Office of Enterprise Assessments
Lessons Learned From Targeted Reviews of Radiological Controls Activity-Level Implementation

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Acronyms

ALARA	As Low As Reasonably Achievable
CA	Contamination Area
CFR	Code of Federal Regulations
CRAD	Criteria, Review, and Approach Document
DOE	U.S. Department of Energy
EA	Office of Enterprise Assessments
FAM	Functional Area Manager
FR	Facility Representative
HEPA	High-Efficiency Particulate Air
HP	Health Physics
LAW	Large Area Wipe
MDA	Minimal Detectable Activity
mrem	Millirem
ORPS	Occurrence Reporting and Processing System
PPE	Personal Protective Equipment
RA	Radiation Area
RBA	Radiological Buffer Area
RCT	Radiological Control Technician
RP	Radiation Protection
RPP	Radiation Protection Program
RWP	Radiological Work Permit
SME	Subject Matter Expert
TED	Total Effective Dose
TWD	Technical Work Document

EXECUTIVE SUMMARY

The Office Enterprise Assessments (EA) periodically performs targeted reviews of areas of specific interest. EA selected radiological controls activity-level implementation (e.g., tasked based hazard analysis and implementation of work controls) as a targeted assessment area for 2013 and 2014. The purpose of these targeted assessments was to evaluate the flowdown of occupational radiation protection program requirements into work planning, control, and execution processes, such as radiological work authorizations that include radiological work permits and other technical work documents. To meet this goal, EA performed assessments that are primarily driven by activity-level observations. This report summarizes and analyzes the results of targeted reviews at 10 U.S. Department of Energy (DOE) sites conducted from September 2012 to August 2014.

Each of the reviewed DOE sites had well established and mature radiation protection programs, including a document hierarchy containing appropriate management policy statements, requirements documents, implementing procedures, and technical basis documents. Radiation protection staff were well qualified and experienced, many with professional certifications and/or advanced degrees in health physics or related disciplines.

Site contractors effectively controlled radiation doses to workers through application of the intended hierarchy of controls including engineered controls, administrative controls, and personal protective equipment, as well as exposure tracking and effective use of time, distance and shielding principles. Recent data from the DOE Radiation Exposure Monitoring System also shows that worker doses across DOE are well controlled to levels far below regulatory dose limits, with only about 1% of monitored workers receiving doses exceeding 10% of the regulatory limits.

Notwithstanding these program strengths and metrics, EA identified certain relatively common weaknesses across the complex in several areas including:

- **Regulatory required radiation protection program documentation**. At a majority of sites reviewed, the DOE approved documented radiation protection program, while formally committing to achieving compliance with each 10 CFR 835, *Occupational Radiation Protection*, requirement, did not include sufficient supporting details and linkage to the overall site document hierarchy and procedures, as expected under 10 CFR 835 and its associated implementing guidance. DOE site offices have generally accepted radiation protection program submittals without questioning the lack of linkage to site documents or level of detail necessary for a document to be considered a radiation protection program.
- **Radiological work planning**. The most commonly identified weaknesses in this area were in the quality of required radiological work authorizations and "as low as reasonably achievable" (ALARA) reviews being conducted for higher hazard radiological work. Consistent with 10 CFR 835 requirements, most sites use a radiological work permit or equivalent written work authorization to control radiological work. However, a prevalent weakness with these authorizations was overly broad work scope, which hindered the ability to perform effective identification and analysis of specific radiological hazards and requisite controls. EA also noted some weaknesses in the conduct of ALARA reviews at several sites, including insufficient procedural guidance for performing these reviews, and where procedures existed, a lack of rigor in following the established requirements. In both cases, the weaknesses resulted in RWPs and work authorizations that lacked the level of detail necessary for effective optimization of radiological controls, such as type and proper placement of air samplers and related controls.
- **Contamination controls and associated radiological surveys**. While contractors at all sites reviewed recognized the importance of contamination control and have established appropriate requirements, weaknesses in aspects of contamination control were evident at nearly half of the sites

visited. The most common areas of concern involved poor personal protective equipment doffing and radiological frisking practices, and insufficient radiological surveys upon completion of radiological work to demonstrate that contamination control measures had been effective in preventing inadvertent spread of contamination to surrounding clean areas.

- **Aspects of radiological air sampling and monitoring.** At several sites, EA noted potentially ineffective job specific air sampling during work with respiratory protection and/or with the potential to create airborne activity, possibly leading to mischaracterization of airborne concentrations in the workers breathing zone. While all sites recognized the need for representative job specific air sampling, collected samples were often not sufficiently representative of the workers breathing zone, as necessary to validate protection factors of respiratory protection and conclusions regarding potential for internal dose during work. In some cases, these concerns can be attributed to radiological work planning weaknesses and specificity of controls as noted above.
- **Effectiveness of DOE program and site office oversight**. The effectiveness of DOE site office oversight of contractor performance in radiological protection varies considerably across the complex. While certain sites exhibited effective performance, oversight at other sites needs improvement in order to effectively identify weaknesses in implementation of radiological protection requirements. Concerns include site office overreliance on the contractor assurance system to identify weaknesses and/or a lack of sufficient DOE independent assessments of radiological controls and/or contractor assurance system effectiveness. Facility Representative programs are generally adequate to maintain operational awareness; however responsibilities for radiological protection subject matter experts and functional area managers are often not sufficiently defined to ensure effective use of their expertise in supplementing assessment and operational awareness activities.

These weaknesses can hinder the effectiveness of radiological controls, reduce the accuracy of internal dose assessments, and hinder the ability to identify and ensure timely correction of performance weaknesses. Additional attention to improvements in these areas may further decrease individual and collective doses across the DOE complex, consistent with the principles of maintaining all doses as low as reasonably achievable. This report provides recommended actions for DOE program and site offices and site contractors to address areas of weakness identified in this report.

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) manages the Department's Independent Oversight Program. The EA assessment program is designed to enhance DOE safety and security programs by providing DOE and contractor managers, Congress, and other stakeholders with an independent assessment of the adequacy of DOE policy and requirements, and the effectiveness of DOE and contractor line management performance in safety and security and other critical functions as directed by the Secretary of Energy. The program is described in and governed by DOE Order 227.1, *Independent Oversight Program*, as well as a comprehensive set of internal protocols and Criteria, Review, and Approach Documents (CRADs).

Radiological controls activity-level implementation (e.g., tasked based hazard analysis and implementation of work controls) was identified as a targeted assessment area beginning in 2013 in a memorandum from EA's predecessor organization to DOE senior line management, *Independent Oversight of Nuclear Safety – Targeted Review Areas starting in FY 2013*, dated November 6, 2012. Independent review teams conducted targeted reviews of radiation protection program (RPP) activity-level implementation at various DOE sites across the complex. These reviews were performed within the broader context of an ongoing program of targeted assessments of radiological control programs, with an emphasis on the implementation of radiological work planning and control across DOE sites that have hazard category 1, 2, and 3 nuclear facilities. The purpose of the facility-specific EA targeted reviews was to evaluate the flowdown of occupational radiation protection (RP) requirements (as expressed in facility RPPs) into work planning, control, and execution processes, including radiological work permits (RWPs), equivalent work authorizations, and related technical work documents (TWDs). To meet this goal, EA performed reviews that were primarily driven by activity-level work observations.

The principal radiological control criteria used for the evaluations were based on the lines of inquiry associated with activity-level work control contained in Sections A, B, and C of CRAD 45-35, *Occupational Radiation Protection Program Inspection Criteria, Review Approach, and Lines of Inquiry*. EA also used applicable elements of CRAD 45-21, Rev. 1, *Feedback and Continuous Improvement Inspection Criteria and Approach – DOE Field Element*, to collect and analyze data on field office oversight activities.

1.1 Report Scope

This report documents the independent reviews of RPP activity-level implementation at a number of DOE sites that have hazard category 1, 2, and 3 facilities from September 2012 to August 2014. The reviews were conducted at 10 sites and involved 12 site contractors and 11 DOE site offices (some sites have multiple contractors and site offices). These reviews were primarily focused on nuclear facilities but also included a sampling of non-nuclear facilities at several sites, such as user and research facilities that involve radiological operations. The sites and facilities reviewed, along with associated contractors and Headquarters program offices, are listed in Table 1 below.

Review Site	Facilities/Operations Reviewed	Operating Contractors	Headquarters Program Office	Site Office
Idaho Site	Idaho National Laboratory (Materials and Fuels Complex and Advanced Test Reactor); Idaho Nuclear Technology and Engineering Center, and Advanced Mixed Waste Treatment Project.	Battelle Energy Alliance, LLC; CH2M-WG Idaho, LLC; Idaho Treatment Group, LLC	Office of Nuclear Energy; Office of Environmental Management	Idaho Operations Office
Hanford Site	Tank Farms	Washington River Protection Solutions, LLC	Office of Environmental Management	Office of River Protection
East Tennessee Technology Park	K-25, K-33	URS CH2M Oak Ridge, LLC	Office of Environmental Management	Oak Ridge Office of Environmental Management
Savannah River Site	Tritium Facilities	Savannah River Nuclear Solutions, LLC	National Nuclear Security Administration	Savannah River Field Office
Los Alamos National Laboratory	G Area, Los Alamos Neutron Science Center	Los Alamos National Security, LLC	National Nuclear Security Administration	Los Alamos Field Office
Sandia National Laboratories	Technical Area 5 Facilities	Sandia Corporation	National Nuclear Security Administration	Sandia Field Office
Oak Ridge National Laboratory	High Flux Isotope Reactor, Radiochemical Engineering Development Center	UT Battelle	Office of Science	Oak Ridge National Laboratory Site Office
Argonne National Laboratory	Alpha-Gamma Hot Cell Facility, Building 306 Waste Operations	University of Chicago, Argonne, LLC	Office of Science	Argonne Site Office
Lawrence Livermore National Laboratory	Radioactive and Hazardous Waste Management, Physical and Life Sciences, Superblock Event Response	Lawrence Livermore National Security, LLC	National Nuclear Security Administration	Livermore Field Office
West Valley Demonstration Project	Main Plant Decommissioning and Decontamination	CH2M HILL B&W West Valley, LLC	Office of Environmental Management	West Valley Site Office

This report includes the following sections:

- Section 2 provides an overall assessment of the results of the targeted reviews and recommendations aligned with the review criteria. It also includes an analysis of operational data.
- Section 3 describes the radiological control attributes and practices that were especially beneficial in promoting effective activity-level radiological work planning and controls at one or more DOE sites.
- Appendix A provides recommended actions for consideration as potential improvements at all sites.
- Appendix B provides supplemental information on the organization and team members contributing to the review.

1.2 Requirements and Guidance

Title 10 CFR Part 835, *Occupational Radiation Protection*, establishes RP standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from conducting DOE activities. Title 10 CFR 835.101(a), *Occupational Radiation Protection*, states, "A DOE activity shall be conducted in compliance with a documented RPP as approved by the DOE." Each DOE site that works with radiological material must develop an RPP and supporting documentation for radiological control.

To assist its operating entities in achieving and maintaining compliance with the requirements of 10 CFR 835, DOE has established its primary regulatory guidance in the DOE G 441.1-1C Guide, *Radiation Protection Programs Guide for use with Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection*. The Guide is structured to assist RP professionals in developing the documented RPP required by 10 CFR 835.101 and the supporting site- and facility-specific policies, programs, and procedures that are necessary to ensure compliance with the related regulatory requirements. The requirements of 10 CFR 835 are enforceable under the provisions of Sections 223(c) and 234A of the Atomic Energy Act of 1954, as amended (Atomic Energy Commission 1954). The Guide establishes a macroscopic view of the various elements of a comprehensive RPP and discusses concepts that RP professionals should consider in developing and implementing the site- and facility-specific programs. Conformance with the Guide will create an inference of compliance with the related regulatory requirements. However, alternate methods that provide an equivalent or better level of protection are acceptable. DOE encourages its contractors to exceed the minimum regulatory requirements and pursue excellence in their programs.

DOE has also developed a technical standard DOE-STD-1098-2008, *Radiological Control*, which supplements the DOE G 441.1-1C Guide and serves as a secondary source of guidance for achieving compliance with 10 CFR 835. While there is significant overlap between the DOE G 441.1-1C Guide and the technical standard, the Standard differs from the Guide in both intent and detail. In contrast to the macroscopic view adopted by the Guide, the Standard discusses specific measures that should be implemented by affected line managers, workers, and support staff to ensure proper fulfillment of their radiological control responsibilities. The Standard states that DOE expects that each site will identify the provisions of the Standard that support its efforts to implement an effective radiological control program and incorporate those provisions, as appropriate, into the site-specific radiological control manual, site procedures, training, or other administrative instruments that are used to guide employee activities. The specific administrative instruments used at DOE sites vary widely, as would be expected given the varying nature of DOE facilities and activities and their associated hazards.

2.0 OVERALL ASSESSMENT

2.1 Radiation Protection Organization and Administration (EA CRAD 45-35, Section A)

Inspection Criteria: *Radiation protection program (RPP) design including organizational structure and administration are sufficient to provide for effective implementation and control of all radiological protection activities. (10 CFR 835.101)*

Results: All of the site contractors reviewed had an effective RP infrastructure consisting of qualified staff and an appropriate document hierarchy containing management policy statements, requirements documents, implementing procedures, and technical basis documents. A sufficient percentage of the health physics (HP) staff at all sites possessed professional certifications (e.g., Certified Health Physicist and Professional Engineer) and/or advanced degrees in HP or related disciplines, as well as years of applied experience.

All sites also had a documented RPP approved by DOE that adequately outlined the scopes of work and activities allowed to be performed under the RPP, consistent with requirements of 10 CFR 835.101. With regard to documented RPPs, 10 CFR 835.101 also requires that (1) "*The content of each RPP shall be commensurate with the nature of the activities performed and shall include formal plans and measures for applying the as low as reasonably achievable (ALARA) process to occupational exposure;*" (2) "*The content of the RPP shall address, but shall not necessarily be limited to, each requirement in this part;" and (3)* "*The RPP shall include plans, schedules, and other measures for achieving compliance with regulations of this part.*"

As indicated later in this report, radiological controls being implemented across the complex provide an adequate level of protection to workers from ionizing radiation hazards. However, at a majority of DOE sites reviewed, the DOE approved documented RPP, while formally committing to achieving compliance with each 10 CFR 835 requirement, did not include the supporting details as called for above. For example, most DOE approved RPPs did not reflect the existence of the overall RP document hierarchy and procedures designed to implement each 10 CFR 835 requirement. Only a few site RPPs contained formal and appropriate linkage between the RPP compliance commitments made in the RPP and the associated implementing mechanisms within their document hierarchy. In some cases, the lack of specific linkage of the implementing mechanisms to compliance commitments contained in the RPP resulted in redundant or conflicting procedures and/or the lack of procedures needed to effectively implement certain requirements, such as in the areas of bioassay and release of materials and equipment from radiation areas (RAs). At one site, the RPP specifically excluded any site procedures and documents from being invoked by the RPP.

The following non-mandatory guidance, excerpted from the DOE Guide 441.1-1C, *Radiation Protection Programs Guide*, Section 3.1, provides guidance intended to meet the requirements of 10 CFR 835 for documented RPPs:

The approved RPP details how a DOE activity shall be in compliance with 10 CFR 835 and should identify the functional elements appropriate for that activity. Additional documentation should be developed and maintained to supplement the approved RPP to demonstrate that an RPP can be effectively managed and administered to achieve compliance with 10 CFR 835. This documentation typically includes a site radiological control manual developed to the guidance contained in the RCS [Radiological Control Standard, DOE-STD-1098-99], as well as detailed implementing procedures, appropriate management policy statements, and technical basis documentation. While this documentation need not be part of the RPP, it should be clearly linked to the compliance commitments contained in the RPP.

The overall RP document hierarchy, which consists of management policy statements, requirements documents, implementing procedures, and technical basis documents, would constitute the foundation of a documented RPP, which is required under 10 CFR 835.101. However, the manner in which RPPs are being developed by site contractors and approved by DOE is highly variable, with most site RPPs lacking sufficient linkage to programmatic documentation and implementing mechanisms intended to be used to meet the compliance commitment made in the RPP. The lack of reference to supporting detail within the RPP does not fully meet 10 CFR 835 requirements and associated implementing guidance, and has in some instances resulted in redundant or conflicting procedures, and/or the lack of procedures needed to effectively implement all requirements at some sites. DOE site offices have generally accepted RPP submittals without questioning the lack of linkage to site documents or level of detail necessary for a document to be considered a RPP.

Recommended Actions:

- Site contractors should ensure RPP submittals include discussion of their overall document hierarchy and clear linkage between each 10 CFR 835 compliance commitment and associated site implementing mechanisms and technical basis documents. This would ensure RPPs adequately meet the intent of 10 CFR 835 as to level of detail necessary to constitute a documented RPP. To avoid administrative burden associated with the DOE approval process, the RPP should clearly distinguish what changes constitute an RPP revision requiring DOE approval (e.g., RPP scope changes) and those changes that do not require DOE approval (e.g., procedure revisions/changes).
- DOE Headquarters offices responsible for safety and health policy and guidance should review current RPP guidance contained in DOE 441.1-1C, revise as necessary and/or issue a technical position that describes for contractors and site offices what specific information is needed in a documented RPP to constitute an acceptable RPP under 10 CFR 835.102.

2.2 Radiological Work Planning, Exposure, and Contamination Control (EA CRAD 45-35, Section B)

Inspection Criteria: *Radiological work planning processes are formally defined, designed, and implemented in a manner that adequately defines work scopes, integrates with other safety and health disciplines, minimizes the potential for spread of contamination, and ensures radiological exposures to personnel are maintained as low as reasonably achievable (ALARA). (10 CFR 835.101)*

Results: Contractors at most DOE sites effectively controlled external radiation hazards through extensive use of engineered controls and shielding. At some sites, external exposure potential is inherently low due to the nature of the operations and materials used. However significant external radiation hazards exist at some sites during activities such as handling of high dose rate waste containers, beam line operations, hot cell maintenance and repair, and deactivation and decommissioning. DOE contractors are effectively controlling this potential for significant external dose through use of dosimetry and proper application of time, distance, and shielding principles.

The potential for internal exposures was prevalent at most sites reviewed because of the common need for handling dispersible radioactive materials in research, production, and manufacturing, as well as during environmental management activities such as deactivation and decommissioning operations. Internal dose evaluation from intakes of radioactive material is more difficult and less accurate than external dosimetry because internal doses cannot be measured directly. Instead, internal doses must be calculated through appropriate biokinetic modeling of suspected intakes and use of various dose conversion factors. As a result, this process is dependent on many variables that result in large error propagation potential in

the calculations. Sites therefore generally attempt to rigorously limit internal exposures through use of engineered controls, air sampling and monitoring, bioassay, and respiratory protection.

At the work activity level, administrative controls and personal protective equipment (PPE) complement engineered controls. Site contractors generally define necessary controls during the radiological work planning and control process for discrete work evolutions. At all sites reviewed, site contractors had appropriate radiological work planning processes which were used in conjunction with other safety and health discipline hazard analyses processes described in site integrated safety management program requirements. However, EA observed some common weaknesses in application of radiological work planning, exposure and contamination control practices at a number of sites, which can impact the effectiveness of ALARA goals and objectives. The most commonly identified weaknesses were in the areas of radiological work authorizations, effectiveness of ALARA reviews for higher hazard radiological work, and the rigor and verification of contamination control practices designed to limit contamination spread to clean areas.

Radiological Work Authorizations

Consistent with 10 CFR 835 requirements, most sites use a RWP or equivalent written work authorization to control radiological work. Institutional processes governing development of these authorizations appropriately allow for a graded approach to rigor in planning and approval depending on the level of complexity and radiological hazards associated with the work. In most cases, contractors developed radiological work authorizations with an appropriate level of involvement of workers and subject matter experts (SMEs). However, a prevalent weakness with these authorizations at several sites was overly broad work scope, which hindered the ability to perform effective identification and analysis of specific radiological hazards and requisite controls. This weakness resulted in the use of generic and/or conditional controls that were not tailored to the specific work being performed. RWPs at several sites had work scope descriptions with the following type of language: "Work in Building XYZ radiation areas [RAs], contamination areas [CAs], high contamination areas, and airborne radioactivity areas." This language was too broad to accurately convey specific radiological hazard conditions or to specify the unique controls. In the preceding example, the RWP was intended to cover work under a variety of radiological conditions and postings, and therefore did not include accurate information on the expected radiological conditions for the observed work, as required by institutional requirements for RWPs. To compensate, broad RWPs often include open-ended authorizations in the control set, such as the words "as directed by the [radiological control technician] RCT" or "per [radiation control organization] RC direction" for needed controls such as breathing zone air sampling or extremity dosimetry. Several sites have recognized this approach to be a concern and have developed institutional requirements that require RWPs to include information on expected radiological hazards (e.g., survey maps of the area and contamination levels) and/or to specifically prohibit the use of open-ended authorizations for specification of controls.

In addition to the above, written authorizations/RWPs often lacked proper integration with associated work control documents such as the job hazard analyses or procedures controlling the work. The specific procedures and TWDs authorized for use under a particular RWP were often missing or not listed within the RWP itself, the JHA or procedure. Coupled with broad work scopes noted above, this has resulted in workers being unable to determine the appropriate RWP for a given task, and instead workers had to rely on verbal direction from radiological control personnel as to which RWP to use. Again, several sites recognize this to be an area of concern and appropriately require that all work control documents/TWDs authorized under a given RWP be specifically listed in the RWP or otherwise documented in an accessible RWP file, job hazard analysis, or the work control procedures.

ALARA Reviews

Consistent with guidance provided in DOE 441.1-1C, *Radiation Protection Programs Guide*, Section 4.2.6, many sites incorporate a requirement for a formal ALARA review for work or experiments with the potential to exceed certain pre-established criteria based on dose, contamination levels, airborne radioactivity, etc. The purpose of the reviews is to provide more rigorous and comprehensive systematic analysis and peer review of higher hazard radiological work to optimize controls for ALARA purposes. The results of these reviews are normally used during work planning and incorporated into RWPs or other equivalent radiological work authorizations. At a few sites, ALARA reviews for high hazard work were effective, comprehensive, and complete, with results appropriately incorporated into RWPs or other work authorizations. However, EA noted some weaknesses in the conduct of ALARA reviews at several sites. These weaknesses were sometimes process related but more often implementation related. Process related problems resulted because the site did not have sufficiently defined methods and expectations for performing and documenting the ALARA reviews, such as insufficient instructions for completion of ALARA review checklists. More frequently, the process adequately defined the methods and expectations, but ALARA reviewers did not rigorously follow the process. For example, instructions for completing ALARA review checklists specified that the results be documented for each area of the checklist reviewed and results incorporated into the associated RWP; however, reviewers did not always document the results. Examples included not specifying required details on air sampling requirements (e.g., type, placement, and location) or worker bioassay protocols applicable for the work. As a result, the RWPs lacked the required level of detail necessary for optimizing these controls. At one site, thresholds for conducting ALARA reviews were adequately defined, but the contractor did not always perform ALARA reviews for work meeting these thresholds. Another concern included revising an RWP to eliminate certain controls required by the ALARA review, without updating the ALARA review to indicate the basis for eliminating the controls.

Contamination Control Practices

Contractors at all sites reviewed recognize the importance of contamination control and have established appropriate requirements designed to minimize the spread of contamination to clean areas. While contamination control practices were generally effective, contractors demonstrated weaknesses in aspects of contamination control at nearly half of the sites visited. The most common areas of concern involved doffing and frisking practices and insufficient verification through radiological surveys that contamination control measures were effective in preventing inadvertent spread of contamination during radiological work. In general, practices while working in CAs were effective, such as frequent glove changes. However at several sites, actions necessary to prevent the inadvertent spread of contamination to clean areas were not always sufficiently rigorous, particularly at sites that use open-faced hoods where the surrounding area is posted as a radiological buffer area (RBA). In these areas, potentially contaminated items being removed from CAs were not always sufficiently controlled or surveyed before being placed in the RBA. Workers and researchers interviewed did not demonstrate a good understanding that the RBA is treated no differently than a clean area under 10CFR 835, and must therefore be controlled as a clean area from a contamination control standpoint. Some of the more prevalent contamination control weaknesses included poor doffing of PPE and self-frisking techniques, inappropriate movement/release of items from posted CAs without radiological surveys, and lack of radiological surveys upon conclusion of work that had the potential to spread contamination to RBAs or adjacent clean areas. Sites often rely on the established routine survey frequencies of weekly or monthly, which would be insufficient to detect inadvertent spread of contamination during or upon conclusion of radiological work.

At several sites, certain established work practices potentially contributed to unexpected alpha contamination. For example, workers in RBAs established outside hoods and gloveboxes are not always required to immediately doff gloves, lab coats, or other PPE if portable instrumentation does not detect

contamination. However, detection sensitivity of portable rate meters is insufficient to detect removable contamination down to 20 disintegrations per minute/100 square centimeters alpha, which is the threshold for CA posting. EA observed some workers who did not doff their gloves before handling outer door surfaces and materials, such as wipe sample envelopes, in these areas. This practice increases the potential for unintentional spread of low level contamination, which cannot be detected during gloved hand frisks with portable radiological survey instrumentation.

Other Concerns

EA also observed a few weaknesses in areas such as quality and effectiveness of pre-job briefings in conveying radiological hazards and controls, and in posting, labeling, and access control of RAs as follows:

- Pre-job briefings did not always include discussion of expected radiological conditions gathered from actual radiological survey data from previous area entries. In some cases, briefings did not cover required coordination among individuals such as RCTs from multiple onsite facilities during shipment of waste materials from one site area to another.

- At a few sites, radiological posting and labeling was sometimes ineffective. For example, posting and labeling lacked standard and consistent wording at some sites, possibly confusing workers as to entry and/or training requirements. Also, required labeling of small quantities of radioactive materials both in research and user facilities was not always performed as necessary to warn individuals of the presence of radioactive materials.

- Sites varied significantly in how they post and control radiological enclosures such as open faced hoods and glove boxes that may or do contain removable contamination at levels exceeding 10 CFR 835 criteria for CAs. Nearly all sites reviewed post open-faced hoods with removable contamination potential as "contamination areas," and a majority also post glove boxes in the same manner. However, a few sites do not consider radiological enclosures, such as hoods or glove boxes, as requiring posting as "contamination areas", based on the lack of total body entry. In these cases the enclosures are generally labeled with a radioactive material label or internally contaminated label. However, the lack of a CA posting designation generally resulted in longer duration radiological survey frequencies for the surrounding clean areas than would be required had they been posted as CAs, possibly contributing to delays in detecting the potential spread of contamination during work, particularly around open-faced hoods.

Radiation Exposure Monitoring System and Occurrence Reporting and Processing System Data

A review of available Radiation Exposure Monitoring System data for recent years demonstrates that worker doses across DOE are well controlled to levels far below regulatory dose limits. For example, for each of the five years ending in 2012, only about 14% of radiation workers who were monitored actually received a measureable dose. For those who received a measureable dose, the average total effective dose (TED) during these years varied only slightly, between 61 and 73 millirem (mrem), values that are below the DOE required dose monitoring threshold of 100 mrem. Of the approximately 14% of monitored workers who received a measurable dose, a much smaller percentage (~1%) received doses exceeding 10% of the annual dose limit of 5 rem. The following table provides a breakdown of individuals with measurable TED within each dose range from the period 2008 through 2012. For each dose range, data for the year with the highest percentage of workers in each dose range are listed. 2013 data has not been published yet, but draft data show similar values for 2013.

TED Range (rem)	Percentage of Workers with measureable TED within TED Range
Measureable to 0.1	83% (9760 workers 2009 highest)
0.1-0.25	14.2% (1858 workers 2010 highest)
0.25-0.5	5.3 % (695 workers in 2010 highest)
0.5-0.75	0.8 % (101, 99, and 87 workers 2010-2012)
0.75-1.0	0.3 % (41, 27 workers in 2010 and 2011)
1-2	0.1 % (<16 each year)
>2	0.001 (1 worker from 2008 through 2012)

While worker doses are well controlled based on the dose metrics, EA identified some common radiological work planning weaknesses discussed above that if corrected, have the potential to lower individual and collective doses to an even greater extent, in keeping with ALARA principles.

EA also reviewed the ORPS contamination events from June 2012 to June 2014 to reveal any themes relevant to activity-level radiological controls. The ORPS data show approximately 135 radiological events, of which approximately 25 were skin contaminations during this time period. While in most cases, root causes are not well documented in the ORPS reports, the details provided in the short narratives point to weaknesses in radiological work planning in some cases, consistent with some of the work planning observations discussed above. A number of events were categorized as "legacy contamination" events (i.e., unexpected contamination found during routine surveys or due diligence surveys prior to work in non-operational areas). ORPS descriptions vary in level of detail, and while some events met the criteria for legacy events, others from operational facilities may actually be the result of over-reliance on routine survey frequencies to capture the inadvertent spread of contamination during work, rather than at the time of occurrence, as noted above.

Recommended Actions: Site contractors should evaluate processes used in development, review, and approval of radiological work authorizations and ALARA reviews, to ensure that work scopes are sufficiently defined to permit effective task specific hazard identification and analysis, and development of controls tailored to the specific work. Resulting radiological work authorizations should be seamlessly integrated with other TWDs and permits controlling the radiological work. Site contractors should also focus additional efforts toward further improving contamination control efforts and ensuring contamination control efforts were successful through more rigorous radiological surveys during and upon completion of work.

To improve consistency of practices associated with posting and control of radiological enclosures, such as open faced hoods, and surrounding clean areas, DOE Headquarters offices responsible for safety and health policy and guidance should provide additional clarification or technical position for 10 CFR 835 in relation to posting of open face hoods and other enclosures which allow partial body entry and contact with surfaces that may exceed the threshold for CAs, as well as the definition of "area" (not currently defined). In addition, updated clarification and guidance related to RBAs surrounding these types of enclosures may be warranted since RBA is not recognized or defined by the current regulatory framework.

2.3 Radiological Surveys and Monitoring (EA CRAD 45-35, Section C)

Inspection Criteria: *Adequate routine and non-routine radiological surveys and monitoring are performed for external radiation, fixed and removable contamination, and airborne radioactivity, as needed to characterize radiological conditions and ensure safety of personnel. (10 CFR 835.401; 10 CFR 835.403)*

Results: At all sites, contractors performed appropriate radiological survey and monitoring activities. The RP organizations at each facility develop radiological survey or surveillance plans to govern routine survey and monitoring activities. Typically, these mechanisms form the basis for each site's conduct of routine radiation and contamination surveys, and air sample collection. With few exceptions, survey frequencies established in the radiological survey or surveillance plans were sufficient given the nature of the facilities, radiological status, and operations at the respective sites. Radiological survey and monitoring instrumentation was adequate for the radiation hazards present. Contamination surveys were taken with large area wipes (LAWs) and quantitative smears in areas with contamination potential, and counted with appropriate instrumentation. External gamma exposure rates and neutron dose rates, when present, were also measured with the appropriate radiation detectors. Instrument calibration procedures at each site were in use, with appropriate calibration sources and predetermined intervals for required efficiency and operational determination.

Contractors at the majority of the sites reviewed established and used appropriate fixed air monitoring programs to monitor potential for changes in ambient air concentrations over time. RCT routine radiological surveillances and RCT job coverage at most sites/facilities were effectively performed. Survey documentation associated with these efforts were generally thorough and complete. In addition to radiation surveys, at a few sites all personnel on RWPs authorizing entry into RAs and high RAs were required to wear alarming electronic personal dosimeters. Use of these systems was a positive initiative, which ensures tracking and real time assessment of external dose and dose rates. The alarming features provide better coverage for varying dose rates than would be accomplished by fixed area radiation monitors.

EA identified some common weaknesses in radiological survey and monitoring practices at several of the reviewed sites. The most significant and common concern involved the adequacy of job specific air sampling during work with respiratory protection or with the potential to create airborne activity, possibly leading to mischaracterizing airborne concentrations in the workers breathing zone. Information on job specific air sampling is needed to assess potential for internal exposures and to validate the protection factor of respirators worn. While all sites recognized the need for job specific air sampling and performed sampling, selection and use of the appropriate type of air sampling equipment to collect a representative sample (e.g., personal air sampler, continuous air monitor, stationary) was often ineffective because the sample was not sufficiently representative of the workers breathing zone. EA identified numerous examples where the sampler placement was inadequate given work location and air flow. Required boundary and job-specific area air samples were not always taken as required, and when taken, were not always placed and/or oriented as needed to collect a representative sample (e.g., located much higher or lower than the breathing zone, or located away from the work being performed). At some facilities, sample heads were not properly positioned to collect a representative sample (i.e., facing away from the work area). At one facility, required high-efficiency particulate air (HEPA) exhaust sampling was sometimes placed and oriented inappropriately to effectively monitor the exhaust (i.e., more than three feet from the exhaust point). In addition, HEPA exhaust sampling was also performed using personal air monitors, and it is uncertain (as there was no documented technical basis determination) whether the low volume flow and restrictive orifice of the personal air monitors would capture a representative particulate sample from the high flow rate of the exhaust stream.

The lack of representative air sampling during work that has the potential for airborne radioactivity can result in misleading or inaccurate conclusions regarding internal dose, particularly when air sampling and derived air concentration-hour tracking are used to compensate for technology shortfalls associated with detection of transuranic isotopes in bioassay samples. Since the potential for unmonitored internal exposure is much greater than for external exposures (which can be measured directly), accurate and representative air sampling is a necessary component of site internal dosimetry programs.

EA identified a few other potential weaknesses, vulnerabilities, or possible "added value" improvements associated with surveys and monitoring at several sites. For example, the conduct of routine contamination surveys (including those used for area down-posting) included LAWs, which are usually collected and field evaluated in high background (high minimal detectable activity [MDA]) areas, before collecting technical smears at the same locations, which are counted in low backgrounds (low MDA). LAWs are typically implemented using sheets of masslin affixed to a pad attached to a mop handle and walked over (in contact with) working area floor surfaces or using a cotton glove liner worn on the RCTs hand and wiped over items and small surface areas. Periodically throughout the process, hand held detectors are used to monitor any residual radiological contaminants on the LAW. While appropriate for use as an indicator, extensive use of LAW before technical smears may, through the cleaning effect, unintentionally mask identification of low levels of contamination below the MDA of hand held instrumentation. In addition, survey results are often recorded as "less than" for values below posting thresholds. Recording more specific low level data above the MDA but below posting thresholds may allow for identification of trends, emerging potential issues, or variations in performance of the surveillance prior to exceeding thresholds.

Recommended Actions: Consider/evaluate the above observations for job specific air sampling and the need to ensure samples representative of the workers' breathing zone are taken during all work that has the potential to create airborne radioactivity or whenever respiratory protection is required for radiological hazards with radiation protection staff. While personal air samplers worn by the worker offer the most likely method of achieving a representative sample, their use may be hindered by low flow rates and short duration jobs, where the sample volume collected may be insufficient to meet the minimum required detection sensitivity, particularly for transuranic materials. In situations where job specific stationary air samplers are used, their placement should be evaluated for area air flow paths and the breathing zone of the potentially maximally exposed individual. Ensure that strategies for employing the use of LAWs minimize masking of the identification of low level spread of contamination due to the cleaning effect of the LAW, and poorer detection sensitivity when counting LAWs versus technical smears.

2.4 DOE Oversight

Results: Six of the eleven DOE site offices within the scope of this review were directly evaluated concurrent with the radiological focus area reviews. Most of the other site offices were reviewed during separate focus area reviews, and oversight results for those will be reported in separate lessons learned reports. The six site offices evaluated during radiological control focus area reviews were West Valley Site Office, Livermore Field Office, Argonne Site Office, Los Alamos Field Office, Savannah River Field Office, and the Oak Ridge Office of Environmental Management. This sampling involved two Office of Environmental Management site offices, one Office of Science site office, and three National Nuclear Security Administration site offices.

DOE site offices were reviewed in relation to several oversight program elements to evaluate the effectiveness of DOE oversight in ensuring contractor performance in implementation of activity-level radiological controls. These include review and approval of RPP documents (see section 2.1); and planning, scheduling, and conducting assessments and operational awareness of SMEs and Facility Representatives (FRs).

All DOE site offices had written plans and procedures defining the approach and responsibilities for oversight of contractor activities, including planning and scheduling assessments and surveillances and performance of field operational awareness activities. Assessments approaches contained in oversight plans varied but in general consisted of a combination of shadow assessments, formal assessments, self-assessments, and external assessments. Training and qualifications of Federal oversight personnel

including SMEs and FRs were adequate and in accordance with DOE expectations.

While oversight plans and procedures were documented and generally acceptable, certain areas lacked sufficient detail to ensure effectiveness. For example, expectations for conduct and documentation of certain types of assessments such as shadow assessments were not always defined, resulting in little or no documentation of results. Also, formal expectations for participation of federal radiological or functional area managers (FAMs) in assessments and operational awareness activities were not always defined. This resulted in SMEs/FAMs self-directing their activities and priorities, sometimes at the expense of more important areas of focus. As a result, the benefit of the added expertise of these individuals in identifying and evaluating radiological concerns was not realized.

While several site offices have conducted effective RP assessments, other site offices have limited formal assessment of RP to participation in triennial reviews of 10 CFR 835 compliance conducted by contractors and/or external resources. These limited assessments often focus mainly on program flowdown of requirements into policies and procedures, with minimal review of implementation. Since most contractors currently have mature RP programs and procedures, such programmatic assessments do not always identify weaknesses in implementation of existing requirements of the type identified in this report.

DOE site offices maintain operational awareness of nuclear facility operations principally through FRs assigned to each facility. In most cases, FRs are located at each facility, and provide the majority of the daily oversight of the contractor through direct observation and routine interactions on a day to day basis. In general, assigned FRs at all sites were familiar with the operations and activities ongoing within their facilities and adequately documented results of walkthroughs and surveillances as required by their internal plans and procedures. While documentation requirements vary by site, FRs are normally required to conduct and document work observations on a defined periodicity (i.e., quarterly) and often are required to document a summary of completed operational awareness activities more frequently (i.e., weekly or bi-weekly).

Although operational awareness provided by FRs is effective at most sites, radiological SMEs/FAMs are not always sufficiently involved in supplementing the FRs abilities in identifying and following up on radiological concerns. EA noted examples where radiological events of potential significance that occurred at certain facilities were not followed up or reviewed by the DOE radiological FAM. As discussed above, part of this may be due to the relative autonomy of these individuals in self-directing their activities and priorities. However, these individuals also do not always have unescorted access to contractor facilities and/or have not taken all required training to be able to conduct operational awareness surveillances on short notice (e.g., respirator qualification and facility qualification).

Overall, the effectiveness of DOE site office oversight of contractor performance in RP varies considerably across the complex. While certain sites exhibited effective performance, oversight at some sites needs improvement in order to effectively identify weaknesses in implementation of RP requirements. Some DOE site offices rely heavily on the contractor assurance system assessments which sometimes lack focus on implementation. FR programs are generally adequate to maintain operational awareness; however responsibilities for RP SMEs/FAMs are often not sufficiently defined to ensure effective use of their expertise in supplementing assessment and operational awareness activities.

Recommended Actions: DOE Program offices and site offices should increase emphasis on improving oversight of contractor RPPs to ensure the RPP elements at their respective sites are adequately assessed and improved. Because some site office oversight processes are reliant more on operational awareness and contractor assurance, site office oversight plans and procedures should include more detail on expectations to ensure that all elements of RP program performance are evaluated (e.g., roles,

responsibilities, and methods). This includes basic oversight elements such as independent RP assessments, shadow assessments, self-assessments, external reviews, contractor assurance assessments, operational awareness activities, and annual assessment reports. Additionally, RP SMEs/FAMs should increase activity-level assessments of RP implementation including areas of weakness identified in this report, such as radiological posting, respiratory protection, contamination control, and air sampling.

3.0 POSITIVE ATTRIBUTES

Radiological control attributes and practices that were especially beneficial in promoting effective activity-level radiological work planning and controls at one or more DOE sites are described below. This information may be useful to sites that are working to improve the effectiveness of their programs. EA recognizes that the information below is derived from a sample of DOE sites and that other sites may also have effective, innovative approaches

3.1 Centralized Organizational Structure

All sites had an appropriate centralized RP organization headed by an RP manager or equivalent. RP managers were senior level personnel with reporting responsibility to either Vice President level management or higher within the organization. RP managers had a staff of health physicists necessary to support RP infrastructure needs such as maintenance of document hierarchy, internal and external dosimetry, radiological measurements and instrument calibration, and related functions. In addition, RP managers had either direct or matrixed field radiological control personnel assigned to individual facilities to support line management in proper implementation of requirements. Field personnel included health physicists, radiological engineers, HP supervisors, and qualified RCTs working in each facility.

3.2 Robust Engineered Controls

Engineering controls were generally robust and used extensively to mitigate the radiological hazards associated with operations that have potential for internal dose. These include hot cells and other engineered containments such as glove boxes, hoods, and temporary tents. One innovative example of an engineered system to minimize dose was use of a remote control transfer system during movement and over-packing of remote handled transuranic waste at Argonne National Laboratory where container external exposure rates were well in excess of 1 roentgen per hour. This operation was performed through use of an elaborate remote control transfer system which moved and over-packed transuranic containers into heavily shielded casks, after which they could be removed from the hot cell and handled directly for transport to a storage location. Other examples included state-of-the-art engineered access control systems including automatic interlocks and visual and audible alarm systems at accelerator facilities at Los Alamos National Laboratory and Oak Ridge National Laboratory, as well as the Lawrence Livermore National Laboratory National Ignition Facility, where high RAs are present during machine operations and/or user experiments.

3.3 Effective Electronic Data Management

Several sites (including Idaho National Laboratory, Savannah River Site, Argonne National Laboratory, Oak Ridge National Laboratory and East Tennessee Technology Park) use electronic data systems effectively to manage a variety of radiological information and implementing requirements, such as RWP sign in and sign out functions, routine radiological survey and monitoring requirements and results, and management of large amounts of survey and monitoring data. Complementary database system have been developed at several sites which provide easily retrievable electronic access to a variety of information, records, and reports in the areas of RWP use, electronic personal dosimeter dose tracking,

radiological surveys, air sampling records, radiological event reports, and RCT routine surveillance requirements.

3.4 Sample Management Practices at User Facilities

As part of corrective actions following offsite contamination spread resulting from lack of proper control and accountability of radioactive samples, sites with user research facilities such as Los Alamos National Laboratory and Oak Ridge National Laboratory have undertaken significant efforts to improve sample handling and management programs. Some of the changes include new requirements for sample storage and labeling, physical security, electronic sample movement tracking, designation of authorized users, and more rigorous RCT coverage requirements. This has significantly improved direct and positive control over all radioactive samples and potentially activated samples at user facilities.

APPENDIX A
Recommended Actions

The recommended actions discussed below are based on lessons learned during the Office of Enterprise Assessments reviews. While the underlying deficiencies and weaknesses did not necessarily apply to all the sites, and many sites have developed and implemented actions for the issues identified at their sites, the recommended actions provide additional insights into potential improvements at all sites. Consequently, U.S. Department of Energy (DOE) organizations and site contractors should evaluate the applicability of the following recommended actions to their operations and consider their use as appropriate in accordance with site-specific program objectives.

DOE/National Nuclear Security Administration Headquarters Program Offices

Review and modify as necessary current DOE guidance associated with documented radiation protection programs (RPPs), contamination areas (CAs), and DOE oversight to ensure alignment with current expectations. Specific actions to consider include:

- Develop additional guidance and/or technical positions for both DOE and contractors that clarify expectations for clear linkage, through formal crosswalks or equivalent, of contractor radiation protection (RP) requirements and related implementing mechanisms, to the DOE approved RPP.

- Develop additional guidance and/or technical positions to provide additional clarification of 10 CFR 835 in relation to posting of open face hoods and other enclosures which allow partial body entry and contact with surfaces that may exceed the threshold for CAs, as well as the definition of "area" (not currently defined). In addition, update and clarification of guidance related to radiological buffer areas (RBAs) surrounding these types of enclosures may be warranted since RBA is not recognized or defined by the current regulatory framework.

- Clarify program office expectations for DOE site office oversight of RP and 10 CFR 835 assessments. This includes expectations for providing additional focus on the review and approval of RPP documentation, determining when site offices should perform independent assessments, shadow contractor self- assessments, and/or assess the contractor's RPPs.

DOE Site Offices

Improve oversight of contractor RPPs to ensure the RPP elements at their respective sites are adequately assessed to inform management on performance. Specific actions to consider include:

- As a learning opportunity, discuss results of this report with management and staff to solicit specific recommendations for improvement.

- Given increased use of operational awareness, ensure there is a defined method to ensure that all elements of contractor performance such as RP are specifically reviewed during oversight activities.

- Establish clear requirements and responsibilities for RP assessments, self-assessments, external reviews, and annual assessment reports. This should include assessments of contractor assurance system performance and related self-assessments in RP, as well as the role of RP functional area managers.

– Focus more attention in the review of RPP submittals to the linkage of site documents and level of detail provided.

Site Contractors

Increase attention toward improvement of RPPs, radiological work authorization such as radiological work permits (RWPs), as low as reasonably achievable (ALARA) reviews, contamination control practices, and radiological air sampling and monitoring. Specific actions to consider include:

– As a learning opportunity, discuss results of this report with appropriate management and staff to solicit specific recommendations for improvement.

– In future revisions to RPPs requiring DOE approval include graphical and/or narrative depiction of the relationship between the RPP and the site's radiological document hierarchy and specific implementing mechanisms and technical basis documents. The relationship description should include a statement that revisions to subordinate implementing mechanisms need not constitute a revision to the RPP requiring DOE approval.

– Revise RP plans and procedures to require specific linkage between RWPs and all associated procedures and work instructions that are authorized under the RWP. This can be accomplished through existing job hazard analysis processes, reference within the RWP or work documents, or an RWP file. In this case, the RWP job description may simply reference the RWP file that workers can access to verify the appropriate RWP for their task.

– Revise RP plans and procedures to provide better RWP work scope guidance and to prohibit language in RWPs that refer a worker to the discretion of RP personnel for authorized activities or radiological controls.

– Where necessary, consider establishing procedures to govern selection and conduct of ALARA reviews, including proper use of thresholds, clear expectations for content and level of detail for each required review element, and proper flowdown of controls into the RWPs or other technical work documents.

– Consider adding radiological work planner position(s) responsible to support existing RP personnel and/or radiological control technicians in preparing RWPs. This position can be used to foster more effective line oversight and accountability in radiological work planning, including review and approval of RWPs and ALARA reviews.

– Increase periodic surveillances by qualified health and safety personnel to observe and provide feedback on contamination control practices of radiation workers/researchers.

– Increase the frequency of performing documented radiological surveys as necessary to verify effectiveness of controls during and after work that has the potential for spread of contamination to clean areas. Revise site-specific procedures as appropriate to drive proper implementation.

– Ensure use of large area wipes (LAWs) appropriately considers the potential for masking low levels of contamination through the cleaning effect of the LAW, and compensate by considering technical smears before LAWs.

- Ensure air sampling programs are designed and implemented in a manner that ensures collection of representative air samples.

- Review existing airflow studies or conduct additional studies to ensure adequacy of the basis for air sampler placement, and ensure air samplers in use accurately represent conditions in workers breathing zones when a potential exists for creating airborne contamination and when respiratory protection is used for radiological hazards.

Appendix B
Supplemental Information

Office of Enterprise Assessments

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