Lessons Learned from Assessments of the Safety of Construction, Demolition, and Maintenance Work at U.S. Department of Energy Sites

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Office of Enterprise Assessments
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Acronyms

ACGIH	American Conference of Government Industrial Hygienists
AHJ	Authority Having Jurisdiction
CAIRS	Computerized Accident/Incident Reporting System
CAS	Contractor Assurance System
CBFO	DOE Carlsbad Field Office
CDM	Construction, Demolition, and Maintenance
CFR	Code of Federal Regulations
CRAD	Criteria and Review Approach Document
DOE	U.S. Department of Energy
EA	Office of Enterprise Assessments
EM	Office of Environmental Management
FR	Facility Representative
FSO	Fermi Site Office
IH	Industrial Hygiene
LOTO	Lockout/Tagout
NNSA	National Nuclear Security Administration
NRTL	Nationally Recognized Testing Laboratory
NWP	Nuclear Waste Partnership, LLC
OII	Occupational Injury and Illness
ORNL	Oak Ridge National Laboratory
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
PPPO	Portsmouth/Paducah Project Office
RWP	Radiological Work Permit
SC	Office of Science
SME	Subject Matter Expert
SOW	Skill of the Worker
TLV	Threshold Limit Values
TQP	Technical Qualification Program
WCD	Work Control Document
WP&C	Work Planning and Control
WVDP	West Valley Demonstration Project
Y-12	Y-12 National Security Complex

LESSONS LEARNED FROM ASSESSMENTS OF THE SAFETY OF CONSTRUCTION, DEMOLITION, AND MAINTENANCE WORK AT U.S. DEPARTMENT OF ENERGY SITES

Executive Summary

The U.S. Department of Energy (DOE) Office of Environment, Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA), conducted 18 independent assessments from January 2018 through November 2022 which included aspects of construction, demolition, and/or maintenance (CDM) in the assessment scope. Fifteen were assessments of work planning and control at 13 DOE sites and 3 were assessments of construction safety at 2 DOE sites. This lessons-learned report is focused on the CDM aspects of these assessments as they relate to occupational safety and health, industrial hygiene, radiological protection, electrical safety, explosives safety, and DOE field element oversight. The flow down of safety requirements to subcontractors was also assessed at selected sites.

The 15 sites are under the direction of the National Nuclear Security Administration, the Office of Environmental Management, the Office of Nuclear Energy, or the Office of Science. The lessons learned presented in this report are based on a collective analysis of the assessment results, as well as Computerized Accident/Incident Reporting System (CAIRS) data for calendar years 2018-2021 and relevant Occurrence Reporting and Processing System (ORPS) data for January 2018 through November 2022. Additionally, information contained in the *2019 Lessons Learned from Assessments of Work Planning and Control at US DOE Laboratories* and the *2022 Lessons Learned from Assessments of Work Planning and Control at US DOE Sites* was included in this report as it relates to CDM activities. This report focuses on issues affecting multiple sites and identifies commonly observed strengths and weaknesses, best practices, and recommendations, with the goal of promoting organizational learning and improving performance throughout the DOE complex.

The assessed sites demonstrated generally well-developed and effectively implemented safety programs for CDM activities. EA identified six best practices in CDM safety programs:

- Bechtel National, Inc. uses the direct inclusion of applicable lessons learned into construction work packages at the Y-12 National Security Complex Uranium Processing Facility project which makes it easy for the supervisor/foreman to include the lessons learned in the pre-job briefing, ensuring that the workforce is aware of the lessons learned and reinforcing the value of the lessons-learned process. (Best Practice)
- Bechtel National, Inc. implements a more robust approach to lift plans at the Y-12 National Security Complex Uranium Processing Facility project than that specified in DOE STD-1090-2011. This approach provides enhanced lift hazard controls. (Best Practice)
- Nuclear Waste Partnership, LLC at the Waste Isolation Pilot Plant includes quick response codes on work package instructions, drawings, and specifications, which can be scanned with a mobile application to inform the user whether they are using the current, authorized version for use in the field. (Best Practice)
- Fermi Research Alliance, LLC at Fermi National Accelerator Laboratory build plans require the identification of risks and potential injuries as well as prevention plans for each work step and are developed for discrete construction activities. (Best Practice)
- Fermi Research Alliance, LLC at Fermi National Accelerator Laboratory uses a radiofrequency identification system (i.e., an audible proximity alarm system) to alert when certain mobile equipment is operating in the vicinity of workers, below and above ground. (Best Practice)

- CH2M Hill BWXT West Valley, LLC at the West Valley Demonstration Project has developed and implemented unique and robust radiological and industrial hygiene controls for an open-air building demolition, including dust suppression methods, daily limits on demolition rate and ground waste accumulation, continuous real time Environmental Continuous Air Monitor monitoring in the control room, and fixed air sampling and deposition surveys, to provide early detection of any contaminant migration beyond posted work area boundaries. (Best Practice)

EA also identified the following areas where improvements are needed:

- EA identified common weaknesses in subcontractor implementation of hazard controls, including but not limited to fall protection, lockout/tagouts (LOTOs), excavations/penetrations, barricades and falling object protection, and eyewash station availability.
- EA identified common weaknesses related to potential worker health effects, including but not limited to industrial hygiene exposure assessments for silica, hazardous noise, and asbestos. Where silica hazards were present, EA identified issues with either programmatic non-compliances or a lack of hazard controls. At each site where the noise hazard was evaluated, the hazard was not identified or sufficiently analyzed by the contractor/subcontractor, or the noise controls were inappropriate or not adequately documented in the work control documents. Four asbestos hazard issues were observed at eight sites, which included not updating work control documents when asbestos work activities were modified and documenting the wrong hazard controls.
- EA identified six weaknesses in the areas of explosives transportation and storage. Although EA's assessments in this area were few, the potential severity of explosives handling mistakes leading to significant safety consequences is large.
- The inconsistent use of CAIRS reporting codes at some sites, for construction work, limits the ability of DOE managers to analyze construction-related occupational injury and illness data for adverse trends and develop targeted corrective actions.
- Limited resources and weaknesses in implementing site office Facility Representative programs are limiting their ability to provide adequate oversight of CDM activities.

Recommendations

This report provides the following recommendations to DOE site contractors and field element managers for improving CDM activity safety programs.

Site Contractors

- Provide increased oversight focus on subcontracted construction and demolition work.
- Conduct reviews of the silica program to ensure all exposed employees are included, all silica hazards are identified, silica exposure assessments are conducted, and hazard controls are properly implemented.
- Conduct reviews of the contractor hearing protection program to ensure all exposed employees are included, all noise hazards and effective controls are identified and implemented in work control documents and procedures, and all sound level instruments are properly calibrated before each use.
- Conduct reviews of the contractor asbestos program with a focus on the ensuring the identification of all asbestos hazards and effective controls in work control documents and procedures.

- Restrict the use of mechanical excavating equipment directly over known energized hazardous energy sources, preclude mechanical equipment use within a specified distance (e.g., three feet) from energized lines, and ensure as-built drawings are accurate and subsurface scanning methods margins of error are properly considered.
- Ensure that separate CAIRS reporting organization codes with construction operations code incorporated are established for each well-defined type of construction work (e.g., capital construction project or sitewide construction activities by prime or subcontractors).

DOE Field Element Managers

- Ensure an adequate Facility Representative (FR) and subject matter expert (SME) staffing level with personnel who are fully qualified through the technical qualification program (TQP). Ensure effective implementation of the TQP including the validation of training and qualification in the electronic TQP, timely qualification of personnel performing oversight of contract construction activities, and continuous training. Provide construction safety training to FRs, SME's and contracted oversight personnel, as needed, to ensure they are capable in hazard identification.
- Integrate oversight of contractor CDM work into site office assessment planning, with a particular emphasis on the contractor industrial hygiene program, explosives safety, LOTO and excavations/penetrations, fall protection, barricade use, and eyewash availability.
- Identify and trend low-level CDM issues to determine if they should be included in contractor assessments.
- Ensure that contractors establish and use CAIRS operation-type reporting codes for construction work in accordance with DOE Order 231.1B.
- Analyze ORPS/CAIRS data specific to CDM and use the results to conduct targeted CDM assessments.

LESSONS LEARNED FROM ASSESSMENTS OF THE SAFETY OF CONSTRUCTION, DEMOLITION, AND MAINTENANCE WORK AT U.S. DEPARTMENT OF ENERGY SITES

1.0 INTRODUCTION

EA conducted 18 construction, demolition, and maintenance (CDM) safety assessments at 15 DOE sites from January 2018 through November 2022. Fifteen of the CDM safety assessments were independent assessments of work planning and control at 13 DOE sites and 3 were independent assessments of construction safety at 2 DOE sites. The 15 sites are under the direction of the National Nuclear Security Administration, the Office of Environmental Management, the Office of Nuclear Energy, or the Office of Science. This report is focused on the aspects of these assessments related to occupational safety and health, industrial hygiene, radiological protection, electrical safety, explosives safety, and DOE field element oversight. The flow down of safety requirements to subcontractors was also assessed at selected sites.

2.0 METHODOLOGY

The lessons learned presented in this report are based on a collective analysis of the assessment results, as well as Computerized Accident/Incident Reporting System (CAIRS) data for calendar years 2018-2021 and relevant Occurrence Reporting and Processing System (ORPS) data for January 2018 through November 2022. Additionally, information contained in the *2019 Lessons Learned from Assessments of Work Planning and Control at US DOE Laboratories* and the *2022 Lessons Learned from Assessments of Work Planning and Control at US DOE Sites* (hereafter referred to as the 2019 Lessons-Learned report and the 2022 Lessons-Learned report, respectively) was also included in this report as it related to CDM activities. For completeness, maintenance activities at operating facilities are included in the analysis. This report focuses on issues affecting multiple sites and identifies commonly observed strengths and weaknesses, best practices, and recommendations, with the goal of promoting organizational learning and improving performance throughout the DOE complex.

The members of the EA report preparation team, the Quality Review Board, and EA management responsible for this lessons-learned report are listed in appendix A. Appendix B addresses the scope of this review, applicable criteria and review approach documents, and the analysis methodology; appendix B also includes a table of the EA assessment reports used for this analysis. Appendix C is the compilation of recommendations from the 2019 and 2022 Lessons-Learned reports.

3.0 RESULTS

This portion of the report summarizes the strengths and weaknesses resulting from the collective analysis of the 18 CDM assessments. This lessons-learned review analyzed 6 best practices, 52 issues (8 findings and 44 deficiencies) associated with contractor performance, and an additional 10 issues (3 findings and 7 deficiencies) associated with Federal oversight identified since January 2018. These assessment results were categorized into six major areas as shown in Table 1 below. Further details are provided in the following sections of this report.

Table 1. EA-identified Best Practices, Findings, and Deficiencies

Major Areas	# Best Practices	# Findings	# Deficiencies	Total Issues
CDM Safety Implementation	5	0	12	12
Industrial Hygiene (IH)	1	5	12	17
Radiological Protection	1*	0	9	9
Electrical Safety	0	2	6	8
Explosives Safety	0	1	5	6
Contractor Totals	6*	8	44	52
DOE Field Element Oversight	0	3	7	10

* One Best Practice addresses both Radiological Protection and Industrial Hygiene

3.1 Safety and Operational Experience Data Analysis

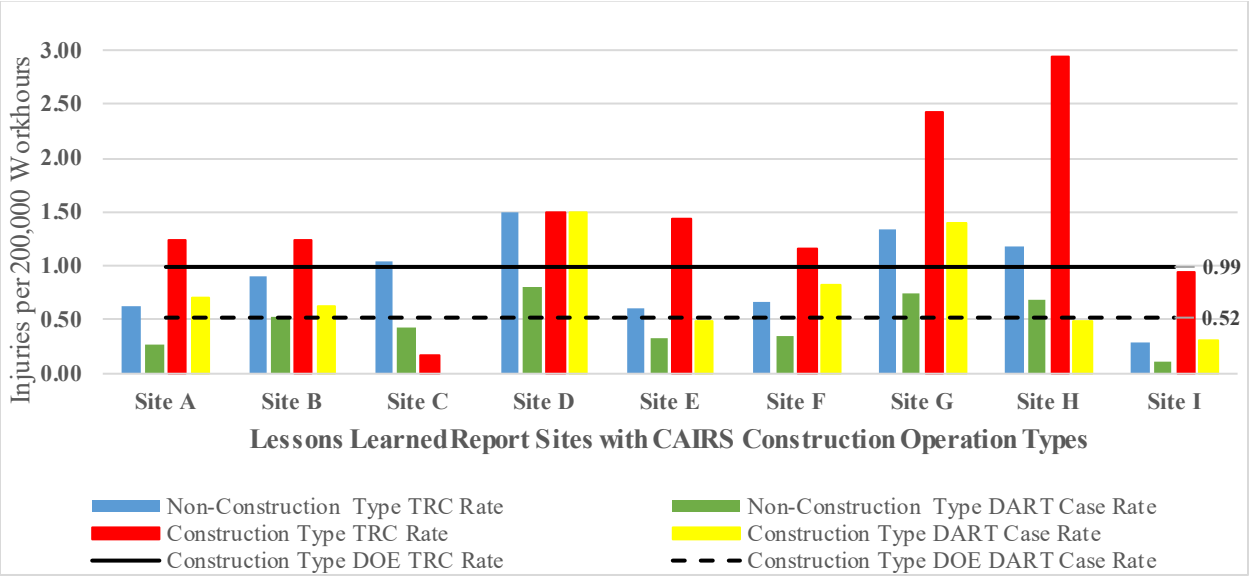
This portion of the lessons-learned review analyzed the available occupational injury and illness (OII) data from CAIRS and operational experience occurrence reports from ORPS to identify trends.

Occupational Injury and Illness Case Incidence Rates

The 15 sites' OII case incidence data in CAIRS suggest needed focus on improved use of CAIRS reporting codes for subcontracted CDM work.

CAIRS uses nine operation codes for reporting OII cases and associated workhours for various types of work conducted at DOE sites. These codes include type #1 for government work and types #2 through #9 for contractor work. The primary contractor codes for construction work are type #5, *cost plus construction*, and type #6, *lump sum construction*. The analyzed CAIRS data (total workhours and OII case data) for calendar years 2018 to 2021 show that 9 of the 14 sites (some with multiple contractors assessed) reported OII incidence rates in the construction work codes (see Chart 1). However, the other five sites (primarily Office of Environmental Management deactivation and demolition work) report OII data using contractor work code #4, *services*, instead of a separate construction work type operation code related to subcontracted work. This reporting approach is not in accordance with DOE Order 231.1B, *Environment, Safety and Health Reporting*, att. 1, sec. 2.a.(3) and limits the ability of DOE managers to analyze subcontractor construction-related OII data for adverse trends and develop targeted corrective actions. Consequently, data for these five sites is not included in Chart 1.

Chart 1. Construction Operation Type Injury Rates 2018-2021



EA's calculated total recordable case (TRC) incidence rate for the nine sites with reported construction operation type work is 15% higher than the DOE-wide construction type TRC rate of 0.99 cases per 200,000 workhours (or 100 employees). Seven of the nine sites' TRC and five of the sites' days away, restricted or transferred (DART) case incidence rates for construction type work are higher than the DOE-wide incidence rates for construction operation type work for the 5-year period evaluated. Based on CAIRS workhour data, construction work is primarily performed by subcontractors. A review of all OII case data shows that construction type OII case rates are higher than they are for other types of work in the DOE complex, except for security work, suggesting a need for enhanced management attention.

Occurrence Reporting and Processing System Reports

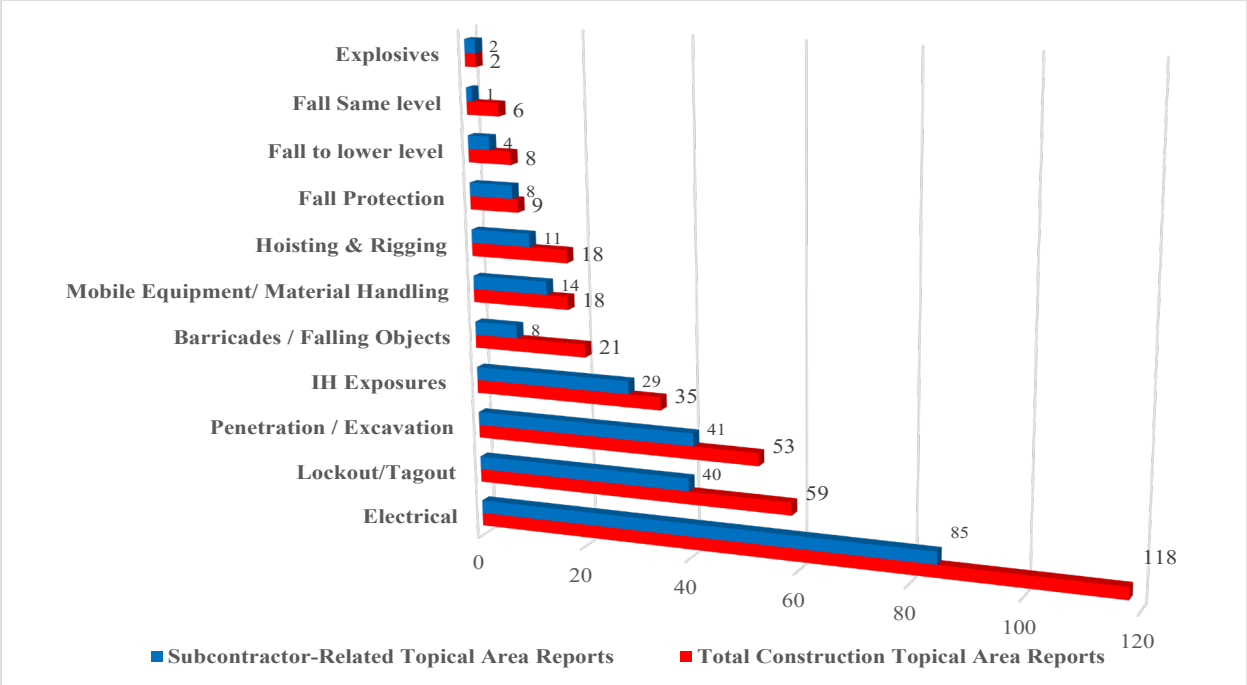
ORPS does not have a direct criterion to search and identify construction-related occurrences. To analyze ORPS data for construction-related occurrences, EA conducted a keyword search for construction-related reports for the period January 2018 through November 2022, resulting in 1,496 ORPS reports from the 15 site contractors included in this lessons-learned report.

Chart 2 identifies the resulting construction-related reports by topical areas (e.g., electrical or IH) and subcontractor contribution. A detailed analysis and interpretation of ORPS data by topical area is addressed in the related sections of this lessons-learned report. Highlights of the ORPS analysis include:

- Of the 1,496 reports, EA identified 256 reports that were related to construction work and 58 reports that were related to construction-like maintenance work. This data demonstrates a disproportionally higher number of safety issues occurring in subcontracted construction work. While only 6% of contractor workhours in CAIRS for the 15 site contractors is reported as subcontractor construction operation types, 70% of these construction-related ORPS reports involve subcontractors.
- 66% of reports were related to electrical safety issues, including the majority of LOTO and penetration/excavation reports, with 72% of the electrical-related reports attributable to subcontract work.

- 10% of reports were related to IH exposure, of which 83% were attributable to subcontract work. IH exposure issues are increasingly being identified during EA assessments using EA-32-03, *Industrial Hygiene Program Criteria and Review Approach Document*.
- 10% of reports were related to the movement of materials and equipment (including hoisting and rigging and material handling), with 42% attributed to subcontract work. EA is increasing its focus on this topical area as well and has developed EA-32-12, *Material Handling Safety Criteria and Review Approach Document* to facilitate assessments.
- While the barricades and falling objects topical areas represent 6% of the reports with 38% of these reports involving subcontract work, controlling the hazards in these areas are important to CDM work as the consequences of being struck by falling objects can result in serious injury.
- 4% of ORPS reports were related to falls at the same level and to a lower level. While this is the lowest number of topical area ORPS reports, falls reported in CAIRS data from CY 2021 for the 15 sites represent 97 of 852 (11%) of recordable occupational injury cases.

Chart 2. Construction-Related ORPS Reports Associated with Assessed Sites by Topical Area



3.2 Construction, Demolition, and Maintenance Safety Requirements Implementation

This portion of the lessons-learned review identified the strengths and weaknesses at the sites in implementing institutional safety programs to address hazards encountered during CDM activities. Elements of CDM work safety were assessed in each of the 18 assessments.

Strengths

Overall, experienced craft workers performed CDM work activities with appropriate work packages. Work observed by EA was generally compliant with the requirements of 10 CFR 851, *Worker Safety and Health Program*. Observed work activities were generally conducted safely. For example:

- Excavations were performed with required excavation permits in accordance with site procedures.
- Trench inspections were completed prior to entry and appropriately documented on forms or tags, with shoring used appropriately.
- Hoisting and rigging equipment was properly inspected and used.
- Crane lifts were appropriately performed by trained and qualified operators with properly documented lift plans in compliance with DOE-STD-1090, *Hoisting and Rigging*. Crane inspections were current with daily inspections appropriately completed.
- Material handling was conducted safely by trained and qualified equipment operators. Equipment inspections were completed, properly documented, and loads were secured to pallets and/or lift structures as needed.
- Observed scaffold erection was properly performed with pre-use inspections completed and documented on scaffold tags. Required handrail protection was provided and work areas were generally barricaded to control falling object hazards.

Weaknesses

EA identified 12 deficiencies in the areas of fall protection, LOTOs, excavations/penetrations, barricades and falling objects, and eyewash station availability that reflect hazard control implementation not fully conducted in accordance with DOE safety requirements. These deficiencies and reviewed ORPS reports associated with these safety areas indicate that increased management attention is merited on subcontractor work performance. For example, eight of nine fall protection-related ORPS reports involved subcontractors, with three of the falls resulting in injuries. Forty-seven of 59 LOTO ORPS reports involved electrical work, and 40 of these involved subcontractors. Twenty-one of 53 ORPS reports involving excavations or penetrations involved striking an unknown line (not identified by subsurface scanning or drawing review) or utility, and 41 of these 53 reports involved subcontractors, with 36 involving criteria 2D(2) "hazardous energy control process or discovery of an uncontrolled hazardous energy source."

Additionally, six ORPS reports involved gas lines, five for line breaks or gas leaks and one for a near miss where a power pole anchor was installed within inches of a 4" gas line. Mechanical equipment was involved in five of these ORPS reports, and one gas line was cracked by hand with a digging bar. Only one ORPS report reported that the gas line was unknown, and in one instance mechanical equipment struck a pressurized 3" gas line that varied 5 inches from its exposed visible location further down the trench. Any break in a gas line exposes workers and co-located individuals to potential fire and explosion if an ignition source is present.

Further, EA observed three instances where required barricades used to control overhead dropped object hazards were not established prior to the start of work. In addition, a review of 314 ORPS reports identified, 2 events involving inadequate barricades, 19 events where falling objects were reported, and 6 instances where one or more employees were struck by a falling object. Eight of the 19 falling object events involved subcontractors.

EA also identified four deficiencies where eyewash stations that meet American National Standards Institute Z358.1 requirements (29 CFR 1926.50(g), *Medical services and first aid*) were not provided. Three of the deficiencies were located in places where concrete was being poured and one was in an underground location where shotcrete was applied.

EA observations and ORPS data supports increased oversight of subcontractor construction to reduce exposure to CDM hazards and potential occupational injuries.

3.3 Industrial Hygiene

This portion of the lessons-learned review identifies the strengths and weaknesses at the sites in implementing IH programs and practices for CDM activities.

Strengths

With some exceptions, site procedures implementing the IH program requirements established by 10 CFR 851 were adequate. Hazard identification processes were generally well developed and integrated into the work planning and control (WP&C) process. Two sites made significant improvements in their IH programs following earlier EA assessments.

In general, assessed sites were observed to be appropriately staffed with capable IH personnel. Two sites exhibited a well-developed formal training process for IH technical personnel. One site developed a formal relationship with a local educational institution for the development of local IH resources. Interviews with numerous IH staff confirmed that they are knowledgeable and have an appropriate understanding of their facilities' IH hazards and controls.

Weaknesses

10 CFR 851 requires contractors to assess worker exposures to workplace hazards using recognized exposure assessment and testing methodologies and to conduct IH initial and baseline surveys, resurveys, and exposure monitoring for all work areas and operations to evaluate potential health risks. Nine of the 15 sites assessed for IH hazards (60%) did not identify all applicable IH work hazards and/or had a less than adequate IH exposure assessment program for performing qualitative or quantitative analysis of such hazards. For four of seven sites in which the exposure assessment process was evaluated by EA, qualitative exposure assessments were not conducted and/or documented for all IH hazards, or IH lacked an adequate program for conducting qualitative exposure assessments. At two of these seven sites, the controls identified in IH exposure assessments were not integrated into work control documents (WCDs). When worker exposures are not adequately assessed, workers may be overexposed to workplace contaminates or be provided with the inappropriate hazard controls to mitigate the hazard. The 2022 Lessons-Learned report includes a recommendation to address improvements in IH exposure assessments, which is also applicable to CDM type work [See page C-2, 1st Bullet].

During eight assessments at seven sites where silica hazards were present, EA identified nine issues (two findings and seven deficiencies) for either programmatic non-compliances or a lack of hazard controls. Each site had at least one deficiency. Four of the seven sites were deficient in the identification or analysis of an observed workplace silica hazard, or their silica IH programs were not in full compliance with 10 CFR 851. A recurrent theme identified at each of these sites was the incorrect reliance on the OSHA permissible exposure limit (0.050 mg/m3 [milligrams per cubic meter] of air) specified in 1926.1153(d)(1) rather than the more protective American Conference of Government Industrial Hygienists (ACGIH) threshold limit value (TLV) (0.025 mg/m3 of air) addressed in 10 CFR 851.123(9).

- In addition, at three of the seven sites, hazard controls for silica were inadequate, particularly for eye and respiratory protection during concrete work. One site did not have the required respirable silica exposure monitoring data, and one observed construction activity did not have the proper controls when drilling holes in concrete. All of the silica-related findings and deficiencies discussed above were related to work

performed by subcontractors. Of the 17 IH-related ORPS reports, 7 (41%) were associated with silica, and 6 of the 7 silica ORPS reports were for work associated with subcontractors.

Noise hazards are typically present at each of the 15 assessed CDM sites. For the six sites in which hazardous noise was evaluated, either the noise hazard was not identified or sufficiently analyzed by the contractor/subcontractor, or the noise controls were inappropriate or not adequately documented in the WCDs. At three sites, noise detection and analysis equipment (e.g., noise survey instruments and noise dosimetry) was not used or available or not calibrated prior to use. At two sites, workers who were required to be in a hearing conservation program were not enrolled.

Asbestos hazards continue to present a worker hazard during CDM work activities, particularly at sites involving demolition work activities. Four asbestos hazard issues were observed at eight sites, which included not updating WCDs when asbestos work activities were modified, and documenting the wrong hazard controls (i.e., application of controls for asbestos glove bag work to asbestos work not associated with glove bags). Additionally, 5 of the 17 IH-related ORPS reports reviewed (29%) were associated with asbestos. Health-related illnesses resulting from exposures to asbestos hazards are often more chronic than acute, and the potential severity is often not reflected in either ORPS or CAIRS data.

CAIRS data indicates that ergonomics is associated with significant sources of injuries and illnesses in the DOE complex. For example, during the period of fiscal year (FY) 2020 through FY 2022, ergonomic hazards (i.e., bodily reaction and exertion) accounted for 1,324 of 3,157 (42%) of all non-Pandemic OII reports in CAIRS. (See DOE Office of Health, Safety & Security, *Operating Experience Summary 2022-5*, dated December 21, 2022).

3.4 Radiological Protection

This portion of the lessons-learned review identified the strengths and weaknesses associated with the implementation of radiological protection requirements at four sites that were performing active demolition of radiologically contaminated facilities.

Strengths

Overall, EA concluded that each of the contractors had mature and formal radiation protection programs that included an extensive document hierarchy consisting of program plans, technical basis documents, and implementing procedures intended to flow down the 10 CFR 835, *Occupational Radiation Protecti*on, radiological requirements to the working level. The radiological programs at these sites were also well-staffed with knowledgeable managers, subject matter experts (SMEs), and staff who were well integrated into the overall WP&C processes used in CDM activities. Radiological hazard analysis and control development was also properly integrated into the work control process. In general, implementation of site radiation protection requirements and procedures was adequate.

Weaknesses

EA identified six radiation protection deficiencies among the four sites that were performing active demolition of radiologically contaminated facilities. These included five deficiencies related to CDM that were identified at three sites in the 2022 Lessons- Learned report involving weaknesses in the proper conduct of job-specific air sampling and radiological performance of contamination surveys necessary to detect the potential for the spread of contamination. EA identified one additional deficiency at a different demolition site than those addressed in the 2022 Lessons-Learned report involving radiological control personnel not verifying air sampler flow rates when restarting air samplers and not including required

calibration stickers on air sampling equipment. Reviewed ORPS reports did not reveal any trends associated with these observations at the assessed sites.

3.5 Electrical Safety

This portion of the lessons-learned review identified the strengths and weaknesses associated with the implementation of electrical safety, including planning for potential hazardous energy control for observed work.

Strengths

Most assessed sites had well defined electrical safety training programs. Assessments revealed that the electrical staff was adhering to electrical safe work practices, personal protective equipment (PPE) requirements, and hazardous energy control. All but one of the assessed sites had established documented electrical safety programs that were well staffed with SMEs and authorities having jurisdiction (AHJ) who are qualified in all aspects of electrical safety. Additionally, employees were adequately informed of electrical arc flash and shock hazards. In general, electrical panels, disconnect switches, motor control centers, and switchgear with a potential for arc flash either had current arc flash and shock warning labels installed on the equipment, or the electrical hazards were documented in the work package on a job-specific electrical task risk assessment or switching procedure. Observed work performed on de-energized electrical equipment involved qualified electrical workers who performed the work safely, appropriate to the risk associated with electrical hazards, and in accordance with the requirements of the electrical safety program or other maintenance procedures.

Weaknesses

As noted in section 3.1 of this report, 47 of the 59 LOTO ORPS involved electrical work, and 32 of these involved subcontractors. In addition, 37 of the 53 penetration/excavation ORPS reports involved striking electrical equipment or wiring, although no electrical shocks were reported. EA identified 8 electrical safety issues (2 findings and 6 deficiencies) at 12 sites that were associated with WP&C programs and implementation, including:

- One site did not have a documented electrical safety program as required by 10 CFR 851.23, *Safety and Health Standards,* sec (a)(14); DOE Order 440.1B, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*, sec.4.m.(14) and att. 1, section 9, and NFPA 70E-2015, *Standard for Electrical Safety in the Workplace*.
- Electricians at one site did not receive training for their work on high-voltage electrical power distribution systems and were not required to demonstrate proficiency as required by OSHA standards. Also, the governing procedure did not fully cover OSHA standard 29 CFR 1910.269, *Electrical Power Generation, Transmission, and Distribution,* requirements for work on or around electrical power distribution equipment.
- One site did not require a pre-job briefing for electrical low-rigor work performed by skill of the craft (e.g., LOTO zero voltage verification).
- The required safe working space around electrical equipment was not maintained as required by NFPA 70E sec. 110.26.
- Work instructions did not provide the shock hazard and PPE requirements as required by NFPA 70E sec. 130.4.

- ES&H plans did not implement the 2015 version of NFPA 70E as required by 10 CFR 851, Technical Amendment (2018).
- Two LOTOs for maintenance work on electrical equipment were not conducted as required by the site procedures.
- A Nationally Recognized Testing Laboratory (NRTL) type inspection was not required for all electrical equipment.

The ORPS data and the EA identified issues indicate the need for continued management attention on electrical safety, including LOTO and penetration/excavation work.

3.6 Explosives Safety

This portion of the lessons-learned review addressed strengths and weaknesses of explosives safety at two DOE sites, which may be applicable at other sites that handle explosives.

Strengths

In general, the explosives safety programs are well established and comprehensive for construction activities. The explosives safety programs implement the requirements of 10 CFR 851, app. A 3(b), and other applicable CFRs to mitigate explosive hazards. Observed explosive handlers generally demonstrated compliance with safety procedures while performing operations with multiple explosive hazards. Explosive storage magazines at both sites met the requirements for compatibility of explosives, displayed safe separation distances of initiators to secondary explosives, and were properly located at minimum distances from other structures. Explosives were properly stored and maintained in accordance with manufacturers' recommendations.

Weaknesses

EA identified one finding and five deficiencies in the areas of explosives transportation and storage. At one site, the explosives were stored properly, but the magazines did not have the correct placards specifying explosive limits and general safety precautions. At the other site, magazine doors were not locked, and the transportation vehicle was not equipped with the required number of proper fire extinguishers. Two ORPS reports addressed the breaching of a safety perimeter during live explosive testing at one site and the exposure of explosives to a vehicle's hot exhaust gases at the other site. Although the explosives sampling data for these assessments is not adequate to establish a trend, the consequence of explosives handling mistakes can be catastrophic, warranting additional management attention.

3.7 DOE Field Element Oversight

This portion of the lessons-learned review identified the strengths and weaknesses of the DOE sites in overseeing contractor CDM safety and assessing implementation effectiveness.

Strengths

DOE field elements at the assessed sites have generally effective procedures for Federal line oversight of construction safety, including assessment planning and performance, operational awareness activities, issues management, and performance assurance. Feedback mechanisms to investigate employee concerns and differing professional opinions were typically effective. The results of DOE oversight of contractor

construction activity-level WP&C were effectively used in performance evaluation feedback and measurement plan and/or integrated safety management system reviews.

Weaknesses

In general, DOE site offices have limited resources to oversee site safety operations and perform oversight of contractor activities, they rely on SMEs, contracted staff support and, in some locations, FRs. DOE site offices adequately focus on overall contractor performance and use a graded approach with greater emphasis on high-risk activities and overall site safety; as a result, construction activities do not always receive adequate oversight.

Four field elements exhibited weaknesses in the implementation of the Facility Representative (FR) program. Specifically, these DOE site offices did not perform FR staffing analysis to ensure adequate staffing levels, timely qualification of FRs, FR performance indicators, or self-assessment to determine the effectiveness of the FR program.

Further, two field elements exhibited weaknesses in the implementation of the technical qualification program (TQP), including continuous training, timely qualification of personnel performing oversight of contract construction activities, or validating training and qualification in the electronic TQP. Additionally, safety training requirements were not identified for support service contract personnel that supported one DOE site office in overseeing contractor construction activities.

Finally, issues resulting from field element oversight are not adequately captured, categorized based on risk and priority, and analyzed for trends to improve focused assessments of contractor construction safety programs.

4.0 BEST PRACTICES

A best practice is a safety-related practice, technique, process, or program attribute observed during an appraisal that may merit consideration by other DOE and contractor organizations for implementation because it: (1) has been demonstrated to substantially improve safety or security performance of a DOE operation; (2) represents or contributes to superior performance (beyond compliance); (3) solves a problem or reduces the risk of a condition or practice that affects multiple DOE sites or programs; or (4) provides an innovative approach or method to improve effectiveness or efficiency. This lessons-learned report summarizes the following best practices related to CDM safety that were identified in the 15 assessment reports reviewed.

- Bechtel National, Inc. uses the direct inclusion of applicable lessons learned into construction work packages at the Y-12 National Security Complex Uranium Processing Facility project which makes it easy for the supervisor/foreman to include the lessons learned in the pre-job briefing, ensuring that the workforce is aware of the lessons learned and reinforcing the value of the lessons learned process.
- Bechtel National, Inc. implements a more robust approach to lift plans at the Y-12 National Security Complex Uranium Processing Facility project than that specified in DOE STD-1090-2011. This approach provides enhanced lift hazard controls including use of a three-tiered lift plan structure for risk categories low, medium, and critical lifts. Each lift risk category defines more restrictive criteria such as weight limits and specialized rigging.
- Nuclear Waste Partnership, LLC at the Waste Isolation Pilot Plant includes quick response codes on work package instructions, drawings, and specifications, which can be scanned with a mobile

application to inform the user whether they are using the current, authorized version for use in the field.

- Fermi Research Alliance, LLC at Fermi National Accelerator Laboratory build plans require the identification of risks and potential injuries as well as prevention plans for each work step and are developed for discrete construction activities.
- Fermi Research Alliance, LLC at Fermi National Accelerator Laboratory uses a radiofrequency identification system (i.e., an audible proximity alarm system) to alert when certain mobile equipment is operating in the vicinity of workers, below and above ground.
- CH2M Hill BWXT West Valley, LLC at the West Valley Demonstration Project has developed and implemented unique and robust radiological and industrial hygiene controls for an open-air building demolition, including dust suppression methods, daily limits on demolition rate and ground waste accumulation, continuous real time Environmental Continuous Air Monitor monitoring in the control room, and fixed air sampling and deposition surveys, to provide early detection of any contaminant migration beyond posted work area boundaries.

5.0 RECOMMENDATIONS

These recommendations are based on the analysis of EA assessments as summarized in section 3 of this report. Although the underlying deficiencies and weaknesses from individual reviews did not apply to every site reviewed, the recommended actions are intended to provide insights for potential improvements at all DOE sites. Consequently, DOE organizations and contractors should evaluate the applicability of the following recommended actions to their respective facilities and/or organizations and consider their use as appropriate in accordance with Headquarters and/or site program objectives. Additional recommendations for CDM safety, including IH exposure assessments, radiological protection, and subcontracted work are included in the 2019 and 2022 Lessons-Learned reports and are summarized in appendix C of this report.

Site Contractors

- Provide increased oversight focus on subcontracted construction and demolition work.
- Conduct reviews of the silica program to ensure all exposed employees are included, all silica hazards are identified, silica exposure assessments are conducted, and hazard controls are properly implemented.
- Conduct reviews of the contractor hearing protection program to ensure all exposed employees are included, all noise hazards and effective controls are identified and implemented in work control documents and procedures, and all sound level instruments are properly calibrated before each use.
- Conduct reviews of the contractor asbestos program with a focus on ensuring the identification of all asbestos hazards and effective controls in work control documents and procedures.
- Restrict the use of mechanical excavating equipment directly over known energized hazardous energy sources, preclude mechanical equipment use within a specified distance (e.g., three feet) from energized lines, and ensure as-built drawings are accurate and subsurface scanning methods margins of error are properly considered.
- Ensure that separate CAIRS reporting organization codes with construction operations code incorporated are established for each well-defined type of construction work (e.g., capital construction project or sitewide construction activities by prime or subcontractors).

DOE Field Element Managers

- Ensure an adequate Facility Representative (FR) and subject matter expert (SME) staffing level with personnel who are fully qualified through the technical qualification program (TQP). Ensure effective implementation of the TQP including the validation of training and qualification in the electronic TQP, timely qualification of personnel performing oversight of contract construction activities, and continuous training. Provide construction safety training to FRs and other oversight personnel as needed to ensure they are capable in hazard identification.
- Integrate oversight of contractor CDM work into site office assessment planning, with a particular emphasis on the contractor industrial hygiene program, explosives safety, LOTO and excavations/penetrations, fall protection, barricade use, and eyewash availability.
- Ensure that contractors establish and use CAIRS operation-type reporting codes for construction work in accordance with DOE Order 231.1B.
- Analyze ORPS/CAIRS data specific to CDM and use the results to conduct targeted CDM assessments.
- Strengthen the issues management process for FR oversight activity to capture, categorize, trend and analyze low-level hazards to better conduct focused assessments of contractor construction safety programs.

Appendix A
Supplemental Information

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Appendix B
Scope, Requirements and Guidance, and Assessed Sites

This lessons-learned report identifies common strengths and weaknesses, best practices, and recommendations, with the goal of increasing organizational learning throughout the U.S. Department of Energy (DOE) complex. This lessons-learned report is based on an analysis of 18 Office of Enterprise Assessments (EA) reports as detailed in Table B-1, which include some attention to construction, demolition, and maintenance (CDM) work. Assessment results related to production, research, or operations were not included in this lessons-learned report. Key elements examined during the assessments included: occupational safety, industrial hygiene (IH), radiological protection, electrical safety, explosive safety, mine safety, and DOE field element oversight. The flowdown of safety requirements to subcontractors was also assessed at selected sites. DOE field element contractor oversight was evaluated at 13 DOE sites.

To address the adequacy of programs and performance, the assessments included elements from the following criteria and review approach documents (CRADs), DOE guide, and industry standards:

- CRAD 45-21, Rev. 1, *Feedback and Continuous Improvement Inspection Criteria and Approach – DOE Field Element*
- CRAD 30-01, Rev. 1, *Contractor Assurance System*
- CRAD EA-30-07, Rev. 0, *Federal Line Management Oversight Processes*
- CRAD EA-32-10, Rev. 0, *Construction Safety*
- CRAD EA-32-03, Rev. 1, *Industrial Hygiene*
- CRAD EA-32-01, Rev. 1, *Explosives Safety*
- CRAD EA-30-09, Rev.0*, Occupational Radiation Protection Program*
- CRAD EA-32-12 Rev. 0*, Material Handling Safety*
- CRAD EA-32-11, Rev. 0, *Control of Hazardous Energy (Lockout/Tagout)*
- Selected elements of DOE Guide 226.1-2A, *Federal Line Management Oversight of Department of Energy Nuclear Facilities*, appendix D: *Activity-Level Work Planning and Control Criterion Review and Approach Documents with Lines of Inquiry*
- Mine Safety and Health Administration Standards.

Section 3 of this lessons-learned report reflects aggregated results from the 18 EA assessment reports detailed in Table B-1, as applicable to CDM type work. Those reports remain snapshots of conditions at the facilities/sites at the time of the assessments. The issued reports were provided to the assessed organizations and may have resulted in corrective actions or enhancements that are not reflected in these discussions.

All findings and deficiencies identified during these assessments were included in a spreadsheet and categorized by a team of subject matter experts. This approach provided insight into the following six key areas for analysis:

- Construction, demolition, and maintenance safety requirements implementation
- Industrial hygiene
- Radiological protection

- Electrical safety
- Explosives safety
- DOE field/site office oversight.

Additionally, an analysis was conducted of occurrence reports submitted to the DOE Occurrence Reporting and Processing System database from January 2018 to November 2022 containing key words related to construction safety. These data were examined to identify any causal relationships with the six key areas. Also, DOE Computerized Accident/Incident Reporting System data for 2018 to 2021 was analyzed to compare the injury and illness rates for construction-related vs non-construction-related work.

Table B-1. Assessed Sites and Associated Source Documents

Assessed Site and Contractor	Key Elements Assessed	Assessed Facilities and Activities	DOE Headquarter and Field/Site Office	Source Document
West Valley Demonstration Project (WVDP) CH2M HILL BWXT West Valley, LLC	Work, Planning and Control (WP&C), subcontractors, IH, general construction safety, electrical safety, radiological, Federal oversight	Open-air demolition of the Main Plant Process Building and the disposal of hazardous debris; maintenance activities	Office of Environmental Management (EM) DOE-WVDP Site Office	EA Report, *Independent Assessment of Work Planning and Control for Cleanup Operations at the West Valley Demonstration Project - February 2023*
Fermi National Accelerator Laboratory Fermi Research Alliance, LLC	WP&C, subcontractors, IH, general construction safety, electrical safety, underground safety, explosives safety, Federal oversight	Long-Baseline Neutrino Facility Far Site underground excavation and construction work	Office of Science (SC) Fermi Site Office (FSO)	EA Report, *Independent Assessment of Work Planning and Control at the Fermi National Accelerator Laboratory Long-Baseline Neutrino Facility Far Site - January 2023*
Oak Ridge Reservation United Cleanup Oak Ridge LLC	WP&C, IH, general construction safety, radiological, electrical safety, Federal oversight	Oak Ridge National Laboratory (ORNL), Y-12 National Security Complex (Y-12) and East Tennessee Technology Park cleanup work, including demolition	EM Oak Ridge Office of Environmental Management	EA Report, *Independent Assessment of Work Planning and Control for Cleanup Work at the Oak Ridge Reservation - November 2022*

Assessed Site and Contractor	Key Elements Assessed	Assessed Facilities and Activities	DOE Headquarter and Field/Site Office	Source Document
Argonne National Laboratory UChicago Argonne, LLC	WP&C, subcontractors, IH, general construction safety, radiological, electrical safety, Federal oversight	Research, operations, maintenance, and construction	SC Argonne Site Office	EA Report, *Independent Assessment of Work Planning and Control at Argonne National Laboratory - August 2022*
Waste Isolation Pilot Plant Nuclear Waste Partnership, LLC (NWP)	Construction safety, subcontractors, IH, mine safety, explosives safety	Utility Shaft Project subcontracted construction activities of Harrison Western-Shaft Sinkers Joint Venture	EM DOE Carlsbad Field Office (CBFO)	EA Report, *Independent Assessment of Construction Safety for the Utility Shaft Project at the Waste Isolation Pilot Plant - June 2022*
Sandia National Laboratories – New Mexico National Technology and Engineering Solutions of Sandia, LLC	WP&C, IH, general construction safety, subcontractors, electrical safety, Federal oversight	Centers 1800 (Material, Physical and Chemical Sciences) and 4700 maintenance and construction projects	National Nuclear Security Administration (NNSA) Sandia Field Office	EA Report, *Independent Assessment of Work Planning and Control at Sandia National Laboratories - New Mexico - May 2022*
Portsmouth Site Fluor-BWXT Portsmouth, LLC	WP&C, IH, subcontractors, electrical safety, radiological, Federal oversight	Demolition and deactivation work	EM Portsmouth/Paducah Project Office (PPPO)	EA Report, *Independent Assessment of Work Planning and Control for Deactivation and Demolition Work at the Portsmouth Site - March 2022*
Y-12 National Security Complex Bechtel National, Inc.	Construction safety, subcontractors, WP&C, general construction safety, IH, electrical safety, Federal oversight	Uranium Processing Facility Project Mechanical Electrical Building, Process Support Facility, Salvage and Accountability Building, and the Main Process Building	NNSA Y-12 Acquisition and Project Management Office	EA Report, *Independent Assessment of Construction Safety at the Y-12 National Security Complex Uranium Processing Facility – February 2022*

Assessed Site and Contractor	Key Elements Assessed	Assessed Facilities and Activities	DOE Headquarter and Field/Site Office	Source Document
Waste Isolation Pilot Plant NWP	Construction safety, subcontractors, WP&C, IH, Federal oversight	Safety Significant Confinement Ventilation System Project	EM CBFO	EA Report, *Independent Assessment of Construction Safety at the Waste Isolation Pilot Plant for the Safety Significant Confinement Ventilation System Project - December 2021*
Paducah Gaseous Diffusion Plant Four Rivers Nuclear Partnership, LLC	WP&C, IH, construction/demolition, radiological, electrical safety, Federal oversight	Deactivation, demolition and maintenance work	EM PPPO	EA Report, *Independent Assessment of Work Planning and Control at the Paducah Gaseous Diffusion Plant - November 2021*
Savannah River Site Savannah River Remediation, LLC	WP&C, construction safety, subcontractors, electrical safety, Federal oversight	F and H Tank Farms construction work	EM DOE Savannah River Operations Office	EA Report, *Independent Assessment of Work Planning and Control at the Savannah River Site F and H Tank Farms - October 2021*
Lawrence Livermore National Laboratory Lawrence Livermore National Security, LLC	WP&C, construction safety, subcontractors, IH, electrical safety, maintenance, Federal oversight	Research, maintenance, and subcontracted construction work at several areas	NNSA Livermore Field Office	EA Report, *Work Planning and Control Assessment at the Lawrence Livermore National Laboratory – August 2020*
Fermi National Accelerator Laboratory Fermi Research Alliance, LLC	WP&C, construction safety, subcontractors, IH	Long-Baseline Neutrino Facility Far Site	SC FSO	EA Report, *Work Planning and Control Assessment at the Fermi National Accelerator Laboratory Long-Baseline Neutrino Facility Far Site – November 2019*
Idaho National Laboratory Battelle Energy Alliance, LLC	WP&C, IH, Radiological, Electrical Safety, Maintenance, Federal oversight	Materials and Fuels Complex and the Advanced Test Reactor	Office of Nuclear Energy DOE Idaho Operations Office	EA Report, *Work Planning and Control Assessment at the Idaho National Laboratory – October 2019*

Assessed Site and Contractor	Key Elements Assessed	Assessed Facilities and Activities	DOE Headquarter and Field/Site Office	Source Document
Fermi National Accelerator Laboratory Fermi Research Alliance, LLC	WP&C, IH, radiological, maintenance	Research Divisions and the Facilities Engineering Services Section	SC FSO	EA Report, *Work Planning and Control Assessment at the Fermi National Accelerator Laboratory – July 2019*
ORNL UT-Battelle, LLC	WP&C, IH, radiological, electrical safety, maintenance	Radiochemical Engineering Development Center Chemical Science Division, and the Mechanical Utilities Complex within the Utilities Division	SC ORNL Site Office	EA Report, *Work Planning and Control Assessment at the Oak Ridge National Laboratory – May 2019*
WVDP	WP&C, IH, Radiological, Maintenance, Federal oversight	Waste and Site Operations and Strategic Operations and Facility Disposition Divisions, Demolition and Maintenance	EM DOE-WVDP Site Office	EA Report, *Assessment of the West Valley Demonstration Project Work Planning and Control Program – October 2018*
Pantex Plant Consolidated Nuclear Security, LLC	WP&C, IH, maintenance, explosives safety	Maintenance, Manufacturing Production Tooling, and Explosives Technology	NNSA NNSA Production Office	EA Report, *Enterprise Assessments Assessment of the Pantex Plant Work Planning and Control Program – June 2018*

Appendix C
Recommendations from 2019 and 2022 Lessons-Learned Reports

***Lessons Learned from Assessments of Work Planning and Control at US DOE Laboratories*, December 2019**

U.S. Department of Energy (DOE) Field Managers

- Explore ways to utilize existing tools (e.g., OPEXShare), or create new tools, to enhance the field element operational experience program efforts to formally capture and share lessons learned.
- Use issue management or document tracking systems (either internally developed or commercially available) to ensure that safety-related contractor deliverables, such as new or required updates to contractor assurance system (CAS) and integrated safety management system descriptions, are received, reviewed, and approved.

Laboratory Managers

- For skill of the craft and/or researcher work, improve work screening requirements and establish a list of specific routine jobs and research activities that can be accomplished as skill of the craft/research work; develop activity screening and binning based on scope of work complexity, consequences, and frequency to help determine the appropriate activity-level work control document (WCD); and develop a skill of the craft/researcher work planning and control (WP&C) process that accounts for a worker's experience, skill, and training and streamlines WCDs while also ensuring that hazard analysis and pre-job briefings are conducted for all work.
- Provide additional focus on hazardous energy control. The following actions should be evaluated:
  - Ensure that electrical safety subject matter experts (SMEs) are included and accountable for development of all hazardous energy controls prior to dispatch of workers into the field.
  - Ensure that maintenance work instruction/work packages predefine and document the following hazardous energy controls: hold points for lockout/tagout (LOTO) placement and removal verification, and sequenced LOTO orders (sign off documentation) where applicable.
  - Ensure that two qualified electrical workers independently implement and verify LOTO and/or establish requirements for supervisory or SME verifications.
- For research work activities, provide additional focus on work scope definition, including:
  - For broad-scope work documents, use multiple WCDs, each with a focused work scope, hazards, and controls.
  - Explore using streamlined activity-based hazard analyses to define the work scope, hazards, and controls associated with each type of experiment enveloped within the WCD.
  - Evaluate including work scope boundary conditions to help the researcher with defining work activities that are beyond the current work scope.
- For work involving radiological hazards, provide additional focus and rigor on ensuring proper implementation of job-specific air sampling and contamination control for laboratory hoods located in radiological buffer areas. This rigor might include targeted training in these areas for radiological control technicians and radiological workers, and/or additional specificity in the radiological work permits (RWPs) governing this work.

- Revise and improve CAS mechanisms, including:
    - Ensure that the organization has well-defined roles for managing the overall assessment process. Include a focus on coordinating lessons learned from OPEXShare and other sources.
    - Reinforce expectations for developing and using lessons learned, specifically including activity level worker involvement in collecting and communicating lessons learned, in planning work.

Lessons Learned from Assessments of Work Planning and Control at US DOE Sites, **December 2022**

DOE Field Element Managers

To promote the effective performance of oversight by a technically competent and qualified staff:

- Conduct periodic self-assessments of the technical qualification program (TQP) to ensure that the TQP is appropriately implemented, including tracking qualification status and establishing a formal continuous training program to provide adequate DOE field element oversight of WP&C.
- Conduct triennial self-assessments of the Facility Representative program to provide adequate DOE field element oversight of WP&C.

Site Contractors

To strengthen WP&C programs:

- Benchmark Lawrence Livermore National Laboratory (LLNL), which has developed a strong WP&C program. Many elements of the LLNL program can be applied to research, operations, and/or maintenance-type work.
- Ensure that the programs include the appropriate standards and specify when a hazard analysis must be performed, including the fall protection program.
- Incorporate guidance from DOE-HDBK-1211-2014, *DOE Handbook: Activity-Level Work Planning and Control Implementation*.

To enhance WP&C programs for research work activities:

- Include a process for identifying and evaluating the critical work tasks within a research experiment (tasks with the greatest hazards), identify the potential adverse consequences and hazard controls to mitigate the consequences, and document an assessment of the overall risk to the researchers (e.g., the "critical thinking" risk assessment approach to WP&C used by Sandia National Laboratories – New Mexico Center 1800 researchers).
- Verify that the research WP&C process incorporates a mechanism for documenting an exposure assessment for each experiment that addresses the potential biological, chemical, physical, and ergonomic hazards of the experiment.

To strengthen WP&C implementation, emphasize the identification and analysis of hazards and development of controls in the following areas:

- Ensure adequate tailoring of hazards and controls to specific work activities and avoid overreliance on general job hazard analyses. Areas of concentration should include work at heights and LOTO.
- Ensure that industrial hygiene (IH) exposure assessments are complete and accurate, and that workplace contaminant, chemical exposure, and physical hazard controls are identified with consistent hazard controls specified and implemented.

For work involving radiological hazards, provide additional focus and rigor in the following areas:

- Ensure that job-specific air sampling is properly conducted and representative of worst-case conditions at posted radiological boundaries during intrusive work. At some sites, RWPs specifying perimeter or job-specific air sampling may need to be improved to achieve this objective.
- Ensure that contamination control practices for areas, equipment, and personnel, including removable contamination surveys and frisking, are adequate to detect the potential spread of contamination beyond posted radiological boundaries during intrusive work, and to verify that RWP contamination limits are not exceeded.

To improve skill-of-the-worker (SOW) programs:

- Develop a SOW program tailored to research work. This recommendation was also included in the Office of Enterprise Assessment's December 2019 WP&C lessons-learned report.
- Clearly define what work can be accomplished as SOW.
- Ensure that all work has some level of hazard analysis, work release, and pre-job briefing.
- Ensure that all workers are trained and qualified to perform SOW activities.
- Incorporate guidance from DOE-HDBK-1211-2014, *DOE Handbook: Activity-Level Work Planning and Control Implementation*, appendix A.

To improve the performance of subcontracted work:

- Establish clear contract flowdown safety requirements in subcontracts and conduct oversight to ensure that DOE and prime contract safety requirements are included in sub-tier contracts.
- Increase oversight for subcontracted work for those areas where the DOE requirements are more stringent than the Occupational Safety and Health Administration requirements (e.g., silica).
- Ensure that subcontractors understand the DOE requirements (e.g., American Conference of Governmental Industrial Hygienists silica requirements).
- Ensure (in the following order) that proper engineering controls, administrative controls, and appropriate personal protective equipment are applied to eliminate or mitigate workplace hazards.
- Increase personal and area IH monitoring on the jobsite.

To strengthen the CAS and feedback and improvement performance:

- Conduct periodic assessments to determine how well applicable lessons learned, areas for improvement, and worker feedback are captured, analyzed, shared, and subsequently implemented in applicable WCDs.
- Develop specific metrics for WP&C performance, including key leading indicators.
- Collect, trend, and analyze available job performance information, such as worker feedback, for potential lessons learned.