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# DRAFT SUPPLEMENT ANALYSIS FOR THE FINAL SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT FOR THE Y-12 NATIONAL SECURITY COMPLEX, EARTHQUAKE ACCIDENT ANALYSIS

National Nuclear Security Administration

# EXECUTIVE SUMMARY

The National Nuclear Security Administration (NNSA), a semi-autonomous agency within the U.S. Department of Energy (DOE), is responsible for meeting the national security requirements established by the Congress and the President and has a statutory mission to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile (50 U.S. Code (U.S.C.) § 2401(b)). The Y-12 National Security Complex (Y-12) is the primary site of uranium operations for NNSA, and it provides manufacturing facilities for maintaining the U.S. nuclear weapons stockpile.

In March 2011, NNSA prepared the Final Site-Wide Environmental Impact Statement (SWEIS) for the Y-12 National Security Complex (Y-12 SWEIS; DOE/EIS-0387) (NNSA 2011), which analyzed the potential environmental impacts of ongoing and future operations and activities at Y-12. In July 2017, a federal lawsuit was filed by four individuals and three nonprofit organizations asserting that NNSA had violated the *National Environmental Policy Act of 1969*, as amended (NEPA) (42 U.S. C. § 4321 et seq.), by failing to prepare a supplement to the Y-12 SWEIS. Among other things, the plaintiffs argued that NNSA should prepare a new or supplemental SWEIS due to new circumstances concerning the decision to construct a smaller-scale Uranium Processing Facility (UPF) and significant new information that came to light after the publication of the 2011 SWEIS. On the latter point, plaintiffs asserted that the seismic risk in East Tennessee had increased as evidenced by seismic hazard maps published in 2014 by the U.S. Geological Survey (USGS).

On September 24, 2019, a Memorandum Opinion and Order was issued by the U.S. District Court of the Eastern District of Tennessee as a result of the July 2017 federal lawsuit. While the Court ruled that NNSA is not required to prepare a new or supplemental SWEIS based upon changes to the UPF, the Court also ruled that "new information revealed since the 2011 SWEIS requires further analysis." The Court ordered that NNSA "shall conduct further NEPA analysis-- including at a minimum, a supplement analysis-- that includes an unbounded accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that incorporated the 2014 USGS map."

In accordance with the Court Order, this Supplement Analysis (SA) presents an accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that have incorporated the 2014 USGS seismic hazard/maps. The purpose of this SA is to determine whether the earthquake consequences constitute a substantial change that is relevant to environmental concerns, or if there are significant new circumstances or information relevant to environmental concerns and bearing on continued operations at Y-12 compared to the analysis in the Y-12 SWEIS.

As shown in Section 3.0 of this SA, the potential impacts associated with an earthquake accident at Y-12 would not be significantly different than impacts in the Y-12 SWEIS. Based on the results of this SA, NNSA has preliminarily determined that: (1) the earthquake consequences and risks do not constitute a substantial change; (2) there are no significant new circumstances or information relevant to environmental concerns; and (3) no additional NEPA documentation is required at this time.

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ARF | airborne release fraction |
| AROD | amended ROD |
| ASCE | American Society of Civil Engineers |
| CEUS SSC | Central and Eastern United States Seismic Source Characterization for Nuclear Facilities |
| CFR | *Code of Federal Regulations* |
| CNS | Consolidated Nuclear Security, LLC |
| DOE | U.S. Department of Energy |
| DR | damage ratio |
| DU | depleted uranium |
| EIS | Environmental Impact Statement |
| ELP | Extended Life Program |
| EPRI | Electric Power Research Institute |
| EU | enriched uranium |
| FR | *Federal Register* |
| HEU | highly enriched uranium |
| HEUMF | Highly Enriched Uranium Materials Facility |
| IBC | International Building Code |
| LCF | latent cancer fatality |
| LPF | leak path factor |
| MACCS | MELCOR Accident Consequence Code Systems |
| MAR | material-at-risk |
| MEI | maximally exposed individual |
| NEHRP | National Earthquake Hazards Reduction Program |
| NEPA | *National Environmental Policy Act of 1969* |
| NGA-East | Next Generation Attenuation-East |
| NNSA | National Nuclear Security Administration |
| NOA | Notice of Availability |
| NRC | Nuclear Regulatory Commission |
| ORNL | Oak Ridge National Laboratory |
| PEER | Pacific Earthquake Engineering Research Center |
| PGA | Peak Ground Acceleration |
| PSHA | Probabilistic Seismic Hazard Analysis |
| RF | respirable fraction |
| ROD | Record of Decision |
| SA | Supplement Analysis |
| SDRS | Safety Detection and Response System |
| SWEIS | Site-Wide Environmental Impact Statement |
| UPF | Uranium Processing Facility |
| USC | U.S. Code |
| USGS | U.S. Geological Survey |
| Y-12 | Y-12 National Security Complex |

# 1.0 INTRODUCTION

The National Nuclear Security Administration (NNSA), a semi-autonomous agency within the U.S. Department of Energy (DOE), is responsible for meeting the national security requirements established by the Congress and the President and has a statutory mission to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile (50 U.S.C. § 2401(b)). The Y-12 National Security Complex (Y-12) is the primary site of uranium operations for NNSA, and it provides manufacturing facilities for maintaining the U.S. nuclear weapons stockpile. Y-12 is unique in that it is the only source of secondaries, cases, and other nuclear weapons components for the NNSA nuclear security mission. Uranium materials, including enriched uranium (EU), and manufacturing capabilities are essential to the missions of NNSA's national security programs.

As explained in Section 1.1, NNSA has prepared this Supplement Analysis (SA) to evaluate the potential impacts of an earthquake accident at Y-12, based on updated seismic hazard information. This SA was prepared in accordance with the DOE procedures implementing the *National Environmental Policy Act of 1969*, as amended (NEPA; 42 U.S. Code (USC) § 4321 et seq.), that require that "[when] it is unclear whether or not an Environmental Impact Statement (EIS) supplement is required, DOE shall prepare a Supplement Analysis [that] shall discuss the circumstances that are pertinent to deciding whether to prepare a supplemental EIS pursuant to 40 CFR 1502.9(c)" (10 *Code of Federal Regulations* [CFR] 1021.314). An SA may also be prepared at any time, as appropriate, to further the purposes of NEPA.

## 1.1 Background

In March 2011, NNSA prepared the Final Site-Wide Environmental Impact Statement (SWEIS) for the Y-12 National Security Complex (Y-12 SWEIS; DOE/EIS-0387) (NNSA 2011), which analyzed the potential environmental impacts of ongoing and future operations and activities at Y-12. Five alternatives were analyzed in the Y-12 SWEIS: (1) No Action Alternative (maintain the status quo), (2) Uranium Processing Facility (UPF) Alternative, (3) Upgrade in-Place Alternative, (4) Capability-sized UPF Alternative, and (5) No Net Production/Capability-sized UPF Alternative. In the Record of Decision (ROD) dated July 20, 2011 (76 *Federal Register* [FR] 43319), NNSA decided to construct and operate a Capability-sized UPF at Y-12 as a replacement for certain EU processing facilities. With regard to other missions at Y-12, NNSA decided to continue those missions in existing facilities with no changes.

In 2016, as a result of concerns about UPF cost and schedule growth, NNSA prepared an SA to the Y-12 SWEIS (2016 SA; DOE/EIS-0387-SA-01) (NNSA 2016a), which evaluated a proposed action to meet EU requirements using a hybrid approach of upgrading existing EU facilities (hereafter, these facilities are referred to as the "Extended Life Program [ELP] facilities") and constructing multiple new buildings (e.g., UPF complex). That proposed action combined elements of two proposed alternatives from the Y-12 SWEIS (called the hybrid approach), which differed from the selected alternative in the ROD. The analysis in the 2016 SA indicated that the identified and projected environmental impacts of the proposed action would not be significantly different from those in the Y-12 SWEIS, and on July 12, 2016, NNSA issued an amended ROD (AROD) to implement the hybrid approach (81 FR 45138) (2016 Amended ROD).

In July 2017, a federal lawsuit was filed by four individuals and three nonprofit organizations asserting that NNSA had violated NEPA by failing to prepare a supplemental SWEIS. Among other things, the plaintiffs argued that NNSA should prepare a supplemental SWEIS due to significant new information that came to light after the publication of the 2011 SWEIS. More specifically, plaintiffs asserted that the seismic risk in East Tennessee had increased as evidenced by seismic hazard maps published in 2014 by the U.S. Geological Survey (USGS).

In August 2018, NNSA prepared another SA to the Y-12 SWEIS (2018 SA; DOE/EIS-0387-SA-03) (NNSA 2018), which evaluated the environmental impacts of continuing site operations against the existing Y-12 SWEIS to determine if significant changes or new information warranted a supplemental or new SWEIS. In the SA, NNSA determined that Y-12 continuing operations were not significantly different than those evaluated in the 2011 SWEIS.

On September 24, 2019, a Memorandum Opinion and Order was issued by the U.S. District Court for the Eastern District of Tennessee as a result of the July 2017 federal lawsuit (USDC 2019). The Court ruled that NNSA is not required to prepare a new or supplemental SWEIS due to the decision to construct a smaller-scale UPF project and continue some EU operations in the ELP facilities. However, the Court also ruled that "new information revealed since the 2011 SWEIS requires further analysis," and consistent with that ruling, the Court vacated the 2016 SA, the 2016 amended ROD, and the 2018 SA. Further, the Court ordered that NNSA "shall conduct further NEPA analysis-- including at a minimum, a supplement analysis-- that includes an unbounded accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that incorporated the 2014 USGS map."[1]

On October 4, 2019, NNSA amended its July 2011 ROD for the Y-12 SWEIS to reflect its decision to continue to implement, on an interim basis, the hybrid approach previously approved in the vacated 2016 AROD. As the Court previously ruled in its Order, that hybrid approach, which combined elements of the two alternatives previously analyzed in the Y-12 SWEIS, was adequately analyzed within the range of alternatives considered in the Y-12 SWEIS. The 2019 AROD enables NNSA to implement safety improvements consistent with the Court Order and conduct the required additional NEPA documentation which is contained in this SA. Once this process is completed, NNSA could issue a new AROD describing what, if any, changes it has decided to make in light of that analysis.

## 1.2 Purpose and Need for this Supplement Analysis

In accordance with the Court Order, this SA presents an unbounded[2] accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses or conservative application of the 2014 USGS hazard/maps in conjunction with information determined through site specific testing and previous analyses. The analysis in this SA is intended

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[1] The Court also ruled that 69 categorical exclusion determinations were in violation of NEPA and ordered that "the relevant exclusions should be prepared in a manner consistent with the letter of the relevant DOE regulations." Consistent with the Court Order, DOE/NNSA has appropriately revised those categorical exclusions, which cover projects that are still ongoing. Those categorical exclusions are not included in the scope of this SA.

[2] The Y-12 SWEIS did not present a specific and detailed assessment of earthquake accidents because the source terms (i.e., hazards) from earthquake accidents were less than or equal to (i.e., "bounded by") other accidents (*see* Table D.9.3-1 of NNSA 2011). By presenting a specific and detailed assessment of earthquake accidents, this SA "unbounds" the earthquake accidents from other accidents, and the results stand on their own.

to ensure informed decision-making by NNSA and disclose to the public: (1) the differences in earthquake hazards among the various facilities at Y-12 that NNSA will use to conduct the ongoing EU mission in accordance with the 2019 AROD; and (2) the differences in the hazards among previously-reviewed alternatives. The purpose of this SA is to determine whether the earthquake consequences constitute a substantial change that is relevant to environmental concerns, or if the new seismic information constitutes significant new circumstances or information relevant to environmental concerns and bearing on continued operations at Y-12 compared to the analysis in the Y-12 SWEIS. Based on the SA, NNSA will determine whether the Y-12 SWEIS should be supplemented, a new SWEIS is warranted, or no further NEPA documentation is required.

## 1.3 Organization of this Supplement Analysis

This SA is organized as follows:

- Section 1.0 contains the introduction and background information;
- Section 2.0 provides seismic and facility information relevant to the analysis in this SA;
- Section 3.0 presents the accident analysis of earthquake consequences at the Y-12 site, and contains the comparative environmental impact analysis;
- Section 4.0 contains the preliminary conclusion and determination; and
- Section 5.0 identifies references used in this SA.

## 1.4 Relevant NEPA Documents and other Documents

This SA tiers from the Y-12 SWEIS and incorporates the analysis from other documents to succinctly present the analysis. Information from these documents provides a context for understanding the current status of NEPA compliance, which forms the foundation for preparing the analysis in this SA.

**Y-12 SWEIS (NNSA 2011).** See description in Section 1.1. The Y-12 SWEIS is the most current site-wide NEPA documentation for Y-12 and provides information about Y-12 site operations, baseline environmental conditions, and ongoing environmental impacts relevant to this SA.

***Seismic Analysis and Consequences of a Seismically-Initiated Accident* (CNS 2020a).** In March 2020, Consolidated Nuclear Security, LLC (CNS), the management and operating contractor for Y-12, prepared a technical document (hereafter, CNS 2020 Seismic Report) to address issues that were raised by the U.S. District Court in the Memorandum Opinion and Order. That document (*see* Appendix B) provides supporting information for this SA and is incorporated by reference, as appropriate. Among other things, that document: (1) discusses the 2014 USGS seismic hazard/maps and the process DOE/NNSA uses to develop a more detailed, multi-parameter site-specific Probabilistic Seismic Hazard Analysis (PSHA) as part of a seismic risk assessment for sites that house nuclear facilities (*see* Sections 2.1.1 and 2.1.2); (2) identifies the site-specific PSHAs that have been developed for Y-12 and the Y-12 nuclear facilities addressed in this SA (*see* Section 2.2); (3) explains how the UPF design requirements account for the 2014 USGS seismic hazard/maps (*see* Section 2.2.1); and (4) explains the process NNSA is employing to account for the 2014 USGS seismic hazard/maps into the site-specific PSHA for the ELP facilities (*see* Section 2.2.2).

## 1.5 Public Process

Although publication of a draft SA is not required, NNSA is making the Draft SA available for public review and comment on the NNSA NEPA web page (https://www.energy.gov/nnsa/nnsa-nepa-reading-room). NNSA announced the availability of the Draft SA in local newspapers and is providing a 30-day public comment period. In the process of preparing the Final SA, NNSA will consider all comments received on the Draft SA.

# 2.0 INFORMATION RELEVANT TO THIS SUPPLEMENT ANALYSIS

## 2.1 Seismic Risk Assessment and Seismic Hazard Analysis

Seismic hazard analysis is an analysis of the impacts of possible future earthquakes based on study and understanding of the geology in a region. In evaluating the risks posed by existing or planned buildings that will hold nuclear materials, NNSA always considers seismic events in the design of facilities and the potential for such events to cause a release of nuclear material into the environment. Based on this potential for release of radioactive materials, the seismic design requirements are defined by DOE requirements and/or consensus engineering codes and standards, as described in this section. In order to do this, NNSA must first consider the material-at-risk (MAR), which is the amount and character of nuclear materials present, and the source term, which is the amount of nuclear material that may be released to the environment in the event of an accident, such as an earthquake. Based on the potential consequences, using extremely conservative methods to maximize consequences, seismic design criteria are determined. The criteria can be summarized as follows: effectively, the greater the hazard the more stringent the structural and confinement design requirements for the facility. These requirements are also used to evaluate existing facilities constructed prior to current requirements. Effectively, the seismic requirements increase based on the magnitude of the event by assuming a greater return interval event (a more severe earthquake).

The potential for seismic events at a site is often defined in terms of probabilistic ground motion. Ground motion means the motion of the ground that is caused by an earthquake. The USGS missions include monitoring and reporting on earthquakes, assessing earthquake impacts and hazards, and conducting targeted research on the causes and effects of earthquakes. As part of that mission, the USGS provides periodic updates to estimates of probabilistic ground motion. The USGS updates to probabilistic ground motion are used by model building codes, such as the International Building Code (IBC) (a consensus standard). NNSA uses IBC standards for non-nuclear facilities. However, NNSA requires a more detailed, multi-parameter site-specific PSHA as part of a seismic risk assessment for sites that house nuclear facilities (*see* Sections 2.1.2 and 2.1.3).

As explained in Section 2.1.2, a PSHA considers a range of site-specific information and data to develop the design response spectra (*see* definition in Section 2.2.1) for all frequencies of ground motion. However, in evaluating the degree to which updated USGS data may affect an existing PSHA, it is useful to pick a data point, such as Peak Ground Acceleration (PGA) in order to conduct an "apples-to-apples" comparison, even though such data are only part of the suite of data that will be used.[3]

**Common Seismic Terms used in this SA**

**Peak Ground Acceleration** (**PGA**) refers to the maximum ground acceleration that occurs during earthquake shaking at a given location.

**Probabilistic Seismic Hazard Analysis (PSHA)** is a method used to estimate the level of ground motion with a specified probability of exceedance. Earthquakes from all possible regional seismic sources, each with a given probability of occurrence, are taken into account in this type of analysis.

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[3] PGA is frequently used for discussion and comparison because it is provided in most PSHAs. PGA also provides a relatively easy comparison of seismic hazard at different sites.

This allows an assessment as to whether the predicted ground motion is more or less severe than that previously predicted, and if it is more severe, whether there is sufficient margin in the design to cover the predicted increase. One public source of information that allows this type of comparison using the PGA is the USGS on-line maps and calculation tools (*see* Section 2.1.1).

### 2.1.1 USGS Seismic Hazard Analysis Tools

In 2014, the USGS issued a report, *Documentation for the 2014 Update of the United States National Seismic Hazards Maps* (USGS 2014), which provides generalized seismic hazard maps by geographic area for the entire country. The USGS provides an on-line tool (*see* footnote 6 below) where specific geographic coordinates (latitude/longitude) can be entered to obtain various parameters that help identify potential seismic hazards in a geographic area.[4]

The USGS seismic hazard maps and earthquake ground motion parameters are updated approximately every six years[5] to account for new data and incorporate recently published findings on earthquake ground shaking, faults, seismicity, and geology. The USGS 2014 Report is the successor to the USGS 2008 Report (USGS 2008). The USGS 2014 Report provides comparative maps that depict the change in seismic hazards since the publication of the USGS 2008 Report (*see* Figure 2-1).

To determine if the earthquake ground motion hazard, as depicted in the USGS 2014 Report, has changed since the issuance of the USGS 2008 Report, NNSA used the USGS on-line tool to compute the earthquake ground motions for rock and the ground motions for the soil conditions at the specific locations of the facilities at Y-12.[6] The earthquake ground motions for the specific soil conditions are calculated to account for local soil amplification. The USGS on-line tool defines the earthquake ground motions for a range of site conditions from hard rock to soft soil and for a range of Risk Categories. The Risk Categories range from Risk Category I to IV as defined in IBC, Table 1604.5. Risk Category IV facilities are those facilities designated as essential facilities and requires the most stringent earthquake design for the facilities. The UPF nuclear related facilities and the ELP facilities are classified as Risk Category IV. The site conditions are classified in the IBC Section 1613.2.2 as Site Class A, B, C D, E and F. The ground motions increase as the Site Class changes from A through F. Based on the specific rock and soil conditions at the ELP and UPF facilities, Site Classes B and C are used to define the ground motions for design and evaluation.

At Y-12, the coordinates of the UPF and ELP facilities (35.99 N, 84.26 W) were entered into the USGS on-line tool to calculate an estimate of the PGA at firm rock with 2-percent probability of

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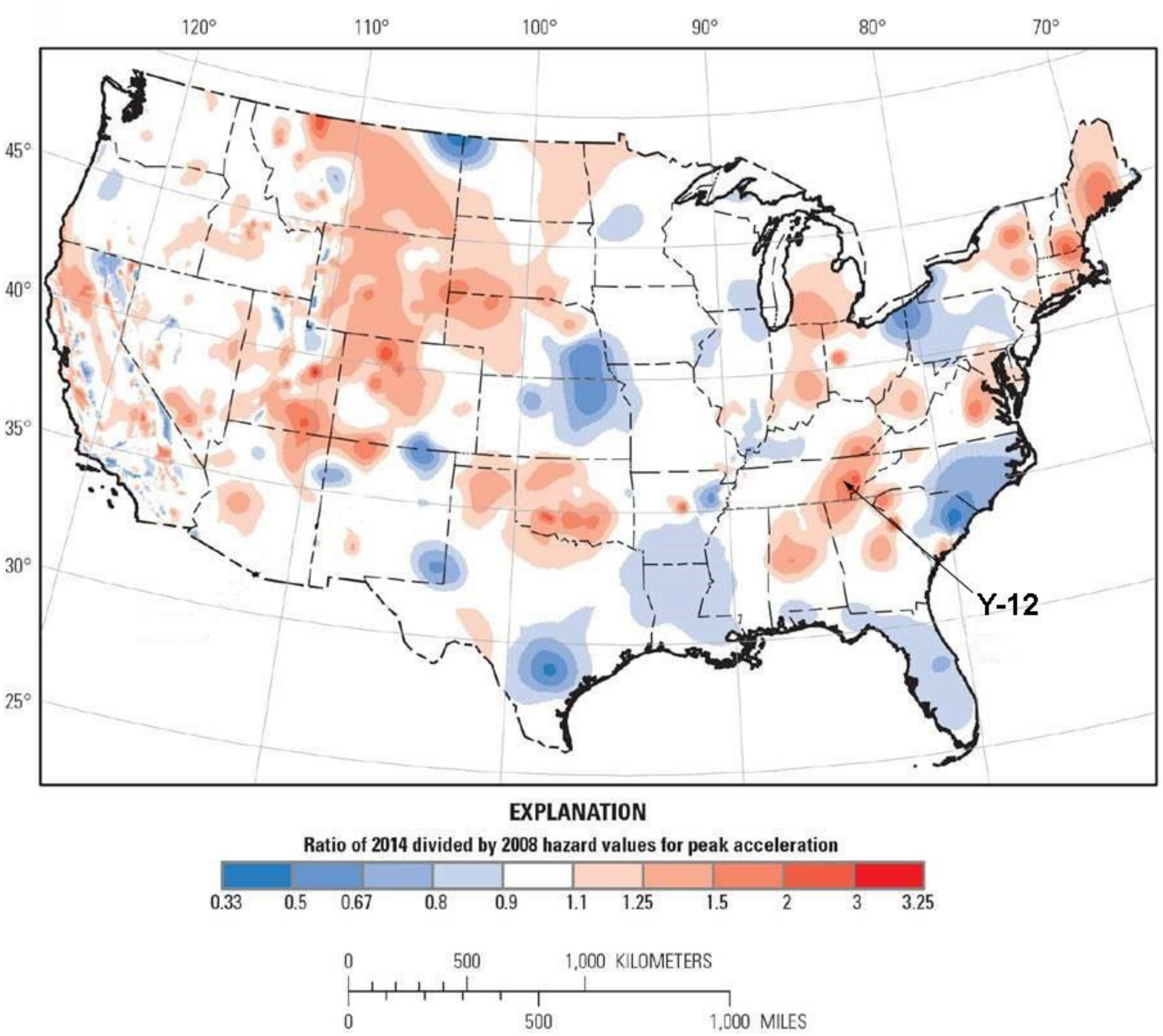
[4] For any given site on the map, the computer calculates earthquake ground motion (peak acceleration) for all the earthquake locations and magnitudes believed possible in the vicinity of the site. Each of these magnitude-location pairs is believed to happen at some average probability per year. Small ground motions are relatively likely, large ground motions are very unlikely. Beginning with the largest ground motions and proceeding to smaller, probabilities are added for the total probability in a particular period of time. The corresponding ground motion (peak acceleration) is said to have a probability of exceedance in time (years). The map contours represent the ground motions corresponding to this probability at all the sites in a grid covering the U.S. Thus, the maps are not actually probability maps, but rather ground motion hazard maps at a given level of probability.

[5] Although USGS has not announced a publication date, an update to the USGS 2014 Report is expected in 2020.

[6] Access to the USGS design ground motion values for a particular latitude, longitude, risk category, and site class, may be obtained at https://earthquake.usgs.gov/ws/designmaps/ (Accessed here on February 24, 2020). The ground motion values for the 2008 National Hazards Maps may be obtained either by using the 2009 NEHRP Standard, or 2010 ASCE 7 Standard. The values for the 2014 National Hazards Maps may be obtained using either the 2015 NEHRP Standard, or the 2016 ASCE 7 Standard.

exceedance in 50 years for both the USGS 2008 Report and the USGS 2014 Report. The USGS on-line tool calculated that the PGA at the surface, corrected for site class C, with 2 percent probability of exceedance in 50 years, changed from approximately 0.22g in 2008 to approximately 0.34g in 2014. The change represents an increase in predicted ground motion of approximately 56 percent. Such an increase, in and of itself, does not mean that the earthquake risk at Y-12 has increased significantly or constitutes significant new circumstances or information relevant to environmental concerns. To make such a determination, NNSA must consider this new information within the framework of the PSHAs that govern the design, construction, and operation of the UPF and ELP facilities, as well as the earthquake accident analysis. Sections 2.1.2 and 2.2 of this SA discuss the relationship between the USGS seismic hazard maps (including the increased PGA from the USGS 2014 Report) and the PSHAs for the UPF and ELP facilities. Section 3 of this SA provides the quantitative analysis of an earthquake accident for the UPF and ELP facilities with consideration of the information from the USGS 2014 Report.



Source: USGS 2014.

**Figure 2-1. USGS Map Comparing Change in Peak Ground Acceleration**

The seismic hazard maps provided by the USGS are integrated into the National Earthquake Hazards Reduction Program (NEHRP). The NEHRP is tasked with reducing the risks to life and property from earthquakes through the development and implementation of hazard reduction measures. One of these measures is the publication of the "Recommended Seismic Provisions for New Buildings and Other Structures" (NEHRP 2015). The publication provides recommendations for standards in the structural designs to withstand seismic hazards. These recommendations, along with the ASCE standards and IBC, are adopted by many states and local building departments into law (ASCE 2016; ICC 2014).

### 2.1.2 NNSA Seismic Hazard Analysis at Y-12

NNSA uses the IBC and hence the USGS ground motion values in the seismic design of low-risk facilities. However, in accordance with DOE Order 420.1C (Facility Safety), NNSA requires a site-specific PSHA to define the seismic ground motion for the design of critical facilities, including high-risk structures. As discussed below, the site-specific PSHA considers a range of regional and site-specific information.

The hazard analysis provided by and periodically updated by the USGS is one of several sources of the relevant seismic information included in a site-specific PSHA. Other available information, such as nuclear industry and Nuclear Regulatory Commission (NRC)-generated analyses, is also included. The site-specific PSHA also requires the incorporation of local geologic data to better characterize local seismic sources and establish facility site conditions affecting ground motion. The incorporation of other available seismic data and site-specific geologic studies in a PSHA can increase or decrease design ground motions as compared to using only the USGS National Seismic Hazards Maps and provides greater detail and understanding of the site (CNS 2020a).

For facilities at Y-12, hazard analyses from a project sponsored by the NRC, DOE, and the Electric Power Research Institute (EPRI) have been incorporated into PSHAs. This project is known as the Central and Eastern United States Seismic Source Characterization for Nuclear Facilities (CEUS SSC) and it was initiated in 2008. This project was commissioned specifically to characterize seismic sources that can affect nuclear facilities. The CEUS SSC project was completed in 2012 and published by the NRC as NUREG-2115, *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities* (NRC 2012).

A second joint project by the NRC, DOE, and EPRI is known as the Next Generation Attenuation-East (NGA-East) project. The NGA-East study was completed in December 2018 and was published in the Pacific Earthquake Engineering Research Center (PEER) Report No. 2018/08, *Central and Eastern North America Ground-Motion Characterization– NGA East Final Report* (PEER 2018).

A full-scale PSHA also involves extensive field work including geologic mapping, fault excavation, geophysics, geologic age dating, evaluation of seismic (vibratory ground motion) wave propagation through rock and soil layers, expert elicitation/judgement, and peer reviews, which has been done at the Y-12 site. Many parameters for a specific site or facility location are evaluated, including PGA and ground velocity and displacement, to define the potential hazard. These parameters and the models based on them are affected by local variables such as bedrock type, depth to bedrock, and local soil thickness and properties (CNS 2020a).

## 2.2 Y-12 Facilities and Site-Specific Probabilistic Seismic Hazard Analysis

This SA includes the evaluation of the potential impacts associated with the operation of three nuclear facilities at Y-12. The first is the UPF, which is being designed and constructed at Y-12 to replace an existing nuclear facility, the 9212 Complex. Evaluation of the risk of a seismically-initiated accident is an important consideration in this activity, because the UPF is designed to protect workers, the public, and the environment against such risks. Accordingly, it is important to assure the public that the UPF has been designed and is being constructed appropriately.

The other facilities involved are the two existing ELP facilities-- the 9215 Complex and the 9204-2E Facility. Nuclear operations are planned to continue in these facilities for potentially two or more decades under the current hybrid approach. NNSA has extensively evaluated the existing facilities, identified and analyzed the hazards, and implemented controls (such as administrative controls that limit MAR) through formal safety analysis and authorization processes as defined in DOE-STD-3009-94, Change Notice 3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses* (DOE 2006). To ensure those future operations are conducted safely, the ELP extends the life of these facilities through refurbishments which reduce risk and ensure the continued reliability of operations in the future. Risk of a seismically-initiated accident is also an important factor in these facilities, but consideration of that risk is different than that for UPF since the facility structures already exist. For the ELP facilities, it is important to not only determine the amount of seismic risk and the feasibility of upgrades, but to also explore risk reduction methods beyond structural upgrades. Ongoing efforts to reduce the inventory of nuclear materials at these facilities by transferring them to other locations, as appropriate, and to upgrade the facilities and processing equipment also reduce nuclear safety risk (CNS 2020a).

There are two site-specific PSHAs (BWXT 2003, B&W 2012a) currently in effect that are applicable to the facilities at Y-12: one is for UPF and the other is for the balance of the facilities at Y-12, including the ELP facilities. These PSHAs were issued in 2015 (UPF) and 2003 (ELP facilities) based on the latest seismic information available at that time. For the ELP facilities, the PHSA was reviewed against updated seismic information in 2012 (*see* Sections 2.2.1 and 2.2.2 below). Each PSHA considers the USGS seismic hazard, as incorporated into codes and standards; nuclear industry data, specifically the CEUS SSC analysis; and the local geologic data. The primary output from the PSHA is site-specific seismic response spectra that provide ground motions over frequency ranges that are key inputs into structural designs for new facilities (UPF) and for evaluations of the performance of existing facilities (ELP facilities). The site-specific seismic response spectra depend on the type of rock, type of soil, and the depth of the soil overburden on the rock at the specific building structure location at Y-12 (CNS 2020a).

USGS seismic hazard analyses are also used to update various codes and standards. Of interest is the ASCE 7, Minimum Design Loads for Buildings and Other Structures, and the IBC, which are among the many requirements for facilities at Y-12. The 2014 USGS study was incorporated into ASCE 7 in 2016 (referred to as ASCE 7-16) and was incorporated in the IBC in 2018 (CNS 2020a).

### 2.2.1 UPF Seismic Analysis

As discussed in CNS 2020a, the UPF project established its site-specific PSHA, site-specific seismic response spectra, and UPF design-basis earthquake spectra in 2015 in the following documents:

- Summary of the UPF Design-Basis Earthquake Response Spectra Development (RP-ES-801768-A040) (CNS 2015a).
- Development of Horizontal Hard Rock Response Spectra and Fine-Spaced Rock Hazard Curves for the Development of the SDC-1, SDC-2, and SDC-3 Design Response Spectra (DAC-ES-801768-A244) (CNS 2015b).
- UPF Horizontal and Vertical Design-Basis Earthquake Spectra (DAC-ES-801768-A330) (CNS 2015c).

**Seismic Response Spectra and Design-Basis Earthquake Spectra**

Earthquake ground motions from the PSHA are defined as "**seismic response spectra**" for the different annual probabilities of occurrence. The seismic response spectra are a plot of accelerations versus frequency. The range of frequencies used to determine the seismic response spectra covers the range of natural frequencies for a building. (Note: natural frequency refers to the frequency that a building sways in when it is returning to its original position after it has been excited).

The "**design-basis earthquake spectra**" is used to determine the earthquake response of a building. For example, when the natural frequencies of a building are determined, the building earthquake accelerations can be determined, and from the accelerations the building earthquake forces can be determined and used to design the building.

The seismic design response spectra were based on both ASCE 7 and the CEUS SSC data, and site-specific geologic information, as discussed in Section 2.1.2. The most recent seismic information available at the time was used and is reflected in the UPF Code of Record (CNS 2020a). UPF used the 2010 version of ASCE 7 (which incorporated the 2008 USGS data) and the 2012 CEUS SSC report. UPF established its design-basis earthquake spectra conservatively, and in particular, did not use reductions in the spectra allowable per ASCE 7 which would normally be taken when a site-specific seismic response spectra are available.[7] This conservative approach was taken, in part, to provide margin for new seismic information that would be forthcoming in future years (CNS 2020a).

As discussed in Section 2.1.1, USGS published new seismic hazard maps in 2014 which were later incorporated into ASCE 7 in 2016 (ASCE 7-2016). In 2017, the UPF project reviewed the impact of the changes in the ASCE 7-2016 spectra. The ASCE 7-2016 response spectra (using the 2014 USGS seismic hazard/maps), with allowable reductions for site-specific analysis (*see* footnote 7), was compared to the UPF design-basis earthquake spectra. For frequencies between 5 Hertz and 15 Hertz, the difference was negligible (approximately 1.5 percent). For frequencies above and below that range, the UPF design-basis earthquake spectra is actually more conservative (i.e., greater) than the ASCE 7-2016 spectra, which incorporated the 2014 USGS seismic hazard/maps.

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[7] Per ASCE 7-16, Section 21.3, when a site-specific PSHA is performed to determine the design spectral response accelerations, the accelerations at any frequency cannot be less than 80 percent of the more generalized spectral response accelerations obtained from the USGS hazard maps.

These favorable results are directly attributable to the decision to establish the UPF design-basis earthquake response spectra conservatively back in 2015 (CNS 2020a). Consequently, NNSA is confident the UPF design conservatively accounts for the 2014 USGS seismic hazard/maps, and that the UPF would therefore withstand the increased magnitude seismic event that is possible under the 2014 USGS seismic hazard/maps.

It should also be noted that the seismic response spectra are an input to the UPF structural design. The UPF structural design was also established conservatively, with adequate design margins, such that the design would perform its required functions even for some increases in the seismic response spectra. To minimize the amplification effects of the earthquake ground motion from the existing soil, a few of the features of the UPF Main Process Building structural design include:

- Excavation of 15 feet of soil to the underlying bedrock.
- Backfill of the excavated soil with engineered mass fill concrete.
- 9-foot-thick reinforced concrete foundation on top of the mass fill concrete.
- Reinforced concrete shear wall system to resist seismic loads with a composite elevated slab system consisting of reinforced concrete slabs and supporting steel beams (CNS 2020a).

In summary, consistent with prior NEPA analysis, UPF has a robust building design that will perform all of its required functions even after a design-basis earthquake (CNS 2020a). This conclusion has not changed as a result of the 2014 USGS seismic hazard/maps.

### 2.2.2 Existing ELP Facilities Seismic Analysis

The relevant ELP facilities consist of the 9215 Complex and the 9204-2E Facility. The 9215 Complex was built in the mid-1950s and the 9204-2E Facility was completed in 1971. They are both industrial facilities that were designed and constructed to the standards that existed at the time they were constructed. Expectations for nuclear facilities have significantly changed since their construction, including seismic design requirements. NNSA requires periodic review of seismic hazard analyses for its existing nuclear facilities. The ELP facilities at Y-12 have been reviewed in the past and updated seismic evaluations are currently being performed (CNS 2020a).

The site-specific PSHA for existing facilities at Y-12 (*Update of the Seismic Hazard at the Department of Energy National Security Administration Y-12 National Security Complex* [RT-ST 921200-A001]) (NNSA 2003), including the ELP facilities, was performed in 2003 with participation from USGS and several industry experts. That approved analysis was used to perform seismic facility evaluations for the ELP facilities in the 2003–2005 timeframe (CNS 2020a).

USGS issued updated seismic hazard maps in 2008 and the CEUS SSC study was published in 2012. The PSHA for existing facilities at Y-12 was formally reviewed against this updated information in 2012 (*Update of the Seismic Hazard at the Department of Energy National Nuclear Security Administration Y-12 National Security Complex* [RP-900000-0029]) (NNSA 2012). That review showed that both the 2008 USGS hazard map and the 2012 CEUS SSC study resulted in a decrease in the seismic hazard when compared to the Y-12 2003 site-specific PSHA. Based on the comparison, and to be conservative, Y-12 decided to continue to use the more conservative 2003 site-specific seismic hazard (CNS 2020a).[8]

As discussed in Section 2.1.1, USGS published updated seismic hazard maps in 2014 which showed an increase in the seismic hazard at Y-12 compared to the 2008 USGS hazard maps. As noted above, the Y-12 2003 site-specific seismic hazard is also greater than the 2008 USGS seismic hazard. Accordingly, the difference between the 2014 USGS seismic hazard/maps and the Y-12 2003 site-specific seismic hazard is less significant than the difference between the 2014 and 2008 USGS seismic hazards. As discussed in Section 2.1.3.1, the 2014 USGS seismic hazard/maps were incorporated into ASCE 7 in 2016. Subsequently, an informal comparison of the ASCE 7-2016 seismic hazard with the Y-12 2003 site-specific seismic hazard shows that the Y-12 2003 site-specific seismic response spectrum is more conservative in some frequency ranges, while the ASCE 7-2016 seismic response spectrum is more conservative in others. These differences merit more formal review, which is currently underway, and described below (CNS 2020a).

The ELP includes a commitment to update the Y-12 site-specific PSHA and then perform new seismic facility evaluations for the ELP facilities. That work is underway, with the updated PSHA anticipated by the end of 2020 and the updated facility evaluations by the end of 2021. The updated PSHA will incorporate the 2014 USGS seismic hazard/maps, as well as the most recent nuclear industry seismic hazard information (2012 CEUS SSC and 2018 NGA-East) (CNS 2020a).

With regard to the ELP facilities, the PSHA is used to evaluate the performance of those facilities under seismic hazard conditions. Among other things, the PSHA aids in understanding and defining the severity (and hence, the probability) of an earthquake capable of causing release of radioactive material. The ELP facilities (the 9215 Complex and the 9204-2E Facility) were designed and constructed before the establishment of modern nuclear safety standards. Some portions of the facilities meet such standards and other portions do not. The new seismic facility evaluations will provide an up-to-date evaluation of any remaining weaknesses and the potential for upgrades will be addressed. Upgrading both structures to fully meet modern seismic standards for new facilities may not be feasible or practical. However, the potential for structural upgrades will also be informed by an independent expert panel review that Y-12 contracted for in 2016 (*Recommendations of the Seismic Expert Panel Review of Buildings 9204-2E and 9215* [RP 900000-0182]) (NNSA 2016b), which provided suggestions for practical approaches to structural upgrade initiatives in these two facilities (CNS 2020a).

It is important to recognize that the planned updated studies are intended to answer in more detail the capacity of the existing structures based on advanced analytical techniques (i.e., accounting for non-linear effects which typically demonstrate additional capacity to resist earthquake ground motion) not previously used. As a result, the potential for improvements will be better understood while reconciling the differences between the USGS data and the other relevant studies discussed earlier. The existing seismic studies for the ELP facilities, however, do provide a solid technical basis on which to judge the effects of the 2014 USGS seismic hazard/maps in support of determining potential consequences to the public.

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[8] NNSA is required to periodically update its seismic hazards to consider new information. The 2012 update (NNSA 2012) did that, specifically considering the 2008 USGS information and the CEUS SSC study.

# 3.0 POTENTIAL ACCIDENT IMPACTS OF AN EARTHQUAKE AT Y-12

## 3.1 Introduction and Technical Approach

This section presents the potential accident impacts of an earthquake at Y-12 and evaluates whether those impacts would be considered significant in the context of NEPA (40 CFR 1508.27) when compared to the analysis in the Y-12 SWEIS. The technical approach for performing this analysis is summarized below. A more detailed description of the technical approach is presented in Appendix A.

In preparing this analysis, NNSA identified the current documentation describing and quantifying the hazards associated with the operation of the UPF and ELP facilities. Some of those safety-basis documents are either classified or contain Unclassified Controlled Nuclear Information and are not releasable to the general public. The following safety-basis documents were reviewed to develop the unclassified input data for the earthquake accident analysis:

- *Preliminary Documented Safety Analysis for the Uranium Processing Facility* (RP-EF-801768-A191) (CNS 2017a);
- *UPF Calculation Cover Sheet: Evaluation of Radiological and Toxicological Exposure for the Uranium Processing Facility* (DAC-EF-801768-A084) (CNS 2017b);
- *Safety Analysis Report for the 9215 Complex* (Y/MA-7886, Rev. 13) (CNS 2015d); and
- *Safety Analysis Report for the 9204-2E Facility* (Y/SAR-003, Rev. 13) (CNS 2015e).

In addition, NNSA utilized subject-matter experts at Y-12 to develop input data for the analysis in this SA. Those data are documented in a Data Call reference document (CNS 2020b). This SA uses unclassified and publicly-releasable data derived from the safety-basis documents and the Data Call reference document to define the earthquake accident scenarios and input parameters for the analysis in this SA.

The potential impacts of accidental radiological releases associated with the earthquake accident scenarios were determined using the MELCOR Accident Consequence Code Systems (MACCS) computer code. MACCS is a DOE/NRC sponsored computer code that has been widely used in support of probabilistic risk assessments for the nuclear power industry and in support of safety and NEPA documentation for facilities throughout the DOE complex. MACCS models the consequences of an accident that releases a plume of radioactive materials to the atmosphere. Should such an accidental release occur, the radioactive gases and aerosols in the plume would be transported by the prevailing wind while dispersing in the atmosphere. The environment would be contaminated by radioactive materials deposited from the plume, and workers and the population would be exposed to radiation. The objectives of a MACCS calculation are to estimate the range and probability of the health impacts induced by the radiation exposures.

The most important inputs to the code were the source terms (i.e., the amount of radioactive material released). Section 3.2 explains how the source terms for the earthquake scenarios were determined. The results obtained by the MACCS model include doses due to inhalation of airborne material as well as external exposure to the passing plume. This represents the major portion of the dose that an individual would receive from a facility accident.

For this analysis, NNSA estimated the potential radiological impacts for three receptors: (1) the maximally exposed individual (MEI)[9] at the Y-12 boundary; (2) the offsite population within 50 miles of the UPF and ELP facilities; and (3) a noninvolved worker at both 100 meters and 1,000 meters[10] from the accident location. The doses were converted to latent cancer fatalities (LCFs)[11] using the factor of 0.0006 LCF per person-rem for both members of the public and workers; if applicable, calculated LCFs were doubled for individual doses greater than 20 rem (NCRP 1993). The MEI, 50-mile offsite population, and noninvolved worker are assumed to be exposed for the duration of the release; they or NNSA would take protective or mitigative actions thereafter if required by the size of the release.

## 3.2 Potential Environmental Impacts and Comparisons

Seismic events have the potential to: (1) produce explosions, induce spills of oxide and aqueous radioactive materials, and cause localized fires which may release radioactive materials to the environment; (2) cause a criticality accident which could produce a direct radiation dose and release radioactive materials to the environment; and (3) cause failures of safety- and non-safety-related structures and systems which are intended to mitigate the effects of an accident.

**Criticality Accident**

A criticality accident is an uncontrolled nuclear fission chain reaction (but not a nuclear detonation). Criticality accidents can release radioactivity to the environment and produce potentially fatal direct radiation doses.

**UPF**. For the UPF, this SA evaluates two scenarios: (1) a beyond design-basis earthquake accident in which engineered safety systems and controls do not prevent/mitigate the accident; and (2) a design-basis earthquake accident in which safety systems and controls mitigate the impacts of the accident. By analyzing a spectrum of earthquake accidents, NNSA and the public are better able to understand the range of accident impacts-- the most likely impacts (based on the design-basis mitigated scenario) and the highest potential impacts (based on the beyond design-basis unmitigated scenario). Based on the safety-basis documents identified in Section 3.1 of this SA, NNSA determined that a beyond design-basis earthquake accident that released radioactive materials through induced explosions, spills of oxide and aqueous radioactive materials, and localized fires is the appropriate earthquake accident scenario to analyze for the UPF (CNS 2020b).

With regard to accident probabilities, because the UPF is being designed and constructed to conservatively meet modern nuclear safety and seismic standards (*see* Section 2.2.1), the design-basis earthquake accident probability is estimated to be $4\times10^{-4}$ per year, which equates to the occurrence of such an accident once every 2,500 years. The beyond design-basis earthquake accident probability is estimated to be a maximum of $1\text{x}10^{-6}$, which equates to the occurrence of such an accident once every million years (CNS 2020b). These probabilities take into account the probability of the initiating event (i.e., earthquake) and the probability of following events that influence the impacts of the accident (e.g., subsequent explosions, spills, localized fires, and the failure of safety systems and controls designed to prevent these events, as well as failure of mitigating safety systems [e.g., ventilation system with High Efficiency Particulate Air filters]).

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[9] The MEI is a hypothetical individual located offsite who could potentially receive the maximum dose of radiation.

[10] The Y-12 SWEIS presented dose results for the noninvolved worker at 1,000 meters from the accident location. Consequently, this SA provides results for both distances to support comparisons in Section 3.3 of this SA.

[11] In this SA, LCF refers to a fatality associated with acute and chronic exposure to radiation.

**ELP Facilities**. For the 9215 Complex and 9204-2E Facility, based on the safety-basis documents identified in Section 3.1 of this SA, NNSA determined that a seismic-induced criticality event with small localized fires is the appropriate scenario to analyze. A review of the safety-basis documents for the 9215 Complex and 9204-2E Facility indicated that the source term associated with a seismic-induced criticality event at these facilities would be significantly greater than the source term associated with seismic-induced localized fires (CNS 2020b).

For the ELP facilities, which were designed and constructed before the establishment of modern nuclear safety and seismic standards, the accident probability is estimated to be $2\times10^{-3}$ per year, which equates to the occurrence of such an accident once every 500 years (CNS 2020b).[12] This takes into account the probability of the initiating event (i.e., earthquake) and the probability of a criticality event with a subsequent direct radiation dose and the release of radioactive materials. As discussed in Section 3.2.2, the earthquake probabilities for both the UPF and ELP facilities account for the 2014 USGS seismic hazard/maps (CNS 2020b).

The source terms shown in Table 3-1 and 3-2 provide the estimated quantity of radioactive material released to the environment for the earthquake accidents at the UPF, 9215 Complex, and the 9204-2E Facility. The source terms are calculated by the equation:

$$\text{Source Term} = \text{MAR} \times \text{ARF} \times \text{RF} \times \text{DR} \times \text{LPF}$$

where:

**MAR** = The amount and form of radioactive material at risk of being released to the environment under accident conditions.
**ARF** = The airborne release fraction reflecting the fraction of damaged MAR that becomes airborne as a result of the accident.
**RF** = The respirable fraction reflecting the fraction of airborne radioactive material that is small enough to be inhaled by a human.
**DR** = The damage ratio reflecting the fraction of MAR that is damaged in the accident and available for release to the environment.
**LPF** = The leak path factor reflecting the fraction of respirable radioactive material that has a pathway out of the facility for dispersal in the environment.

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[12] Earthquakes with a probability of $2\times10^{-3}$ or less are assumed to result in a seismic-induced criticality event; consequently, for the ELP facilities, this SA evaluates an earthquake with a probability of $2\text{x}10^{-3}$.

### Table 3-1. Postulated Earthquake Accident Parameters—UPF

| Accident | Source Term | | | |
|---|---|---|---|---|
| | **Event** | **Material** | **Source Term for Beyond Design-Basis Earthquake (kg)** | **Source Term for Design-Basis Earthquake (kg)** |
| Earthquake that causes explosions, radioactive material spills, and localized fires at UPF | Explosion | EU Aqueous | $6 \times 10^{-6}$ | 0 |
| | | EU Oxide | 0.4515 | 0 |
| | | EU Contaminated Combustibles | 0.008 | 0 |
| | | Filters (EU Oxide) | 1.19 | 0 |
| | | Furnace (EU Oxide) | 1.355 | 0 |
| | | Calciner | 2.818 | 0 |
| | Spills | Depleted Uranium (DU) Aqueous | 0.235 | 0 |
| | | EU Aqueous | 3.744 | 0.0432 |
| | | EU Organic | 0.0138 | 0.00264 |
| | | EU Oxide (spilled from 3 meters) | 5.39 | 0.0374 |
| | | EU Oxide (spilled from 1 meter) | 0.377 | 0 |
| | | DU Oxide (spilled from 3 meters) | 0.13 | 0 |
| | | DU Oxide (spilled from 1 meter) | 0.009 | 0 |
| | Fires | EU Aqueous | 0.02 | 0.02 |
| | | EU Chip | 0.06 | 0.06 |
| | | EU Alloy (not in racks) | 0.005 | 0.005 |
| | | EU Slurry | 0.17 | 0.17 |
| | | EU Slurry | 0.2 | 0.2 |
| | | EU Contaminated Combustibles | 0.0125 | 0.0125 |
| | | EU Crystals | 0.3 | 0.3 |

Source: CNS 2017b, CNS 2020b.

**Table 3-2. Postulated Earthquake Accident Parameters—ELP Facilities**

| Accident | Source Term | | |
|---|---|---|---|
| | **Radionuclide** | **Half Life** | **Curies released** |
| Earthquake that causes criticality event at either the 9215 Complex or the 9204-2E Facility | Kr-83m | 1.8 hr | 8.0 |
| | Kr-85m | 4.5 yr | 7.5 |
| | Kr-85 | 1.7 yr | $8.00 \times 10^{-5}$ |
| | Kr-87 | 76.3 min | 49.5 |
| | Kr-88 | 2.8 hr | 32.5 |
| | Kr-89 | 3.2 min | 0.0021 |
| | Xe-131m | 11.9 day | 0.004 |
| | Xe-133m | 2.0 day | 0.09 |
| | Xe-133 | 5.2 day | 1.35 |
| | Xe-135m | 15.6 min | 110 |
| | Xe-135 | 9.1 hr | 18 |
| | Xe-137 | 3.8 min | 2,450 |
| | Xe-138 | 14.2 min | 650 |
| | I-131 | 8.1 day | 0.0435 |
| | I-132 | 2.3 hr | 5.5 |
| | I-133 | 0.8 hr | 0.8 |
| | I-134 | 52.6 min | 22.5 |
| | I-135 | 6.6 hr | 2.35 |

Note 1: Kr = Krypton; Xe = Xenon; I = Iodine.
Note 2: Uranium metal criticality is assumed to have $1 \times 10^{18}$ total fissions.
Source: CNS 2020b.

In preparing this earthquake accident analysis, NNSA has made conservative assumptions related to facility damage and radioactive material release (CNS 2020b). NNSA also assumed that no special actions (i.e., emergency response) would be taken to avoid or mitigate exposure to the general population following an accidental release of radioactive material. Doses were also calculated using conservative assumptions, such as the wind blowing toward the MEI and locating the receptor along the plume centerline, where potential impacts would be maximized. For the beyond design-basis UPF earthquake accident and the earthquake accidents involving the ELP facilities, no credit is taken for the preventive or mitigating effects of active safety systems (i.e., systems designed to perform automatic actions based on some input parameter) or fire suppression efforts and equipment.

### 3.2.1 Consequences

Consequence analysis is independent of the probability that an earthquake accident would occur (i.e., the consequence analysis assumes the earthquake accident will occur). As a result of that analytical construct, seismic hazard probability is not a factor in determining the potential consequences that may result from an earthquake. Consequently, even if the probability of the earthquake accident analyzed in this SA were to change (regardless of the reason for that change), the consequences presented in this SA would not change. Based on that rationale, the 2014 USGS seismic hazard/maps would not constitute significant new circumstances or information relevant to environmental consequences compared to the consequence analysis in the Y-12 SWEIS.

**Consequence, Probability, and Risk**

This SA presents both the consequences and risks of a seismic accident (*see* Tables 3-3 and 3-4).

- "Consequence" refers to the results of an accident without consideration of the probability of the accident (i.e., accident consequences are independent of probability).
- "Probability" refers to the likelihood of an accident occurring. The probability of occurrence is expressed as a number between 0 (no chance of occurring) and 1 (certain to occur). Alternatively, instead of probability of occurrence, one can specify the frequency of occurrence (i.e., once in 2,500 years, which also can be expressed as 0.0004 times per year).
- "Risk" is the chance, high or low, that an accident will cause the consequences. Risk is determined by multiplying the consequences and the probability.

As shown in Table 3-3, the UPF beyond design-basis earthquake accident was determined to have the highest potential consequences to the MEI, offsite population, and noninvolved worker. For the UPF beyond design-basis earthquake accident, a dose of 424 person-rem (which equates to less than one [approximately 0.25] LCFs) in the offsite population could result in the absence of mitigation (i.e., under the worst case scenario of all alternatives previously reviewed in the Y-12 SWEIS, as well as in this SA, less than one LCF would be expected to occur in the offsite population). An offsite MEI would receive a dose of approximately 0.484 rem. Statistically, the MEI would have a 0.00029 chance, or about 1 in 3,500, of developing an LCF. A noninvolved worker, located 1,000 meters from the accident, would receive a dose of approximately 1.4 rem. Statistically, the noninvolved worker would have a 0.00086 chance, or about 1 in 1,200, of developing an LCF. As shown in Table 3-3, the UPF design-basis earthquake accident and a seismic-induced criticality event in either the 9215 Complex or 9204-2E Facility would have virtually no likely impacts to the offsite population and non-involved worker. Under the worst case scenario of a beyond design-basis earthquake at the UPF, consequences of less than 1 LCF (0.25 LCF) would be expected.

**Radiation Dose Measurement**

In this SA, radiation doses are measured in units of either "person-rem" or "rem."

**Person-rem** is used to measure the total collective radiation dose for a group of people. To determine the population dose, this SA sums up the individual dose of every person within a 50-mile radius of Y-12. Statistically, approximately 1,667 person-rem would result in one LCF.

**Rem** is used to measure the radiation dose for a single individual. Individual doses are converted to LCFs by multiplying the dose by 0.0006. For example, an individual who receives a dose of 1.5 rem would have a 0.0009 chance of developing an LCF.

**Table 3-3. Radiological Consequences for Earthquake Accident**

| Accident | Maximally Exposed Individual[a,d] | | Offsite Population[b] | | Noninvolved Worker[c,d] | |
|---|---|---|---|---|---|---|
| | Dose (rem) | Latent Cancer Fatality | Dose (Person-rem) | Latent Cancer Fatality | Dose (rem) | Latent Cancer Fatality |
| Beyond design-basis earthquake that causes explosions, radioactive material spills, and localized fires at UPF | 0.48 | 0 (0.0003) | 424 | 0.25 | 17 - 48[e]<br>(100 meters) | 0 (0.01-0.06) |
| | | | | | 1.4<br>(1,000 meters) | 0 (8.6x10$^{-4}$) |
| Design-basis earthquake that causes radioactive material spills and localized fires at UPF | 0.0296 | 0 (1.8x10$^{-5}$) | 24.9 | 0 (0.015) | 2.93<br>(100 meters) | 0 (1.8x10$^{-3}$) |
| | | | | | 0.088<br>(1,000 meters) | 0 (5.3x10$^{-5}$) |
| Earthquake that causes criticality event at either the 9215 Complex or 9204-2E Facility | 0.0021 | 0 (1.3x10$^{-6}$) | 0.76 | 0 (4.5x10$^{-4}$) | 5.8[f]<br>(100 meters) | 0 (0.0035) |
| | | | | | 0.007[f]<br>(1,000 meters) | 0 (4.2x10$^{-6}$) |

a. At site boundary, approximately 1.2 miles from release.

b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.

c. This SA presents dose results for the noninvolved worker at 100 and 1,000 meters from the accident location.

d. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.

e. For the beyond design-basis UPF earthquake accident in this SA, the noninvolved worker dose of 48 rem at 100 meters is based on a ground-level release of radioactive material. A ground-level release generally maximizes the dose to the noninvolved worker. At close distances, where a noninvolved worker is assumed to be located, an elevated release generally results in a reduced dose because more of the radioactive plume passes overhead and there is less inhalation. For the beyond design-basis UPF earthquake accident in this SA, NNSA also performed a sensitivity analysis to determine the dose to the noninvolved worker from an elevated release. Based on that revised assumption, the noninvolved worker dose at 100 meters would be approximately 17 rem (NuScale 2020).

f. Includes a direct radiation dose of 5.7 rem at 100 meters or 0.0011 rem at 1,000 meters (*see* Table D.9.3-4 of NNSA 2011).

Source: CNS 2020b, NNSA 2011, NuScale 2020.

### 3.2.2 Risks

While risk analysis also incorporates the same conservative assumptions relating to radioactive material release, the results are determined by multiplying the accident consequences and the earthquake probability. Such an approach accounts for differences in the vulnerability of facilities to seismic hazards. For example, as discussed in Section 3.2, the probability of an earthquake accident (with resultant release of radioactive material) associated with the ELP facilities is estimated to be greater than the probabilities for the UPF earthquake accidents. This is due to the fact that the ELP facilities, while safe, do not meet modern codes and standards for new facilities (CNS 2020a). As a result, radioactive material release could occur in the ELP facilities in the event of a less severe, more probable earthquake.

As shown in Table 3-4, when probabilities are taken into account, all of the earthquake accident scenarios were determined to have virtually zero risks to the MEI, offsite population, and noninvolved worker. As shown in Table 3-4, the maximum risk to the MEI is 0 (7.0x10$^{-9}$ per year, or approximately one statistical fatality in 143 million years); the maximum risk to the population is 0 (6.0×10$^{-6}$ per year, or approximately one statistical fatality in 167,000 years); and the maximum risk to the noninvolved worker at 100 meters is 0 ($7.0\times10^{-6}$ per year, or approximately one statistical fatality in 140,000 years).

**Table 3-4. Radiological Risks for Earthquake Accident**

| Accident | Probability | Maximally Exposed Individual[a] (LCFs) | Offsite Population[b] (LCFs) | Noninvolved Worker[c] (LCFs) |
|---|---|---|---|---|
| Beyond design-basis earthquake that causes explosions, radioactive material spills, and localized fires at UPF | $1\times10^{-6}$ | 0 ($3.0\times10^{-10}$) | 0 ($2.5\times10^{-7}$) | 0 ($1.0\text{x}10^{-8} – 6.0\times10^{-8}$)<br>(100 meters) |
| | | | | 0 ($8.6\times10^{-10}$)<br>(1,000 meters) |
| Design-basis earthquake that causes radioactive material spills and localized fires at UPF | $4\times10^{-4}$ | 0 ($7.0\times10^{-9}$) | 0 ($6.0\times10^{-6}$) | 0 ($7.2\times10^{-7}$)<br>(100 meters) |
| | | | | 0 ($2.1\times10^{-8}$)<br>(1,000 meters) |
| Earthquake that causes criticality event at either the 9215 Complex or 9204-2E Facility | $2\times10^{-3}$ | 0 ($2.6\text{x}10^{-9}$) | 0 ($9.0\text{x}10^{-7}$) | 0 ($7.0\text{x}10^{-6}$)[d]<br>(100 meters) |
| | | | | 0 ($8.4\text{x}10^{-9}$)[d]<br>(1,000 meters) |

a. At site boundary, approximately 1.2 miles from release.

b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.

c. This SA presents risk results for the noninvolved worker at 100 and 1,000 meters from the accident location. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.

d. Includes LCFs from a direct radiation dose of 5.7 rem at 100 meters and 0.0011 rem at 1,000 meters (*see* Table D.9.3-4 of NNSA 2011).

Source: CNS 2020b, NNSA 2011, NuScale 2020.

As discussed in Section 2.2.1, the UPF design accounts for the 2014 USGS seismic hazard/maps. With regard to the ELP facilities, as discussed in Section 2.2.2, NNSA is currently in the process of updating the PSHA, which is anticipated by the end of 2020. The updated PSHA will incorporate the 2014 USGS seismic hazard/maps, as well as the most recent nuclear industry seismic hazard information (2012 CEUS SSC and 2018 NGA-East) (CNS 2020a). In preparing this SA, NNSA has evaluated the 2014 USGS seismic hazard/maps and conservatively estimated the probability of the earthquake accident for the ELP facilities. Based on existing structural analyses, NNSA is confident that the updated PSHA would not increase the earthquake probability used in this SA (CNS 2020b). Consequently, the risks would be no greater than the risks presented in this SA.

### 3.2.3 Involved Workers

For each of the earthquake accidents evaluated, there is a potential for injury or death to involved workers in the vicinity of the accident. Estimation of potential health effects becomes increasingly difficult to quantify as the distance between the accident location and the worker decreases because the exposure cannot be adequately established with respect to the presence of shielding and other protective features. The worker also may be acutely injured or killed by physical effects of the accident. An earthquake accident with subsequent fire could have substantial consequences, ranging from workers being killed by debris from explosions to high radiation exposure.

Because the design of UPF would meet modern codes and standards, the areas containing the equipment which could cause explosions, spills, or localized fires are normally unoccupied enclosures. UPF is designed with a Safety Detection and Response System (SDRS) which alerts personnel to evacuate the facility prior to spills or localized fires being able to overcome the initial/closest barrier. The SDRS also isolates potential accident initiators to further minimize impacts to personnel and to protect property (e.g., from explosions). As a result of the SDRS and the UPF facility layout, which places potential spill locations away from main egress paths, only a fraction of the design occupant load would be exposed. Consequently, it is likely that no workers would be exposed to seismic-induced explosions and no more than 100 workers would be exposed to spills and local fires, which could lead to injuries or deaths (CNS 2020b).

With regard to a criticality event in the 9215 Complex or 9204-2E Facility, in addition to the potential for injury or death from the physical effects of the accident, severe worker exposures could also occur inside the facility. Depending on distance and the amount of intervening shielding material, lethal doses composed of radiation could occur. NNSA expects that less than 100 workers would be in either the 9215 Complex or 9204-2E Facility. NNSA further expects that the direct radiation doses of a nuclear criticality event, if one occurred, would likely not extend beyond the building boundary, and that distance and shielding (e.g., containers, process equipment, and the walls of the facility) would make the likely effects of direct radiation at the site boundary negligible (CNS 2020a). With a seismically-qualified system, a criticality would be detected by the criticality alarm system, and an evacuation alarm would be sounded. All personnel would immediately evacuate the building. The existing criticality alarm systems in the 9215 Complex and 9204-2E Facility are not seismically-qualified. A current project under the ELP is, however, installing a modern, seismically-qualified criticality alarm system in the 9204-2E Facility. A similar project is planned for the 9215 Complex in the near future.

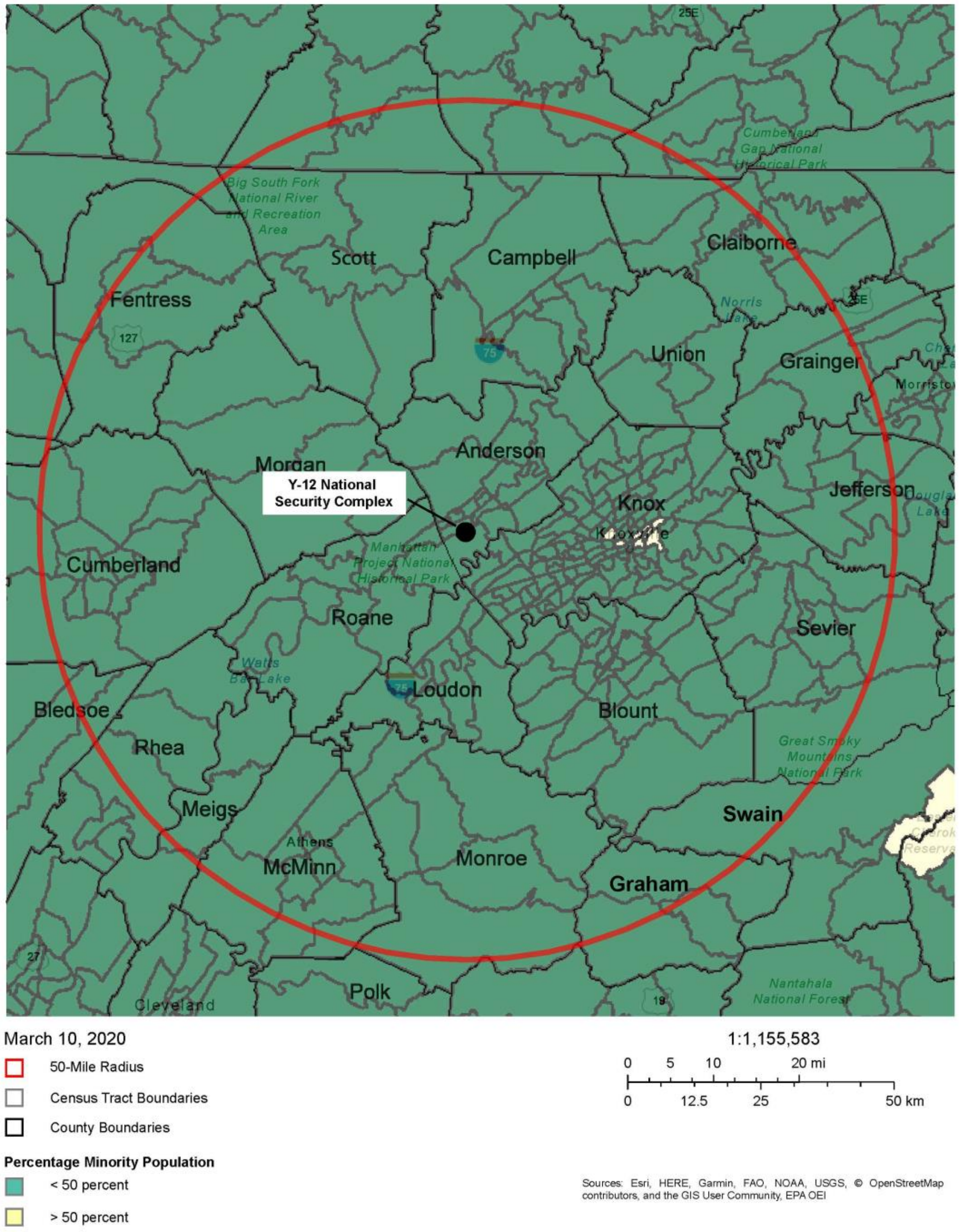
Immediate emergency response actions could reduce the potential for injuries and deaths for workers near the accident. Established emergency management programs would be activated in the event of an accident. Following initiation of accident/site emergency alarms, workers would evacuate the area in accordance with site emergency operating procedures.

Section 3.3.1 provides comparisons of the potential impacts to involved workers from accidents involving the smaller-scale UPF and the ELP facilities against the facility accidents analyzed in the Y-12 SWEIS.

### 3.2.4 Environmental Justice Impacts

Under Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” Federal agencies are responsible for identifying and addressing the possibility of disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. Minority populations refer to persons of any race self-designated as Asian, Black, Native American, or Hispanic. Low-income populations refer to households with incomes below the Federal poverty thresholds. Environmental justice concerns the environmental impacts that proposed actions may have on minority and low-income populations, and whether such impacts are disproportionate to those on the population as a whole in the potentially affected area. Figures 3-1 and 3-2 show the geographic distribution of minority and low-income populations near Y-12.

As shown in Table 3-3, an offsite MEI would receive a dose of approximately 0.484 rem. Statistically, the MEI would have a 0.00029 chance of developing an LCF, or about 1 in 3,500. The impacts to the MEI, who is assumed to be located at the site boundary approximately 1.2 miles from the release, would be small. Because the nearest minority populations and low-income populations are located approximately 15 miles east of Y-12 (*see* Figures 3-1 and 3-2), potential accidental doses at those locations would be even less than the MEI dose. Based on modelling results, a person located approximately 15 miles east of Y-12 would receive a maximum dose of approximately $3.9 \times 10^{-4}$ rem from an earthquake accident at Y-12. Statistically, this person would have a $2.4 \times 10^{-7}$ chance of developing an LCF, or about 1 in 4.2 million. Consequently, NNSA has concluded that there would be no disproportionately high and adverse human health impacts on minority populations and low-income populations from an earthquake accident at the UPF, 9215 Complex, or the 9204-2E Facility.



Source: EJSCREEN 2020.

**Figure 3-1. Minority Population – Census Tracts with More than 50 Percent Minority Population in a 50-Mile Radius of Y-12.**

Source: EJSCREEN 2020.

**Figure 3-2. Low-Income Population – Census Tracts with More than 50 Percent Low-Income Population in a 50-Mile Radius of Y-12.**

## 3.3 Comparison of Impacts

Section 3.2 presents the earthquake impacts for the UPF and ELP facilities based upon seismic hazard information and analyses that account for the 2014 USGS seismic hazard/maps. Using the information in Sections 3.2, this section compares and contrasts those impacts with impacts from the Y-12 SWEIS accident analysis. Two types of impact comparisons are presented: (1) facility-to-facility (*see* Section 3.3.1); and (2) alternative-to-alternative (*see* Section 3.3.2). These comparisons are intended to support conclusions/determinations as to whether the earthquake consequences constitute a substantial change that is relevant to environmental concerns; or if the new seismic information constitutes significant new circumstances or information relevant to environmental concerns and bearing on continued operations at Y-12 compared to the analysis in the Y-12 SWEIS. To aid in understanding the comparisons in this section, a brief discussion of the Y-12 SWEIS accident analysis is provided.

**Y-12 SWEIS Accident Analysis.** The approach to the accident analysis for the Y-12 SWEIS is described in Section D.9.1 of the Y-12 SWEIS and summarized as follows:

1. NNSA screened out buildings without radioactive materials or with low-hazard rankings;

2. For high-hazard facilities such as the 9215 Complex, 9204-2E Facility, and Building 9212,[13] NNSA reviewed relevant safety-basis documents specific to each building and its operations. Through those reviews, NNSA identified potential accident scenarios and source terms (release rates and probabilities) associated with those facilities. Table D.9.3-1 of the Y-12 SWEIS shows the accidents considered for the nine high-hazard facilities. As shown in that table, a total of 56 accidents were considered. Earthquake accidents were considered for seven of the nine facilities.[14]

3. Based on the potential accident scenarios and source terms, NNSA identified the highest consequence accident for five high-hazard facilities, including the 9215 Complex, 9204-2E Facility, and Building 9212. For each of these facilities, consequences from earthquakes were determined to be equal to, or less than, consequences from other accidents such as fires, explosions, and airplane crashes. Consequently, the impacts of earthquake accidents were not carried forward for detailed analysis in the SWEIS.

4. Detailed analyses were conducted for the highest consequence accidents for each of the five high-hazard facilities. Those impacts are presented in Table D.9.4-1 (consequences) and Table D.9.4-2 (risks) of the Y-12 SWEIS.

5. With regard to the UPF, because detailed design descriptions of the UPF were not available, NNSA used the accident analyses of the 9215 Complex, 9204-2E Facility, and Building 9212 as surrogates to conservatively represent the UPF accidents.[15] Such an approach was conservative because it did not take into account the robust design and construction features of the UPF (*see* Section 2.2.1 of this SA) that would reduce accident

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[13] The smaller-scale UPF would replace a majority of the EU operations located in Building 9212.

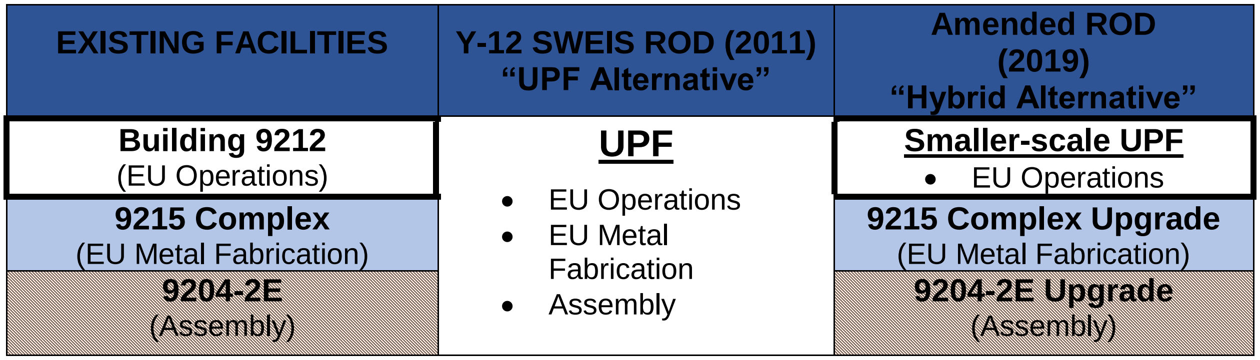
[14] The Analytical Laboratory and Machine Shop Special Materials were exceptions. Because these two facilities were not among the five highest hazard facilities at Y-12, accidents from these two facilities were not among the accidents analyzed in detail.

[15] The UPF evaluated in the SWEIS was intended to replace the operations in Building 9212, the 9215 Complex, and 9204-2E.

impacts compared to the existing facilities analyzed in detail in the Y-12 SWEIS. Although NNSA acknowledged that "new facilities such as the UPF would be constructed to current building design standards and would be designed and built to withstand higher seismic accelerations and thus would be more resistant to earthquake damage," the SWEIS accident analysis took no credit for these advancements over existing facilities. Based on the conservative approach, NNSA concluded that the risks presented for the current Y-12 facilities (both individually and additive) would be bounding for the UPF (NNSA 2011).

### 3.3.1 Facility-to-Facility Comparisons

To aid in understanding the facility-to-facility comparisons that will be presented in this section, Figure 3-3 identifies the three relevant high-hazard facilities/missions that were originally intended to be replaced by the UPF. Figure 3-3 also shows the differences between the 2011 ROD and the 2019 AROD. As shown in Figure 3-3, the following generalities can be made: (1) the smaller-scale UPF is essentially a replacement for the operations in Building 9212; and (2) operations in the 9215 Complex and the 9204-2E Facility will continue in upgraded facilities.



| EXISTING FACILITIES | Y-12 SWEIS ROD (2011) "UPF Alternative" | Amended ROD (2019) "Hybrid Alternative" |
|---|---|---|
| **Building 9212**<br>(EU Operations) | **UPF**<br>• EU Operations<br>• EU Metal Fabrication<br>• Assembly | **Smaller-scale UPF**<br>• EU Operations |
| **9215 Complex**<br>(EU Metal Fabrication) | | **9215 Complex Upgrade**<br>(EU Metal Fabrication) |
| **9204-2E**<br>(Assembly) | | **9204-2E Upgrade**<br>(Assembly) |

Note: borders/shadings/hashmarks are used to show the relationship of existing facilities to the Hybrid Alternative.

**Figure 3-3. Relationship of Facilities to 2011 ROD and 2019 AROD**

Table 3-5 provides the rationale for the facility-to-facility comparisons in this SA. (Note: comparisons of the earthquake accidents in this SA cannot be made against earthquake accidents in the Y-12 SWEIS because, as explained in Section 3.3, earthquake accidents were not analyzed in detail in the 2011 SWEIS because an earthquake accident was not the highest consequence accident for any of the high-hazard facilities). Sub-sections that follow provide the impact comparisons for each facility pairing.

### Table 3-5. Rationale for Facility Pairings/Comparisons

| Facility/Accident Analyzed in this SA | Facility/Accident Analyzed in Y-12 SWEIS | Rationale |
|---|---|---|
| UPF/Design-Basis Earthquake that causes radioactive material spills and localized fires | 9212 Facility/ Aircraft Crash and Fire | • Smaller-scale UPF would replace 9212 Facility;<br>• Similar operations (EU operations) and types of MAR;<br>• Similar accident probabilities<br>➢ UPF earthquake: $4x10^{-4}$<br>➢ Aircraft crash in 9212 Facility: $1x10^{-4}$ (highest in range)[a] |
| 9215 Complex/ Earthquake that causes criticality event | 9215 Complex/ Major fire | • Same facility evaluated in both SA and Y-12 SWEIS;<br>• Similar operations (EU Metal Fabrication) and types of MAR;<br>• Similar accident probabilities<br>➢ Earthquake: $2x10^{-3}$<br>➢ Major fire: $1x10^{-2}$ (highest in range)[a] |
| 9204-2E Facility/ Earthquake that causes criticality event | 9204-2E/ Explosion | • Same facility evaluated in both SA and Y-12 SWEIS;<br>• Similar operations (Assembly) and types of MAR;<br>• Similar accident probabilities<br>➢ Earthquake: $2x10^{-3}$<br>➢ Explosion: $1x10^{-4}$ (highest in range)[a] |

a. Table 5.14.1-1 of the Y-12 SWEIS shows the ranges of probabilities estimated for an airplane crash, major fire, and explosion. The term "highest in range" refers to the highest probability in each range.

#### 3.3.1.1 UPF and Building 9212 Comparison

Tables 3-6 and 3-7 show the impact comparisons for the UPF earthquake accident analyzed in this SA and the most applicable 9212 Facility accident analyzed in the Y-12 SWEIS. As shown in those tables, the consequences and risks associated with a UPF design-basis earthquake accident would be significantly less than those for the 9212 Facility accident analyzed in the Y-12 SWEIS. With regard to involved workers, the modern design and construction features of the smaller-scale UPF would reduce risks to involved workers compared to workers in the 9212 Building. Depending on the accident, there are approximately 100-400 involved workers in the 9212 Building who would be at risk from an accident. For the smaller-scale UPF, it is likely that no workers would be exposed to seismic-induced explosions and no more than 100 workers would be exposed to spills and local fires which could lead to injury or death (CNS 2020b).

### Table 3-6. Radiological Consequence Comparison for UPF and 9212 Facility

| Accident | Maximally Exposed Individual[a,d] | | Offsite Population[b] | | Noninvolved Worker[c,d] | |
|---|---|---|---|---|---|---|
| | Dose (rem) | Latent Cancer Fatality | Dose (Person-rem) | Latent Cancer Fatality | Dose (rem) | Latent Cancer Fatality |
| **SA**: Design-basis earthquake that causes radioactive material spills and localized fires at UPF | 0.0296 | 0 ($1.8x10^{-5}$) | 24.9 | 0 (0.015) | 0.088 | 0 ($5.3x10^{-5}$) |
| **Y-12 SWEIS**: Aircraft Crash in 9212 Facility | 0.3 | 0 ($2.0x10^{-4}$) | 665 | 0.4 | 0.388 | 0 ($2.3x10^{-4}$) |

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.
d. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.
Source: CNS 2020b, NNSA 2011, NuScale 2020.

**Table 3-7. Radiological Risk Comparison for UPF and 9212 Facility**

| Accident | Probability | Maximally Exposed Individual[a] (LCFs) | Offsite Population[b] (LCFs) | Noninvolved Worker[c] (LCFs) |
|---|---|---|---|---|
| **SA**: Design-basis earthquake that causes radioactive material spills and localized fires at UPF | $4\times10^{-4}$ | 0 ($7.0\times10^{-9}$) | 0 ($6.0\times10^{-6}$) | 0 ($2.1\times10^{-8}$) |
| **Y-12 SWEIS**: Aircraft Crash in 9212 Facility | $1\times10^{-4}$ | 0 ($2.0 \times 10^{-8}$) | 0 ($4.0\times10^{-5}$) | 0 ($2.3 \times 10^{-8}$) |

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.
Source: CNS 2020b, NNSA 2011, NuScale 2020.

### 3.3.1.2 9215 Complex Comparison

Tables 3-8 and 3-9 show the impact comparisons for the 9215 Complex earthquake accident analyzed in this SA and the most applicable 9215 Complex accident analyzed in the Y-12 SWEIS. As shown in those tables, the consequences and risks associated with an earthquake accident in the 9215 Complex would be significantly less than those for the 9215 Complex accident analyzed in the Y-12 SWEIS. For involved workers, the number of workers in the 9215 Complex would be no different than the number of involved workers estimated in that facility when the Y-12 SWEIS was prepared. Consequently, potential accident impacts from an accident, whether a criticality event or another type of accident, would not change: no more than 100 workers in the 9215 Complex would be at risk of injury or death (CNS 2020b).

**Table 3-8. Radiological Consequence Comparison for 9215 Complex**

| Accident | Maximally Exposed Individual[a,d] | | Offsite Population[b] | | Noninvolved Worker[c,d] | |
|---|---|---|---|---|---|---|
| | Dose (rem) | Latent Cancer Fatality | Dose (Person-rem) | Latent Cancer Fatality | Dose (rem) | Latent Cancer Fatality |
| **SA**: Earthquake that causes criticality event in 9215 Complex | 0.0021 | 0 ($1.3\text{x}10^{-6}$) | 0.76 | 0 ($4.5\text{x}10^{-4}$) | 0.007[e] | 0 ($4.2\text{x}10^{-6}$) |
| **Y-12 SWEIS**: Major fire in 9215 Complex | 0.59 | 0 ($3.6\text{x}10^{-4}$) | 520 | 0.31 | 16.3 | 0 ($9.8\text{x}10^{-3}$) |

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.
d. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.
e. Includes a direct radiation dose of 0.0011 rem at 1,000 meters (see Table D.9.3-4 of NNSA 2011).
Source: CNS 2020b, NNSA 2011, NuScale 2020.

Table 3-9. Radiological Risk Comparison for 9215 Complex

| Accident | Probability | Maximally Exposed Individual[a] (LCFs) | Offsite Population[b] (LCFs) | Noninvolved Worker[c] (LCFs) |
|---|---|---|---|---|
| **SA**: Earthquake that causes criticality event in 9215 Complex | $2\times10^{-3}$ | 0 ($2.6\text{x}10^{-9}$) | 0 ($9.0\text{x}10^{-7}$) | 0 ($8.4\text{x}10^{-9}$)[d] |
| **Y-12 SWEIS**: Major fire in 9215 Complex | $1\times10^{-4}$ | 0 ($3.6\times10^{-8}$) | 0 ($3.1\times10^{-5}$) | 0 ($9.8\times10^{-7}$) |

a. At site boundary, approximately 1.2 to 1.3 miles from release.

b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.

c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.

d. Includes LCFs from a direct radiation dose of 0.0011 rem at 1,000 meters (*see* Table D.9.3-4 of NNSA 2011).

Source: CNS 2020b, NNSA 2011, NuScale 2020.

### 3.3.1.3 9204-2E Facility Comparison

Tables 3-10 and 3-11 show the impact comparisons for the 9204-2E Facility earthquake accident analyzed in this SA and the most applicable 9204-2E Facility accident analyzed in the Y-12 SWEIS. As shown in Tables 3-10 and 3-11, the consequences and risks associated with an earthquake accident in the 9204-2E Facility would be significantly less than those for the 9204-2E Facility accident analyzed in the Y-12 SWEIS. For involved workers, the number of workers in the 9204-2E Facility would be no different than the number of involved workers estimated in that facility when the Y-12 SWEIS was prepared. Consequently, potential accident impacts from an accident, whether a criticality event or another type of accident, would not change: no more than 100 workers in the 9204-2E Facility would be at risk of injury or death (CNS 2020b).

Table 3-10. Radiological Consequence Comparison for 9204-2E Facility

| Accident | Maximally Exposed Individual[a,d] | | Offsite Population[b] | | Noninvolved Worker[c,d] | |
|---|---|---|---|---|---|---|
| | Dose (rem) | Latent Cancer Fatality | Dose (Person-rem) | Latent Cancer Fatality | Dose (rem) | Latent Cancer Fatality |
| **SA**: Earthquake that causes criticality event in 9204-2E Facility | 0.0021 | 0 ($1.3\text{x}10^{-6}$) | 0.76 | 0 ($4.5\text{x}10^{-4}$) | 0.007[e] | 0 ($4.2\text{x}10^{-6}$) |
| **Y-12 SWEIS**: Explosion in 9204-2E Facility | 0.058 | 0 ($3.5\text{x}10^{-5}$) | 51.2 | 0.031 | 1.18 | 0 ($7.1\text{x}10^{-4}$) |

a. At site boundary, approximately 1.2 to 1.3 miles from release.

b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.

c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.

d. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed. The maximum number of workers expected within 1,000 meters of the accident would be 5,700.

e. Includes a direct radiation dose of 0.0011 rem at 1,000 meters (see Table D.9.3-4 of NNSA 2011).

Source: CNS 2020b, NNSA 2011, NuScale 2020.

**Table 3-11. Radiological Risk Comparison for 9204-2E Facility**

| Accident | Probability | Maximally Exposed Individual[a] (LCFs) | Offsite Population[b] (LCFs) | Noninvolved Worker[c] (LCFs) |
|---|---|---|---|---|
| **SA**: Earthquake that causes criticality event in 9204-2E Facility | $2\times10^{-3}$ | 0 ($2.6x10^{-9}$) | 0 ($9.0x10^{-7}$) | 0 ($8.4x10^{-9}$)[d] |
| **Y-12 SWEIS**: Explosion in 9204-2E Facility | $1\times10^{-4}$ | 0 ($3.5\times10^{-9}$) | 0 ($3.1\times10^{-6}$) | 0 ($7.1\times10^{-7}$) |

a. At site boundary, approximately 1.2 to 1.3 miles from release.

b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.

c. Based on a noninvolved worker assumed to be 1,000 meters from the accident location.

d. Includes LCFs from a direct radiation dose of 0.0011 rem at 1,000 meters (*see* Table D.9.3-4 of NNSA 2011).

Source: CNS 2020b, NNSA 2011, NuScale 2020.

### 3.3.2 Alternative-to-Alternative Comparisons

Section 3.2 presents the potential impacts associated with an earthquake accident at each of three facilities (smaller-scale UPF, 9215 Complex, and the 9204-2E Facility). Taken together, those three facilities reflect the “Hybrid Alternative.” This section compares the accident impacts of the Hybrid Alternative against the Y-12 SWEIS alternatives. These alternative-to-alternative comparisons are based on the potential consequences of site-wide accidents that cause a simultaneous release of radioactive material for the Hybrid Alternative, the Y-12 SWEIS Capability-sized UPF Alternative,[16] and the No Action Alternative.

For the Hybrid Alternative, two site-wide accident scenarios are presented: (1) a design-basis earthquake that causes radioactive material spills and localized fires in the UPF, and simultaneous criticality events in the 9215 Complex and 9204-2E Facility; and (2) worst-case design-basis accidents that occur simultaneously as follows: a design-basis earthquake accident in the smaller-size UPF; a large fire in the 9215 Complex; and an explosion in the 9204-2E Facility.

For the Capability-sized UPF Alternative, NNSA utilized the *Preliminary Safety Design Report for the Uranium Processing Facility* (B&W 2012b) to develop the input data needed for the accident analysis of the full-size (single building) UPF. Using that data, NNSA developed the source term data for a design-basis earthquake that causes localized process area fires in a single building UPF that was intended to house EU operations, EU metal fabrication, and assembly operations.[17]

For the No Action Alternative, the Y-12 SWEIS presents the following accident consequences: (1) a fire from an airplane crash into Building 9212, which houses EU operations; (2) a major fire in the 9215 Facility, which houses EU metal fabrication; and (3) an explosion in the 9204-2E Facility, which houses assembly operations. As discussed in Section 3.3.1, operations in those three facilities are similar and comparable to operations that would be conducted in the facilities that comprise the Hybrid Alternative or the single building UPF.

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[16] The Capability-sized UPF Alternative was the preferred alternative in the Y-12 SWEIS.

[17] The *Preliminary Safety Design Report for the Uranium Processing Facility* (B&W 2012b) is classified. However, NNSA developed unclassified data for this SA. That data is contained in the Data Call reference document (CNS 2020b). The source term associated with spills was insignificant compared to the source term for localized fires.

The Y-12 SWEIS does not identify and analyze a single accident, such as a site-wide earthquake accident, that could simultaneously release radioactive materials from multiple facilities. As such, a direct comparison of accident risk (which requires a consideration of the accident probability associated with the accident) between the Y-12 SWEIS and this SA is not applicable. However, for the No Action Alternative, the Y-12 SWEIS presents the consequences of accidents in multiple facilities, and those additive consequences can be compared against the simultaneous accident consequences presented in this SA. (Note: a comparison of consequences does not require consideration of the initiating event(s) or the accident probability(ies)).

Table 3-12 presents the potential consequences of site-wide accidents for the Hybrid Alternative and the Y-12 SWEIS alternatives. As shown in Table 3-12, the No Action Alternative, which would continue operations in existing facilities, would have the highest consequences compared to the Hybrid Alternative and the Capability-sized UPF Alternative. That conclusion is consistent with the conclusions presented in the Y-12 SWEIS (*see* Section 5.14.3 of NNSA 2011). Although the consequences would be highest for the No Action Alternative, those consequences would be small (i.e., a total dose of 1,236 person-rem, which equates to less than one [approximately 0.72] LCF in the offsite population).

As shown in Table 3-12, the consequences from accidents for the Hybrid Alternative would be much smaller than the No Action Alternative. That reduction would largely be the result of transferring Building 9212 operations to a modern UPF and reducing MAR in the 9215 Complex. As noted in footnote “e” of Table 3-12, the consequences of a large fire in the 9215 Complex for the Hybrid Alternative would be: 274 person-rem to the population; 0.327 rem to the MEI; and 0.97 rem to the noninvolved worker (*see* NuScale 2020). To put these consequences into perspective, the Y-12 SWEIS estimated the consequences of a large fire in the 9215 Complex as: 520 person-rem to the population; 0.59 rem to the MEI; and 16.3 rem to the noninvolved worker (*see* Table 5.14.1-1 of NNSA 2011). The MAR reductions in the 9215 Complex have resulted in an approximately 45-47 percentage reduction in offsite consequences for the worst-case design-basis accident in that facility.

As shown in Table 3-12, the consequences of an accident involving the Capability-sized UPF Alternative are the smallest of the worst-case accidents, and similar to the design-basis earthquake accident for the Hybrid Alternative. This is largely due to the consolidation of EU operations from the older nuclear facilities into a modern UPF. For either alternative, the offsite consequences would be very small (i.e., a total dose of 26.4-29.6 person-rem, which equates to less than one [approximately 0.016-0.018] LCF in the offsite population). The consequences of the worst-case design-basis accidents for the Hybrid Alternative are approximately ten times larger than the consequences for the Capability-sized UPF Alternative, although significantly smaller than the worst-case design-basis accidents for the No Action Alternative.

**Table 3-12. Consequence Comparison: Hybrid Alternative and Y-12 SWEIS Alternatives**

| Accident | Maximally Exposed Individual[a,d] | | Offsite Population[b] | | Noninvolved Worker[c,d] | |
|---|---|---|---|---|---|---|
| | Dose (rem) | Latent Cancer Fatality | Dose (Person-rem) | Latent Cancer Fatality | Dose (rem) | Latent Cancer Fatality[d] |
| **Hybrid Alternative (smaller-scale UPF, 9215, 9204-2E)**<br>Scenario 1: Design-basis earthquake causes the following simultaneous events:<br>Smaller-scale UPF: radioactive material spills and localized fires;<br>9215: criticality event;<br>9204-2E: criticality event. | 0.034 | 0 (2.0x10$^{-5}$) | 26.4 | 0 (0.016) | 0.10<br>(1,000 meters) | 0 (6.1x10$^{-5}$) |
| **Y-12 SWEIS Capability-sized UPF Alternative**<br>Design-basis earthquake (which is also the worst-case design-basis accident) causes radioactive material spills and localized fires in full-size (single building) UPF that was intended to house EU operations, EU metal fabrication, and assembly | 0.0352 | 0 (2.1x10$^{-5}$) | 29.6 | 0 (0.018) | 0.104<br>(1,000 meters) | 0 (6.2x10$^{-5}$) |
| **Hybrid Alternative (smaller-scale UPF, 9215, 9204-2E)**<br>Scenario 2: Worst-case design-basis accidents occur simultaneously:<br>Smaller-scale UPF: design-basis earthquake accident;<br>9215: large fire;[e]<br>9204-2E: explosion. | 0.415 | 0 (0.0025) | 350.1 | 0.21 | 2.24<br>(1,000 meters) | 0 (0.0013) |
| **Y-12 SWEIS No-Action Alternative**<br>Worst-case design-basis accidents occur simultaneously in existing EU facilities:<br>9212: airplane crash;<br>9215: major fire;<br>9204-2E: explosion | 0.948 | 0 (0.00059) | 1,236 | 0.74 | 17.9<br>(1,000 meters) | 0 (0.011) |

a. At site boundary, approximately 1.2 to 1.3 miles from release.
b. Based on a projected future population (2030) of approximately 1,548,207 persons residing within 50 miles of Y-12.
c. Based on a noninvolved worker assumed to be 1,000 meters from the accident locations.
d. The MEI and the noninvolved worker results assume that one person is exposed. If more than one person is exposed, the total dose and the number of LCFs would be multiplied by the number of persons exposed.
e. Source term for large fire in 9215 Complex revised from data in Y-12 SWEIS to account for reductions in MAR (*see* CNS 2020b). The facility-specific consequences of a large fire in the 9215 Complex would be: 274 person-rem to the population; 0.327 rem to the MEI; and 0.97 rem to the noninvolved worker (*see* NuScale 2020).

Source: NNSA 2011, CNS 2020b, NuScale 2020.

## 3.4 Cumulative Impacts

The Council of Environmental Quality regulations (40 CFR § 1508.7) define cumulative impacts as "the incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." The analysis in Section 3.3.2 addresses site-wide accidents/simultaneous accidents in multiple facilities. That analysis provides cumulative impacts information regarding accidents.

## 4.0 CONCLUSION AND PRELIMINARY DETERMINATION

NNSA has prepared this SA to evaluate the potential impacts of an earthquake accident at Y-12, based on updated seismic hazard information. This SA was prepared in accordance with the DOE procedures implementing NEPA (10 CFR 1021) that require that "[when] it is unclear whether or not an Environmental Impact Statement (EIS) supplement is required, DOE shall prepare a Supplement Analysis [that] shall discuss the circumstances that are pertinent to deciding whether to prepare a supplemental EIS pursuant to 40 CFR 1502.9(c)" (10 CFR 1021.314). An SA may also be prepared at any time, as appropriate, to further the purposes of NEPA.

As shown in Section 3.0, the potential impacts associated with an earthquake accident at Y-12 would not be significantly different than impacts presented in the Y-12 SWEIS. Based on the results of this draft SA, NNSA has preliminarily determined that: (1) the earthquake consequences and risks do not constitute a substantial change; (2) there are no significant new circumstances or information relevant to environmental concerns; and (3) no additional NEPA documentation is required at this time.

Based on my review of the information in this SA and pursuant to NNSA's Administrative Procedure and DOE's NEPA implementing procedures (10 CFR 1021.314(c)), I have preliminarily determined, with the concurrence of the NNSA Production Office Counsel, that no further NEPA documentation is required at this time. However, NNSA will continue to evaluate new seismic information as it is developed, including upon the completion of the updated PSHA that is anticipated to be issued by the end of 2020 and the updated facility evaluations that are anticipated to be completed by the end of 2021.

## 5.0 REFERENCES

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# APPENDIX A

# Technical Approach for the Earthquake Accident Analysis

Consequences of accidental radiological releases were determined using the MACCS computer code. MACCS is a DOE/NRC sponsored computer code that has been widely used in support of probabilistic risk assessments for the nuclear power industry and in support of safety and NEPA documentation for facilities throughout the DOE complex. A detailed description of the MACCS model is available in a technical report: Code Manual for MELCOR Accident Consequence Code System2 (MACCS) (NUREG/CR-6613 (NRC 1998).

MACCS estimates the radiological doses, health effects, and economic consequences that could result from postulated accidental releases of radioactive materials to the atmosphere. The release of radioactive materials to the environment is commonly referred to as a source term. MACCS simulates the atmospheric transport and dispersion of the source term as a plume (or series of plumes) and estimates the health and economic consequences due to radioactive contamination from the plume(s) during transport. MACCS calculations are divided into 3 primary modules: ATMOS, EARLY, and CHRONC.

ATMOS performs the calculations related to atmospheric transport, dispersion, deposition, and the radioactive decay of materials prior to release and during the release and transport in the atmosphere. The user defines the initial inventory of radionuclides available for release: each individual nuclide and their initial inventory of activity. The plume release can be divided into multiple plume segments to match the temporal resolution of the meteorological data file. To model a radionuclide release, a user provides MACCS with the characteristics of each plume segment:

- time between the accident occurring and the plume releasing to the environment
- duration of the plume segment release
- plume release height
- plume dimensions at the time of release
- plume buoyancy
- particle size distribution of any aerosols in the plume
- fraction of the initial nuclide inventory for each radionuclide that is released to the environment in the plume segment.

The plume is released into meteorological conditions identified in the meteorological data file. Each plume segment travels in the wind direction and at the wind speed that is present at the time of that plume segment's release. MACCS employs a straight-line Gaussian plume model, meaning that each plume segment travels in a straight line and does not change directions following its release to the environment. Modeling multiple plume segments in a release allows MACCS to more realistically evaluate the consequences of shifting wind conditions during long releases. As each plume segment travels downwind, the plume expands in the vertical and lateral directions based on its current distance from the release point of the plume, and the atmospheric stability at that time. The plume can become depleted due to dry deposition (fallout), wet deposition (washout, i.e. knockout due to rain), and radioactive decay of the materials in the plume. After the ground level airborne and deposited radionuclide concentrations have been calculated in ATMOS, this information is passed to EARLY.

EARLY estimates the dose consequences and health effects due to radiation exposure during the emergency phase. The emergency phase begins when the first plume segment of a release arrives in a grid element, and can last up to 40 days. There are five dose pathways considered in EARLY: cloudshine (submersion in the plume), groundshine (exposure to radionuclides deposited during plume transport), inhalation of the passing plume, inhalation of resuspended radionuclides that were once deposited on the ground, and dose due to exposure from radionuclides deposited on the skin. Dose exposures can be calculated to a variety of organs in the body, as well as a total effective dose equivalent. The EARLY module can model protective actions to reduce radiation exposure including sheltering in place, ordered evacuation through a predetermined route, ad-hoc relocation of individuals in high exposure areas, and potassium iodide prophylaxis. Multiple portions of the population, referred to as cohorts, can be modeled independently and take different protective actions than other cohorts or perform protective actions at different times. Actions following the emergency phase are handled by the CHRONC module.

CHRONC performs all of the calculations related to the intermediate and long-term phases. The intermediate phase begins immediately at the conclusion of the emergency phase, and can last up to 1 year. The intermediate phase is not required to be modeled, and can have zero duration. Only groundshine and resuspension inhalation are considered during this phase. If individuals incur doses over a user-defined threshold, they are relocated for the duration of this phase. The long-term phase begins immediately after the intermediate phase. Exposure pathways resulting from ground-deposited material are considered in the long-term phase: groundshine, resuspension inhalation, and food and water ingestion. Various long-term protective actions can be modeled, including decontamination, interdiction, and condemnation of property, as well as food and crop disposal. These actions are considered separately depending on non-farm and farm land usage.

Due to two conservative assumptions made in this analysis-- deposition of radionuclides is prohibited and protective actions are not considered-- not all aspects of the MACCS code are used. Without ground contamination to consider, the CHRONC module is unnecessary. Additionally, without protective actions, the evacuation, sheltering, relocation, and prophylaxis measures that can be credited by MACCS during the emergency phase to reduce dose consequences are unused.

As implemented, the MACCS2 model evaluates doses due to inhalation of airborne material, as well as external exposure to the passing plume. This represents the major portion of the dose that an individual would receive because of a facility accident. The longer-term effects of radioactive material deposited on the ground after a postulated accident, including the resuspension and subsequent inhalation of radioactive material and the ingestion of contaminated crops, were not modeled for this SA because these pathways have been studied and found to contribute less significantly to the dosage than the inhalation of radioactive material in the passing plume; they are also controllable through interdiction. Instead, the deposition velocity of the radioactive material was set to zero, so that material that might otherwise be deposited on surfaces remained airborne and available for inhalation. This assumption is conservative for the postulated UPF uranium release and realistic for the postulated 9215 and 9204-2E criticality releases. The uranium isotopes released from a UPF accident would be alpha particle emitters that primarily contribute to inhalation dose, as alpha particles do not penetrate skin. Prohibiting deposition maximizes the uranium available for inhalation. The criticality release is comprised of noble gases and vapors, which are nonreactive and do not deposit in the environment.

The source terms were handled by the code by considering the MAR as the inventory. The release fraction of each scenario was then the product of the various factors (DR, ARF, RF, and LPF) that describe the material available to actually impact a receptor.

Meteorological data for Y-12 is taken from 10 meter elevation measurements at weather Tower W of Oak Ridge National Laboratory (ORNL). The meteorological data contains hourly wind speed, wind direction in 16 compass sectors, atmospheric stability, and precipitation rate. Tower W is the meteorological tower nearest the Y-12 site, with a latitude and longitude of 35.98 N, 84.27 W. Hourly wind speed, wind direction, and atmospheric stability is provided in MACCS format by ORNL for 2015 through 2019. Hourly precipitation data is provided by ORNL for 2001 through 2019. Data provided by ORNL for these years is complete and quality assured; therefore, no modifications were made to these data in this analysis. Each four-hour period of the annual meteorological site specific data set for each site was randomly sampled, assuring a good representation of the entire meteorological data set. The results from each of these samples were then ranked and combined (according to their frequency of occurrence) and a distribution of results is presented by the code. This distribution includes statistics such as 95th percentile, 50th percentile, and mean dose. The latter is presented in this SA.

It was conservatively assumed that no special actions would be taken to avoid or mitigate exposure to the general population following an accidental release of radionuclides. For example, there would be no evacuation or protection of the surrounding population. Potential protective actions are not modeled. All individuals, both workers and members of the public, are assumed to be standing outside, unprotected, for the duration of the hypothetical release. This is a conservative assumption because neglecting protective actions maximizes the potential dose consequences.

The spatial grid at the Y-12 site is set up with radial distances that capture the MEI and worker dose at 100 meters, 1,000 meters, 1.24 miles, 15 miles due east, and the total population dose within 50 miles. Consistent with the resolution of meteorological data available from ORNL, the spatial grid has 16 compass sectors. Dose receptors were at 100 meters, 1,000 meters, 1.24 miles, and due east at 15 miles. The cumulative population dose is based on the total population within 50 miles of the release. These distances are consistent with co-located workers at Y-12 and the area of the affected environment surrounding Y-12. The Y-12 site boundary distance is shown to be 1.3 miles in the 2011 SWEIS, and modeling the closest member of the public at 1.24 miles adds slight conservatism to the dose estimate. The nearest environmental justice population to Y-12 is shown to be about 15 miles due east; therefore, this location is evaluated for environmental justice purposes. Population and individual doses were statistically sampled by assuming an equally likely accident start time during any hour of the year. All hours were sampled. The results from each of these samples were then sorted to obtain a distribution of results (radiation dose).

MEI and noninvolved worker doses were calculated using conservative assumptions, such as the wind blowing toward the MEI and locating the receptor along the plume centerline. The doses were converted to LCFs using the factor of 0.0006 LCF per person-rem for both members of the public and workers; if applicable, calculated LCFs were doubled for individual doses greater than 20 rem (NCRP 1993). The MEI and non-involved worker are assumed to be exposed for the duration of the release; they or DOE would take protective or mitigative actions thereafter if required by the size of the release.

Plumes are assumed to release at ground level.  This assumption is conservative and consistent with the postulated release height for a hypothetical EU Warehouse earthquake release.  A ground level release maximizes the radionuclide concentration at ground level, which then maximizes the absorbed dose to the ground level receptor.  A sensitivity case is evaluated at an 8 meter release height to confirm that a ground level release is conservative.

Neutrally buoyant plumes (i.e., plumes that do not rise nor fall during transport) are modeled, using the heat buoyancy model and a plume heat content of 0 watts.  This assumption is conservative and consistent with the Y-12 safety analysis of the UPF.  Neglecting plume rise is a bounding assumption that maximizes the plume centerline relative radionuclide concentration at ground level at all radial distances when radionuclide deposition is also prohibited.  The plume radionuclide concentration is largest at the plume centerline, and neglecting plume rise prohibits the plume centerline from rising above dose receptors.

The analysis of accidents is based on calculations relevant to hypothetical sequences of events and models of their potential impacts.  The models provide estimates of the frequencies, source terms, pathways for dispersion, exposures, and the effects on human health and the environment as realistic as possible within the scope of the analysis.  In many cases, the scarcity of experience with the postulated accidents leads to uncertainty in the calculation of the consequences and frequencies.  This fact has promoted the use of models or input values that yield conservative estimates of consequences and frequency.  Additionally, since no credit is taken for safety systems that may function during an event, these events do not represent expected conditions within the facility at any point in its lifetime.

Due to the layers of conservatism built into the accident analysis for the spectrum of postulated accidents, the estimated consequences and risks to the public represent the upper limit for the individual classes of accidents.  A conservative approach is appropriate and standard practice for analyses of this type, which involve high degrees of uncertainty associated with analytical factors such as accident frequency, MAR, and LPF.

More details regarding the MACCS modeling that was conducted for this SA can be found in “Dose Consequence Modeling Results for the Y-12 Earthquake Accident Supplement Analysis” (NuScale 2020).

# APPENDIX B

## Seismic Analysis and Consequences of a Seismically-Initiated Accident

RP YAREA-F-1709 000 01

# Seismic Analysis and Consequences of a Seismically-Initiated Accident

March 2020

# Seismic Analysis and Consequences of a Seismically-Initiated Accident

March 2020

Prepared by
Consolidated Nuclear Security, LLC
Management & Operating Contractor
for the
Pantex Plant and Y-12 National Security Complex
under Contract No. DE-NA0001942
with the
U.S. Department of Energy
National Nuclear Security Administration

# APPROVALS

| | |
|---|---|
| John H. Gertsen<br>UPF Operators Representative and<br>Uranium Transformation Manager | Date |

# REVISION LOG

| Revision No. | Date | Description | Pages Affected |
|---|---|---|---|
| 0 | January 17, 2020 | Initial issue. | All |
| 1 | March 26, 2020 | Revised to clarify worst-case accident consequences in Sect. 4.2 | 14 |

# CONTENTS

# ABBREVIATIONS

| | |
|---|---|
| ASCE | American Society of Civil Engineers |
| CEUS SSC | Central and Eastern United States Seismic Source Characterization for Nuclear Facilities |
| DOE | U.S. Department of Energy |
| ELP | Extended Life Program |
| EPRI | Electric Power Research Institute |
| HEPA | high-efficiency particulate air |
| IBC | International Building Code |
| MAR | material at risk |
| NEPA | National Environment Policy Act |
| NGA-East | Next Generation Attenuation-East |
| NNSA | National Nuclear Security Administration |
| NRC | Nuclear Regulatory Commission |
| PEER | Pacific Earthquake Engineering Research Center |
| PDSA | Preliminary Documented Safety Analysis |
| PSHA | Probabilistic Seismic Hazard Analysis |
| SA | Supplement Analysis |
| SWEIS | Site-Wide Environmental Impact Statement |
| UPF | Uranium Processing Facility |
| USGS | United States Geological Survey |
| Y-12 | Y-12 National Security Complex |

# 1. INTRODUCTION

This report is intended to address issues that were raised by the U.S. District Court in the Memorandum Opinion and Order (Case 3:18-cv-00150-PLR-DCP Document 63) filed September 24, 2019. This report is also intended to support future supplement analysis.

In evaluating the risks posed by existing or planned buildings that will hold nuclear materials, the National Nuclear Security Administration (NNSA) considers the risk that impacts from seismic events may affect facilities and cause a release of nuclear material into the environment. In order to do this, NNSA must consider a number of variables, each one of which may influence the results of the risk analysis. These include such things as the design of the facility; the material at risk (MAR), which is the amount and character of nuclear materials present; the likelihood and severity of a seismic event (seismic hazard); and the impact of the event on the structure.

Seismic analysis and accident analysis are specialty technical fields that involve in-depth technical analyses and technical terminology. This report attempts to respond to the issues raised by the court by summarizing the technical analyses in a manner that the public can understand.

The issues that are addressed involve multiple nuclear facilities at the Y-12 National Security Complex (Y-12). The first is the Uranium Processing Facility (UPF), which is being designed and constructed at Y-12 to replace an existing nuclear facility, the 9212 Complex. Risk of a seismically-initiated accident is an important consideration in this activity, since UPF is designed to protect workers, the public, and the environment against such risks. Accordingly, it is important to address the issues that have been raised, and to reassure the public that UPF has been designed and is being constructed appropriately.

The other facilities involved are the existing nuclear facilities, the 9215 Complex and the 9204-2E Facility. Nuclear operations are planned to continue in these facilities for more than two decades under the current strategy. To ensure those future operations are conducted safely, an Extended Life Program (ELP) is being implemented to reduce the risk in these facilities and refurbish the facilities to ensure their continued reliability in the future. These facilities are referred to as the ELP facilities. Risk of a seismically-initiated accident is also important in these facilities, but the consideration of that risk is different than that for UPF since the facility structures already exist and upgrades to meet modern seismic structural standards for new facilities may not be feasible or practical. For the ELP facilities, it is important to not only determine the amount of seismic risk and the feasibility of upgrades, but to also explore ways beyond structural upgrades to reduce risk.

This report provides background information on the court request, seismic analysis, and accident analysis, then addresses UPF seismic analysis and accident analysis, followed by seismic analysis and accident analysis of ELP facilities, and concludes with clarifying information about nuclear criticality safety.

It is also important to recognize that a report of this nature unavoidably focuses on weaknesses in existing facilities that are aging, particularly in the 9212 Complex, the 9215 Complex, and the 9204-2E Facility. These weaknesses can and will be addressed for future operations through replacement (UPF) or upgrades (ELP facilities). These weaknesses should not, however, be mistaken to imply that the ELP facilities are unsafe for current operations. To the contrary, the existing facilities have been extensively evaluated, hazards have been identified and analyzed, and controls are implemented through formal safety analysis and authorization processes as defined in DOE-STD-3009-94, Change Notice 3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*. Administrative controls are relied on in some cases where engineered controls do not exist or are of questionable reliability. In all cases, safety controls are implemented and routine assessments ensure that safety controls are effective. Ongoing efforts to remove unnecessary nuclear materials and to upgrade the facilities and processing equipment also reduce nuclear safety risk.

# 2. BACKGROUND

## 2.1 COURT REQUEST

The court order states that NNSA "shall conduct further NEPA [National Environment Policy Act] analysis – including at a minimum, a supplement analysis – that includes an unbounded accident analysis of earthquake consequences at the Y-12 site, performed using updated seismic hazard analyses that incorporate the 2014 USGS [United States Geological Survey] seismic hazard map."

There are several underlying issues that were explained in the memorandum opinion. They are summarized here:

- 2014 USGS seismic hazard maps showed an increase in the hazard for East Tennessee compared to the earlier 2008 USGS seismic maps. While NNSA explained the impact of this new information in the 2016 Supplement Analysis (DOE/EIS-0387-SA-01, *Supplement Analysis for Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*) (2016 SA) and the 2018 Supplement Analysis (DOE/EIS-0387-SA-03, *Supplement Analysis for the Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*) (2018 SA), the court questioned perceived discrepancies between the 2016 SA explanation for UPF and the response to an internal UPF project peer review.
- For ELP facilities, the 2018 SA discussed a 2003 site-specific seismic hazard analysis that is not discussed in the 2011 Site-Wide Environmental Impact Statement (DOE/EIS-0387, *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*) (2011 SWEIS) nor in the 2016 SA. Furthermore, the impact of the 2014 USGS data on ELP facilities is not clear. Finally, none of these documents explain the fact that there are two separate site-specific seismic hazard analyses, one for UPF and a separate one for all other facilities at Y-12.
- The court criticized the use of bounding analysis to compare accident consequences impact in the 2011 SWEIS since the only comparison was to the no action alternative. That bounding comparison was subsequently continued in the 2016 SA and the 2018 SA. The result is that the public cannot reasonably compare the differences between alternatives other than with the no action alternative, and cannot discern any differences with the current strategy, which is a combination of the capability-sized UPF and upgrade-in-place alternatives.
- Furthermore, due to the less mature nature of UPF design and safety analysis at that time, there could be no specific comparisons made to UPF accident consequences in the 2011 SWEIS, but that design and safety analysis has been completed since then.
- NNSA did not make "explicit reference" to methodologies or studies it relied upon, specifically not referencing Y-12 site-specific seismic hazard analyses in either the 2011 SWEIS nor the 2016 SA.
- The court expressed concerns about the impact of a seismically-initiated nuclear criticality accident—the potential of a "nuclear explosion"—based on a November 2016 Defense Nuclear Facilities Safety Board on-site review. Based on this concern raised by the court, the consequences of a potential nuclear criticality accident merit discussion.

## 2.2 SEISMIC INFORMATION AND ITS USE IN SEISMIC ANALYSIS

For the design of nuclear facilities, DOE-STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*, requires the development of a site-specific Probabilistic Seismic Hazard Analysis (PSHA) that considers a range of regional and site-specific information. The hazard analysis provided by and periodically updated by the USGS is some, but not all, of the relevant seismic information included in a site-specific PSHA. Other available information, such as nuclear industry and Nuclear Regulatory Commission (NRC)-generated analyses, is also included. The site-specific PSHA also requires the incorporation of local geologic data to better characterize local seismic sources and establish facility site conditions affecting ground motion. The incorporation of other available seismic data and site-specific geologic studies in a PSHA can increase or decrease design ground motions as compared to using only the USGS hazard map.

Hazard analyses from a project sponsored by the NRC, U.S. Department of Energy (DOE), and the Electric Power Research Institute (EPRI) were incorporated into both the UPF and Y-12 PSHAs. This project is known as the Central and Eastern United States Seismic Source Characterization for Nuclear Facilities (CEUS SSC) and it was initiated in 2008. This project was commissioned specifically to characterize seismic sources that can affect nuclear facilities. The CEUS SSC project was completed in 2012 and published by the NRC as NUREG-2115, *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*.

A second joint project by the NRC, DOE, and EPRI is known as the Next Generation Attenuation-East (NGA-East) project. The NGA-East study was completed in December 2018 and was published in the Pacific Earthquake Engineering Research Center (PEER) Report No. 2018/08, *Central and Eastern North America Ground-Motion Characterization– NGA East Final Report*.

There are two site-specific PSHAs applicable to the facilities at Y-12. One is for UPF and the other is for the balance of the facilities at Y-12. These are discussed separately in this report. However, each PSHA considers the USGS seismic hazard, as incorporated into codes and standards; nuclear industry data, specifically the CEUS SSC analysis; and the local geologic data. The primary output from the PSHA is site-specific seismic response spectra that provides ground motions over frequency ranges that are key inputs into structural designs for new facilities (UPF) and for evaluations of the performance of existing facilities (ELP facilities). The site-specific seismic response spectra depends on the type of rock, type of soil, and the depth of the soil overburden on the rock at the specific building structure location at Y-12.

USGS seismic hazard analyses are also used to update various codes and standards. Of interest is the American Society of Civil Engineers (ASCE) ASCE 7, *Minimum Design Loads for Buildings and Other Structures*, and the *International Building Code* (IBC), which are among the many requirements for facilities at Y-12. The 2014 USGS study was incorporated into ASCE 7 in 2016 (referred to as ASCE 7-16) and was incorporated in the IBC in 2018.

## 2.3 “UNBOUNDED” CONSEQUENCE ANALYSIS

The court order requested “unbounded accident analysis of earthquake consequences,” consistent with its criticism of bounding analysis, as described in Sect. 2.1. To address this topic, this report compares facility-specific earthquake consequences between specific relevant facilities/alternatives. This comparison was accomplished by comparing the consequences that are reported in the respective facility safety basis documents.

The UPF safety basis document was approved in July 2017 (and updated in 2019), which enables comparisons that were previously not possible. In the current strategy, UPF replaces the 9212 Complex at Y-12. Accordingly, UPF consequences, as defined in its 2017 safety basis, are compared to consequences for the 9212 Complex, as defined in the safety basis that was in effect at the time of the 2011 SWEIS (Sect. D.9.1.2). This comparison is essentially the UPF alternative versus the no-action alternative for the facility being replaced by UPF.

ELP facilities represent the upgrade-in-place alternative for those facilities. New safety basis documents are planned for these facilities in 2025. However, updates have been made since 2011 to implement changes associated with ongoing MAR inventory reductions, specifically in the 9215 Complex. Accordingly, current consequences are compared with those that were defined in safety basis documents referenced in the 2011 SWEIS (Sect. D.9.1.2), which essentially provides a comparison between the upgrade-in-place and no-action alternatives for the ELP facilities.

There is no mature safety basis documentation for the replacement (original UPF concept) of the ELP facilities, so a quantitative comparison of consequences cannot be made. Replacement of these facilities was included with the UPF alternative as discussed in the 2011 SWEIS and the 2016 SA, and consequences were compared qualitatively, but bounded by the no-action alternative. For this report, a qualitative comparison of consequences is made between a potential replacement (original UPF concept) for the ELP facilities and the upgrade-in-place alternative, but not bounded by the consequences associated with the site-wide no-action alternative.

Accident consequences defined in the relevant safety basis documents do not take credit for any mitigation from facility design features. The accident consequence analysis in the 2011 SWEIS does take credit for some facility design features, including seismic qualification and air filtration. For this report, the consequences as reported in the safety basis documents are compared directly, and that is followed by a qualitative discussion of mitigation from design features. However, the comparisons presented here are still valid. In fact, the benefits of new facilities and upgraded facilities will be even more pronounced when mitigation is taken into account.

# 3. UPF

## 3.1 UPF SEISMIC ANALYSIS

The UPF project established its site-specific PSHA, site-specific seismic response spectra, and UPF design basis earthquake spectra in 2015 in the following documents:

- RP-ES-801768-A040, *Summary of the UPF Design Basis Earthquake Response Spectra Development*, dated September 2015
- DAC-ES-801768-A244, *Development of Horizontal Hard Rock Response Spectra and Fine-Spaced Rock Hazard Curves for the Development of the SDC-1, SDC-2, and SDC-3 Design Response Spectra*, dated June 18, 2015
- DAC-ES-801768-A330, *UPF Horizontal and Vertical DBE [Design Basis Earthquake] Spectra*, dated September 17, 2015

The seismic design response spectra were based on both ASCE 7 and the CEUS SSC data, and site-specific geologic information, as discussed in Sect. 2.2. The most recent seismic information available at the time was used and is reflected in the UPF Code of Record. UPF used the 2010 version of ASCE 7 (which incorporated the 2008 USGS data) and the 2012 CEUS SSC report. UPF established its design basis earthquake spectra conservatively, and in particular, did not use reductions in the spectra allowable per ASCE 7 which would normally be taken when a site-specific seismic response spectra are available. This conservative approach was taken, in part, to provide margin for new seismic information that would be forthcoming in future years.

A new USGS seismic hazard analysis was published in 2014, and that was later incorporated into ASCE 7 in 2016 (ASCE 7-2016). In 2017, the UPF project reviewed the impact of the changes in the ASCE 7-2016 spectra. The ASCE 7-2016 response spectra (using the USGS 2014 hazard map), with allowable reductions for site-specific analysis, was compared to the UPF design basis earthquake spectra. For frequencies between 5 Hz and 15 Hz, the difference was negligible. For frequencies above and below that range, the UPF design basis earthquake spectra is actually more conservative than the ASCE 7-2016 (USGS 2014) data. These favorable results are directly attributable to the decision to establish the UPF design basis earthquake response spectra conservatively back in 2015.

It should also be noted that the seismic response spectra are an input to the UPF structural design. The UPF structural design was also established conservatively, with adequate design margins, such that the design would perform its required functions even for some increases in the seismic response spectra. For context, just a few of the robust features of the UPF Main Process Building structural design include:

- Excavation of 15 ft of soil to the underlying bedrock.
- Backfill of the excavated soil with engineered mass fill concrete.
- 9-ft-thick reinforced concrete foundation on top of the mass fill concrete.
- Reinforced concrete shear wall system to resist seismic loads with a composite elevated slab system consisting of reinforced concrete slabs and supporting steel beams.

UPF has a robust building design that will perform all of its required functions even after a design basis earthquake.

Finally, the court perceived a discrepancy between two statements about the impact of the USGS 2014 hazard on UPF seismic analysis. Those statements are both true and are not discrepant, but their context, including time and audience, need to be more fully explained. One of these statements was the response in March 2016 to a project seismic peer review recommendation from late 2015. The recommendation was that the project needed to develop a formal position regarding the new, increased hazard from the USGS 2014 map. In the response, UPF cited the lack of maturity of the USGS 2014 data, the fact that it had not yet been adopted into codes that UPF was required to follow (ASCE 7), and acknowledged that it may have to incorporate the data once the data were more mature, incorporated into ASCE 7, and evaluated. For purposes of managing design requirements that statement was true, and reflected formal management practices for design requirements. As noted above, the new data was subsequently incorporated into ASCE 7 and was then compared with the UPF design basis earthquake spectra. The second statement, made in the public 2016 SA, stated the following:

> Although different, the new USGS seismic hazard map does not change the site-specific seismic data at Y-12 which is used to determine facility design and construction requirements. The site-specific design-basis earthquake spectra that would be factored into the requirements for any new UPF buildings has been conservatively developed, and contains margin to address both current requirements and possible future modification of the spectra input, such as the input from the recent USGS seismic hazard changes.

This statement is also true. When looking at the USGS 2014 study that was available at the time, it was apparent that the USGS results would not change the UPF design basis earthquake spectra since UPF had chosen to incorporate the unreduced ASCE 7-2010 (USGS 2008) response spectra back in 2015 to address anticipated changes. This result was later confirmed in the UPF 2017 review of the impact of the changes in the ASCE 7-2016 spectra, described in this section.

For completeness, the 2018 SA addressed this same topic, consistent with the evolution of available information, as follows:

> For the UPF specifically, the seismic forces used for the design are based upon values developed prior to the 2014 USGS maps being accepted into industry codes. The design of the UPF is conservative, in that the design accounts for earthquakes as if they had magnitudes greater than what the codes had defined at the time. The earthquake forces utilized in the UPF design are not significantly different than the 2014 USGS map data. Coupling this with other conservative aspects of the structural design, there is high confidence that the 2014 USGS results do not pose an issue for the UPF.

### 3.2 UPF – CONSEQUENCES OF A SEISMICALLY-INITIATED ACCIDENT

In the 2011 SWEIS, UPF had not yet established an approved formal safety analysis. Since then, in July 2017, the UPF Preliminary Documented Safety Analysis (PDSA) (RP-EF-801768-A191, *Preliminary Documented Safety Analysis for the Uranium Processing Facility*) was approved. The PDSA evaluates many potential accidents, including seismically-initiated ones, which facilitates comparisons with other Y-12 facilities.

The planned operations for UPF are comparable to the current operations in Building 9212. Consequences of the worst-case, seismically-initiated facility accident for UPF are about 80% lower than the equivalent accident in the 9212 Complex, the facility that it replaces, as defined in the 2011 SWEIS. This result is essentially a comparison between the UPF alternative and the no-action alternative for the 9212 Complex only, and is not bounded by the site-wide consequences of the no-action alternative.

That consequence comparison does not, however, take credit for nuclear safety controls and design features. In reality, the worst-case consequence analyzed in the UPF PDSA will likely never occur. UPF was designed and is being constructed to modern nuclear safety and nuclear security standards that make it nearly impossible to ever experience those consequences. Design features that prevent or mitigate such an accident include:

- The seismically-qualified structure will be intact and structurally stable even after an earthquake, providing a robust platform for other safety equipment.
- Seismic equipment qualifications enable confinement of nuclear materials and enable safety systems to perform their safety function even after an earthquake.
- Nuclear-grade high-efficiency particulate air (HEPA) filters, provided as part of a multi-tiered confinement ventilation system, filter any potential hazardous material releases prior to exiting the building via the exhaust stack.
- Modern fire suppression systems (sprinklers) will operate before, during, and after an earthquake, and are fed by an independent, seismically-qualified water tank.

In contrast, the facility UPF replaces, the 9212 Complex, is not seismically qualified, has less comprehensive ventilation filtration, and older, less robust fire protection systems.

It should be noted that NNSA has continued efforts to improve the safety posture of the 9212 Complex in parallel with UPF design and construction. In particular, nuclear material reduction efforts have reduced the consequences of a worst-case accident by 40% since the 2011 SWEIS, and new limits have been established to keep the nuclear inventory low. NNSA has also invested $76M in a Nuclear Facilities Risk Reduction project that upgraded aging electrical and ventilation systems in the 9212 Complex in order to ensure its reliability until UPF is completed.

## 4. EXTENDED LIFE PROGRAM FACILITIES

### 4.1 ELP FACILITIES SEISMIC ANALYSIS

The ELP facilities consist of the 9215 Complex and the 9204-2E Facility. The 9215 Complex was built in the mid-1950s and the 9204-2E Facility was completed in 1971. They are both significant industrial facilities that were designed and constructed to the standards that existed at the time they were constructed. They are facilities that have served their missions well and they provide a stable home for the nuclear operations that they support. Based on the amount and forms of nuclear material processed, the nuclear operations in these facilities have less nuclear safety risk than those in the 9212 Complex.

The ELP facilities have aged and many of their mechanical and electrical systems are in need of refurbishment. Expectations for nuclear facilities have also significantly increased since their construction. Seismic design requirements are one area that has significantly changed. DOE requires periodic review of seismic hazard analyses for its existing nuclear facilities. The ELP facilities at Y-12 have been reviewed in the past and updated seismic evaluations are currently being performed.

The site-specific PSHA for existing facilities at Y-12 (RT-ST 921200-A001, *Update of the Seismic Hazard at the Department of Energy National Security Administration Y-12 National Security Complex*), including the ELP facilities, was performed in 2003 with participation from USGS and several industry experts. That approved analysis was used to perform seismic facility evaluations for the ELP facilities in the 2003–2005 timeframe.

USGS issued a new seismic hazard map in 2008 and the CEUS SSC study was published in 2012. The PSHA for existing facilities at Y-12 was formally reviewed against this new information in 2012 (RP-900000-0029, *Update of the Seismic Hazard at the Department of Energy National Nuclear Security Administration Y-12 National Security Complex*). That review showed that both the 2008 USGS hazard map and the 2012 CEUS SSC study resulted in a decrease in the seismic hazard when compared to the Y-12 2003 site-specific PSHA. Based on the comparison, and to be conservative, Y-12 decided to continue to use the more conservative 2003 site-specific seismic hazard.

In 2014, USGS published an updated national seismic hazard map. That map showed an increase in the seismic hazard, when compared to the 2008 USGS hazard map. As noted above, the Y-12 2003 site-specific seismic hazard is also greater than the 2008 USGS hazard. Accordingly, the difference between the 2014 USGS hazard and the Y-12 2003 site-specific hazard is less significant than the difference between the 2014 and 2008 USGS hazards. The 2014 USGS hazard was incorporated into ASCE 7 in 2016. Subsequently, an informal comparison of the ASCE 7-2016 seismic hazard with the Y-12 2003 site-specific seismic hazard shows that the Y-12 2003 site-specific seismic response spectrum is more conservative in some frequency ranges, while the ASCE 7-2016 (based on the 2014 USGS map) seismic response spectrum is more conservative in others. These differences merit more formal review, which is currently underway, and described below.

The ELP was established in 2016 (RP YAREA-F-0602 000 00, *Extended Life Program, Buildings 9204-2E and 9215*, January 2016), which includes a commitment to update the Y-12 site-specific PSHA and then perform new seismic facility evaluations for the ELP facilities. That work is underway, with the updated PSHA anticipated by the end of 2020 and the updated facility evaluations by the end of 2021. The updated PSHA will incorporate the USGS 2014 hazard, as well as the most recent nuclear industry seismic hazard information (2012 CEUS SSC and 2018 NGA-East).

The ELP facilities (the 9215 Complex and the 9204-2E Facility) were designed and constructed before the establishment of modern nuclear safety standards. Previous facility evaluations have shown some seismic deficiencies of these facilities when evaluated against modern standards for new facilities. Some portions of the facilities meet such standards and other portions do not. The new seismic facility evaluations will provide an up-to-date evaluation of any remaining weaknesses and the potential for upgrades will be addressed. Upgrading both structures to fully meet modern seismic standards for new facilities may not be feasible or practical. However, the potential for structural upgrades will also be informed by an independent expert panel review that Y-12 contracted for in 2016 (RP 900000-0182, *Recommendations of the Seismic Expert Panel Review of Buildings 9204-2E and 9215*, September 2016), which provided suggestions for practical approaches to structural upgrade initiatives in these two facilities.

As discussed earlier, the ELP facilities were designed to the structural codes in place at the time of their construction, not to the seismic requirements for a new facility today. These facilities are considered acceptable today through the safety analysis and safety controls that are implemented in the approved safety basis documents. Any upgrades accomplished by the ELP will improve upon that safety posture, even if it is not feasible to fully meet the requirements for new facilities.

## 4.2 ELP FACILITIES – CONSEQUENCES OF A SEISMICALLY-INITIATED ACCIDENT

As part of the ELP, it was recognized that it may not be feasible or practical to make all upgrades to meet modern nuclear safety standards for new facilities, and that even when upgrades are made, they take significant time to complete. This is particularly true of structural upgrades to meet seismic requirements.

At the same time, the ELP also recognized that a faster way to reduce the consequences of potential facility accidents, including seismically-initiated accidents, is to reduce the amount of nuclear material that could be involved in such an accident. That material is called MAR. Accordingly, an aggressive MAR reduction program was planned and initiated, reducing in-process inventories to the minimum needed for efficient operations, and moving the rest to storage in the Highly Enriched Uranium Materials Facility, a facility that was designed and constructed to modern nuclear standards.

The reduction of worst-case consequences has been significant. Consequences of the worst-case facility accident in the ELP facilities, as defined in the facility safety analysis documents, have been reduced by 50% since the SWEIS was issued in 2011 as a direct result of the MAR reductions. Furthermore, the reductions have been codified in the formal safety analysis documents (DCN-03 to Y/MA-7886, Rev. 10, *Safety Analysis Report for the 9215 Complex*, and DCN-02 to Y/MA-7887, Rev. 10, *Technical Safety Requirements for the 9215 Complex*), which provide the limits for operations (like a nuclear license), so that these lower inventory levels will be maintained.

In the ELP facilities, a seismic accident is not the worst-case accident. A seismic accident is analyzed to include a criticality and small, localized fires. MAR reductions reduce the risk of such events but not as significantly as in the worst-case accident because not all facility inventory is involved.

Additional MAR reductions will be made in the future, as process changes are implemented, that will reduce worst-case accident consequences even more. Accordingly, the consequence comparison above is essentially a comparison of the upgrade-in-place alternative (but with more improvement to go) with the no-action alternative.

ELP investments are reducing the probability of some accidents and improving the safety systems that prevent or mitigate other accidents. One example is the electrical refurbishments that replace aging equipment and bring it up to modern codes, which reduces the likelihood of an electrically initiated fire. Refurbishments of ventilation systems and fire protection systems improves the ability to prevent or mitigate accidents. Furthermore, any structural/seismic improvements that may be initiated after the new facility evaluations would reduce the probability and consequence of seismically-initiated accidents even more. The mitigation of consequences for the upgrade-in-place alternative (ELP) will be better than the mitigation for the no-action alternative because of the upgrades described above.

Another comparison to be made is that of the upgrade-in-place alternative for the ELP facilities with a potential new replacement for the ELP facilities, which would have happened if the original UPF concept, as described in the 2011 SWEIS, had been pursued. Consequences of the worst-case seismically-initiated accident for the ELP facilities as defined in their safety basis documentation would likely be similar to the consequences in a replacement facility (original UPF concept), for the similar operations, because the new facility would be designed as a low-MAR facility and because the safety basis documents do not take credit for mitigation from facility design features.

When considering mitigation from facility design features, a new facility would provide more mitigation than the upgrade-in-place facility. New facilities would be constructed to modern seismic requirements and designed and built to withstand anticipated seismic accelerations, which would prevent any significant damage from the design basis earthquake. The upgrade-in-place alternative would also decrease the seismic accident risks, but not to the extent of a new facility. The upgrades would meet modern nuclear requirements to the extent possible, but some systems—even with refurbishment—will not be as reliable as new replacements. The upgrade-in-place alternative is still be significantly better than the no-action alternative, as previously described.

Finally, it is important to note that the Y-12 safety posture has already been improved by the ELP. Some upgrades, like sprinkler head replacements, have already been completed and most of the highest priority electrical upgrades are complete. The ELP upgrades are broken into small projects and incremental benefits are achieved as each project is completed.

# 5. CONSEQUENCES – NUCLEAR CRITICALITY

A nuclear criticality accident can contribute indirectly to the worst-case consequence, and those impacts were included in Sects. 3.2 and 4.2, above. However, in order to have a complete discussion of consequences of seismic accidents at Y-12, the direct impacts of a nuclear criticality accident must be considered. Prevention of a nuclear criticality accident is extremely important for ensuring safety of Y-12 workers; however, a nuclear criticality accident at Y-12 would not significantly impact the public.

A nuclear criticality accident can cause significant impact in the local area of the event, including large radiation doses and energy releases. This is a significant hazard to the direct workers involved and to other workers in the immediate vicinity. Because of these impacts, NNSA has a robust program to prevent such accidents, including engineered features, administrative controls, and training. Nuclear criticality safety is a dominant consideration in existing, upgraded, and new nuclear facilities at Y-12.

However, the impacts of a nuclear criticality accident, if one occurred, would likely not extend beyond the building boundary. Distance and shielding (e.g., containers, process equipment, and the walls of the facility) make the likely effects at the site boundary negligible.

Finally, designs for upgraded and new facilities attempt to eliminate or minimize nuclear criticality risk. The highest risk of nuclear criticality is associated with processing of highly concentrated high-equity solutions of enriched uranium, like those in the 9212 Complex. The design and construction of UPF, combined with new technologies in the ELP facilities, eliminate seismic concerns associated with these processes. UPF is seismically qualified and the ELP facilities are focused on enriched uranium metal, which has a much lower risk of seismically-initiated nuclear criticality.

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