Lessons Learned from the Assessment of Software Quality Assurance Program Implementation at U.S. Department of Energy Nuclear Facilities

March 2025

U.S. DEPARTMENT of ENERGY | Office of Enterprise Assessments

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Acronyms

CFR	Code of Federal Regulations
CRAD	Criteria and Review Approach Document
DOE	U.S. Department of Energy
EA	Office of Enterprise Assessments
NQA	Nuclear Quality Assurance
QAP	Quality Assurance Program
SQA	Software Quality Assurance

LESSONS LEARNED FROM THE ASSESSMENT OF SOFTWARE QUALITY ASSURANCE PROGRAM IMPLEMENTATION AT U.S. DEPARTMENT OF ENERGY NUCLEAR FACILITIES

Executive Summary

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted a two-phase independent assessment of software quality assurance (SQA) program implementation across the DOE enterprise. The phase 1 comparative analysis was conducted from July 2022 through January 2023, and phase 2 assessments were conducted at five selected DOE sites with nuclear facilities from March 2023 through May 2024. By comparing the contractor SQA programs and associated DOE field element oversight strategies, and by performing assessments to evaluate the implementation of those programs, lessons were learned related to SQA program and process implementation. This lessons-learned report identifies best practices, strengths, and weaknesses observed during the assessments and analysis of collected data. In addition, this report provides recommendations to promote organizational learning and improve performance throughout the DOE enterprise.

Overall, the assessed contractors established and implemented SQA programs that demonstrated adequate compliance with applicable quality assurance requirements. EA identified several strengths in SQA program implementation, including the following best practices:

- Bechtel National, Inc. identified a non-nuclear safety category for software that would be associated with facility chemical hazards at the Hanford Site. This practice enhanced the process for implementing controls commensurate with an identified risk.
- Battelle Memorial Institute identified a non-nuclear safety software risk level category/grade for software that would be used in association with facility radiological, biological, chemical, or physical hazards at Pacific Northwest National Laboratory. This practice enhanced the process for implementing controls commensurate with an identified risk.
- National Technology and Engineering Solutions of Sandia, LLC identified a non-nuclear safety category for software that can inadvertently respond, resulting in an accident; be used to mitigate the result of an accident; or be used to recover from the effects of an accident. This practice enhanced the process for implementing controls commensurate with an identified risk.

However, EA also identified weaknesses in SQA program implementation and DOE field element oversight, including the following:

- Contractors have not consistently established a methodology to ensure that SQA procedures thoroughly reflect the DOE Order 414.1D, *Quality Assurance*, quality assurance criteria and that each criterion is applied to all software.
- Software applications are at times inappropriately exempted from quality assurance program (QAP) requirements. This occurred most frequently when they were not managed as part of the established SQA program.
- Not all SQA-related issues are documented in and tracked through institutional issues management systems.
- SQA oversight and assessment activities are, at times, limited to safety software, and independent assessments of SQA effectiveness are not always performed.

- SQA program management and contractor assurance at some sites is decentralized and consequently inhibits the ability of the organizations to maintain knowledge of sitewide SQA program implementation and trend performance.
- Field elements do not always maintain trained and qualified SQA subject matter experts to review and approve contractor SQA programs and conduct ongoing evaluations of SQA program implementation.
- Field elements do not always formally review and approve all elements of the contractor QAP required for implementation of the SQA program and its underlying graded approach and established software grading levels.
- Field elements do not always evaluate SQA program implementation across all contractor organizations or for all grades of software.

Overall, site contractors have established SQA programs consistent with most applicable requirements, and the assessed sites have generally demonstrated adequate SQA program implementation. Notably, contractor SQA programs have been well-designed to manage the quality of safety software, and in general, the assessed contractor SQA programs have been well-implemented for safety software. However, several important weaknesses in the design and implementation of contractor SQA programs were identified, most significantly impacting the quality of non-safety software and potentially its reliability to perform its intended function. In addition, though generally adequate, the effectiveness of DOE field element oversight of SQA programs is limited by persistent challenges with maintaining adequate subject matter expertise on staff.

Recommendations

The recommendations identified in this lessons-learned report for DOE field element and program office managers and site contractor managers are summarized below and are more fully described in section 5.0.

DOE Field Element and Program Office Managers

- Develop strategies to ensure adequate SQA oversight staffing levels, and where necessary incorporate the use of qualified, short-term SQA subject matter expert support from external organizations into the SQA oversight approach.
- Develop oversight strategies to ensure the appropriate scope and frequency of SQA assessments, and enhance assessment criteria and review objectives, lines of inquiry, and schedules to ensure that adequate oversight of SQA program implementation is provided for all types and grades of software across a given site.
- Incentivize the successful completion of needed SQA program improvements in performance evaluation and measurement plans.

Site Contractor Managers

- Develop strategies, such as crosswalks and checklists, to ensure adequate flowdown of quality assurance criteria into QAPs and SQA program implementing procedures and to facilitate DOE review, approval, and oversight.
- Ensure that the established graded approach requires that all software applications, regardless of grading level, comply with all quality assurance criteria, with a graded approach, as set forth in DOE Order 414.1D and 10 CFR 830, *Nuclear Safety Management*, subpart A, *Quality Assurance Requirements*.

- Involve cybersecurity organizations in SQA decision-making by integrating cybersecurity processes with SQA processes to simplify workflow activities for software owners.
- Establish an SQA program management strategy to ensure corporate program assurance capability as well as thorough and detailed knowledge of how the SQA program has been implemented throughout the organization down to the facility level.
- Perform periodic and routine self-assessments and reviews of SQA program implementation that evaluate all software grading levels.

LESSONS LEARNED FROM THE ASSESSMENT OF SOFTWARE QUALITY ASSURANCE PROGRAM IMPLEMENTATION AT U.S. DEPARTMENT OF ENERGY NUCLEAR FACILITIES

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted a two-phase independent assessment of software quality assurance (SQA) program implementation across the DOE enterprise. The phase 1 comparative analysis was conducted from July 2022 through January 2023, and phase 2 assessments were conducted at five selected DOE sites with nuclear facilities from March 2023 through May 2024. The comparative analysis included 25 individual contractor organizations, contracted to 4 program offices, responsible for 27 separate projects, representing 14 sites, and overseen by 17 field element organizations. The phase 2 assessments comprised eight contractor and five field element organizations at sites under the direction of the DOE Office of Science, the Office of Environmental Management, and the National Nuclear Security Administration. By comparing the contractor SQA programs and associated DOE field element oversight strategies, and by performing assessments to evaluate the implementation of those programs, lessons were learned related to SQA program and process implementation. This lessons-learned report identifies best practices, strengths, and weaknesses observed during the assessments and analysis of collected data. In addition, this report provides recommendations to promote organizational learning and improve performance throughout the DOE enterprise.

This lessons-learned effort considered the individual assessments performed in accordance with the *EA Plan for Phase 2 of the Enterprise-wide Independent Assessment of Software Quality Assurance Process Implementation, January 2023*, and was informed by the previously completed phase 1 analysis, FN-EA-34-DOE-2023-01-20, *Enterprise-wide Assessment of Software Quality Assurance – Phase 1: Comparative Analysis of SQA Processes*. Phase 1 compared and analyzed the design of SQA programs across the DOE enterprise and helped to identify common and divergent characteristics of the programs. Phase 1 also helped to inform the development of the plan for phase 2 and the selection of the sites to be assessed. Accordingly, phase 2 evaluated SQA program implementation by examining SQA processes at the selected sites. Each assessment evaluated a sample of safety and non-safety software, including software that has been assigned varying grading levels and implemented for a variety of functions (e.g., nuclear safety analyses, security, radiological safety, and administrative activities).

2.0 METHODOLOGY

EA manages the Department's independent oversight program. This program is designed to enhance DOE safety and security programs by providing the Secretary and Deputy Secretary of Energy, Under Secretaries of Energy, DOE managers, senior contractor managers, Congress, and other stakeholders with an independent evaluation of the adequacy of DOE policy and requirements, as well as the effectiveness of DOE and contractor line management performance, risk management in safety and security, and other critical functions as directed by the Secretary. DOE Order 227.1A, *Independent Oversight Program*, describes and governs the DOE independent oversight program. EA implements the program through a comprehensive set of internal protocols and assessment guides.

This report and the recommendations detailed herein reflect an analysis of the collective results from the five assessments that evaluated SQA program implementation, as well as the results of the phase 1 analysis of program design completed in January 2023. As informed by phase 1, the five sites assessed during phase 2 were selected based on several factors, such as phase 1 observations and data clarity,

breadth of SQA program applicability, and program office mix. The selection of these sites provided an opportunity to sample SQA program implementation for hazard category 1 and 2 nuclear facilities that are under the direction of multiple program offices and execute diverse missions.

Appendix A lists the contributors to this lessons-learned effort, the members of the Quality Review Board, and the EA management responsible for this evaluation. Appendix B details the assessed sites and responsible contractors, implemented consensus standards, and DOE Headquarters program offices and field elements, as well as the EA assessment reports used in this evaluation.

3.0 RESULTS

The significant observations from the five supporting assessments have been grouped into the following topical areas: development of SQA program requirements, SQA program implementation, training and qualification, contractor assurance of SQA program performance, and DOE field element oversight and training. Table 1 summarizes the observations related to contractor implementation (see section 3.1) and DOE field element oversight (see section 3.2).

Table 1 - EA-identified Best Practices, Findings, and Deficiencies[1]

Topical Area	Best Practices	Findings	Deficiencies
Development of SQA Program Requirements	3	1	7
SQA Program Implementation	0	1	4
Training and Qualification	0	0	6
Contractor Assurance of SQA Program Performance	0	0	3
DOE Field Element Oversight and Training	0	0	5
Totals	**3**	**2**	**25**

3.1 Contractor Performance

Overall, seven of the eight assessed contractors have implemented generally adequate SQA programs. Most safety and non-safety software is managed using processes that provide adequate assurance of software quality, including software that supports nuclear safety. However, several weaknesses identified by EA during the assessments, as well as weaknesses self-identified by the contractors and field elements, demonstrate that improvements are needed.

3.1.1 Development of SQA Program Requirements

This portion of the lessons-learned review addresses the strengths and weaknesses associated with contractor development and flowdown of SQA program requirements.

[1] Best practices, findings, and deficiencies are defined in DOE Order 227.1A, *Independent Oversight Program*. In summary, best practices are safety or security-related practices, techniques, processes, or program attributes observed during an appraisal that may merit consideration by other DOE and contractor organizations for implementation; deficiencies are inadequacies in the implementation of an applicable requirement or standard; and findings are deficiencies that warrant a high level of attention from management.

Strengths

All assessed contractors had established DOE-approved SQA programs. Two contractors incorporated practices that enhanced the efficiency and effectiveness of their SQA programs. Bechtel National, Inc. improved approval status visibility by including the approval reference number on the cover page of DOE-approved quality documents. Including the approval reference number makes it clear to the user community which documents require DOE approval upon revision. Washington River Protection Solutions, LLC incorporated standards and guidance in several SQA implementing procedures to support the user in conducting activities and preparing deliverables. This practice supports users in obtaining real-time assistance, when needed, in the absence of readily accessible subject matter expertise.

Three of the assessed contractors implemented a single edition of the American Society of Mechanical Engineers Nuclear Quality Assurance (NQA)-1, *Quality Assurance Requirements for Nuclear Facility Applications*, consensus standard for all SQA activities. Another contractor that was implementing multiple editions of the NQA-1 consensus standard was in the process of combining the existing quality programs to reduce program complexity and support consistent implementation. Implementing a single consensus standard helps ensure consistency in SQA program implementation across all software grades. Additionally, some contractors used review boards for SQA-related actions and others incorporated management review hold points into the online workflow processes. The use of such review boards and hold points can serve to systematically ensure that processes and procedures are adhered to.

All assessed contractors established safety software grading levels in their DOE-approved SQA programs that comply with DOE Order 414.1D, *Quality Assurance*, attachment 4. Battelle Memorial Institute, Bechtel National, Inc., and National Technology and Engineering Solutions of Sandia, LLC also established non-nuclear safety software category/grading levels for implementing controls commensurate with an identified non-nuclear risk. Further, all assessed contractors maintained a safety software inventory, as required, and seven also maintained a non-safety software inventory.

Weaknesses

Although the assessed contractors had established DOE-approved SQA programs, some of these programs did not meet all DOE requirements. Significantly, the DOE-approved quality assurance program (QAP) and SQA implementing documents for one contractor did not adequately establish requirements and processes for identifying and controlling all software used at the site; this issue was categorized as a finding in the associated assessment report. One or more of the following weaknesses relating to DOE-approved SQA programs were identified for four of the eight assessed contractors:

- SQA program documents were not always submitted for field office approval due to confusion about which documents required DOE approval.
- Needed changes to SQA program documents were sometimes allowed to accumulate for dispositioning at a later time, instead of being incorporated in a timely manner.
- Software inventories did not always identify the specific nuclear facility where each safety software application was used and include the minimum elements specified by implementing procedures.
- Processes and procedures to detect and prevent software quality issues were not always established.
- Organization- and/or project-specific SQA plans and procedures were sometimes allowed to be independently developed, thereby adding complexity and inconsistencies with sitewide SQA requirements.

In addition, one contractor did not maintain a comprehensive software inventory that included non-safety software. Though not a non-compliance, the lack of such a comprehensive software inventory presented several obstacles to effective SQA program implementation. When an inventory of non-safety software is unavailable, not maintained, or incomplete, actions to determine software status, location, applied grading level, and other key details present a significant challenge to contractors and responsible internal and external oversight organizations. Maintaining a comprehensive inventory of all software that, at a minimum, includes where each software application is used and how it has been graded is valuable for assessing and helping to ensure effective SQA program implementation.

Further, four of the eight assessed contractors implemented two editions of the NQA-1 consensus standard, and one contractor used three editions. Invoking multiple NQA-1 consensus standard editions for separate scopes of work complicates the flowdown of requirements. Specifically, support organizations providing software-related services to multiple facilities at a site encounter facility-specific SQA procedures that are not consistent and/or equivalent.

Additionally, three of the eight assessed contractors demonstrated one or more of the following weaknesses associated with identifying and controlling software:

- Processes and procedures for identifying major modifications to software and applying sitewide SQA program requirements had not been established in all cases.
- SQA procedures and processes for research-related software were sometimes recommended and not required.
- DOE Order 414.1D, attachment 2, criteria were omitted from the requirements flowdown matrix for the SQA topical area of the QAP.

Finally, five of the eight assessed contractors demonstrated one or more of the following weaknesses associated with software grading processes and quality levels:

- Grading processes for non-safety software were not documented.
- Some software applications were inappropriately exempted from QAP requirements when they were not managed as part of the established SQA program. Phase 1 of this assessment also collected data that indicated this may be a broad, enterprise-wide concern.
- Graded approaches and grading levels applied to non-safety software were sometimes omitted from documentation submitted for DOE field element review and approval.

For non-safety software in particular, these weaknesses in SQA processes and procedures can result in inadequate assurance that software will adequately perform its intended function.

3.1.2 SQA Program Implementation

This portion of the lessons-learned review addresses the strengths and weaknesses associated with the implementation of contractor SQA programs.

Strengths

For the reviewed software applications, seven of the eight assessed contractors adequately adhered to established SQA procedures and were generally successful in implementing DOE Order 414.1D, attachment 2, *Quality Assurance Criteria*. Contractor SQA programs have been well-designed to manage the quality of safety software, and in general, the assessed contractor SQA programs have been well-implemented for safety software. UT-Battelle, LLC used a crosswalk to demonstrate the flowdown of

quality assurance requirements into SQA program implementing procedures. The crosswalk simplified the oversight process and facilitated efforts to identify applicable implementing documents; this was also seen during the phase 1 analysis of this assessment. In the absence of explicit requirements to integrate cybersecurity and SQA processes, the assessed contractors have implemented processes that involve cybersecurity organizations and practitioners in SQA decision-making. In so doing, the assessed contractors have begun to address the impact of cybersecurity-related vulnerabilities on software quality ahead of potential future rulemakings that may require these considerations as part of QAP implementation.

Weaknesses

Although seven of the eight assessed contractors were generally successful in implementing DOE Order 414.1D, attachment 2, quality assurance criteria for the reviewed software applications, most contractors did not use a systematic approach. In general, contractors did not establish a consistently structured methodology to ensure that their procedures flowed directly from DOE Order 414.1D requirements and that the management of each software application addressed each quality assurance criterion. As a result, depending on the software application to which the SQA program was being applied, inconsistent methodologies were often used by contractors to apply quality assurance criteria.

Significantly, one contractor did not adequately adhere to its established SQA procedures for the reviewed software applications; this issue was categorized as a finding in the associated assessment report. Further, six of the eight assessed contractors demonstrated one or more of the following implementation weaknesses associated with the reviewed software applications:

- Changes made to software were not always reflected in revisions to the software inventory.
- Evaluations and reviews performed before software was added to the software inventory were not always documented.
- Software management plans did not always include the requirement to maintain software such that damage, loss, and/or deterioration would be prevented.

While most assessed contractors adhered to their SQA procedures and processes, weaknesses in the flowdown of requirements and implementation non-compliances hindered procedural adherence, resulting in inadequate assurance that software performance will be consistent and reproducible.

3.1.3 Training and Qualification

This portion of the lessons-learned review addresses the strengths and weaknesses associated with contractor SQA training and qualification.

Strengths

With few exceptions, software application owners exhibited a thorough knowledge of their respective applications and associated functionality. During several assessments, the knowledge of software application owners helped mitigate the impact of a lack of formal and consistent processes for maintaining documentation to demonstrate compliance with quality assurance requirements. In general, software application owners had completed required SQA program training through sitewide training programs, as well as application-specific training, where required.

Weaknesses

Three of the eight assessed contractors did not specify the minimum training and qualification requirements for some reviewed software applications. For example, one contractor did not establish and require SQA program training for all roles and responsibilities. Another contractor did not ensure that functional responsibilities, levels of authority, and interfaces for maintaining the quality of software were consistently understood by all stakeholders. In these cases, interviews revealed an underlying confusion about the applicability of DOE Order 414.1D to non-safety software that contributed, in part, to an assumption that training criteria (among other requirements) need not be addressed for software applications of lower grading levels.

3.1.4 Contractor Assurance of SQA Program Performance

This portion of the lessons-learned review addresses the strengths and weaknesses associated with contractor assurance of SQA program performance and corrective actions.

Strengths

Two of the eight assessed contractors required annual self-assessments and internal reviews of SQA program implementation. Six assessed contractors had corrective action plans in place and were taking appropriate actions to address programmatic SQA issues that were either self-identified or identified through DOE field element oversight. Additionally, three assessed contractors adequately documented known quality issues and associated mitigation activities for a specific safety software application (i.e., RadCalc 4.1).

Weaknesses

Four of the eight assessed contractors demonstrated one or more of the following weaknesses associated with assurance of SQA program performance and corrective actions:

- SQA-related issues from management assessments and surveillances were not always documented in the contractor issues management system.
- Software-related errors that were not tracked through a software change control process were also not managed through established issues tracking and trending processes. Phase 1 of this assessment also collected enterprise-wide data, which indicated that some contractors may encounter obstacles that inhibit the effective implementation of software change control processes for commercial-off-the-shelf software and software used for physical security systems.
- Known quality issues with acquired software were not always documented and addressed to justify continued use of the software.
- Contractor assurance of SQA and associated assessment activities were, at times, limited to safety software; in one case, management or independent assessments of SQA effectiveness were not being performed.

Additionally, for two assessed contractors, assurance of SQA program implementation was largely decentralized such that SQA program performance evaluation was the responsibility of software owners and users at the sub-organization and facility level. In these cases, corporate assurance organizations were limited in their ability to trend performance or remain knowledgeable of sitewide SQA program performance.

The identified weaknesses reduce the availability of feedback associated with SQA program performance, hindering efforts to improve software quality. In some cases, these weaknesses inhibited the establishment of a common, corporate understanding of what SQA programs apply to, how they are applicable, and how they are implemented across a site.

3.2 DOE Field Element Oversight and Training

This portion of the lessons-learned review addresses the strengths and weaknesses associated with DOE oversight of contractor SQA programs and training for field element staff.

Strengths

All five assessed field elements reviewed and approved their respective contractor's software QAP, including safety software grading levels, as required by DOE Order 414.1D. SQA program oversight conducted by two of the five field elements resulted in contractor corrective action plans to address programmatic weaknesses prior to the EA assessments.

Four of the five assessed field elements utilized SQA subject matter expertise to support oversight. Two employed trained and qualified SQA subject matter experts who maintained qualification to DOE-STD-1172, *Safety Software Quality Assurance Functional Area Qualification Standard*; one had assigned an individual nearing completion of qualification to DOE-STD-1172; and another used qualified SQA subject matter expertise from an external organization for assistance with review and approval of the contractor SQA program. In the absence of readily available and sufficient SQA subject matter expertise, acquiring external expert support on a temporary or periodic basis is an effective method to enhance SQA program oversight capabilities.

One assessed field element included SQA in the performance evaluation measurement plan to incentivize successful completion of needed SQA program improvements. The three field elements with SQA subject matter experts assigned to complete qualification to DOE-STD-1172 regularly met with contractor personnel to discuss SQA activities and improvement efforts.

Weaknesses

Two of the five assessed field elements did not maintain trained and qualified SQA subject matter experts to review and approve contractor SQA programs or perform ongoing evaluations of SQA program performance. These two field elements did not formally review and approve all elements of the contractor QAP as applied to the implementation of the SQA program and its underlying graded approach and established software grading levels.

Although SQA program oversight conducted by two of the five assessed field elements resulted in contractor corrective action plans to address significant programmatic weaknesses prior to the EA assessments, EA identified additional weaknesses. In the cases where large programmatic corrective action plans are being executed, routine SQA program oversight can be overlooked; when this occurs, new and/or different unidentified issues may develop and go unaddressed.

One assessed field element did not evaluate SQA program implementation across all contractor organizations or for all grades of software, but rather limited oversight to safety software owned by one contractor business unit. Despite conducting SQA oversight, another field element did not identify the significant SQA program weaknesses identified by EA. Finally, one assessed field element did not conduct any documented SQA oversight within the past five years.

Weaknesses in field element oversight were largely attributable to inadequate Federal SQA oversight staffing. In several cases, SQA oversight staffing was well below expectations documented in approved staffing plans. Additional challenges (e.g., lack of available training) with acquiring the DOE-STD-1172 qualification limited DOE field element access to trained and qualified SQA oversight staff. Phase 1 of this assessment also identified an enterprise-wide challenge with staffing sufficient numbers of qualified SQA oversight personnel at the field element level.

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 has been demonstrated to substantially improve the safety or security performance of a DOE operation, or it represents or contributes to superior performance (beyond compliance). Additionally, a best practice could be identified because it solves a problem or reduces the risk of a condition or practice that affects multiple DOE sites or programs, or it provides an innovative approach or method to improve effectiveness or efficiency. The following best practices were identified at the time that the individual assessments were conducted and may be valuable to other DOE nuclear facility projects:

- Bechtel National, Inc. identified a non-nuclear safety category for software that would be associated with facility chemical hazards at the Hanford Site. This practice enhanced the process for implementing controls commensurate with an identified risk.
- Battelle Memorial Institute identified a non-nuclear safety software risk level category/grade for software that would be used in association with facility radiological, biological, chemical, or physical hazards at Pacific Northwest National Laboratory. This practice enhanced the process for implementing controls commensurate with an identified risk.
- National Technology and Engineering Solutions of Sandia, LLC identified a non-nuclear safety category for software that can inadvertently respond, resulting in an accident; be used to mitigate the result of an accident; or be used to recover from the effects of an accident. This practice enhanced the process for implementing controls commensurate with an identified risk.

5.0 RECOMMENDATIONS

The following recommendations are based on the analysis of assessments as summarized in section 3.0 of this report. While the underlying weaknesses (findings and deficiencies) from the individual assessments did not apply to every reviewed site, the recommended actions are intended to provide insights for potential improvements at all DOE sites with nuclear facilities. Consequently, DOE field element and program office managers and site 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-specific program objectives.

DOE Field Element and Program Office Managers

To enhance DOE staff training and oversight of SQA activities, consider the following actions:

- Develop strategies to ensure adequate SQA oversight staffing levels, and where necessary incorporate the use of qualified, short-term SQA subject matter expert support from external organizations into the SQA oversight approach.

- Develop mechanisms, such as job-detail opportunities and cross-training across the DOE enterprise, to assist Headquarters and field element staff in obtaining SQA qualifications and experience.
- Develop oversight strategies to ensure the appropriate scope and frequency of SQA assessments, and enhance assessment criteria and review objectives, lines of inquiry, and schedules to ensure that adequate oversight of SQA program implementation is provided for all types and grades of software across a given site.
- Incentivize the successful completion of needed SQA program improvements in performance evaluation and measurement plans.
- Encourage adoption of a single edition of NQA-1 at a site to reduce complexity, and allow use of any of the Nuclear-Regulatory-Commission-endorsed NQA-1 editions without having to prove equivalency to NQA-1-2008/NQA-1a-2009.
- Encourage the integration of cybersecurity processes into SQA processes to reduce complexity and errors of omission, and to facilitate software owners' ability to fully implement all applicable requirements.

Site Contractor Managers

To improve the establishment of and compliance with SQA requirements, consider the following actions:

- Develop strategies, such as crosswalks and checklists, to ensure adequate flowdown of quality assurance criteria into QAPs and SQA program implementing procedures and to facilitate DOE review, approval, and oversight.
- Ensure that the established graded approach requires that all software applications, regardless of grading level, comply with all quality assurance criteria, with a graded approach, as set forth in DOE Order 414.1D and 10 CFR 830, *Nuclear Safety Management*, subpart A, *Quality Assurance Requirements*.
- Establish a safety software category and grading level within the SQA graded approach to implement controls commensurate with risk for software related to non-nuclear hazards.
- Consider adopting a single edition of NQA-1 at a given site to reduce the complexity of quality assurance processes, including SQA.
- Involve cybersecurity organizations in SQA decision-making by integrating cybersecurity processes with SQA processes to simplify workflow activities for software owners.
- Develop and maintain a comprehensive software inventory that identifies all safety and non-safety software and, at a minimum, documents grading level, status, and facilities where used.
- Establish an SQA program management strategy to ensure corporate program assurance capability as well as thorough and detailed knowledge of how the SQA program has been implemented throughout the organization down to the facility level.
- Develop effective management and independent assessment strategies, such as CRADs, lines of inquiry, and assessment schedules, to ensure adequate implementation of the SQA program for all types and grades of software across the site.
- Perform periodic and routine self-assessments and reviews of SQA program implementation that evaluate all software grading levels.
- Develop effective strategies, programs, and incentives to ensure adequate staffing and training for all roles, as applicable to a given SQA program.

Appendix A
Supplemental Information

Office of Enterprise Assessments (EA) Management

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Appendix B
Assessed Sites and Source Documents

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) enterprise. This lessons-learned report is based on data obtained from the phase 1 comparative analysis of 25 contractor software quality assurance (SQA) programs and the phase 2 assessments of 8 contractor SQA programs at 5 DOE sites responsible for the operation of high-hazard nuclear facilities conducted between March 2023 and May 2024.

The sites, operating contractors, and consensus standard implemented by each site contractor assessed during phase 2 are detailed in Table B-1. These facilities are under the direction of the DOE Office of Science, the Office of Environmental Management, and the National Nuclear Security Administration. The objective of the assessments was to evaluate the performance of contractor SQA programs in maintaining software quality used at high-hazard nuclear facilities, and to evaluate DOE field element oversight of those programs.

The assessments included elements from EA CRAD 30-10, Revision 0, *Software Quality Assurance*, to determine whether the policies, procedures, and operational performance met DOE objectives for effectiveness in the areas examined. Strengths, weaknesses, and deficiencies identified in the independent assessment reports for the sites listed in Table B-1 were binned into the following topical areas:

- Establishment of SQA program requirements
- SQA program implementation
- Training and qualification
- Contractor assurance of SQA program performance
- DOE field element oversight and training.

Table B-1. Assessed Sites

Assessed Site	Contractor	Implemented Consensus Standards	DOE Headquarters Program Office	DOE Field Element
Hanford Site	Hanford Mission Integration Solutions, LLC	NQA-1-2008/ NQA-1a-2009 addenda	Office of Environmental Management	Richland Operations Office and Office of River Protection[2]
	Central Plateau Cleanup Company	NQA-1-2008/ NQA-1a-2009 addenda		
	Washington River Protection Solutions, LLC	NQA-1-2008/ NQA-1a-2009 addenda Portions of NQA-1-2019		
	Bechtel National, Inc.	NQA-1-2000 NQA-1-2008/ NQA-1a-2009 addenda		
Pacific Northwest National Laboratory	Battelle Memorial Institute	NQA-1-2000 NQA-1-2012 NQA-1-2015	Office of Science	Pacific Northwest Site Office
Nevada National Security Sites	Mission Support and Test Services, LLC	NQA-1-2015	National Nuclear Security Administration	Nevada Field Office
Oak Ridge National Laboratory (ORNL)	UT-Battelle, LLC	NQA-1-2000 NQA-1-2008/ NQA-1a-2009 addenda	Office of Science	ORNL Site Office
Sandia National Laboratories – New Mexico	National Technology and Engineering Solutions of Sandia, LLC	NQA-1-2008/ NQA-1a-2009 addenda NQA-1-2017	National Nuclear Security Administration	Sandia Field Office

[2] Effective October 1, 2024, the Richland Operations Office and Office of River Protection were combined into the Hanford Field Office.

Source Documents

- EA Field Note, FN-EA-34-DOE-2023-01-20, *Enterprise-wide Assessment of Software Quality Assurance – Phase 1: Comparative Analysis of SQA Processes*
- EA Report, *Independent Assessment of Software Quality Assurance Program Implementation at the Hanford Site, October 2023*
- EA Report, *Independent Assessment of Software Quality Assurance Program Implementation at the Pacific Northwest National Laboratory, October 2023*
- EA Report, *Independent Assessment of Software Quality Assurance Program Implementation at the Nevada National Security Sites, November 2023*
- EA Report, *Independent Assessment of Software Quality Assurance Program Implementation at the Oak Ridge National Laboratory, February 2024*
- EA Report, *Independent Assessment of Software Quality Assurance Program Implementation at Sandia National Laboratories – New Mexico, August 2024*