, and approve radiological records must sign and date the record and follow all quality standards in accordance with this procedure.

If working copies of records are used for reference, they will be stored separately from the original.

5.0 DOCUMENT QUALITY STANDARDS

Records shall be legible and completed with an indelible ink that provides reproducible and legible copies. Records shall be dated and contain a verifiable signature of the originator. Errors shall be corrected by marking a single line through the error and by initialing and dating the correction. Radiological records shall not be corrected using an opaque substance. Shorthand, or other nonstandardized terms, may not be used.

To ensure retrievability, each record shall clearly indicate:

- Identification of the facility
- Specific location
- Function and process
- Document number (if applicable)

To the maximum extent possible, upload electronic copies of radiological records to the TtEC sharepoint site to ensure retrievability by the RSO and RSORs in the event of program audits or inspections.

The quantities used in records shall be clearly indicated in standard units (curie, rad, rem, disintegrations per minute [dpm]), including multiples and subdivisions of these units.

6.0 PROCEDURE

6.1 Preparation of Radiological Records

Prior to preparing a document for which a standard form exists, verify that the form is current. Verify that copies of master forms are in good quality.

Prepare the document in accordance with the applicable guidance for that specific document, if any, and in accordance with the quality standards established by this procedure.

Review the completed document for accuracy of calculations, legibility, proper units, proper forms, and so forth. The document should meet all quality standards before it is submitted for final review and approval.

6.2 Review of Records

Supervisory reviews should focus on identification of trends, validity of recorded data and information, and identification of originators.

Subsequent quality reviews should verify that documents are complete, legible, and in compliance with the quality standards outlined in this procedure.

6.3 Approval of Records

Verify that all documents are correct and in compliance with this procedure and applicable regulatory requirements prior to transmittal to storage.

6.4 Individual Monitoring

The records required by this procedure will be protected from public disclosure because of their personal privacy nature. The results of any individual external and internal dose monitoring that is performed will be recorded at least annually, including doses received during planned special exposures, unplanned doses exceeding TtEC dose limits, and authorized emergency exposures.

Monitoring records will be maintained on Nuclear Regulatory Commission (NRC) Form 5, or in clear and legible records containing all of the information required by NRC Form 5.

- Data necessary for future verification or reassessment of the recorded doses will be recorded.
- Individual monitoring records that are identified with a specific individual will be readily available to that individual.

6.4.1 Monitoring Records

For personnel whose occupational dose is monitored, reasonable efforts will be made to obtain records of the current year for occupational internal and external doses. If complete records documenting previous occupational dose during the year cannot be obtained, a written estimate signed by the individual may be accepted to demonstrate compliance.

External dose records include the following:

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- The effective dose equivalent from external sources of radiation (deep dose equivalent may be used as effective dose equivalent for external exposure).
- The lens of the eye dose equivalent.
- The shallow dose equivalent to the skin.
- The shallow dose equivalent to the extremities.

Internal doses from intakes received during the year include the following:

- An estimate of the identified intake of radionuclides.
- Committed effective dose equivalent.
- Committed dose equivalent to any organ or tissue of concern.

The summation of external and internal doses includes:

- Total effective dose equivalent in a year.
- For any organ or tissue assigned an internal dose during the year, the sum of the deep dose equivalent from external exposures and the committed dose equivalent to that organ or tissue.
- The dose equivalent to the embryo/fetus of a declared pregnant worker will be located with the records of dose to the declared pregnant woman.
- Incident reports, findings, conclusions, or other information describing off-normal events in which the employee was involved. These include, but are not limited to, cases of accidental exposures, skin contamination, failure of personal protective equipment (PPE), exceeding TtEC dose limits (unauthorized), injuries inside a radiological area, or positive bioassay.

6.4.2 Other Monitoring Records

The following other information will be documented and maintained:

- Results of area monitoring
- Results of dosimetry, surveys, air sampling/monitoring, and bioassay results used to determine individual doses
- Results of monitoring for the release and control of material and equipment, the records of released property will include:
 - (a) A description or identification of the property
 - (b) The date of the survey
 - (c) The identity of the individual who performed the monitoring operation
 - (d) The type and identification number of monitoring instruments
 - (e) The results of the monitoring operation
- Results of maintenance and calibration performed on instruments and equipment
- Results of monitoring and documentation of approval for planned special exposures

7.0 RECORD RETENTION

All radiation records will be retained by TtEC for a minimum of 3 years from the date of the generation of the record.

8.0 REFERENCES

RADIOLOGICAL RECORDS

None.

9.0 ATTACHMENTS

None.

Standard Operating Procedure

RADIOLOGICAL PROTECTIVE CLOTHING SELECTION, MONITORING, AND DECONTAMINATION

SOP-005

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

11/15/12

Date

REVISION HISTORY

<i>Revision (Date)</i>	<i>Rev. No</i>	<i>Prepared By</i>	<i>Description of Changes</i>	<i>Affected Pages</i>
11/15/12	0	E. Abkemeier	Original	All

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1.0 PURPOSE

This procedure provides the guidance for selecting protective clothing, performing personnel surveys, and decontaminating personnel.

2.0 SCOPE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors while performing activities in known or suspected areas with radioactive contamination.

3.0 DEFINITIONS AND ABBREVIATIONS

Contaminated Area – Any area where removable surface contamination levels exceed the following limits in Table 3-1:

TABLE 3-1
EQUIPMENT AND MATERIAL SURFACE CONTAMINATION LIMITS

Radiation Type	Release Limits ¹ (Fixed) (dpm per 100 cm ²)	Release Limits ¹ (Removable) (dpm per 100 cm ²)
Alpha (α) Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	20
Beta (β -) Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000	200
Beta-Gamma (β - γ) Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	1,000

Notes:

¹ Limits for equipment and materials based on Regulatory Guide 1.86 (AEC, 1974)

AEC – Atomic Energy Commission

cm² – square centimeter

dpm – disintegration per minute

Types of radiation: α - alpha, β - beta, γ - gamma

Hot Particle – A discrete, minute, fragment of radioactive material.

Radiologically Controlled Area (RCA) – An area to which access is controlled in order to protect individuals from exposure to radiation and radioactive materials and/or to prevent the release of radioactive materials to the uncontrolled areas.

4.0 PROCEDURE DETAILS

4.1 Selection of Personnel Protective Equipment

The following factors should be considered when selecting personnel protective equipment (PPE):

- The levels and types of radiological material present, or expected, in the work area
- The presence of chemical hazards
- The base in which the contamination is carried (dry, wet, oily)
- The work to be performed, or work in progress
- The location of the contamination (e.g., floor, walls, overhead, air handling systems, sewer systems)
- The physical configuration of the work area
- Environmental conditions such as heat and humidity
- Exposure situation (vapor, pressured splash, liquid splash, intermittent liquid contact, and continuous liquid contact)
- Toxicity of the radioactive materials and/or chemical(s) (i.e., ability to permeate the skin, and systemic toxicity)
- Physical properties of the contaminant (vapor pressure, molecular weight, and polarity)
- Functional requirements of the task (dexterity, thermal protection, fire protection, and mechanical durability requirements)

Table 4-1 provides guidance for the selection of PPE when radiological hazards are present or suspected.

TABLE 4-1
GUIDE FOR THE SELECTION OF RADIOLOGICAL PROTECTIVE CLOTHING

Removable Contamination Levels	Clothing for Access Only <u>No Work</u> *	Clothing for Work or Access During Work *
General contamination levels < 1,000 dpm/100 cm ²	Level D PPE	Level D PPE
General contamination levels > 1,000 dpm/100 cm ² , but ≤ 10,000 dpm/100 cm ²	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**
General contamination levels > 10,000 dpm/ 100 cm ² , but ≤ 100,000 dpm/100 cm ²	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (or hood) Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**
General contamination levels > 100,000 dpm/100 cm ²	Glove liners Gloves (2 pair) Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**	Glove liners Gloves (2 pair) Booties (2 pair), cloth or PVC Tyvek (2 pair) Cap Hood Rubber shoe covers**

Notes:

* Plastics or partial plastics may be required anytime water or liquid chemicals are present, such as when handling wet components.

** Composition of rubber shoe covers will be selected based on work area conditions and presence of any chemical hazards.

cm² – square centimeter

dpm – disintegration per minute

PPE – personal protective equipment

PVC – polyvinyl chloride

The guidelines specified in Table 4-1 for PPE selection may be modified under unusual circumstances. The following are examples:

- Wet areas – Where splashing water or spray is present, use rain suits in addition to the protective clothing listed in Table 4-1. A second set of coveralls may not be necessary when a rain suit is worn.
- Standing water – In addition to the clothing requirements for wet areas, use hip boots or waders for deep standing water areas.
- Face shields – Consider for use when there is significant beta radiation, or a likelihood of water splashing and respirators are not required.
- High temperature areas – Consult with the Radiation Safety Officer Representative (RSOR) and Site Health and Safety Specialist (SHSS).

4.2 Procedure Process

4.2.1 Donning Protective Clothing

1. Select the appropriate PPE.
2. Inspect the clothing for holes, tears, or other indications of damage. If damaged, remove PPE from service.
3. Place dosimetry, if worn, in the upper body area on the interior of the breast tab with the window of the dosimeter facing out. When coveralls that do not have a breast tab or pocket are worn, dosimetry should be attached per the direction of the RSOR or designee.
 - The dosimeter shall not be worn inside clothing or placed in pockets if exposure of bare skin to beta radiation is expected.
4. If a respirator is specified on the RWP, then:
 - Ensure that any required surgeons cap or hood is situated such that it will not interfere with the respirator face to facepiece seal area.
 - Don the respirator.
 - Don the hood if required, allowing it to overlap the rubber around the lens of the face piece and fall over the shoulder.
 - If required, tape the hood to the respirator and to the coveralls.
 - Ensure that any required hood is slack enough around the shoulders to allow for full head movement.
5. Don rubber gloves.
 - More than one pair of rubber gloves may be required for certain jobs.
 - Tape the innermost pair of rubber gloves to the coverall sleeves.
 - Leather work gloves may be substituted for outer rubber gloves on some jobs as specified by the corresponding Radiation Work Permit.
6. If specified on the RWP, then don additional PPE as required.

4.2.2 Removal of Protective Clothing

1. Remove any tape and place in the designated collection receptacle.
2. Remove outer gloves, if worn.
3. If worn, remove the hood.
4. If worn, remove the respirator.
5. If worn exterior to coveralls, remove dosimetry.
6. Remove coveralls, if worn, by peeling off inside out and rolling downward over the shoes or inner booties.
7. Remove booties.
8. Carefully place coveralls in the designated collection receptacle.

CAUTION: Pushing clothing or trash into an already full collection container to compress the contents is forbidden as the act can result in the potential for airborne radioactivity.

9. Have the Radiological Control Technician (RCT) perform a personnel exit survey.

The sequence for protective clothing removal may vary from that described above:

- At the discretion of the RCT, providing job coverage
- As designated in the assigned Radiation Work permit (RWP)
- Dependent upon radiological and hazardous material conditions encountered during the work evolution

4.2.3 Monitoring

4.2.3.1 Exit Surveys

Note: Site conditions may merit only a hand and foot survey. If this is the case, only the hands and shoe bottom are surveyed by the RCT.

1. Use the portable instrument staged for the area of concern, which should have both a visual and an audible response.
2. Ensure that the instrument is set on slow response, if available, and operating with an audible response.
3. Verify that the instrument is operational on the lowest scale and that the area background count rate is acceptable.
4. Hold the detector with the window at approximately 1/4 inch from the surface being monitored.
5. Move the detector over the surface being monitored at a rate not-to-exceed 2 to 3 inches per second.
6. If an increase in the audible response is noted, then cease detector movement and allow the meter 5 to 10 seconds to stabilize.
7. Pause (approximately 5 seconds) at the nose and mouth area to check for indications of inhalation/ingestion of radioactive material.
8. Pay particular attention to hands, feet (shoes), elbows, knees, or other areas with a high potential for contamination.
9. If no contamination can be detected, as indicated by an alarm or by an audible or visual response distinguishable from background, then exit the area.
10. If an audible or visual response distinguishable from background is noted, then the RCT will further investigate to verify if contamination is present.
11. If personnel are found to be contaminated, proceed to the procedures outlined in Section 4.2.3.2.

4.2.3.2 Contaminated Personnel

1. Notify the RSOR of any individual with known or suspected contamination.

2. If the contamination is on a personal article of clothing, then perform the following:
 - Survey the inside surface(s), which was against the skin.
 - Verify that no contamination was transferred to the skin.
3. If the contamination is on the skin, then determine if the contamination is in the form of a hot particle.
4. If the contamination is a hot particle, then:
 - Quickly evaluate the particle.
 - Particle size
 - Radiation type
 - Visible characteristics
 - Attempt to collect and retain the particle for subsequent evaluation.
 - Decontaminate the individual in accordance with Section 4.2.4.
5. If the contamination is not a particle, then:
 - Evaluate the contamination levels.
 - Decontaminate the individual in accordance with Section 4.2.4.
6. Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

4.2.4 Personnel Decontamination

NOTE: First aid measures take precedence over decontamination efforts. The RCT shall request support from qualified medical personnel when an injured person requires decontamination.

1. Perform personnel decontamination in a manner that prevents the spread of contamination to other body parts, or the ingestion or inhalation of radioactive material.
2. Take appropriate precautions to minimize the spread of contamination when proceeding from the control point or step-off pad to the decontamination area.
3. Personnel will not be released if detectable skin contamination is present, unless authorized by the RSOR.
4. When performing skin decontamination:
 - Exercise care to avoid damaging the skin.
 - If skin irritation becomes apparent, then discontinue the decontamination and notify the RSOR.
 - Record results after each decontamination attempt.
 - Indicate the method of decontamination used.
 - Decontamination of ears, eyes and mouth shall be limited to damp swabs, water, or saline solution rinses conducted by the individual. Further decontamination shall be performed under the direction of qualified medical personnel.

**RADIOLOGICAL PROTECTIVE CLOTHING SELECTION,
MONITORING, AND DECONTAMINATION**

- Decontamination of nasal passages shall be limited to repeated nose blowing by the individual. Supplemental nasal irrigations shall be performed under the direction of qualified medical personnel, as required.
- Use of decontamination processes, or materials other than those listed in Table 4-2, will only be performed under the specific direction of qualified medical personnel.
- Immediately report incidents of individual contamination to the RSOR.
- Note the final survey results and time of survey.
- Record the area of the skin contaminated in cm² on the Personnel Contamination Report (Attachment 1).
- For contamination distributed over an area greater than or equal to the area of the probe, the measured activity may be assumed to be distributed over the probe area (area of typical pancake probe is 15.5 cm²).
- If the area of contamination is less than the area of the probe but greater than 1 cm², the actual area of the activity must be determined.
- If the contamination area is less than or equal to 1 cm², assume an area of 1 cm².
- When skin decontamination has been successfully completed, obtain the information needed to complete the Personnel Contamination Report (Attachment 1).
- Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

**TABLE 4-2
PERSONNEL DECONTAMINATION METHODS**

METHOD	EFFECTIVE FOR	INSTRUCTIONS
Masking Tape	Dry contamination, hot particles	Apply tape to skin by lightly patting. Remove carefully.
Waterless Hand Cleaner	All skin contamination	Apply to affected area and allow it to melt onto the skin. Remove with cotton or soft disposable towel.
Soap and Tepid Water	All skin contamination except tritium	Wash area with soap and lukewarm water. Repeat until further attempts do not reduce the level. A cloth or surgical hand brush may be used with moderate pressure.
Soap and Cool Water	Tritium contamination	Wash area with soap and cool water. Repeat until further attempts do not reduce the level. A cloth may be used with moderate pressure.
Carbonated Water	All skin contamination	Apply to affected area with cotton or soft disposable towel and wipe with dry towel.
Cornmeal Detergent Paste	All skin contamination	Mix cornmeal and powder detergent in equal parts with enough water to form a paste. Rub onto affected area for 5 minutes. Remove with cotton or disposable towel. Rinse skin.
Shampoo	Hair contamination	Wash hair and rinse. Repeat as necessary.
Parafilm	All particulate contamination	Apply to affected area of skin. Remove.

Sweating	All skin contaminations	Cover affected area with impermeable cover (plastic, glove, Parafilm) to cause sweating. Remove after sweating has occurred and wipe area.
----------	-------------------------	--

4.2.5 Radiological Follow-up

The RCT shall:

1. Ensure that the Personnel Contamination Report (Attachment 1) has been completed.
2. Check the location of the contamination event – Contaminated Area, Hot Particle Area, clean area inside a RCA, or clean area outside RCA.
3. Enter any additional information felt to be pertinent.
4. Complete the “Contamination Event Description and Cause” sections of Attachment 1.
5. If the event was directly related to wearing PPE, then complete Section A, “Event Directly Related to Wearing PPE.”
 - Check the appropriate Contamination Event Description.
 - Check the appropriate Basic Cause.
6. If the contamination occurred while removing PPE, then complete Section B, “Event Occurred While Removing PPE.”
 - Check the appropriate “Contaminating Event Description.”
 - Check the appropriate “Basic Cause.”
7. If the contamination event was not related to wearing PPE, then complete Section C, “Event Not Directly Related to Using PPE.”
 - Check the appropriate “Contaminating Event Description.”
 - Check the appropriate “Basic Cause.”
8. Review the report with the individual and have them sign and date the form.
9. Sign and date the form.

The RSOR shall:

1. Review the Personnel Contamination Report to verify that all required information has been accurately recorded.
2. Complete the “RSOR” section.
 - Check the appropriate brackets ([]) to indicate actions taken.
 - Enter any comments.
3. Sign and date the form.
4. Request support from the qualified medical personnel when:
 - The personnel decontamination methods provided in this procedure are ineffective;
 - or

- Injured personnel require decontamination.
5. Determine reimbursements and disposition of personal property that cannot be decontaminated.
 6. Forward the completed Personnel Contamination Report to the Site Health and Safety Specialist (SHSS) for review.

The SHSS shall:

1. Review and sign the Personnel Contamination Report (Attachment 1).
2. Conduct an investigation into the cause of the contamination.
3. Conduct training on the cause of the contamination and lessons learned and preventive measures.
4. Sign and transmit the Personnel Contamination Report (Attachment 1) to the RSO for review.

5.0 RECORDS

The administrative form included in this procedure (Personnel Contamination Report) shall not be modified without the written authorization of the Project Manager and the documented concurrence of the RSO or designee. In no case shall modifications reduce the content required by the original form.

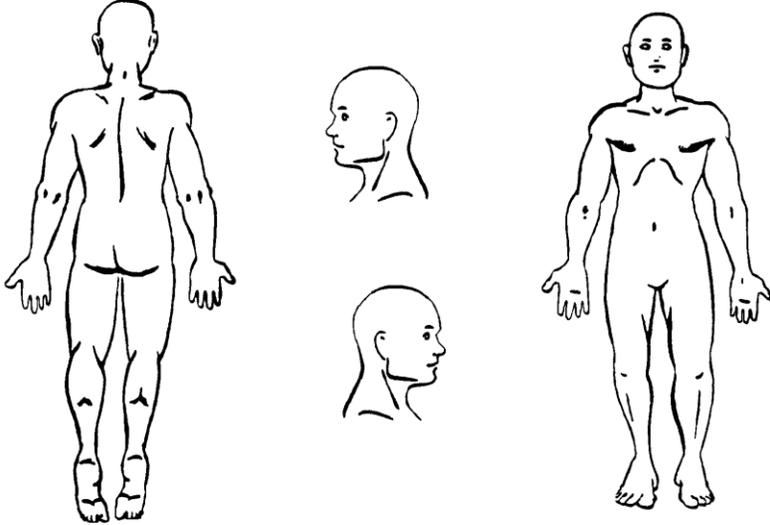
6.0 REFERENCES

<i>Number</i>	<i>Title</i>
AEC Regulatory Guide 1.86	<i>Termination of Operating Licenses for Nuclear Reactors</i>

7.0 ATTACHMENTS

Personnel Contamination Report

**ATTACHMENT 1
PERSONNEL CONTAMINATION REPORT**

Name		Company	Date	Time
EID	Dosimeter#	Dept.	Supervisor	
Instrument		Serial #	Cal. Due Date	
Probe		Serial #	Cal. Due Date	
Location of Personnel Contamination			RWP #	Survey #
				

Contamination Levels (Use # to reference drawing)					
Number	Time	Initial Count Rate	Size of Area (cm ²)	Time	Final Count Rate
Decontamination Methods	___ Wash ___ Number of washes			___ Other:	
	___ Shower ___ Number of showers				
Radiological Control Technician Signature:				Date	
I acknowledge the above information represents the contamination event.					
Individual Signature:				Date	

**RADIOLOGICAL PROTECTIVE CLOTHING SELECTION,
MONITORING, AND DECONTAMINATION**

Name

EID

CLOTHING CONTAMINATION

Item:	Max cpm	<input type="checkbox"/> Decon/Return	<input type="checkbox"/> Contaminated/Retained
Item:	Max cpm	<input type="checkbox"/> Decon/Return	<input type="checkbox"/> Contaminated/Retained
Item:	Max cpm	<input type="checkbox"/> Decon/Return	<input type="checkbox"/> Contaminated/Retained

RADIOLOGICAL FOLLOW-UP

Location of Event:	<input type="checkbox"/> Contamination Area	<input type="checkbox"/> Clean area inside RCA	<input type="checkbox"/> Clean area outside RCA
Follow-up actions:			
Additional information:			

CONTAMINATION EVENT DESCRIPTION and CAUSE
A - Event Directly Related To Wearing PPE
Contaminating Event Description
Basic Cause

- | | |
|--|--|
| <input type="checkbox"/> Contaminated by physical compromise of PPE (tear, etc.) | <input type="checkbox"/> Improper donning of PPE |
| <input type="checkbox"/> Contamination penetration of intact PPE | <input type="checkbox"/> Improper PPE use related to worker knowledge/experience |
| <input type="checkbox"/> Contamination came from PPE | <input type="checkbox"/> Work area not deconned to extent practicable |
| <input type="checkbox"/> Contaminated skin by touching contaminated item | <input type="checkbox"/> Practical limitation of available alternatives |
| <input type="checkbox"/> Contamination came from contaminated liquid | <input type="checkbox"/> Improper PPE requirement on RWP |
| <input type="checkbox"/> Contamination came from airborne radioactivity | <input type="checkbox"/> Improper control by RCT of worker activity in PPE |
| | <input type="checkbox"/> Improper laundry/monitoring of PPE |

B - Event Occurred While Removing PPE
Contaminating Event Description
Basic Cause

- | | |
|---|---|
| <input type="checkbox"/> Contaminated during removal of hood | <input type="checkbox"/> Lack of knowledge in proper methods to remove PPE |
| <input type="checkbox"/> Contaminated during removal of respiratory equipment | <input type="checkbox"/> Lack of knowledge in proper methods to remove respirator |
| <input type="checkbox"/> Contaminated during removal of outer PPE | <input type="checkbox"/> Worker actions while removing PPE - accident |
| <input type="checkbox"/> Contaminated during removal of inner PPE | <input type="checkbox"/> RCT technician actions |
| <input type="checkbox"/> Contaminated during removal of plastics | <input type="checkbox"/> Improper monitoring of PPE |
| <input type="checkbox"/> Contamination came from airborne radioactivity | |

C - Event Not Directly Related To Using PPE
Contaminating Event Description
Basic Cause

- | | |
|--|--|
| <input type="checkbox"/> Contaminated while in area designated as clean RCA | <input type="checkbox"/> Noncompliance with postings/rad controls |
| <input type="checkbox"/> Contaminated while in area designated clean non - RCA | <input type="checkbox"/> Improper monitoring/control of rad material by worker |
| <input type="checkbox"/> Contaminated by liquid | <input type="checkbox"/> Improper actions at work area (sitting, lying) |
| <input type="checkbox"/> Contamination spread to area and not identified | <input type="checkbox"/> Accidental contact with contamination beyond worker control |
| <input type="checkbox"/> Improper control of airborne radioactive material | <input type="checkbox"/> Surveys not appropriate for existing conditions |

Radiation Safety Officer Representative

- | | |
|---|--|
| <input type="checkbox"/> Interview with job coverage RCT | <input type="checkbox"/> Released with residual contamination |
| <input type="checkbox"/> Exclude individual from further RCA access | <input type="checkbox"/> Initiated skin dose calculation |
| <input type="checkbox"/> Discussed with individual and supervisor | <input type="checkbox"/> No further action required, routine close out |

RSOR

Print

/

Sign

Date

SHSS

Print

/

Sign

Date

RSO

Print

/

Sign

Date

Standard Operating Procedure

SAMPLING PROCEDURES FOR RADIOLOGICAL SURVEYS

SOP-006

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

11/9/12

Date

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1.0 PURPOSE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors to perform swipe sampling and sampling of various types of media including soil and water.

2.0 SCOPE

This procedure shall be implemented by TtEC staff and subcontractor personnel when collecting samples on field projects related to radiological surveys.

3.0 DEFINITIONS AND ABBREVIATIONS

Swipe Samples – Swipe samples are materials, which after being wiped over a surface, are analyzed to determine the presence of removable radioactivity on the surface area that was wiped.

Soil Samples – Soil samples are defined as soil collected for analytical purposes. Soil samples will be collected from the top 15 centimeters (cm) (6 inches) of the surface, unless otherwise noted in the applicable work-planning document [e.g. a Task-specific Plan (TSP), Work Instruction or Work Plan].

Sediment Samples – Sediment samples are defined as a collection of clay, silt, sand, and/or gravel deposited by water, wind, or glaciers used for analytical purposes.

Solid Material Samples – Solid material samples are defined as pieces of concrete, brick, porcelain, wood, or any other hard material collected for analytical purposes from buildings or surrounding areas. The samples could include accumulations from ventilation systems or drain systems.

Liquid Samples – Liquid samples are defined as liquid collected for analytical purposes from sinks, drain piping, sewer systems, rinsate, groundwater, leachate, liquid investigation-derived waste, and low-point accumulation areas inside of buildings, sumps, and excavation pits.

4.0 SAMPLING PROCEDURE DETAILS

4.1 General Procedures

Field instruments used for measurements required by this procedure shall be function checked daily with NIST traceable standards and verified to have current calibration.

Anytime this procedure is in effect, the Radiation Safety Officer Representative (RSOR) (or qualified designee) should ensure, by periodic personal observation, that samples are appropriately collected and controlled.

Surface scan surveys are to be performed at each location before initiating sampling. This will identify the presence of gross contamination, which will require that samples and equipment be treated as radioactive, and handled in accordance with applicable license requirements. Samples will be recorded on chain-of-custody (COC) documentation.

4.2 Sampling Procedure Process

Sample activities will be recorded in the field logbook as directed by the applicable Sampling and Analysis Plan (SAP). Sampling personnel will don a new pair of disposable nitrile gloves immediately before collecting samples at each location.

4.2.1 SWIPE SAMPLING

Swipe samples will be obtained in accordance with SOP 001, *Radiation and Contamination Surveys*. Swipe samples will be documented in a logbook as applicable. Sample COC records shall be completed in accordance with the applicable SAP.

4.2.2 SOIL SAMPLING

Because standard surface soil contamination criteria for radionuclides are applicable to the average concentration in *the upper 15 cm (6 inches) of soil*, the sampling protocol described here is based on obtaining a sample of this upper 15 cm (6 inches). Special situations, such as sampling at depths greater than 15 cm (6 inches), evaluating trends or airborne deposition, determining near-surface contamination profiles, and measuring non-radiological contaminants, may require special sampling procedures. These special situations will be evaluated and incorporated into TSPs as the need arises.

Samples will be collected with a hand-auger, hollow-stem auger, split-spoon sampler, disposable scoop, or equivalent. The soil removed for sampling must be sufficient to yield a sample of sufficient volume for the sample container being used. Soil samples will be collected and handled as follows:

1. Loosen the soil at the selected sampling location to a depth of approximately 15 cm (6 inches), using a clean trowel or other digging instrument. In rocky terrain, a pick axe or mechanical means such as a Hilti gun may be used to remove soil for sampling. If an excavator is used due to health and safety reasons, extreme care should be used to ensure that the soil collected is from the upper 15 cm (6 inches) of the original surface.
2. Remove large rocks, vegetation and foreign objects. In some cases, however, these objects may be the source of the contamination and may be collected as separate samples for characterization.
3. Place as much soil as practical into a 250-milliliter (mL)-wide mouth plastic bottle, plastic 500-mL Marinelli container, plastic ziplock bag, or other suitable collection device. Approximately 1000 grams may be necessary for soil with significant moisture. Note that if a "split sample" is necessary for a regulatory agency to perform confirmatory analysis, collection of up to 2000 grams of soil will be necessary. Ensure that the material collected is from the upper 15 cm (6 inches) of soil. Note that this may require digging a hole wider, as opposed to deeper.
4. Tape the cap of the container in place or seal the ziplock plastic bag.
5. Label the sample container in accordance with the applicable SAP.
6. Document all samples collected in the sample logbook as applicable. Sample COC records shall be completed in accordance with the applicable SAP.

7. Transport samples in a project vehicle to the on-site laboratory for analysis as soon as possible after sample collection. Sample packaging and shipment procedures for transporting samples to an off-site laboratory are described in Section 4.3 of this procedure.
8. Clean or decontaminated tools will be used at each sampling location. Sampling tools will be decontaminated as described in the applicable SAP.

4.2.3 SEDIMENT SAMPLING

Several methods are available to collect sediment samples. The tools used will be appropriate to the circumstances and may include use of trowels, augers, or other hand tools. Sediment sampling will be conducted as follows:

1. A hand-auger, trowel or similar device will be used to access each sampling location. The sample collection tool will be selected based on physical limitations accessing the sample location.
2. Place as much material as practical into a 250-mL-wide mouth plastic bottle, plastic 500-mL Marinelli container, plastic ziplok bag or other suitable container.
3. Follow steps 4 through 8 of Section 4.2.2 to complete sample collection.

4.2.4 SOLID MATERIAL SAMPLING

Several methods are available to collect solid material samples. To collect samples, solid materials may need to be broken into smaller pieces. Solid materials will be collected as follows:

1. Break up the material into small enough pieces to fill a 250-mL-wide mouth plastic bottle, plastic 500-mL Marinelli container, plastic ziplok bag or other suitable container. A pick axe or mechanical means such as a Hilti gun may be used to remove solid material for sampling. At no time shall an excavator be used to collect samples.
2. Follow steps 4 through 8 of Section 4.2.2 to complete sample collection.

4.2.4.1 Pipe and Drain Line Sampling

Pipe and drain line sampling is conducted to assess residual radioactivity that may be inside of drain lines or materials within sanitary sewer and storm drain systems.

1. Since the type of material found inside drain lines varies, there is no specific method identified to collect these samples. Samples may be collected using a plumber's snake, swabs, scraper, trowel, etc.
2. Place as much material as practical into a 250-mL-wide mouth plastic bottle, plastic 500-mL Marinelli container, plastic ziplok bag or other suitable container.
3. Follow steps 4 through 8 of Section 4.2.2 to complete sample collection.

4.2.4.2 Ventilation Sampling

Ventilation sampling will be performed to identify if the system is impacted and assess the residual radioactivity that may be present.

SAMPLING PROCEDURES FOR RADIOLOGICAL SURVEYS

1. If visible dust is present inside the ventilation system, use a masslin cloth to accumulate the material into a pile. (If no visible dust is present, collect a swipe sample as discussed in SOP 001, *Radiation and Contamination Surveys*.)
2. Using a flat utensil such as a piece of paper or scraper carefully place as much material as possible into a 250-mL-wide mouth plastic bottle, plastic 500-mL Marinelli container, plastic ziplok bag or other suitable container.
3. Follow steps 4 through 8 of Section 4.2.2 to complete sample collection.

4.2.5 WATER SAMPLING

Water samples will be collected as follows:

1. Collect water using any of the following sampling equipment: disposable bailer, pump, coliwassa-type tube sampler, or equivalent. Care will be taken to avoid collection of bottom sediment or vegetation.
2. Fill completely a 250-mL-wide mouth plastic bottle, plastic 500-mL Marinelli container or two liter plastic bottles.
3. Follow steps 4 through 8 of Section 4.2.2 to complete sample collection.

4.3 Sample Packaging and Transport

Samples will be delivered for analysis to the laboratory via a box, cooler, or similar container (ice is not required if only radiological analysis will be performed), along with the COC completed as described in the applicable SAP..

The applicable SAP may require samples to be sent to an off-site laboratory for analysis, (e.g., total strontium, isotopic uranium, isotopic plutonium). Samples designated for transport off-site will be packaged in accordance with applicable Department of Transportation (DOT) and International Air Transport Association (IATA) procedures. At a minimum, sample containers will be placed in a box, cooler, or similar container for shipment and packaged with bubble wrap or other materials, as necessary, to prevent container breakage. Prepared packages will be surveyed prior to shipment using an appropriate exposure rate meter in accordance with SOP 001, *Radiation and Contamination Surveys*.

5.0 RECORDS

Sample collection records will include field logbooks and COCs. These records will be completed and maintained in accordance with the SAP.

6.0 REFERENCES

<i>Number</i>	<i>Title</i>
SOP 001	Radiation and Contamination Surveys

7.0 ATTACHMENTS

None.

Standard Operating Procedure

DECONTAMINATION OF EQUIPMENT AND TOOLS

SOP-007

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
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DECONTAMINATION OF EQUIPMENT AND TOOLS

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PURPOSE

This procedure provides instruction and methods for the decontamination of equipment and tools.

1.0 SCOPE

This procedure describes the methods Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors will use for decontamination of equipment and tools that are contaminated with radioactive material.

2.0 DEFINITIONS AND ABBREVIATIONS

Decontamination – The processes whereby contamination can be safely and effectively removed from equipment and tools.

HERCULITE[®] – A plastic or polyethylene floor covering and containment material used for decontamination operations. HERCULITE is a brand name.

Material Safety Data Sheet (MSDS) – Manufacturer directions, safety information, and limitations for use of decontamination-related solvents or cleaning solution.

3.0 PROCEDURE DETAILS**3.1 General****3.1.1 Precautions**

The following precautions shall be observed during decontamination activities:

- Decontamination of contaminated tools or equipment shall be performed under the supervision of the Radiological Control Technician (RCT) providing the job coverage.
- Controls to contain the spread of loose contamination during the decontamination activity shall be planned and established prior to the decontamination of equipment, material, and tools.
- Use of chemicals or solvents for decontamination purposes that have the potential to produce mixed waste shall be avoided whenever possible. Use of these chemicals or solvents requires the prior approval of the Radiation Safety Officer Representative (RSOR) and Radiological Affairs Support Office (RASO).
- Survey instruments that will be used to survey suspected contaminated equipment or tools should be protected (wrapped in plastic, etc.) against possible contamination before use.
- Abrasive measures should only be applied to surfaces that are not critical for operation of devices being returned to working condition.

DECONTAMINATION OF EQUIPMENT AND TOOLS

- Electric power tools should not be used on a wet working surface. Liquids will be kept away from electric power tools.

3.1.2 Limitations

The following limitations apply to decontamination activities:

- Protective clothing worn by the personnel involved in decontamination activities as determined by the RSOR.
- Decontamination cleaning solvents/solutions shall only be used in accordance with the directions and limitations listed on the manufacturer-supplied MSDS.
- Contamination controls shall be observed throughout a decontamination operation.
- Radiation and contamination surveys shall be performed in accordance with the provisions of SOP 001, Radiation and Contamination Surveys.
- Release of equipment and tools from the decontamination area shall be performed in accordance with SOP 003, Release of Materials and Equipment from Radiologically Controlled Areas.

3.2 Pre-Decontamination Preparation

The following steps shall be used for pre-decontamination preparation:

1. The RSOR, or designee, shall review available data regarding the item(s) requiring decontamination and develop a decontamination approach based on conditions of the Radiation Work Permit (RWP) and the cost-effectiveness of the operation versus disposal costs.
2. A radiological survey shall be performed to identify the level of radioactive contamination that is present by an RCT on objects that are to be removed from a controlled area.

3.3 Establishment of Decontamination Areas

The RSOR, working with the Project Manager, shall determine a location for setup of decontamination areas. As applicable to the specific decontamination activity being performed, a decontamination area may consist of and contain one or more of the following (as needed):

- Covered floor surfaces. A double-layer of HERCULITE (or equivalent) may be laid on the floor at the direction of the RCT.
- Covered (HERCULITE or equivalent) wall surfaces.
- Engineering controls (high-efficiency particulate air [HEPA] ventilation, vacuum cleaners, containment tent walls, glove bags, etc.). Engineering controls shall be determined on the basis of the *as low as reasonably achievable* (ALARA) philosophy.
- Safe, sturdy work stations with contamination-resistant surfaces; tables that will support decontamination attempts on heavy pieces of equipment.

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- Adequate lighting.
- Electrical and compressed air supply for the operation of electrical and/or pneumatic-driven equipment.
- Overhead lifting equipment.
- Adequate supply of approved cleaning solutions and solvents; adequate supply of decontamination equipment such as:
 - Light-duty decontamination equipment such as paper wipes, paper towels, masslin towels, etc.
 - Medium- to heavy-duty decontamination equipment such as scrub pads, wire brushes, steel wool, files, sandpaper, etc.
 - Fully stocked hand tool kit for disassembly of contaminated equipment
 - Power tools such as drills, saws, needle-guns, electric screwdrivers, etc.
 - Radioactive material storage bags and stickers
 - Buckets, barrels, or drums for the storage of contaminated liquids, sludges or slurries
 - Blotter paper or sorbent
 - Approved absorbent material such as oil dry
 - Storage drums/bags for the storage of contaminated protective clothing
 - Proper surveillance instruments (air monitor/sampler, contamination monitor, friskers, exposure rate meter, etc.)
 - Adequate supply of personal protective clothing, gloves, respiratory equipment
 - A designated area within the decontamination area for the segregation of radioactive waste
 - Fire extinguisher(s)

3.4 Item Preparation for Decontamination

Contaminated or controlled items should always be escorted under the direction of a RCT to the decontamination area.

If an item is wrapped, position it so that the written information on the wrapping is visible and then perform the following:

- The RCT shall direct the removal of the item from the wrapping in such a manner (rolling plastic wrapping inside out, etc.) to control the spread of contamination.
- An item that is highly contaminated with removable contamination may need to be misted with an approved liquid to minimize the possibility of creating airborne contamination.
- Once the item has been removed from the wrapping and has been properly positioned, discard the wrapping as radioactive waste.

The following conditions shall be considered for the decontamination of equipment and tools:

- Any equipment with inaccessible areas shall be dismantled so that all surfaces are accessible for decontamination and survey.
- Decontamination shall be performed in a safe, effective manner.
- The RSOR shall be notified immediately if the job conditions change (e.g., suspected asbestos is found, the presence of mercury in a switch or a light bulb, a fluid leak, or any other special circumstances).
- A fire watch shall be assigned to watch if any spark-producing decontamination techniques (grinding, etc.) are used. There shall be a dedicated fire extinguisher located within the decontamination area.
- The decontamination area shall remain organized and free of debris. The Radiological Control/ Decontamination Technicians shall “clean as they go.”
- Air monitoring for airborne radioactivity shall be conducted, as needed, or directed by the RSOR.
- A HEPA vacuum cleaner may be used during the decontamination operation.

3.5 Decontamination of Removable Contamination

When an item is properly positioned for decontamination and the pre-survey activities have been completed, the RCT will perform one or more of the following activities in accordance with the decontamination action approach approved by the RSOR:

- Moisten the surface of the item with an approved liquid.
- Fold a paper or cloth wipe into sections. Using one surface of the wipe, gently wipe contamination off in one direction away from the user's body to reduce the possibility of personnel contamination.
- Re-fold the paper or cloth wipe so that a clean surface is available to prevent cross-contamination and continue until item is ready for survey.
- For some equipment or tools, duct tape will effectively remove removable contamination. Wrap the duct tape loosely around the gloved hand, adhesive side out. Roll the tape over the contaminated area.

3.6 Decontamination of Fixed Contamination

There are many techniques that can be used to remove fixed contamination. The general idea is to remove the material that is fixing the activity to the surface, or remove a very thin layer of the surface material. It is very important to note that fixed contamination decontamination methods can, and do, result in the creation of removable surface contamination. This creates a condition that may generate airborne radioactive materials. The activities should be controlled in such a manner that airborne radioactivity is minimized. Air sampling shall be performed during these operations to properly evaluate any resultant airborne radioactivity.

For the purposes of this procedure, the potential removal techniques have been divided into the following two categories:

- Abrasive hand decontamination

DECONTAMINATION OF EQUIPMENT AND TOOLS

Page 8 of 10

- Power tool decontamination

In addition, the following methods could be used, but are not defined in this procedure and would require the development of a Task-specific Plan or Work Instruction:

- Machine decontamination (use of abrasive bead blasters, grit blasters, high-pressure water wash systems, etc.)
- Cleaning solutions/solvents (use of ultrasonic cleaners, acid baths, electropolishing, etc.)

The actual method or combination of methods applied will be in accordance with the decontamination approach approved by the RSOR.

3.6.1 Abrasive Hand Decontamination

Abrasive hand decontamination shall be performed in the following manner:

1. Remove as much removable contamination as possible, as indicated in Section 4.5 of this procedure.
2. Moisten the surface of the item(s) to help contain contamination.
3. Use an abrasive cleaning tool (e.g., sandpaper, steel wool, steel brush, hand grinder, etc.) to loosen fixed contamination. Clean in one direction only, away from the body to prevent personnel contamination.
4. Continue to moisten the surface of the item(s) to contain contamination.
5. Remove as much of the loosened contamination as possible as per Section 4.5 of this procedure.

3.6.2 Power Tool Decontamination

Power tool decontamination shall be performed under the direction of the RCT, with concurrence from the RSOR.

3.6.2.1 Electric Power Tools

Electric power tools that may be used in decontamination operations are:

- Drills – used to drill out contaminated areas, to disassemble contaminated components, and when used with grinding wheels or disks, may be used as an abrasive tool
- Saws – used to separate contaminated pieces from clean pieces
- Grinders – used to grind fixed contamination from surfaces
- Electric screwdrivers – used in the disassembly of component parts

DECONTAMINATION OF EQUIPMENT AND TOOLS**3.6.2.2 Air-powered Tools**

Air-powered tools that may be used in decontamination operations are:

- Needle gun – a pneumatic tool that can remove contamination from concrete and/or steel surfaces
- Socket tools or impact hammer – used in disassembly of component parts
- Jackhammer/rotary hammer – a pneumatic tool which can remove contamination from concrete and/or steel surfaces

3.6.2.3 Decontamination of Power Tools

Power tool decontamination shall be performed in the following manner:

1. Remove as much removable contamination as possible, as per Section 4.5 of this procedure.
2. Moisten the surface of the item lightly to help contain contamination. Use a spray bottle for moistening.
3. Whenever feasible, the use of containment devices (e.g., glove box, etc.) should be used to contain the spread of contamination when using power tools for decontamination operations.
4. Use the power tool to remove fixed contamination. Clean in one direction only, and away from the body to prevent personnel contamination.

3.7 Post-Decontamination

Following decontamination procedures, the RCT shall perform a release survey. The survey will include the work area and any tools, equipment, and materials used during decontamination activities and shall be conducted in accordance with SOP 003, Release of Materials and Equipment from Radiologically Controlled Areas. Post-decontamination release shall be performed as follows:

1. If the item satisfies the criteria for release, remove the item to a holding area and document results.
2. If the item remains contaminated, inform the RSOR and repeat the decontamination.
3. If the item remains contaminated, attempt a third decontamination only by direction of the RSOR.

If an item cannot be effectively or economically decontaminated, the Project Manager may direct the crew to volume-reduce (reduce to component parts) the equipment, material, or tools as much as possible. If the item is expendable, the individual parts may be surveyed and released.

Any tools, equipment, or materials that cannot be decontaminated will be packaged in an appropriate waste container for subsequent disposal as radioactive waste. The waste containers will be staged in an area agreed upon by RASO and the Department of the Navy.

DECONTAMINATION OF EQUIPMENT AND TOOLS

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After decontamination operations have been completed, an RCT shall perform a release survey of the decontamination area in accordance with SOP 001, Radiation and Contamination Surveys and SOP 003, Release of Materials and Equipment from Radiologically Controlled Areas.

4.0 RECORDS

The records generated by the use of this procedure are documented in accordance with the provisions of SOP 003, Release of Materials and Equipment from Radiologically Controlled Areas.

5.0 REFERENCES

<i>Number</i>	<i>Title</i>
SOP 001	<i>Radiation and Contamination Surveys</i>
SOP 003	<i>Release of Materials and Equipment from Radiologically Controlled Areas</i>

6.0 ATTACHMENTS

None.

Standard Operating Procedure

CONTROL OF RADIOACTIVE MATERIAL

SOP-008

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

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1.0 PURPOSE

The purpose of this procedure is to specify methods and requirements for tracking and controlling radioactive material (RAM) collected or generated during survey, characterization and remediation activities at Navy facilities by Tetra Tech EC, Inc. (TtEC) and its subcontractors.

Through the use of the guidance in this procedure, TtEC and its subcontractors shall meet or exceed the requirements for its respective Nuclear Regulatory Commission or Agreement State Radioactive Materials License (RML), as applicable based on exclusive federal jurisdiction.

2.0 SCOPE

This procedure governs control of RAM on site and shall be implemented by TtEC staff and subcontractor personnel when handling RAM. The requirements given in this procedure are limited to RAM collected or generated during survey, characterization, and remediation activities.

Procedures for the preparation and labeling of RAM for shipment are beyond the scope of this document. Packaging, labeling, and shipment of RAM shall be conducted in accordance with the requirements of 49 Code of Federal Regulations (CFR) and other applicable regulations.

Radioactive waste will be packaged in an appropriate container. The waste containers will be maintained under TtEC's applicable RML, until transferred to the Navy's Low-level Radioactive Waste program.

3.0 DEFINITIONS AND ABBREVIATIONS

Container – Any package or barrier which is used to enclose RAM so that it can be easily handled and contained. Examples of containers include drums, roll-off boxes, conex boxes, fiber, metal, wooden or cardboard boxes, plastic or glass jars, metal cans, bags (ziplock or open top), plastic sheeting or any other package that meets the requirements of this definition.

Control - In relation to handling of RAM, control is defined as having physical custody, being in the immediate vicinity of, or in line-of sight of the RAM. Control also refers to being responsible for the securing of RAM to prevent unauthorized access.

Mixed Waste – Waste that contains a hazardous waste component and a RAM component.

Radioactive Material (RAM) – For purpose of activities at naval facilities, RAM is defined as any material (e.g. soil, demolition debris, etc.), solid samples or swipes, or equipment (tools, instruments, etc.), that has a radioactive component (fixed or

removable) at or above the levels specified in Table 6-1 or the project specific Sampling and Analysis Plan.

Radioactive Materials Area (RMA) – Any designated area where RAM is stored or used. Posting of an RMA is not required if the RAM is stored inside a posted, radiation area, contaminated area or airborne radioactivity area.

Radiologically Controlled Area (RCA) – An area to which access is controlled in order to protect individuals from exposure to radiation and radioactive materials and/or to prevent the release of radioactive materials to the uncontrolled areas.

Samples – Aliquots (portions) of material deposited on or placed within a container for the purposes of transferring and performing a quantitative or qualitative analysis of that material.

4.0 PROCEDURE DETAILS

4.1 Classification and Identification of Radioactive Material

4.1.1 Radioactive Material Limits

Table 4-1 identifies the limits of contamination for defining RAM. Activity concentrations defining RAM are the release criteria listed in the project-specific SAP.

TABLE 4-1

RELEASE LIMITS FOR MATERIALS AND EQUIPMENT

Radiation Type	Release Limits ¹ (Fixed) (dpm per 100 cm ²)	Release Limits ¹ (Removable) (dpm per 100 cm ²)
Alpha (α) Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	20
Beta (β -) Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000	200
Beta-Gamma (β - γ) Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others	5,000	1,000

noted above.		
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Notes:

¹ These limits are based on AEC Regulatory Guide 1.86 (AEC, 1974)

Abbreviations and Acronyms:

AEC – Atomic Energy Commission

cm² – square centimeter

dpm – disintegrations per minute

4.1.2 Identification of Radioactive Material

Determination of whether or not to classify material or equipment as RAM waste is accomplished by surveying and/or sampling the material or equipment. In the absence of survey data, material originating from impacted areas or RCAs shall be classified as RAM and handled accordingly until proven otherwise by instrument survey or laboratory analysis.

4.1.3 Mixed Waste

Mixed waste may be encountered or generated during remediation or decontamination activities. If the radiological and chemical components in the waste can be easily separated by physical means, this shall be done to allow for each component to be handled separately. Work to be performed shall be conducted to minimize mixed waste. Chemicals used for chemical decontamination activities shall be selected to minimize the creation of mixed waste. When it is impossible to segregate hazardous and radioactive components of materials or equipment designated for disposal, then the item(s) must be handled as a mixed waste. Applicable precautions and guidance for handling both RAM and hazardous material must be used for mixed wastes.

4.2 Storage of Radioactive Material

Radioactive material must be stored in a posted area as specified below to communicate the material hazard present to personnel that may encounter the material. Posting will be done in accordance with SOP 012, *Radiologically Restricted Areas – Posting and Access Control*. RAM waste shall be containerized, whenever possible, or otherwise protected and stored in pre-authorized areas determined concurrently by the Radiological Affairs Support Office (RASO) and the Remedial Project Manager. Control must be maintained over all RAM to minimize personnel exposure and the spread of contamination. Requirements for containerizing, posting, and control of RAM are given below.

4.2.1 Containerizing

To the greatest extent possible, RAM waste should be containerized for storage. To facilitate containerization, equipment that can be disassembled should be broken down into the smallest number of components practical. Sharp edges or projections should be blunted, taped or otherwise secured to ensure that the package will maintain integrity during subsequent handling operations.

If object size does not allow for disassembly and containerization is not possible, then a plastic covering can be used to minimize the potential for the spread of contamination.

For bulk items, such as soil stockpiles, where containerization is not practicable, the materials will be placed on an impervious material and covered to prevent the spread of the material.

Items that exceed 100 times the limits in Table 4-1 should be packaged such that two barriers exist (i.e., double-wrapped or bagged inside a rigid container).

4.2.2 Posting

Posting will be done in accordance SOP 012, *Radiologically Restricted Areas - Posting and Access Control*

RAM waste that is stored in a building requires that the entrances to the building be posted as an RCA, and a cordoned off area within the building posted as the RMA. If RAM waste is stored in stockpiles or in large containers that are stored outdoors, the stockpiles or containers shall be located within an RCA. The immediate area around the stockpile or containers will be cordoned off and posted as an RMA.

4.2.3 Control

The control of RAM shall be performed in accordance with the provisions of 10 CFR 20, Standards for Protection Against Radiation; SOP 012, *Radiologically Restricted Areas – Posting and Access Control*, SOP 003, *Release of Materials and Equipment from Radiologically Controlled Areas*, SOP 0007, *Decontamination of Equipment and Tools*.

Radioactive material should be consolidated in common RMAs to the greatest extent possible to simplify the implementation of adequate materials control. RMAs posted because of potentially radiologically impacted material that has not been remediated need not have locked entrances. Control of RMAs with containerized RAM will include security measures (i.e., locks, fencing, packaging, etc.) to preclude unauthorized access to or removal of RAM. Access shall also be controlled to prevent non-radiation workers from gaining entry to RMAs. RMAs with containerized RAM will be inspected at least once a week by an RCT. RCTs shall note the physical status of RMAs noting:

- Locked/secure status

- Labeling/posting
- Condition of containers

4.3 Radioactive Waste Inventory Management

A radioactive waste inventory (RWI) program will be used to track RAM waste generated during survey and remediation activities. The program includes the provision for regular inventory checks. The specific requirements for inventory management are given in the following sections.

4.3.1 Container/Stockpile Inventory

If material is not immediately transferred to a Low Level Radioactive Waste contractor, a running inventory of materials in a container will be kept on the container. Stockpile inventories will be kept in the TtEC site trailer. Inventories of material in a container or stockpile will be kept on the Stockpile/Container Inventory Log Sheet, or equivalent, (Attachment 1). The log sheet will be updated as material is added to containers or stockpiles.

4.3.2 Records

TtEC will maintain reports including the following information for RAM waste:

- Point of origin
- Storage location
- Removal Date
- Waste description
- Isotope and activity (If known)
- Other hazardous constituents (If known)
- Quantity or volume
- Waste packaging dates
- Any additional comments

TtEC will maintain a master RAM inventory at each project site. The RSOR will ensure the inventory is updated at least weekly.

4.4 Disposition of Radioactive Material

Disposition of RAM collected during remediation, surveys, or generated through site activities will either be disposal or reduction in volume by decontamination. The considerations for these two activities are discussed below.

4.4.1 Decontamination

In some instances, it may be possible to reduce the volume of RAM by decontaminating items contaminated with RAM to levels at which the item no longer needs to be

classified as RAM. The guidance for determining if decontamination is appropriate and for actually performing decontamination is given in SOP 007, *Decontamination of Equipment and Tools*.

Any former RAM that has been decontaminated to levels below those requiring classification as RAM shall have any RAM labels removed or otherwise defaced such that the wording and radiation symbol are no longer legible. Additionally, the status of any inventoried RAM that has been decontaminated shall be updated on the associated data sheets and in the RWI to indicate that it is no longer an actively tracked RWI item.

4.4.2 Disposal

Unwanted RAM will be disposed of as LLRW. Preparation of material for disposal and actual disposal shall be conducted under the approved procedures of a licensed waste broker through the Navy Low-Level Radioactive Waste Disposal Program. The status of RAM waste that has been disposed of and removed from the site shall be updated on inventory data sheets and in the RWI to indicate that the item is no longer in storage on site.

5.0 RECORDS

Weekly waste inventory reports will be retained as records. Additionally, an electronic RWI containing a master list of all RAM waste on site shall be maintained as part of the project files.

6.0 REFERENCES

Number	Title
AEC Regulatory Guide 1.86	<i>Termination of Operating Licenses for Nuclear Reactors</i>
10 CFR 20	<i>Standards for Protection Against Radiation</i>
SOP 012	<i>Radiologically Restricted Areas – Posting and Access Control</i>
SOP 003	<i>Release of Materials and Equipment from Radiologically Controlled Areas</i>
SOP 007	<i>Decontamination of Equipment and Tools</i>

7.0 ATTACHMENTS

Attachment 1 – Stockpile/Container Inventory Log Sheet

Attachment 2 – Radioactive Waste Inventory Log Sheet

Standard Operating Procedure

AIR SAMPLING AND SAMPLE ANALYSIS

SOP-009

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
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11/15/12

Date

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1.0 PURPOSE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors to perform air sampling and to document the results. Results will be used to determine what respiratory protection, if any, is required for the work area.

Air sample analysis will be performed by trained personnel using approved procedures specific to the alpha and beta radiation counting equipment. Further discussion of sample analysis is not within the scope of this procedure.

2.0 SCOPE

This procedure will be used for all TtEC and subcontractor radiological air sampling activities supporting field projects, regardless of the organization performing the work. Results will be used to determine respiratory protection requirements, and assign dose to workers from inhalation and/or ingestion when necessary.

3.0 DEFINITIONS AND ABBREVIATIONS

Airborne Radioactivity Area – A room, enclosure, or area in which airborne radioactive material is dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases, exist in concentrations:

- In excess of the derived air concentrations (DACs) specified in the Code of Federal Regulations (CFR), Title 10 Part 20, Appendix B; or
- To such a degree that an individual present in the area without respiratory protection could exceed, during the hours that the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-HR.

Annual Limit on Intake (ALI) – The annual limit on intake (ALI) is the derived limit for the quantity of radioactive material taken into the body of a worker by inhalation or ingestion in a year.

Breathing Zone – That region adjacent to the worker's mouth and nostrils from which air is drawn into the lungs while he/she performs his/her assigned work. Air taken from this region will represent the air the worker is breathing while he/she works. The samples collected to assess breathing zone concentrations are normally collected from an area within 12 inches of the face.

Derived Air Concentration (DAC) – DAC is the concentration of a given radionuclide (as specified in 10 CFR 20, Appendix B) in air which, if breathed by the "reference man" for a working year (40 hours per week for 50 weeks) under the conditions of light work (inhalation rate of 1.2 cubic meters of air per hour), results in an intake of one ALI.

DAC-HR – The product of the concentration of radioactive material in air (expressed as a multiple of the DAC for each nuclide) and the time of exposure to that nuclide, in hours. Two-thousand DAC-HRs represents one ALI.

Grab Sample – A random, single sample taken over a short period of time (dependent upon flow rate) and based upon the minimum volume required.

High-volume Air Sample – Air sample taken at an air flow rate of 5 cubic feet per minute (cfm) to 30 cfm.

Lapel Sampler – A battery-operated portable air sampler with a sample collector fastened near the breathing zone.

Low-volume Air Sample – Air sample taken at an air flow rate of 1 cfm to 5 cfm.

Particle – An aggregate of molecules forming a solid or liquid ranging in size from a few molecular diameters to some tenths of millimeters (several hundred microns).

Representative – Having the same quality and characteristics of the entire volume from which a sample is drawn.

Sample – A representative portion of an atmosphere of interest, or one or more separated constituents from a representative portion of an atmosphere.

4.0 PROCEDURE DETAILS

Air samples will be taken in areas with the potential to exceed ten (10) percent of the DAC for any radionuclide.

Ambient air monitoring equipment shall be placed in locations representative of the airborne contamination in the work location.

Data obtained from air monitoring shall be used for assessing the control of airborne radioactivity in the workplace and to evaluate the dose equivalent to radiation workers from internal sources.

Process or other engineering controls (e.g., containment or ventilation) shall be used, to the extent practicable, to control the concentration of radioactive material in air.

Air samplers shall be operated in accordance with the manufacturers' operation and calibration procedures.

Filters of different air samples shall be placed in a separate envelope, polybag, or other suitable container to ensure that there is no possibility of cross-contamination.

During collection and handling of air samples, caution must be used to prevent the samples from being contaminated by other sources of radioactive material.

4.1 Precautions

Avoid unnecessary contamination of air sampling equipment through the use of plastic coverings and care in handling. Do not cover the air intakes or exhausts on air samplers.

Avoid unnecessary exposure when conducting air monitoring surveys by using as *low as reasonably achievable* (ALARA) practices.

Air samplers used in confined spaces may ignite explosive gases. Extreme care shall be exercised, including prior sampling of the atmosphere for explosive gas and oxygen content.

Samples should be taken in such a manner as to not contaminate the sample filter with materials that are not airborne, or by sucking up loose contamination from surfaces near the sampling head. Caution should be used to minimize producing airborne material by the exhaust of the sampler.

When air sample results exceed 10 percent of the DAC value, report this information to the Radiation Safety Officer Representative (RSOR) (or qualified designee) immediately. Also, consideration should be given to isotopic analysis and area access restriction/posting.

4.2 Type of Air Samples

4.2.1 General Area Air Samples

General area air samples provide data representative of the work area for determining if the area should be controlled as an airborne radioactivity area. Samples are normally taken over a short period of time ranging from an hour, up to one or more days. This type of sample is:

- Taken on a routine basis at predetermined times and locations, as specified by the Radiation Work Permit (RWP) or other work documents
- Uses a low-volume air sampler
- Consists of a minimum of 100 cubic feet (ft³) (2,832 liters) of air passed through the sample filter
- Collected at between 3 and 6 feet above the floor level, in the vicinity of the workers performing the fieldwork
- Analyzed for alpha and beta activity

4.2.2 Grab Samples

Grab air samples are taken to evaluate the concentration of airborne radioactive radionuclides during the relatively short sampling period. This type of sample is useful for estimating the instantaneous or peak concentration, of airborne contamination. This type of sample is:

- Taken, as needed, during radiological work coverage at the discretion of the Radiological Control Technician (RCT), or as directed by the RSOR
- Uses a high-volume air sampler
- Consists of a minimum of 100 ft³ (2,832 liters) of air passed through the sample filter
- Collected in the vicinity of the workers performing the fieldwork

- Analyzed for alpha and beta activity

4.2.3 Breathing Zone Air Samples

Breathing zone air samples provide data representative of the concentration of airborne radioactive material that a worker would be breathing during a particular task. This type of sample:

- Is used during the work activities with widely varying airborne contamination concentrations across the work area
- Uses a small portable air sampler with sample head attached on the worker's collar or alternate method in which to take the sample from this location (e.g., extended tubing attached to a low volume air sampler).
- The sample head is usually positioned within 12 inches of the worker's face
- Consists of a minimum of 50 ft³ (1,416 liters) of air passed through the sample filter
- Is analyzed for alpha and beta activity

4.3 Air Sampling Procedures

4.3.1 General

Sample types, number, locations, and volumes will be collected as specified in an RWP or other work document.

Samples will be surveyed with a portable alpha/beta survey meter before placing in an envelope or baggie. If the survey indicates the presence of contamination that exceeds background, appropriate steps will be taken to determine the source of contamination and to secure the area.

Samples will be analyzed, as a minimum, for gross alpha and beta-gamma and determination (if any) of the DAC.

If sample analysis indicates airborne contamination which exceed 10 percent of a DAC, appropriate steps will be taken to determine the source of contamination and secure the area, and notify the RSOR. The RSOR will notify Radiological Affairs Support Office (RASO) upon validation of the air sample analysis.

The Air Sample Identification Record (Attachment 1) and Personal Air Monitoring Log (Attachment 2) provide examples of air sampling record sheets. Equivalent or electronic forms, which provide at a minimum the information on these forms, may be used.

Air samples will be preserved and archived after analysis.

4.3.2 General Area Air Sampling

1. Determine the requirements for air sampling prior to initiating any work activities. This may be done by reviewing the Work Plan, RWP, discussion with the RSOR (or designee), Project Manager (PM), and/or workers assigned to the task.

2. Test the functionality of the air sampling equipment prior to entering the work area. Check for current dates on calibration tags and recent calibration of the sampler flow meter. Any equipment not functioning properly, or with calibrations out of date, will not be used. Notify the RSOR (or designee) of any equipment that does not function properly.
3. Gather essential supplies before entering the work area. This may include:
 - Extension cords
 - Air sample filters
 - Tongs (if necessary)
 - Additional gloves
 - Air sample envelopes
 - Pen or marker
 - Backup air sample equipment
4. Record the following information on the air sample envelope:
 - Sample identification number
 - Date
 - Location
 - Air sampler identification number
 - Start time
5. Place the air sampler on a stable surface 3 to 6 feet from the ground, in the vicinity of the workers performing the field activities.
6. Place an unused sample filter into the sample holder, using care not to contaminate the filter with material on the tongs or gloves used to hold the filter while placing it into the holder. If the sampler has been in the contaminated area for some time, it is good practice to clean any visible debris or dust from around the sampler filter holder housing before placing the unused filter into the holder.
7. Operate the air sampler for the predetermined time. Verify the sampler flow rate, if a flow meter is provided on the sampler. Record any deviation from the predetermined flow rate.
8. If not provided with an automatic shut-off timer, turn the air sampler off as soon as practical after the predetermined sampling time has elapsed.
9. Prior to removing the sample from the holder, survey the sample using a hand-held alpha and beta contamination survey meter. Note the activity observed on the outside of the sample envelope.
10. If the sample survey indicates the presence of radioactive contamination and the area is not already controlled as an airborne radiation area, stop work, notify the RSOR (or designee), and implement appropriate controls, including postings. Record sample information on the sample envelope, place the sample in the envelope, and immediately send to the project laboratory for immediate analysis and percent DAC determination.
11. Using caution not to knock debris or dust from the sample filter holder housing onto the air sample, remove the air sample from the holder using clean gloved hands or clean tongs.

12. Place the sample into the sample envelope, using caution not to scrape or remove contamination from the surface of the sample.
13. Record the following information on the air sample envelope:
 - Stop time
 - Sample volume
 - Sample pump flow rate
14. Analyze and determine percent DAC.
15. On Attachment 1, Air Sample Identification Record (or equivalent including electronic), note the sample analysis information provided by the laboratory as soon as the data is available, including:
 - Alpha count results [microCuries per milliliters ($\mu\text{Ci}/\text{mL}$)]
 - Beta count results ($\mu\text{Ci}/\text{mL}$)
 - Percent DAC
16. Complete Attachment 1 by transcribing the information from the sample envelope to Attachment 1 and initialing.
17. Report any higher than normal, higher than expected, greater than 10 percent of the DAC, or trending upward results to the RSOR (or designee) immediately.

4.3.3 Breathing zone Air Sampling

The following steps will be taken for breathing zone air sampling:

1. Determine the requirements for breathing zone air sampling prior to initiating any work activities. This may be done by reviewing the Work Plan, RWP, discussion with the RSOR, PM, and/or workers assigned to the task.
2. Assemble the individual breathing zone air sampler sets. Make sure that all hoses are firmly seated in the hose connectors found on the sample head and sample pump. Make sure that the sample head is not cracked or damaged in any way. Set any damaged or unusable equipment aside and notify the RSOR (or designee).
3. Note the relative size of the individual to whom the sampler will be issued. It may be necessary to replace the standard length belt with a longer belt, or chain two belts together to achieve the required length. Make sure that the belt buckle is not damaged and will function properly to restrain the sampler around the worker. Set any damaged or unusable equipment aside and notify the RSOR (or designee).
4. Test the functionality of the air sampling equipment prior to entering the work area. Check for current dates on calibration tags and recent calibration of the sampler flow meter. Any equipment not functioning properly, or with calibrations out of date, will not be used. Notify the RSOR (or designee) of any equipment that does not function properly.

Note: Only use a sample pump containing a battery that is known to be fully charged.
5. Insert a new, unused sample filter paper into the sample head and tighten the sample head. Take care not to damage the filter paper or the sample head during this operation.
6. Prior to issuing any equipment to a worker, instruct the worker to:

- Refrain from touching or tampering with the pump or the sample head;
 - Leave the work area if the sampler fails and note the stop time;
 - Contact the RCT for assistance when leaving the work area and at completion of work.
7. Prior to issuing any equipment to a worker, enter the following information on Attachment 2, Personal Air Monitoring Log:
 - Wearers' Name
 - Wearers' social security number
 - Sampler ID number
 - Date
 8. Attach the personal breathing zone air sampler to the worker. Make sure that the belt is tight, but not uncomfortable.
 9. Attach the sample head to the worker. Make sure that the sample head is clipped securely to the worker's lapel or other piece of clothing close to the worker's face. Make sure that opening in the end of the sample head is unobstructed.
 10. Check the hose connecting the sample head to the sample pump. Make sure that the hose is not kinked, crimped, or folded. Make sure that the hose is not in a position where it may become kinked, crimped, or folded during work. Make sure that it will not interfere with routine work. If any of these conditions are found, reorient the hose. It may be necessary to find alternate places to position the sample head or sample pump so the hose is unobstructed.
 11. Upon arrival at the work location, turn the pump ON. Note the START TIME and flow rate on Attachment 2, Personal Air Monitoring Log.

Note: Make sure to note whether flow rate is in units of cfm or lpm.
 12. Every time a worker leaves the work area, turn the sample pump OFF and note the stop time. Upon re-entering the work area, turn the sample pump back ON and make a new notation of the re-start time.
 13. At the end of the sampling period (end of the task, or end of the shift), turn the pump OFF and note the stop time on Attachment 2, Personal Air Monitoring Log.
 14. Calculate the total time that the sample pump was operating by adding together the operating periods of time.
 15. Calculate the total sample volume by multiplying the operating time by sampler flow rate. The result may be in units of cfm or lpm.
 16. Record the total sample volume on Attachment 2, Personal Air Monitoring Log. Note the appropriate units (cfm or lpm) on Attachment 2, Personal Air Monitoring Log.
 17. Select a clean, unused sample envelope. Label the envelope with the following information:
 - Sample ID number
 - Date
 - Location

- Worker name
 - Total sample volume (use the appropriate units – cfm or lpm)
18. Open the sample holder, using caution not to remove or add to the contamination on the sample.
 19. Prior to removing the sample from the holder, survey the sample using a hand-held alpha and beta contamination survey meter. Note the activity observed on the outside of the sample envelope.
 20. If the sample survey indicates the presence of radioactive contamination, and the area is not already controlled as an airborne radiation area, stop work, notify the RSOR, and implement appropriate controls, including postings.
 21. Using caution not to knock debris or dust from the sample filter holder housing onto the air sample, remove the air sample from the holder using clean gloved hands or clean tongs.
 22. Place the sample into the sample envelope, using caution not to scrape or remove contamination from the surface of the sample.
 23. Confirm that the information on the sample envelope matches the information in Attachment 2, Personal Air Monitoring Log.
 24. Analyze and determine percent DAC.
 25. On Attachment 2, Personal Air Monitoring Log, note the sample analysis information provided by the laboratory as soon as the data is available, including:
 - Alpha count results ($\mu\text{Ci/ml}$)
 - Beta count results ($\mu\text{Ci/ml}$)
 - Percent DAC
 26. Complete the Attachment 2, Personal Air Monitoring Log.
 27. Report any higher than normal, higher than expected, or trending upward results to the RSOR (or designee) immediately.

4.3.4 Documentation

Air samples shall be documented using either an Air Sample Identification Record or Personal Air Monitoring Log (or equivalent).

5.0 REFERENCES

None

6.0 ATTACHMENTS

Attachment 1, Air Sample Identification Record

Attachment 2, Personal Air Monitoring Log

Standard Operating Procedure

ISSUE AND USE OF RADIATION WORK PERMITS

SOP-010

Revision 0

Approved By:



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Corporate Health Physics Manager

11/15/12

Date

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1.0 PURPOSE

This procedure is used to specify the general requirements for preparing, issuing, and using radiation work permits at field locations. The procedures presented below may be supplemented by Tetra Tech EC, Inc. (TtEC)-approved subcontractor procedures, and specific work documents.

2.0 SCOPE

This procedure will be used by TtEC personnel and its subcontractors for preparation and issuance of radiation work permits used on site.

In certain instances the requirements of this procedure may need to be added to or modified for specific field operations. Additional requirements and guidance for these cases will be provided in work-specific documents, will be subject to the same review process as this document, and will have precedence over the guidelines in this document as appropriate.

A Radiation Work Permit (RWP) will be required for:

- Personnel entry into a Radiologically Controlled Area (RCA)
- Personnel entry into an area where air concentrations could exceed 10 percent of the derived air concentration (DAC) for a specific radionuclide.
- At the discretion of the Radiation Safety Officer Representative (RSOR) or representative

This procedure describes the radiological surveys required to generate an RWP and provides guidelines to specific protective measures required based upon the radiological conditions in the work area.

In addition to RWPs written to cover specific work tasks, general RWPs (GRWPs) may be created for tasks such as tours or survey/remediation activities in areas in which a worker is not expected to receive 100 mrem annual total effective dose equivalent. In such cases, the GRWP should not span a time period of greater than 6 months. GRWPs do not have the requirement for an Access Log (Attachment 2).

3.0 DEFINITIONS AND ABBREVIATIONS

Airborne Radioactivity Area (ARA) – A room, enclosure, or area in which radioactive material is dispersed in the air in the form of dusts, fumes, particulates, mists, vapors or gases, and where the concentration of the dispersed radioactive materials is in excess of:

- The derived air concentrations (DACs) specified in Table 1, Column 3 of Appendix B, Title 10 Part 20 of CFR.
- Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI).

Contaminated Area (CA) – Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 20 percent of the contamination limits provided in Attachment 1 (Table 1).

General Radiation Work Permit (GRWP) – A Radiation Work Permit created for tasks such as tours or surveys/remediation activities in areas in which a worker is not expected to receive in excess of 100 mrem annual total effective dose equivalent. These tasks are typically ongoing, for routine tasks and require minimal anti-contamination personal protection equipment.

Non-Workers – Any persons entering an area covered by a work specific RWP or a general RWP whose sole purpose is only for observation or other tasks, not directly related to the work outlined in the RWP. Individuals that are escorted inside an area covered by a job-specific RWP are exempt from the requirements of this procedure. The Radiation Safety Officer Representative (RSOR) has sole discretion in determining who qualifies to be a non-worker.

Radiation Area (RA) – Any area accessible to individuals in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 millisievert) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates.

Radiologically Controlled Area – An area to which access is controlled in order to protect individuals from exposure to radiation and radioactive materials and/or to prevent the release of radioactive materials to the uncontrolled areas.

Specific Radiation Work Permit (SRWP)– A Radiation Work Permit created for tasks in areas in which a worker could reasonably receive in excess of 100 mrem annual total effective dose equivalent (based on current radiological surveys) and/or contamination areas and/or airborne radioactivity areas. These tasks are typically finite in duration (less than one month), for non-routine tasks and require additional anti-contamination personnel protection equipment and/or monitoring.

Total Effective Dose Equivalent (TEDE) – TEDE is the sum of the DDE (external dose) and the committed effective dose equivalent (internal dose).

4.0 PROCEDURE DETAILS

4.1 General

4.1.1 Criteria for Initiating Radiation Work Permit

An RWP is required when entering radiologically impacted areas (i.e., RCAs, RMAs, radiation areas, contaminated areas, airborne radioactivity areas).

4.1.2 Planning and Prerequisites

4.1.2.1 Planning the RWP

The RSOR, or designee initiates the RWP process by filling in the General Information section of the RWP. The accepted form to use for an RWP is included as Attachment 4 of this document. The RSOR enters the effective date (date the RWP was initiated) and the expiration date that will correspond to the estimated completion date for the project.

The RSOR, or designee, completes the Task section of the RWP. This includes an estimate of the number of personnel required for each task and the number of personnel-hours that will be spent inside a RCA. A detailed description is encouraged but not required, and can be attached to the RWP. Work performed in areas with different radiological conditions should be listed as

ISSUE AND USE OF RADIATION WORK PERMITS

different tasks. This may not become apparent until after the surveys performed to support preparing the RWP are completed.

The RSOR, or designee:

- Obtains and reviews any previous surveys performed in the work area.
- Obtains all information available on the identity, form, and quantities of radionuclides present in the work area.
- Reviews facility drawings, if available, to determine ventilation flows, component and equipment layouts, and building structures which can be used for contamination barriers.

The Site Superintendent meets with the RSOR, or designee, to discuss the nature of the work to be performed, the specific components or equipment to be worked on, the positions the personnel may take to perform the work, the possibility of releasing radioactive contamination during the work activities, and the potential for changing radiation exposure rates as work progresses.

The RSOR, or designee, selects the necessary instrumentation, equipment and protective clothing to perform surveys in the work area. If contamination is expected in the work area, equipment to be taken into the work area may be wrapped to prevent contamination of equipment.

If anticipated contamination levels are above the limits given in Table 1 (Attachment 1) for classification of an area as a contaminated area, contamination controls will be established before entry into the area to prevent the spread of contamination upon exiting.

4.1.2.2 The RWP Pre-job Survey

Safety hazards that may be encountered during the work are evaluated (confined space entry, electric equipment or mechanical equipment requiring lock-out tags, falling objects, bumping hazards, slippery surfaces, fire hazards, etc.). An analysis of each hazard and precautions to be taken shall be documented and provided to personnel prior to entry into the area.

RCTs obtain radiation exposure rates in the area where the personnel will be positioned during work activities as required. The adjacent area is surveyed to identify any locations where elevated readings are observed and a route to the work area is established. Readings are recorded on survey forms, as specified in procedure SOP 001, Radiation and Contamination Surveys.

Swipe samples are obtained from the work area, adjacent areas, and along the route to the work area in sufficient quantity to adequately design work controls to maintain exposures ALARA. RCTs will rely on their professional experience or consultation with the RSOR, or designee, to determine what constitutes "sufficient quantity." Swipe samples and air samples collected in the area are then processed and recorded on survey forms, as specified in procedure SOP 001, Radiation and Contamination Surveys.

The issuance of an RWP for work in an ARA will require air sampling to be done as part of the RWP. Air sampling is conducted in accordance with SOP 009, Air Sampling and Sample Analysis.

The RCT who surveyed the work area and obtained information from prior surveys, when available, records the exposure rates measured during the survey of work area on survey forms, as specified in procedure SOP 001, Radiation and Contamination Surveys.

4.2 Procedure Process

4.2.1 Specifying Worker and Work Site Requirements

Based on and the data obtained from the pre-job survey and factoring in anticipated contamination conditions in the area, the RSOR, or designee, determines the quantities to specify in Radiological Limits section of the RWP. Limits should be specified as an order of magnitude bound (i.e., whole-body exposure < 10 mrem/ hour) that would not be expected to be exceeded under normal working conditions. Space is provided for clarifying remarks or other specific points of note. The radiological limits will govern the work to be done under the RWP. If, at any point during the work, the limits are known to be exceeded, then work must cease and the RWP must be modified or a new RWP must be issued to reflect the current radiological conditions. A well-selected limit will be one general enough to avoid unnecessary stoppages of work, while still protecting worker safety per the ALARA philosophy.

Next, the RSOR, or designee, determines the types of protective clothing required to be used by personnel performing prescribed tasks, the respiratory protection requirements, dosimetry requirements, and monitoring requirements and indicates them under the protection requirements section of the RWP. Finally, any additional training requirements for personnel and the need for ALARA briefings or reviews are noted on the RWP.

Determinations of protection requirements are to be performed by the RSOR, or designee, using their professional judgment and in accordance with industry standard practices and appropriate regulatory guidelines. Air monitoring is required if it is likely that airborne contamination may be present or created (i.e., during excavation and demolition) during work activities. Work activities will be stopped if the concentrations of airborne contaminants exceed 10 percent of the DAC.

4.2.2 Special Instructions

Special instructions associated with personal protective clothing, dosimetry, monitoring and inspection, respiratory protection, training or ALARA are indicated in this section of the RWP.

4.2.3 Review and Approvals

The RSOR and SHSS, or designees, as a minimum, shall approve the RWP prior to work. The SHSS shall verify that relevant non-radiological safety considerations are addressed. When the non-radiological concerns of the SHSS have been adequately addressed, the RSOR will approve the RWP.

RASO shall be notified if any of the following atypical work site conditions are anticipated:

- An individual TEDE exceeding 500 mrem
- The collective TEDE for the job exceeding 1 rem
- Individual airborne exposures exceeding 10 DAC-hours in a 7-day period
- General area exposure rates exceeding 200 mrem/hour

ISSUE AND USE OF RADIATION WORK PERMITS

- Contamination levels exceeding 10 times the limits requiring classification of an area as a CA.

The check boxes in the approval section will be marked to indicate which of the approvers is required for each particular RWP. Any mandatory approver may prescribe changes to the draft RWP prior to final approval.

4.2.4 Using the Radiation Work Permit

A pre-job briefing is held with the individuals performing the work described in the RWP. The following topics are discussed in the pre-job briefing:

- Complete descriptions of the work tasks to be performed, and methods to minimize exposures to radiation and contamination while performing these work tasks.
- Discussions of the radiation, contamination, and airborne radioactive materials in the work area, and situations which could result in increased levels of these components.
- Health and safety issues which could be encountered during work activities.
- Emergency procedures and responsibilities.
- Discussions of the protective equipment requirements and the monitoring requirements.

The RSOR, or designee, compiles the current year dose for the individuals performing RWP work to verify that the radiation exposure received during the work activities will not result in the individuals' dose exceeding administrative limits. The individuals' current radiation exposures will be listed on Radiation Work Permit Authorization Log (Attachment 3).

Each individual entering the RWP work area is required to understand the RWP and to sign the Radiation Work Permit Authorization Log, indicating that the individual understands the provisions of the RWP, is aware of his/her current year dose, and will comply with the RWP requirements.

An RWP that covers work to be performed at a field site or in a building shall have an Access Log (Attachment 2) appended to the RWP. RWPs that cover general work areas are not required to have an access log, but an access log may be appended to the RWP if desired.

In cases where an Access Log is used, the RCT (or individual) logs the time the individual entered the work area, along with the reading on the individuals Pocket Ion Chamber (PIC) or Direct Reading Dosimeter (DRD), if worn. The RCT (or individual) also indicates if the individual wore a respirator during the work activities.

When an individual who signed in on a Radiation Work Permit Access Log exits the work area, the RCT (or individual) logs the time the individual leaves the area, and the individual's DRD reading, if worn. If the individual returns to the work area, another signature entry (and corresponding line entries) must be made on the Radiation Work Permit Access Log.

As previously noted, if the radiological limits listed on the RWP are exceeded at any point during a prescribed work task, then all work shall be stopped until the RWP can be modified to address the over-limit condition, or a new RWP is issued.

ISSUE AND USE OF RADIATION WORK PERMITS**4.2.5 Modifying the Radiation Work Permit**

In the event of changes to the conditions or scope of the work that do not justify the generation of a new RWP, modifications to the RWP may be made by the RSOR. No more than two modifications can be made to an RWP before a new RWP must be issued. Modifications to the RWPs will be reviewed and approved in accordance with the initial requirements, as specified in Section 4.2.3 above.

To modify the RWP, each change is made with a single line cross-out of the text or item. The RSOR, or designee, must initial and date adjacent to each change.

The RSOR, or designee, must communicate all changes to the individuals working under the RWP.

4.2.6 Terminating the Radiation Work Permit

The RWP is terminated when the end date of the RWP is reached, or can be terminated by one of the following reasons:

- The job has been completed.
- There is a significant change in the scope of work.
- There is a significant change in the radiological conditions.
- The RWP is revised.

When the RWP is terminated before the end date, a single line is drawn through the end date and a new end date recorded in its place. The person terminating the RWP initials adjacent to the change. Extension of the end date of the RWP must be done per the change procedure noted in the previous section. The RWP can be terminated by the RSOR or designee. As part of the termination of an RWP, the Post-job Radiological Conditions and Closeout Review sections of the RWP shall be completed.

To complete the Post-job Radiological Conditions section, the RCT shall conduct a survey of the work site governed by the RWP. This survey should be conducted in a manner similar to the pre-job survey and should include determination of the current measurements for all quantities obtained in the pre-job survey. In addition, if personnel monitoring was in effect during work under the RWP and/or an individual was found to have contamination above the monitoring limits, then the appropriate checkbox should be marked.

At a minimum, the closeout review will be conducted by the RSOR. As part of the closeout review, the reviewer(s) shall verify that associated records for the RWP are noted on the RWP form and that they are present in the project files. Reviewers shall also determine if there were any lessons learned that might be of value to future work to be performed on site. If so, then lessons learned synopsis shall be written and communicated/incorporated to project personnel.

5.0 RECORDS

Radiation Work Permit Access Log

Radiation Work Permit Authorization Log

Radiation Work Permit.

6.0 REFERENCES

<i>Number</i>	<i>Title</i>
AEC Regulatory Guide 1.86	<i>Termination of Operating Licenses for Nuclear Reactors</i>
SOP 001	<i>Radiation and Contamination Surveys</i>
SOP 009	<i>Air Sampling and Sample Analysis</i>

7.0 ATTACHMENTS

Forms provided in this section illustrate the minimum requirements for their respective subject matter. Alternative documents may be used, providing the information is presented in a clear and concise manner and the content meets or exceeds the information required to complete these documents.

Attachment 1 – Table 1 Contamination Limits Table

Attachment 2 – Radiation Work Permit Access Log

Attachment 3 – Radiation Work Permit Authorization Log

Attachment 4 – Radiation Work Permit

ATTACHMENT 1

TABLE 1
CONTAMINATION LIMITS TABLE

Radiation Type	Release Limits ¹ (Fixed) (dpm per 100 cm ²)	Release Limits ¹ (Removable) (dpm per 100 cm ²)
Alpha (α) Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	20
Beta (β -) Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000	200
Beta-Gamma (β - γ) Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	1,000

Notes:

¹ These limits are based on AEC Regulatory Guide 1.86 (AEC, 1974)

Abbreviations and Acronyms:

AEC – Atomic Energy Commission

cm² – square centimeter

dpm – disintegrations per minute

ATTACHMENT 3 – RADIATION WORK PERMIT AUTHORIZATION LOG

RWP NUMBER: _____ **REVISION:** _____ **DATE:** _____

WORK LOCATION: _____ **START DATE:** _____ **END DATE:** _____

Worker Name	Employee ID Number	Current year TEDE (mrem)	*Signature	RCT Authorization	Date

* By my signature, I indicate that I have read, understand, and will comply with all requirements of this RWP.

ATTACHMENT 4 – RADIATION WORK PERMIT

Tetra Tech EC, Inc.

RSOR USE ONLY	
Permit Number	
Effective Date	Expiration Date

RADIOLOGICAL WORK PERMIT

GENERAL INFORMATION (to be completed by the Requestor)					
Requested by (Name & Project)		Date	Phone No.	Site Mailing Address	
Work Location		Work Area	Building/Site	Extent	Room No.
Work Plan	Health & Safety Plan	Contract Number	Expected Start Date	Expected End Date	
Tasks to be performed inside an RCA (add attachment if necessary)				Estimated No. Personnel	Estimated No. Personnel-hours
RADIOLOGICAL LIMITS (to be completed by the RCT)					
<input type="checkbox"/> Anticipated radiological conditions			<input type="checkbox"/> See Attached Map		
Surface Contamination (dpm/100 cm sq)			External Dose Rate (mrem/hr in work area)		
	Direct	Swipe	LAS (Large Area Swipe)	Beta + gamma	
Alpha	_____	_____	_____	Neutron	_____
Beta/gamma	_____	_____	_____	Total (b + g + n)	_____
Tritium	_____	_____	_____		
Airborne Radioactivity			DAC	<input type="checkbox"/> Anticipated or <input type="checkbox"/> Measured	
Radionuclide(s)					
Completed by	Name	Signature	ID Number	Date	
ALARA/RADIOLOGICAL PROTECTION REQUIREMENTS (to be completed by RCT)					
Protective Clothing Requirements		<input type="checkbox"/> None	<input type="checkbox"/> Rubber Overshoes	<input type="checkbox"/> Double Coveralls	
<input type="checkbox"/> Lab Coat	<input type="checkbox"/> Skull Cap	<input type="checkbox"/> Hood	<input type="checkbox"/> Double Gloves	<input type="checkbox"/> Plastic Coverall	
<input type="checkbox"/> Gloves	<input type="checkbox"/> Booties	<input type="checkbox"/> Single Coverall	<input type="checkbox"/> Double Booties	<input type="checkbox"/> Tape Openings	
<input type="checkbox"/> Other: _____					
Respiratory Requirements		<input type="checkbox"/> None	<input type="checkbox"/> Combination cartridge*	<input type="checkbox"/> Chemical cartridge*	
<input type="checkbox"/> Powered Air Purifying Respirator	<input type="checkbox"/> Ventilation	<input type="checkbox"/> Air Line Respirator*	<input type="checkbox"/> SCBA*		
<input type="checkbox"/> Negative Pressure Respirator	<input type="checkbox"/> Supplied air suit*	<input type="checkbox"/> Bubble Hood*	* Requires Health & Safety approval		
<input type="checkbox"/> Other: _____					
Dosimetry Requirements		<input type="checkbox"/> None	<input type="checkbox"/> WB dosimeter	<input type="checkbox"/> Supplemental dosimeter	
<input type="checkbox"/> TLD finger rings	<input type="checkbox"/> Special neutron dosimetry	<input type="checkbox"/> Pu access list	<input type="checkbox"/> Alarming dosimeter		
<input type="checkbox"/> Bioassay sample	<input type="checkbox"/> Whole-body count	<input type="checkbox"/> Accident dosimeter	<input type="checkbox"/> Nasal swipes		
<input type="checkbox"/> Other: _____					
Monitoring Requirements		<input type="checkbox"/> None	<input type="checkbox"/> Notify RCT before job starts		
<input type="checkbox"/> Intermittent coverage	<input type="checkbox"/> Personnel before leaving job	<input type="checkbox"/> Equipment and tools before removal			
<input type="checkbox"/> Continuous coverage	<input type="checkbox"/> RCT monitor doffing of PCs	<input type="checkbox"/> Air monitoring			
<input type="checkbox"/> Self-frisking	<input type="checkbox"/> Other: _____				
Additional Training Requirements					
<input type="checkbox"/> ALARA Pre-job briefing			<input type="checkbox"/> ALARA review (see attachments)		
Completed by RCT	Name	Signature	Employee ID Number	Date	
<input type="checkbox"/> Completed					

SPECIAL INSTRUCTIONS (to be completed by the RCT)				
<i>Special Instructions:</i>				
Completed by RCT <input type="checkbox"/> Completed	Name	Signature	ID Number	Date
APPROVALS				
1. RSOR <input type="checkbox"/>	Name	Signature	ID Number	Date
2. SHSS <input type="checkbox"/>	Name	Signature	ID Number	Date
3. <input type="checkbox"/>	Names	Signatures	ID Numbers	Date
<input type="checkbox"/>				
POST-JOB RADIOLOGICAL CONDITIONS (to be completed by the RCT/HPT)				
Measured Radiological Conditions (Record all readings as highest / general area)				
	Surface Contamination (dpm 100 sq cm)			<input type="checkbox"/> See attached map
	Direct	Swipe	LAS (large area swipe)	External Dose Rate (mrem/hr in work area)
Alpha	_____	_____	_____	Beta + gamma _____
Beta/gamma	_____	_____	_____	Neutron _____
Tritium	_____	_____	_____	Total (b + g + n) _____
Airborne Radioactivity DAC _____		<input type="checkbox"/> Estimated or <input type="checkbox"/> Measured	Survey of Personnel Leaving Job Site <input type="checkbox"/> Personnel contaminated above applicable limits <i>(If yes, attach the Radiological Incident Report)</i>	
Completed by RCT <input type="checkbox"/> Completed	Name	Signature	ID Number	Date
REVIEW				
Associated reports for this job (indicate the ones that apply):				
<input type="checkbox"/> CAM Results	<input type="checkbox"/> Job-specific air monitoring	<input type="checkbox"/> Pre-job survey data	<input type="checkbox"/> Post-job survey data	<input type="checkbox"/> Finger ring data
<input type="checkbox"/> Special dosimetry results	<input type="checkbox"/> Other: _____	<input type="checkbox"/> Nasal swipe data	<input type="checkbox"/> Bioassay sample(s)	<input type="checkbox"/> Whole Body Count(s)
		<input type="checkbox"/> Wound count	<input type="checkbox"/> Skin contamination	<input type="checkbox"/> Personal clothing survey
		<input type="checkbox"/> RWP acknowledgement log	<input type="checkbox"/> Dose tracking report	<input type="checkbox"/> Radiological occurrence/incident report
		<input type="checkbox"/> ALARA Pre-job briefing	<input type="checkbox"/> Formal ALARA review	<input type="checkbox"/>
<input type="checkbox"/> Lessons Learned		(If Yes, then briefly explain. Add attachment(s) if necessary)		
Reviewed by RCT <input type="checkbox"/> Reviewed	Name	Signature	ID Number	Date
Reviewed by RSOR (or designee)	Name	Signature	ID Number	Date

Standard Operating Procedure

GAMMA SCREENING OF TRUCKS USING THE STATIONARY PORTAL MONITOR AND USING PORTABLE SURVEY INSTRUMENTATION

SOP-011

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

11/15/12

Date

**GAMMA SCREENING OF TRUCKS USING THE STATIONARY
PORTAL MONITOR AND USING PORTABLE SURVEY
INSTRUMENTATION****REVISION HISTORY**

<i>Revision (Date)</i>	<i>Rev. No</i>	<i>Prepared By</i>	<i>Description of Changes</i>	<i>Affected Pages</i>
11/15/12	0	E. Abkemeier	Original	All

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**GAMMA SCREENING OF TRUCKS USING THE STATIONARY
PORTAL MONITOR AND USING PORTABLE SURVEY
INSTRUMENTATION****1.0 PURPOSE**

The purpose of this procedure is to provide guidelines for performing gamma radiation screening of trucks loaded with non-contaminated soils and debris leaving the site using a Ludlum Model 3500-1000RMW portal monitor or equivalent. The purpose of the portal scan is to protect against the inadvertent shipment of materials exhibiting elevated radiation levels. In other words, the scan serves only to release the contents of the truck and not the truck itself. This procedure also covers hand screening of trucks using portable survey instruments.

2.0 SCOPE

This procedure describes the appropriate methods for using the portal monitor and portable survey instruments to perform gamma radiation screening of trucks loaded with non-radioactive soils and debris that will be transported to recycling centers, landfills, and other licensed disposal facilities.

3.0 DEFINITIONS AND ABBREVIATIONS

None.

4.0 PROCEDURE DETAILS**4.1 General****4.1.1 Precautions**

The following precautions will be used:

- The detector alarm set point will be set not to exceed the setting of 8.5 deviations above background at the location of the portal monitor at Alameda Point. Any change to this set point will be directed by the site RSOR with the concurrence of RASO.
- Trucks should adhere to the required pauses and speed indicated in Section 4.2 of this procedure when passing through the detectors. Failure to carefully follow these requirements will result in invalid or incomplete screenings and will cause the screening to have to be repeated.

4.1.2 Limitations

The following limitations will be in place:

- Calibration shall be performed annually, after maintenance is performed or if the instrument fails the performance test or if proper operation is in question. Calibration is to be conducted by the manufacturer per the manufacturer's instruction manual.
- Setup and daily performance tests will be conducted in accordance with the operating manual for the Ludlum Model 3500-1000 portal monitor. Only one performance test need be performed per day if the monitor will be turned on and off throughout the day.

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4.2 Portal Monitoring Screening

NOTE: The system continuously monitors radiation when the portal is occupied and compares the readings to the alarm level determined by using an average of the background levels. If the alarm threshold is breached, the audible and visual alarms will be activated.

When using the Ludlum Model 3500-1000RMW for gamma screening surveys of trucks loaded with soils and/or debris, an RCT trained in the operation of the Model 3500-1000RMW will be present to monitor the instrumentation. The RCT's training on portal monitor must be officially documented and said documentation shall be verified by the RSOR before assigning an individual to operate the portal monitor.

The following steps will be used for portal monitor screening:

1. Turn the instrument to the "on" position if not already on.
2. Ensure that the green lights on the "Power OK" and "System OK" are illuminated. If both lights are not illuminated, contact the RSOR.
3. Record the date, time, type of material, material location (origin of material) and license plate of the vehicle on the Truck Survey Log (Attachment 1).
4. Have the truck advance toward the detector slowly until the occupancy sensor is tripped.
5. Inform the truck driver to proceed slowly through the detectors. The rate of travel should be as slow as possible (not to exceed 3 miles per hour). If the truck is traveling too fast, a red over speed light will illuminate on the instrument panel.
6. If the over speed light illuminates, request that the truck driver proceed forward and turn around to restart the screening process. Wait for the instrument to be manually reset before proceeding.
7. While the truck is passing through the detectors, a green "checking" light will illuminate to tell the operator that the infrared motion detectors are operating properly. When the truck completes its pass (indicated by the checking light going off), it is necessary for the driver to pause the truck until cleared by the RCT to proceed or return for a rescreen. If the checking light repeatedly does not illuminate while a truck is passing through, have the truck stop in a convenient location nearby. Notify the RSOR that the unit is not operational. At this point, the load contents have not been released and the portal monitor will have to be repaired and the truck re-scanned or a hand survey conducted. If a hand survey is to be used, proceed to Step 1 of Section 4.3 below.
8. If the checking light illuminates and the red alarm light does not illuminate when the truck has completed a pass, record the results (clean) under the Pass 1 column on Attachment 1 and proceed to Step 14. In the event that the red alarm light illuminates, let the truck continue through the detectors and record results (alarm) under the Pass 1 column on Attachment 1 and continue at Step 9.

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9. Inform the truck driver that it will be necessary to pass through the detectors again to confirm the alarm. Direct the truck driver to reposition the truck for another pass through the detector.
10. Push the reset button (if necessary). If the checking light illuminates and the red alarm light illuminates, let the truck continue through the detectors and record results (alarm) under the Pass 2 column on Attachment 1 and proceed to Step 13. In the event that the red alarm light does not illuminate, let the truck continue through the detectors and record results (clean) under the Pass 2 column on Attachment 1 and continue at Step 11.
11. Inform the truck driver that it will be necessary to pass through the detectors again to confirm the alarm. Direct the truck driver to reposition the truck for another pass through the detector.
12. Push the reset button (if necessary). If the checking light illuminates and the red alarm light does not illuminate when the truck passes through, record the results (clean) under the Pass 3 column on Attachment 1 and proceed to Step 14. In the event that the red alarm light illuminates, let the truck continue through the detectors and record results (alarm) under the Pass 3 column on Attachment 1 and continue at Step 13.
13. Inform the truck driver that the load is not releasable and follow the steps in Section 4.4 below. Indicate "Ret." under the Disposition header of the Truck Survey Log to indicate the load has been returned and initial the appropriate line on the Truck Survey Log. Have the truck driver initial the log as well. Subsequent truck surveys can now be conducted beginning at Step 1 above.
14. The truck load can be released. Indicate "Rel." under the Disposition heading on the Truck Survey Log and sign next to the appropriate row. Have the truck driver initial the log as well. Subsequent truck surveys can now be conducted beginning at Step 1 above.

4.3 Hand Screening

In instances where the portal monitor malfunctions while a truck is being surveyed or if the portal monitor is inoperable, a hand survey will be required. Hand-held gamma instruments (Ludlum Model 2350-1 with Ludlum Model 44-10 2 inch by 2 inch sodium iodide (NaI) detector or equivalent) used to survey trucks should be operated in accordance with the requirements of Appendix SOP 002, Preparation of Portable Radiation and Contamination Survey Meters and Instruments for Field Use and any applicable requirements from work-specific documents. Surveys should be performed in an area that is convenient to the workplace traffic flow. The area should be sufficiently isolated from any potential sources of radiation and allow the technician to obtain easy access to all sides of the vehicle. It is anticipated that when hand surveys are necessary, they will be conducted adjacent to the location where the portal monitor has been installed; however, an alternate location may be used. The following steps will be performed for a hand survey:

1. In an area adjacent to where the trucks are being screened and known to be free of radioactive material, establish a background count rate and record it on the Radiological Truck Survey Form for Portable Instruments (Attachment 2). If multiple

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surveys are to be performed in a single area, then the background only needs to be established once for that area.

2. The end of the detector should be held approximately 4 inches from the surface of the truck containing the load when performing surveys.
3. Move the detector over the surface of the truck or containers in a serpentine pattern at a rate of approximately 0.5 meter per second (m/sec) covering 100 percent of the surface of the sides, the undercarriage, and the rear portion of the truck where the load is contained. Extra scrutiny should be used for any areas that result in significant increase in the audible signal of the meter. For maximum readings as specified on Attachment 2, the technician performing the survey will use experience and judgment to take a meter level reading at the point of greatest audio response for the given side/area being surveyed.
4. When taking a reading for a maximum count-rate on a given side/area, read the meter after sufficient response time has elapsed (i.e., the meter needle is relatively stable and the audible count rate is relatively stable).
5. If radiation levels above 10,000 cpm are identified, the RSOR and Radiological Affairs Support Office (RASO) will be notified. Document the survey results on the appropriate survey form (Attachment 2). Inform the truck driver that the load is not releasable and follow the steps in Section 4.4 below.

4.4 Protocol for Trucks Failing to Receive Portal Monitor or Hand Survey Clearance

When a truck causes two or three portal monitor alarms in three passes, or fails a hand screening using portable survey instrumentation, the truck will not be released off-site. The RSOR shall be contacted immediately and apprised of the situation. The following steps shall then be taken in response to a truck that does not receive portal monitor clearance:

1. Copies of the portal monitor output for all passes resulting in an alarm shall be retained by the operators for inclusion with the truck survey log.
2. The offending truck, with load in place, shall initially be subjected to a hand survey per the procedures in Section 4.3. If a hand survey has already been completed and documented per the procedures in Section 4.2, proceed to step 4 below.
3. A hand survey log shall be completed and also appended to the truck survey log. The purpose of the hand survey is to identify if elevated areas of radiation exist that may indicate the presence of radioactive material. Particular attention should be given to the area of the truck that caused the alarm according the portal monitor (i.e. Alarm in back).

NOTE: If a hand survey does locate an area of elevated activity, immediate notification should be given to the RSOR who will inform RASO.

4. All rejected trucks shall be directed to an appropriate rejected truck pile pad and dumped to further characterize and survey the material. Material should be placed on a visqueen liner or other surface to prevent the spread of potential contamination.

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NOTE: If multiple contractors exist on an installation, the truck will be sent to an area controlled by the contractor from which the load originated. More than one rejected truck pile pad may exist at each installation.

5. Rejected truckload piles must be kept segregated until the pile has been surveyed, sampled, and the results have been reviewed by the RSOR, with concurrence from RASO.
6. Trucks that dump their loads shall be scanned upon exiting the impacted area and the empty truck will be rerun through the portal monitor. If the truck does not alarm the portal monitor, it is free to return to service. If the empty truck alarms the portal monitor, RASO and the RSOR shall be notified and all portal monitor operations shall be temporarily halted pending resolution by RSOR and RASO concurrence.

NOTE: Trucks that have material removed due to elevated measurements during portal monitor or portable instrument surveys shall have truck tires surveyed for contamination in accordance with SOP 001, Radiation and Contamination Surveys.

7. The truckload pile will be rescanned by hand. The pile shall be spread into a 6" laydown and a hand survey shall be conducted. Any sources located during the rescan of a rejected truckload pile require notification to be given to the RSOR, who will notify RASO. Pile disposition will be determined by the RSOR or designee with RASO concurrence. If no sources are found, a minimum of two samples shall be taken from the pile and sent for gamma spectroscopic analysis. Samples will be collected at areas exhibiting radiation equal to or greater than 3 sigma plus background. If radiation measurements do not exceed 3 sigma plus background, the samples will be selected from two areas exhibiting the largest gamma readings. All areas exhibiting a gamma radiation count rate exceeding 10,000 cpm will be sampled.
8. If the sample results do not indicate the presence of any of the radionuclides of concern above the release limits, then the stockpile can be either reloaded and run through the portal monitor again or aggregated with an existing clean stockpile. If the sample results indicate one or more radionuclides above the release criteria, the entire load shall be placed into a waste bin for further characterization and offsite disposal.

5.0 RECORDS

A Truck Survey Log, provided as Attachment 1, will be generated and retained in the permanent project file as a result of using this procedure. Multiple entries can be made on the same survey form for trucks that do not set off the alarm on the detector.

If a hand survey is performed a separate survey form Attachment 2 will be used.

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6.0 REFERENCES

<i>Number</i>	<i>Title</i>
SOP 001	Radiation and Contamination Surveys
SOP 002	Preparation of Portable Radiation and Contamination Survey Meters and Instruments for Field Use

7.0 ATTACHMENTS

The following form is attached to this procedure:

Attachment 1, Truck Survey Log

Attachment 2, Radiological Truck Survey Form for Portable Instruments

**GAMMA SCREENING OF TRUCKS USING THE STATIONARY
PORTAL MONITOR AND USING PORTABLE SURVEY
INSTRUMENTATION**

Attachment 2
Radiological Truck Survey Form for Portable Instruments

Date:	Time:	Truck Identification (i.e. tag number):
Purpose of Survey: (include load origin)		

INSTRUMENTS USED

Model Number	Serial Number	Calibration Due Date	Background
1.			
2.			
3.			

Item Or Location	Count Rate Gross CPM	Distance or location
1. Max Reading on the sides of the vehicle		4"
2. Max Reading on the underside of the vehicle		4"
3. Max Reading on the rear of the vehicle		4"
4.		
5.		
6.		
7.		
8.		

Sketch/Diagram (optional):

Remarks:

Disposition (Released/Returned):

Surveyor (initials):	Reviewed by (signature):	Date:
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Standard Operating Procedure

RADIOLOGICALLY CONTROLLED AREAS POSTING AND ACCESS CONTROL

SOP-012

Revision 0

Approved By:



11/15/12

Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

Date

REVISION HISTORY

<i>Revision (Date)</i>	<i>Rev. No</i>	<i>Prepared By</i>	<i>Description of Changes</i>	<i>Affected Pages</i>
11/15/12	0	E. Abkemeier	Original	All

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1.0 PURPOSE

The purpose of this procedure is to specify methods and requirements for consistent posting and control of radiologically controlled areas. This procedure is intended to satisfy the posting requirements of 10 Code of Federal Regulations (CFR) 20 (1-92), Standards for Protection Against Radiation.

2.0 SCOPE

This procedure identifies the types of postings necessary and requirements to clearly identify radiological conditions in a specific area or location within an area. It also specifies the requirements for access into and egress from radiologically controlled areas. This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors to control entry and egress from radiologically controlled areas (RCAs).

3.0 DEFINITIONS AND ABBREVIATIONS

Airborne Radioactivity Area – A room, enclosure or area in which radioactive material is dispersed in air in the form of dusts, fumes, particulates, mists, vapors, or gases, and the concentration of the dispersed radioactive materials is in excess of:

- The derived air concentrations (DACs) specified in Table 1, Column 3 of Appendix B, Title 10 Part 20 of CFR.
- Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI).

Annual Limit on Intake (ALI) – The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a 1-year period. ALI is the smaller value of intake of a given radionuclide by the reference man that would result in a committed effective dose equivalent of 5 rems (0.05 sievert [Sv]) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. (ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Table 1, Columns 1 and 2 of Appendix B of 10 CFR 20.) One ALI is equivalent to 2,000 DAC-hrs.

As Low As Reasonably Achievable (ALARA) – An approach to radiation protection for the control and management of exposure (both individual and collective) to the workforce and the general public; thus ensuring a level of exposure as low as social, technical, economic, practical, and public policy considerations permit. The ALARA program is structured to increase worker awareness of exposure reduction techniques and the associated benefits of that reduction.

Contamination Area – Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors* in Table 1 (Attachment 1), but do not exceed 100 times those values.

Derived Air Concentration (DAC) – The concentration of a given radionuclide in air which, if breathed for a working year of 2,000 hours under conditions of light work (inhalation rate of 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in Table 1, Column 3, of Appendix B of 10 CFR 20 (1-92), Standards for Protection Against Radiation.

Fixed Contamination –Surface contamination exceeding the contamination limits provided in Table 1 (Attachment 1) that can not be readily removed from a surface by applying light to moderate pressure when wiping with a paper or cloth disk swipe, or masslin.

High contamination area - Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in Regulatory Guide 1.86 (Table1, Attachment 1).

Radiation Area – Any area accessible to personnel in which there exists ionizing radiation at exposure rates such that an individual could receive a deep dose equivalent (DDE) in excess of 5millirem (mrem) in 1 hour at 30 centimeters (cm) from the radiation source or from any surface that the radiation penetrates.

Radiation Work Permit (RWP) – A document generated, in accordance with Appendix K-10, Issue and Use of Radiation Work Permits, to provide specific requirements for radiological activities.

Radioactive Materials Area (RMA) – Any area or room in which there is used or stored an amount of licensed material exceeding 10 times the quantity of such material specified in Appendix C, Title 10 Part 20 of the CFR.

Radiologically Controlled Area (RCA) – An area to which access is controlled in order to protect individuals from exposure to radiation and radioactive materials and/or to prevent the release of radioactive materials to the uncontrolled areas.

Underground Radioactive Materials (URM) –An underground area that is known to contain radioactive materials such as pipelines, tanks, cribs, covered ponds, covered ditches, catch basins, inactive burial grounds and sites of known, covered spills.

4.0 PROCEDURE DETAILS

4.1 General

This procedure will address establishing and posting:

- RCAs
- RMAs
- Radiation areas
- Contamination areas
- Airborne radioactivity areas
- Underground RMAs

4.1.1 Precautions

Personnel working in a RCA shall:

- Comply with all radiation protection instructions and postings.
- Refrain from eating, drinking, smoking or chewing while in a RCA.
- Perform jobs or tasks in such a manner that minimizes the creation or spread of contamination.
- Ensure that tools and equipment are surveyed prior to removing the items from a RCA.
- Refrain from loitering in radiation areas.
- Wear dosimetry in a manner required by the RWP.
- Perform a personal contamination survey upon exit from a RCA.
- Immediately report the loss, damage or unexpected exposure of dosimetry to the RSOR.
- Notify the RCT of any wounds, sores or rashes before entering any area where contamination exists.
- Exit immediately if a wound occurs in a RCA, notify the RCT and seek first aid.
- Follow any additional requirements dictated by the RSOR or RCT.

4.1.2 Signage

All radiologically controlled areas will be designated an RCA. Additional restricted areas (such as a CA, RA, RMA, ARA) may be posted within an RCA, as necessary, to identify additional precautions that may be required.

Signs identifying radiological hazards shall be posted on all entrances and accessible sides of the barrier surrounding the identified RCA. Signs identifying radiological hazards shall be firmly attached to the barrier or entrances with materials that will withstand the effects of adverse weather and normal use conditions. If signs with the exact wording are not readily available, alternative phrases may be used as long as the same requirements are clearly communicated by the posting. Signs may be identified in English and Spanish.

4.1.3 Surveys

Radiation and contamination surveys for establishing and maintaining RCAs shall be performed in accordance with SOP 001, Radiation and Contamination Surveys.

4.2 Procedure Process

4.2.1 Establishing and Posting Radiologically Controlled Areas

RCAs shall be designated by clearly and conspicuously posting all entrances and all other accessible sides of the area with a sign bearing the following:



The sign will also list requirements for entering the RCA. To enter a RCA, a person must meet all posted requirements or be escorted by a trained individual.

4.2.2 Posting Requirements for Radioactive Materials Areas

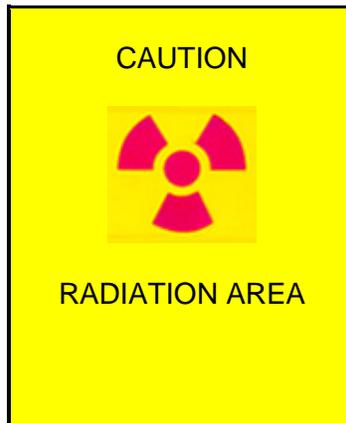
Radiation protection personnel shall post any area or room in which radioactive materials are stored or used with a sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIALS AREA."



When posting a room, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area containing the radioactive material shall be bounded by signs fastened to stanchions, posts or other sturdy structures. The signs will be positioned such that they are conspicuous when the area is approached from any accessible direction. If signs with these exact words are not readily available, alternative phrases may be used as long as the same requirements are clearly communicated by the posting.

4.2.3 Establishing and Posting Radiation Areas

Radiation protection personnel shall post radiation areas with signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA."



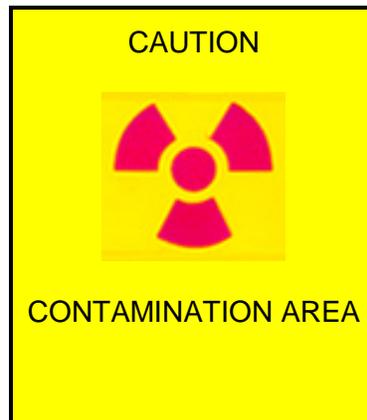
If an entire room or most of a room is at or above the 5 millirem per hour (mrem/hr) level, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area at or above the 5 mrem/hr level shall be bounded by signs fastened to stanchions, posts or other sturdy structures. The signs will be positioned such that they are conspicuous when the area is approached from any accessible direction. If a posting is placed on a door in a manner that would prevent the posting from being observed if the door is propped open, an additional posting shall be placed in the doorway.

A single entry/exit point shall be established to access the radiation area. Access into radiation areas shall be limited to radiation workers wearing dosimetry that are signed-in on an approved RWP.

4.2.4 Establishing and Posting Contamination Areas

4.2.4.1 Removable Surface Contamination

Radiation protection personnel shall post any contamination area or high contamination area with a sign or signs bearing the radiation symbol and the words "CAUTION, CONTAMINATION AREA", or "CAUTION, HIGH CONTAMINATION AREA" as appropriate.



When posting a room, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area containing the contamination shall be bounded by signs fastened to stanchions, posts or other sturdy structures. The signs will be positioned such that they are conspicuous when the area is approached from any accessible direction.

A single entry/exit point shall be established to access the contamination area. A step-off pad is placed at the entry/exit point that provides a defined boundary between contaminated and non-contaminated areas. Each contamination area that is to be entered shall have a step-off pad maintained in an uncontaminated condition located at the access/egress point.

Contamination areas, which require personnel access on a daily basis, should have a frisking station located as close to the access/egress point as is reasonably possible, taking background radiation levels and work processes into consideration. All personnel exiting a contamination area shall perform personnel contamination monitoring in accordance with the applicable RWP.

4.2.4.2 Fixed Contamination

If the area of contamination is within a RCA, the boundaries of the contamination area will be delineated in such a way to identify it for future characterization.

If the area of contamination is not within a RCA, then the area will be posted as a contamination area, as described in Section 4.2.4.1.

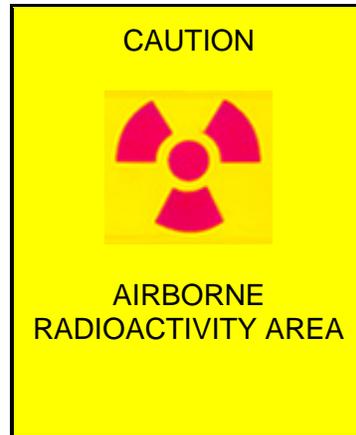
4.2.5 Establishing and Posting Airborne Radioactivity Areas

TtEC policy is to minimize the amount of radioactive materials taken into a worker's body. In order to accomplish this, Airborne Radioactivity Areas are posted at 10 percent DAC, as specified in Table 1, Column 3 of Appendix B of 10 CFR 20. Maintaining the airborne activity below these limits will eliminate any posting requirements.

To verify that the limits for airborne radioactivity are not exceeded, air sampling will be performed continuously during each work activity. The results of the air samples are compared with the limits above to verify that the limits are not exceeded. If the limits are exceeded, immediately contact the RSOR or designee.

**RADIOLOGICALLY CONTROLLED AREAS
POSTING AND ACCESS CONTROL**

Radiation protection personnel shall post any Airborne Radioactivity Area or room with a sign or signs bearing the radiation symbol and the words "CAUTION, AIRBORNE RADIOACTIVITY AREA."



When posting a room, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area containing the airborne radioactivity shall be bounded by signs fastened to stanchions, posts or other sturdy structures. The signs will be positioned such that they are conspicuous when the area is approached from any accessible direction.

4.2.6 Establishing and Posting Underground Radioactive Materials Areas

The entrance to any area (normally outside areas) shall be posted to indicate the presence of identified underground items that are known to contain radioactive materials such as pipelines, tanks, cribs, covered ponds, covered ditches, catch basins, inactive burial grounds and sites of known, covered, spills.

The entrances to the areas shall be clearly and conspicuously posted:



Underground radioactive material areas shall also be posted "Authorized Personnel, RWP Required for Entry." If signs with these exact words are not readily available, alternative

**RADIOLOGICALLY CONTROLLED AREAS
POSTING AND ACCESS CONTROL**

phrases may be used as long as the same requirements are clearly communicated by the posting.

5.0 RECORDS

Documentation generated by the implementation of this procedure shall consist of recording the date and location of any radiologically controlled, radioactive material, radiation, contaminated or airborne radioactivity areas established in the project logbook. Include a sketch of the area and area boundary on survey forms.

6.0 REFERENCES

<i>Number</i>	<i>Title</i>
SOP 010	<i>Issue and Use of Radiation Work Permits</i>
SOP 011	<i>Radiation and Contamination Surveys</i>
NRC Reg. Guide 1.86	<i>Termination of Operating Licenses for Nuclear Reactors</i>

7.0 ATTACHMENTS

Table 1

ATTACHMENT 1

TABLE 1

CONTAMINATION LIMITS TABLE

Radiation Type	Release Limits ¹ (Fixed) (dpm per 100 cm ²)	Release Limits ¹ (Removable) (dpm per 100 cm ²)
Alpha (α) Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	20
Beta (β -) Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000	200
Beta-Gamma (β - γ) Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	1,000

Notes:

¹ These limits are based on AEC Regulatory Guide 1.86 (AEC, 1974)

Abbreviations and Acronyms:

AEC – Atomic Energy Commission

cm² – square centimeter

dpm – disintegrations per minute

Standard Operating Procedure

VEHICLE TOWED ARRAY (VTA)

SOP-013

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

11/15/12

Date

REVISION HISTORY

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11/15/12	0	E. Abkemeier	Original	All

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1.0 PURPOSE

The purpose of this SOP is to specify methods and requirements for conducting consistent radiological surveys and ensuring the proper documentation of acquired data. This standard operating procedure (SOP) has been developed to conduct radiological surveys using a vehicle towed array (VTA). The VTA is used to identify surface areas (within the top 4 to 6 inches of soil depending on the gamma energy emission of the radionuclide being surveyed) that represent anomalies from local background areas. The VTA will be used to survey to generate real-time maps illustrating radioactivity responses.

The VTA is composed of off-the-shelf components and includes TSA gamma scintillation detectors, Leica Global Positioning System (GPS), TSA control system, trailer, and a small tractor. The system is capable of storing data collected, and producing site maps to illustrate instrument responses.

Adherence to this SOP will ensure that the surveys performed have reproducible results. The guidance for control of radiation exposures provided in this SOP is in accordance with the as low as reasonably achievable (ALARA) philosophy.

2.0 SCOPE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors when conducting VTA surveys for radiological contaminants.

3.0 TRAINING REQUIREMENTS

All personnel using the VTA will be trained in their task specific duties in the operation of the equipment. For example, the driver of the tractor must be trained on the operation of the detectors, and the data handler must be trained on transferring the detector data with the GPS coordinates to usable files.

4.0 GENERAL REQUIREMENTS FOR VEHICLE TOWED ARRAY

4.1 General

VTA surveys are performed to identify areas with measurable radiation, and assess the intensity and shape of areas of observed elevated radiation.

Survey results will be provided as a file of geospatially positioned data, and MS-Excel spreadsheet of the X-Y position with measurement data, and an X-Y plot of the relative intensity of the measurement results. The GPS component of the VTA system can replicate the location of gamma scintillation detector results to an accuracy of 12 inches.

VEHICLE TOWED ARRAY (VTA)**4.1.1 Equipment Required**

- Three dual frequency, high resolution Leica GPS (or equivalent) with real-time kinematic (RTK) positioning capabilities that provides fixed solution accuracy (1 to 5 cm). One GPS is for the detector positioning, one GPS is for the swath guidance system, and one GPS is for the RTK base station.
- Two TSA DA372 gamma scintillation detector assemblies
- TSA SC-770 data controller
- One Kawasaki Mule (or equivalent) with a trailer capable of mounting the detectors evenly over a variety of heights
- One swath guidance system to provide Kawasaki Mule operator ability to drive parallel lines five to six feet apart.
- Laptop computer (Tough Book equivalent)

4.1.2 Initial Set-up of the Vehicle Towed Array (VTA)

Instruments used to perform radiation and contamination surveys shall be calibrated, operated, and maintained in accordance with their manufacturer's procedures. Steps to be completed during the initial set-up phase include the following:

1. Remove the detectors, SC-770 data controller, detector cables, GPS, laptop, and power connectors from packaging.
2. Visually inspect all equipment for damage
3. Connect the detectors to the framework of the trailer in the indicated locations. The exact locations for the detectors are clearly marked on the trailer framework.
4. The detectors should be mounted in the correct position and verified using measuring tape.
5. The detectors should be mounted in a position so that the bottom of the detector is 4 inches from the ground surface.
6. The data controller and batteries will be secured in the vehicle bed or vehicle cab with provided mounting brackets and fasteners. All items in the trailer will also be secured using the appropriate safety cording.
7. Connect all the power sources and ensure they are securely connected from the detectors, data controller and GPS to the supplied power sources.
8. Connect data cables from data controller and GPS to laptop.
9. Ensure all batteries are fully charged.
10. Verify all connections are tightened.

VEHICLE TOWED ARRAY (VTA)

If any of the above conditions are unsatisfactory, the instrument shall be tagged as out of service and will not be used.

4.1.3 Initial QA/QC Setup

An initial QA/QC check is required prior to daily use of the VTA at the project site. The initial check is to verify proper systems operations.

The initial QA/QC check will be conducted as follows:

1. Ensure the system is fully operational and all of the detectors and GPS unit are powered on.
2. Perform the initial start up of the GPS unit
 - a. Go to the main menu of the GPS unit and ensure the unit is receiving base station corrections and has a fixed solution.
 - b. Check GPS configuration to ensure the unit is exporting a GGA NMEA message from appropriate port.
3. Confirm antenna height to ensure proper elevations will be recorded
4. Perform initial background setup
 - a. Find a location suitable for conducting the initial test. This location should be free from elevated radioactivity and flat. Background locations will be determined by recommendation of the RSOR and the concurrence of the RASO.
 - b. Layout the boundary of the initial background test area.
 - c. Ensure there are no radioactive sources in the immediate vicinity of the test area.
 - d. Set up the data unit to collect data on a 1 second interval, with input from the GPS unit.
 - e. Check the file input to ensure the radiation data and GPS data are both streaming.
 - f. Drive the system over the entire area at a rate not to exceed 0.5 meters per second (1.8 km/hr), with a detector height of 4 inches. Begin logging data to the GPS unit.
 - g. Calculate the average background using the data collected.
 - h. Calculate one, two and three standard deviations above the mean background using the data collected. If necessary, calculate further

deviations above mean background.

Note: In the event that the mean of the survey unit plus a specified number of standard deviations is used for investigation or remediation decisions, follow the previous “initial background set up” steps; however, perform the steps on the survey unit to be surveyed. These steps will be performed in conjunction with the VTA survey of the survey unit.

5. Perform the initial check source measurements
 - a. Ensure all sources, with the exception of the check source, have been removed from the immediate area where the initial test is being performed.
 - b. Ensure the same check source is used throughout the project.
 - c. As above, collect data as specified in Initial Background Setup with the exception of remaining stationary.
 - d. Calculate the average over 1 minute with the source under the detectors in a static condition and + or – 20 % acceptance criteria.
- 4.1.4 Operation of the VTA System
1. The unit will be source checked daily using a check source. The geometry should be the same, and the results should be within +/- 20% of the values calculated in Section 4.1.3.
 2. The survey area will be determined in the field prior to beginning the survey.
 3. The operator will drive the vehicle at a rate not to exceed 0.5 meters per second (1.8 km/hr), with detectors at a height of no more than 4 inches above the surface.
 4. Data logging and GPS measurements will be collected concurrent with the detectors being towed across the surface.
 5. The scan data will be collected at 1 second time intervals to obtain measurements required for sample density, and to preclude any time circuitry errors within the data controller.
 6. Ensure all measurement results are recorded in total counts (counts per second).
- 4.1.5 Data Collection, Storage and Processing
1. The data collected by the SC-770 data control unit and GPS unit will be collected and stored on the laptop.
 2. The operator transmits the data to the TtEC GIS technician

VEHICLE TOWED ARRAY (VTA)

3. The TtEC GIS technician correlates the data using a simple in-house program to assign GPS position data to each of the DA372 detectors. The TtEC GIS technician provides the data in the required grid coordinates (State Plane Colorado Central NAD83 feet, or as otherwise directed.)
4. The TtEC GIS technician provides a map corresponding radiological data to physical position in increasing sigma ranges.
5. RSOR (or designated individual) interprets data, delivers data to the RASO for review and makes field decisions based on relevant work documents and in coordination with RASO.

4.1.6 System Shutdown and Temporary Storage

At the conclusion of each day's activities the unit will be shutdown as follows:

1. Visually inspect the unit by doing a careful walk around. Note any items of significance, and report them to the RSOR (or designated individual).
2. Power down the GPS unit.
3. Power down the laptop.
4. Power down the data logging unit.
5. Visually inspect the detectors to ensure they are free from dirt/dust/grime. Clean as needed and in accordance with SOP 007, Decontamination of Equipment and Tools.
6. Remove the VTA electronics and properly store in an enclosed space or park the Kawasaki Mule including electronics in an enclosed space (e.g., conex).
7. Visually inspect the tractor and ensure there is no damage. Ensure all tires are properly inflated. Fill the tractor with gas, and store in the designated area.
8. Charge all electronics batteries.

5.0 SPECIFICATIONS AND LIMITATIONS**TSA Detector System****Detectors:**

Two 12" x 39" x 1.5" (30.5 x 99 x 3.8 cm) organic plastic scintillators in each cabinet, for a total detector volume of 2808 in³ (46016 cm³) per system

Sensitivity:

0.2μCi of ¹³⁷Cs with a 60 second Count Time

Power:

VEHICLE TOWED ARRAY (VTA)

100 - 240V, 50 - 60Hz power at 0.5 amp

Count Time:

Adjustable

Serviceability:

Self-checking routines and easily performed tests simplify board level trouble shooting.

The modular design allows quick and easy repair and maintenance.

Weight:

Approximately 47 lb (21.3 kg) per cabinet

Dimensions:

Two, 36.3" long x 8.25" wide x 8.25" deep cabinets (92.7 x 21 x 21 cm)

Leica GPS Specifications:

GPS1200+ receivers	GX1230+ (GNSS)/ GX1220+ (GNSS)	GX1210+	ATX1230+ GNSS
Ports	1 power port, 3 serial ports, 1 controller port, 1 antenna port		1 power/controller port, Bluetooth/Wireless-Technology port
Supply voltage,	Nominal 12 VDC		Nominal 12 VDC
Consumption	4.6 W receiver + controller + antenna		1.8 W
Event Input and PPS	Optional: 1 PPS output port 2 event Input ports	Optional: 1 PPS output port 2 event Input ports	
Standard antenna	SmartTrack+ AX1203+ GNSS	SmartTrack AX1201	SmartTrack+ ATX1230+ GNSS
Built-in groundplane	Built-in groundplane	Built-in groundplane	Built-in groundplane

The following apply to all receivers except where stated.

Power supply	Two Li-Ion 4.4 Ah/7.4 V plug into receiver. One Li-Ion 2.2 Ah/7.4 V plugs into ATX1230+ GNSS and RX1250.
Plug-In Li-Ion batteries Same for GNSS and TPS	Power receiver + controller + SmartTrack antenna for about 17 hours (for data logging). Power receiver + controller + SmartTrack antenna + low power radio modem or phone for about 11 hours (for RTK/DGPS). Power SmartAntenna + RX1250 controller for about 6 hours (for RTK/DGPS)
External power	External power Input 10.5 V to 28 V.
Weights	Receiver 1.20 kg, Controller 0.48 kg (RX1210) and 0.75 kg (RX1250). SmartTrack antenna 0.44 kg, SmartAntenna 1.12 kg. Plug-In Li-Ion battery 0.11 kg (2.2 Ah) and 0.2 kg (4.4 Ah) Carbon fiber pole with SmartTrack antenna and RX1210 controller: 1.80 kg. All on pole: carbon fiber pole with SmartAntenna, RX1250 controller and plug-in batteries: 2.74 kg.

Temperature	Operation: Receiver -40° C to +65° C
ISO9022	Antennas -40° C to +70° C
MIL-STD-810F	Controllers -30° C to +65° C Controller RX1250c -30° C to +50° C
	Storage: Receiver -40° C to +80° C
	Antennas -55° C to +85° C
	Controllers -40° C to +80° C
	Controller RX1250c -40° C to +80° C
Humidity	Receiver, antennas and controllers
ISO9022, MIL-STD-810F	Up to 100% humidity.
Protection against water, dust and sand	Receiver, antennas and controllers:
IP67, MIL-STD-810F	Waterproof to 1 m temporary submersion. Dust tight
Shock/drop onto hard surface	Receiver: withstands 1 m drop onto hard surface. Antennas: withstand 1.5 m drop onto hard surface.
Topple over on pole	Receiver, antennas and controllers: withstand fall if pole topples over.
Vibrations	Receiver, antennas and controllers:
ISO9022	withstand vibrations on large construction machines. No loss of lock.
MIL-STD-810F	

6.0 REFERENCES

- 10 CFR 20 Standards for Protection Against Radiation
- NUREG-1507 Minimum Detectable Concentration/Activities for Typical Radiation Survey Instruments for Various Contaminants and Field Conditions
- GPS Standard Operating Procedure – Setting Up the Leica Base Station
- TSA Model GPRS-TT Operating and Service Manual

Standard Operating Procedure

STANDARD OPERATING PROCEDURE (SOP) 14 TRANSFER OF LOW LEVEL RADIOACTIVE WASTE TO ANOTHER CONTRACTOR FOR WASTE DISPOSAL SOP-014

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

11/15/12

Date

REVISION HISTORY

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11/15/12	0	E. Abkemeier	Original	All

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**TRANSFER OF LOW LEVEL RADIOACTIVE WASTE TO
ANOTHER CONTRACTOR FOR WASTE DISPOSAL****1.0 PURPOSE**

The purpose of this procedure is to provide guidelines for transfer of Low Level Radioactive Waste (LLRW) items, material and soil to a contractor designated by the Navy to accept LLRW.

2.0 SCOPE

This procedure describes the requirements for transfer of LLRW to the onsite LLRW contractor. This procedure covers the documents and information required for an LLRW transfer.

3.0 DEFINITIONS AND ABBREVIATIONS

None.

4.0 PROCEDURE DETAILS**4.1 General**

All LLRW transferred from Tetra Tech control to an LLRW waste contractor will be documented on the attached LLRW Transfer Form (Attachment 1) (or equivalent).

4.2 Transfer Requirements

LLRW that is transferred to another contractor will be documented on Attachment 1 (or equivalent). The information provided will be at a minimum:

- a. Discrete items will have a survey on file that includes the isotope/s of concern, gamma dose rate on contact and at 30 centimeters, the fixed and removable alpha and beta/gamma dpm/100 cm². This information will be recorded on the LLRW Transfer Form along with the item number and estimated activity. The Site Radiation Safety Officer Representative (RSOR) will be informed prior to the transfer of discrete items to ensure that the site inventory is updated.
- b. Material and equipment will be documented with the same information as indicated above, with the exception of estimated activity and will include pertinent information about the material or equipment in the comment box.
- c. The information required in item 1 above will not be required to be filled out on the Transfer Form for trash and debris disposed of as LLRW. The number of cubic yards of material and the type of material disposed of will be documented on the Transfer Form. The comment box will indicate trash and debris. Note that an estimate of activity will not be included.
- d. Soil data documented on the Transfer Form will include the estimated volume of soil in cubic yards. The bin number that the soil is placed into will be recorded in the comment box of the Transfer Form.

The following steps will be used for transferring material, equipment and soil:

1. The Tetra Tech representative and the waste contractor representative will meet prior to transfer to agree that the LLRW is acceptable for disposal in the LLRW

**TRANSFER OF LOW LEVEL RADIOACTIVE WASTE TO
ANOTHER CONTRACTOR FOR WASTE DISPOSAL**

contractors shipping container. As an example, liquids should not be placed in a container that is not approved for liquids.

2. If both contractor representatives agree that the material is acceptable for transfer both individuals will sign the Transfer Form prior to the release of the LLRW.
3. Once the LLRW is placed into the shipping container, it becomes the responsibility of the waste contractor and will be removed from the Tetra Tech inventory.
4. If the material has to be transferred back to Tetra Tech, such as when a bin is overweight, a new entry will be made in the LLRW Transfer Form to correct the previous entry, i.e., for the soil that is placed into a new container.

If radioactive items are removed from the Tetra Tech Radioactive Materials Area (RMA) a new weekly survey of the container/storage area will be completed to document the exposure rate levels at the perimeter of the RMA.

5.0 RECORDS

The Transfer Form provided as Attachment 1, will be generated and retained in the permanent project file as a result of using this procedure.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

The following form is attached to this procedure:

Attachment 1, LLRW Transfer Form

Standard Operating Procedure

USE OF THE BERKELEY NUCLEONICS CORPORATION SAM-940-3G RADIOISOTOPE IDENTIFIER

SOP-015

Revision 0

Approved By:



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

11/15/12

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1.0 PURPOSE

This procedure is used to specify the requirements for operation of the Berkeley Nucleonics Corporation (BNC) SAM-940-3G radioisotope identifier connected to a Model 6998, 3-inch by 3-inch sodium iodide scintillation detector. The procedures presented below will be used for survey of elevated field locations and radioactive devices discovered as a part of TtEC contract operations at Navy sites. Results of surveys will be used to assist in radionuclide identification, particularly for radionuclide identification and waste characterization.

2.0 SCOPE

This procedure will be used by TtEC personnel and its subcontractors for use of the SAM-940-3G to identify isotopes associated with elevated field locations and radiological devices discovered during contract operations including, but not limited to, survey of discrete items found during excavation operations as well as surveying contaminated locations in the field. This procedure is intended to provide general instructions for setup, gross calibration, background determination and sample analysis of the SAM-940-3G.

In certain instances the requirements of this procedure may need to be added to or modified for specific field operations. Any changes required will be approved by the site RSOR prior to operation of the SAM-940. This procedure is developed only for the use of the SAM-940. Personnel assigned to use the SAM-940 must be trained by the Radiation Safety Officer Representative (RSOR) or their designee prior to using the instrument. **Refer to the SAM-940 Instruction Manual for specific information on the operation of the instrument.**

3.0 PROCEDURE DETAILS

3.1 Calibration

Instrument calibration shall be performed using measuring and test equipment and National Institute of Standards and Technology (NIST) traceable sources. Calibrations will be performed at an accredited calibration laboratory. Calibration will be performed in accordance with the equipment manufacturer's manuals or a subcontractor's TtEC-approved procedure. Properly calibrated instruments shall include a calibration certificate.

Calibration shall be performed annually (± 15 days) or on a schedule consistent with the manufacturer's recommendation if more restrictive. The routine frequency may be extended by up to one additional month with written approval of the RSOR, or designee. In addition to the routine frequency of performance, calibration shall be performed under the following conditions:

- Prior to placing a new instrument into service.
- After any major repair or alteration to the instrument or detector.

3.2 General Considerations

The compact flash card unique to the instrument must be inserted in the SAM-940 prior to operation. The instrument will not operate without the compact flash card installed. The compact flash card contains operational information for the SAM-940; therefore, the card cannot be interchanged with any other instrument's compact flash card. Assure that the compact flash card has the correct SAM-940 and detector serial number that match the

instrument. Prior to operation of the instrument, the date and time should be set in accordance with the user's manual.

Pre-operational setup of the instrument will be done in accordance with the BNC Model 940 Instruction Manual. Pre-operational setup of the SAM-940 includes an auto calibration process that must be performed in a low background location such as an office location. After the instrument is operational, a coarse calibration should be done using a 0.5 to 5 microcurie (uCi) Cs-137 check source. The coarse calibration requires the use of the Cs-137 check source to verify that the instrument is identifying gamma peaks in the proper energy channels. The instrument should be allowed to warm up/stabilize for 30 minutes prior to conducting any gamma analyses.

The SAM-940 is most efficient for identifying isotopes at a range of 3,000 to 5,000 counts per second (cps). When possible, discrete radioactive items should be removed from the field and surveyed in a low background Radioactive Materials Area (RMA). The SAM-940 should be positioned at an optimum distance from the item being surveyed to achieve a count within this range (nominally 4,000 cps). As a result, the count rate and dose rate identified in the SAM-940 analysis results reports may be similar for the majority of the reports. Some of the items may not have sufficient activity to generate counts greater than 3,000 cps; therefore, these items should be counted at the maximum contact count rate achievable.

When surveying a location, such as an excavation in the field, the instrument will be taken to that location. Once the highest area of radiation has been located, the instrument will be positioned at a distance above the soil to obtain a count rate of approximately 4,000 cps. In cases where this count rate cannot be reached, a measurement may still be taken with the understanding that the statistical quality of the data is not ideal.

3.3 Determination of Instrument Background

The SAM-940 subtracts the background reading from the survey; therefore, background determination must be performed in an area with similar characteristics to the area the survey is to be conducted. For controlled environments where devices will be surveyed, the background location may be the same location as the survey location. A five minute background and count time should be sufficient for accurate detection of isotopes commonly encountered. For field identification, the background measurement should be performed in a location near the area to be surveyed to eliminate effects from naturally occurring radiation.

The background should always be measured for the same period as the count time. The background and coarse calibration analysis reports will be saved and included with the analysis reports for the devices or locations evaluated.

3.4 Instrument Operation

The following is a detailed discussion of the operation of the SAM-940-3G. **The BNC SAM-940 Instruction Manual must be referenced to determine how a specific operation is to be performed.** Personnel using the instrument must be trained in its operation prior to use. Attachment 1 should be used to document all survey information required below:

- If using the instrument in the field, ensure that the battery is charged prior to operation.

- For bench type operations, the instrument may be operated using the AC power adapter.
- Insert the compact flash card. The instrument will not operate unless the compact flash card is installed.
- Turn on the SAM-940 and wait for the “autocal” process to complete.
- Check to ensure that the date and time are correct.
- Conduct the coarse calibration using a Cs-137 check source and document the analysis report number on the survey log.
- Proceed to the background location and measure a background gamma spectrum. The standard background gamma spectrum collection time is five minutes, but this time may be altered in order to obtain better results with RSOR approval. Document the analysis report number on the survey log.
- Set the SAM-940 to the count time. The standard gamma spectrum collection time is five minutes, but this time may be altered in order to obtain better results with RSOR approval.
- Place the SAM-940 in front of the item or location being analyzed at a distance that generates approximately 4,000 cps.
- Some locations and devices may not have sufficient activity to generate 4,000 cps. If 4,000 cps cannot be generated, put the SAM-940 as close to contact as possible with the item or location, and start the count. If the count rate drops below 300 cps, the analysis report may not be statistically reliable for radionuclide identification.
- After the count has finished, review the analysis report to determine if the report is acceptable
- A recount may be necessary if the analysis report has extraneous information (e.g., radionuclides that logically cannot be present due to short half-lives).
- Record the required information of the survey in Attachment 1 (or equivalent), and recount if necessary, or continue to the next item or location and follow the steps indicated above.
- Provide the survey log and the analysis reports to the RSOR or designee for evaluation.

3.5 Maintenance

Instruments shall be stored in areas which prevent damage by movement, accumulation of moisture or dust. Detector covers shall be used for storage when practical.

Instrument maintenance shall be performed by the manufacturer or an approved vendor.

4.0 RECORDS

Records that result from this procedure may include forms that document background analysis reports, coarse calibration analysis reports, item analysis reports, and survey logs.

5.0 REFERENCES

BNC Model 940 Instruction Manual.

6.0 ATTACHMENTS

Attachment 1 – Example SAM-940 Survey Log

