Technical Support Branch
Safety Evaluation Report
Nuclear Criticality Safety Assessment of Buried Waste and Contaminated Soil Remediation at the Shallow Land Disposal Area Site, Parks Township, Armstrong County, Pennsylvania

1.0 INTRODUCTION

This section presents the findings of the criticality safety review for the Shallow Land Disposal Area (SLDA) Remediation Plan (TAC. No. J00346). The staff evaluated the Final Work Plan, responses to NRC's requests for additional information (RAIs), and other supporting documents submitted in response to NRC's questions. The staff performed its review to determine whether there was reasonable assurance that the U.S. Army Corps of Engineers (USACE) planned facilities and procedures would provide adequate protection against the consequences of a nuclear criticality accident, including both prevention of criticality and protection of workers and the public in the event of criticality.

While the planned work would not be done under a 10 CFR Part 70 license, the staff applied the same reasonable assurance of safety standard to planned activities as for an NRC-regulated Part 70 fuel facility. This encompassed assurance of subcriticality under normal and credible abnormal conditions, compliance with the double contingency principle, and evaluation of the need for a criticality accident alarm system (CAAS) as specified in §70.24.

2.0 SLDA SITE OVERVIEW

The SLDA was formerly owned by Nuclear Materials and Equipment Corporation (NUMEC). In the 1960s and 1970s, NUMEC disposed of radioactive and non-radioactive material waste generated from the Apollo facility at the SLDA site in accordance with regulations found in 10 CFR 20.304 (rescinded in 1981). The uranium-contaminated materials logged as having been placed in the trench are believed to be present at various levels of enrichment, ranging from depleted uranium up to high enriched uranium (HEU).

According to reports prepared by Atlantic Richfield Company (ARCO)/Babcock & Wilcox Company (B&W), the waste materials were placed into a series of pits that were constructed adjacent to one another. From geophysical surveys performed at the site, these pits have the appearance of linear trenches. Trenches 1 through 9 are located in the topographically elevated area in the eastern/central part of the site, and Trench 10 is located in a topographically lower area.

Radiological and chemical waste placed within the SLDA trenches is documented as consisting of process waste, laboratory waste, outdated or broken equipment, building materials, used protecting clothing, general maintenance material, solvents, and trash.

Based on the information provided by the USACE, the trenches at the SLDA site were used for waste disposal from 1960 to 1971. Following waste disposal, the trenches were capped with four feet of soil. The USACE estimated the total volume of potentially contaminated waste and soil in the ten trenches to be 990,000 cubic feet (ft^3).

3.0 SAFETY EVALUATION

NRC staff reviewed the following documents to determine whether criticality safety was assured through engineered and administrative controls, for the most risk-significant operations and with adequate safety margin, and whether the documents were prepared and reviewed by qualified staff:

- "Hazard Identification Report for Buried Waste and Contaminated Soil Remediation Operation at Parks Township Shallow Land Disposal Area Site," NSA-TR-SLDA-10-01, Rev. 1, dated April 2011.
- "Parks Township Shallow Land Disposal Area Remediation Project Nuclear Criticality Safety Assessment Procedure," NSA-TR-SLDA-10-02, Rev. 1, dated April 2011.
- "Parks Township Shallow Land Disposal Area Remediation Project Nuclear Criticality Safety Program Summary," NSA-TR-SLDA-10-03, Rev. 1, dated April 2011.
- "Nuclear Criticality Safety Assessment of Buried Waste and Contaminated Soil Remediation at the Parks Township Shallow Land Disposal Area Site," NSA-TR-SLDA-10-04, Rev. 2, dated April 2011.
- "Technical Basis for Omission of Criticality Accident Alarm Systems at the Parks Township Shallow Land Disposal Area Site for Operations Involving Low Fissile Nuclide Concentration NCS Materials," NSA-TR-SLDA-10-05, Rev.1, dated April 2011.
- "Parks Township Shallow Land Disposal Area Remediation Project Nuclear Criticality Safety CAAS Omission Procedure," NSA-TR-SLDA-10-14, Rev.1, dated April 2011.
- "Hazard Identification Report for Non-NCS Exempt Material Operations at the Parks Township Shallow Land Disposal Area Site," NSA-TR-SLDA-10-15, Rev.1, dated April 2011.
- "Nuclear Criticality Safety Assessment of Exhumed Non-NCS Exempt Material Transit and Buffer Storage at the Parks Township Shallow Land Disposal Area Site," NSA-TR-SLDA-10-16, Rev.1, dated April 2011.
- "Nuclear Criticality Safety Assessment of Exhumed Non-NCS Exempt Material Evaluation and Assay at the Parks Township Shallow Land Disposal Area Site," NSA-TR-SLDA-10-17, Rev.1, dated April 2011.
- "Nuclear Criticality Safety Calculation to determine Subcritical Limits for ^{235}U in Isolation Containers during Packaging, Handling, and Storage," NSA-TR-SLDA-10-18, Rev.1, dated April 2011.
- "Nuclear Criticality Safety Assessment of the Waste Water Treatment Facility and the Material Processing Building Ventilation System at the Parks Township Shallow Land Disposal Area Site," NSA-TR-SLDA-10-19, Rev.1, dated April 2011.
- "Fissile Equivalent Relations for the Parks Township Shallow Land Disposal Area Remediation Project", NSA-TR-SLDA-10-21, Rev.1, April 2011.
- "Hazards Identification Report for Waste Water Treatment Facility Operations and the Material Processing Building Ventilation System at the Parks Township Shallow Land Disposal Area Site," NSA-TR-SLDA-10-22, Rev.1, dated April 2011.
- "Technical Basis for Omission of Criticality Accident Alarm Systems at the Parks Township Shallow Land Disposal Area Site for Operations Involving Non-NCS Exempt Material Excavation and Packaging," NSA-TR-SLDA-11-01, Rev.1, dated April 2011.
- "Technical Basis for Omission of Criticality Accident Alarm Systems at the Parks Township Shallow Land Disposal Area Site for Operations Involving Exhumed Non-NCS Exempt Material Evaluation and Assay," NSA-TR-SLDA-11-02, Rev.1, dated April 2011.

- “Technical Basis for Omission of Criticality Accident Alarm Systems at the Parks Township Shallow Land Disposal Area Site for Operations Involving Exhumed Non-NCS Exempt Material Transit and Buffer Storage,” NSA-TR-SLDA-11-03, Rev.1, dated April 2011.
- “Technical Basis for Omission of Criticality Accident Alarm Systems at the Parks Township Shallow Land Disposal Area Site for the Waste Water Treatment Facility,” NSA-TR-SLDA-11-04, Rev.1, dated April 2011.
- “Technical Basis for Omission of Criticality Accident Alarm Systems at the Parks Township Shallow Land Disposal Area Site for Operations Involving the Material Processing Building Ventilation System,” NSA-TR-SLDA-11-05, Rev.1, dated April 2011.

The staff reviewed select portions of the aforementioned documents, as needed to determine whether USACE’s planned facilities and procedures provided for a reasonable assurance of safety. The staff’s review of these documents is described below.

3.1 Criticality Safety of In-Situ Fissionable Materials and Excavation

The NRC staff reviewed the buried waste and contaminated soil remediation plan for the SLDA site, to determine if the final work plan provides for adequate protection of workers and the public.

The primary objectives of the buried waste and contaminated soil remediation activities at the SLDA site are to identify, carefully extract, and segregate any items or regions of soil/waste that contain, or could potentially contain, fissile material in quantities that would warrant Nuclear Criticality Safety (NCS) control. USACE refers to these items as *Non-NCS Exempt Materials*. These activities also include the evaluation and characterization of the segregated Non-NCS Exempt Materials for fissile material content to ensure proper disposition.

USACE’s nuclear criticality safety assessment (NCSA) documents described anticipated normal conditions for the buried waste and contaminated soil remediation operations and documented the basis for safety. According to the regulation (10 CFR 20.304) in place at the time of the Parks Township SLDA site waste burials, which prescribed limits for burial in soil, the maximum quantity of ^{235}U (Uranium-235) that was allowed to be consigned to any single burial location was approximately 690 g ^{235}U per year, assuming no other isotopes limited by the regulation co-existed at the same burial location. USACE in their assessment assumed that 12 burials occurred each year, thus this regulatory limit of 690 g ^{235}U per burial location results in a combined waste consignment limit of 8.28 kilograms (kg) ^{235}U per year. Assuming 10 combined years of waste consignments, this results in a total of 82.8 kg ^{235}U. Dividing 82.8 kg ^{235}U by the total estimated waste volume of 990,000 ft^3, this results in an average of 3 milligram of ^{235}U per liter (mg ^{235}U/L). By comparison, the worst case burial trench 7 tabulated inventory of 19.670 kg ^{235}U/L in a corresponding waste volume of 100,000 ft^3 would produce an average concentration of 7.0 mg ^{235}U/L.

Based on the above analysis, USACE assumed a conservative average concentration of 10 mg ^{235}U/L as the normal anticipated concentration for the buried wastes and contaminated soils. According to USACE, this value bounds the average ^{235}U concentration values based on the regulatory limit, the worst case burial trench 7, and the average recorded concentration of wastes within the ten disposal trenches, which is 1.0 mg ^{235}U/L.

This conservative average concentration of 10 mg ^{235}U/L is more than three time orders of magnitude less than the maximum safe fissile concentration for an infinite system comprising only ^{235}U and water, which is 11.6 g ^{235}U Fissile Gram Equivalent per Liter (FGE/L) established by the American Nuclear Society in the American National standard "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," ANSI/ANS-8.1-1998. Furthermore, this anticipated average concentration of 10 mg ^{235}U/L is more than two orders of magnitude below the minimum critical infinite sea concentration of 1.4 g ^{235}U FGE/L for a fictitious bounding medium consisting of SiO_2 and ^{235}U, as documented in NUREG/CR-6505, "The Potential for Criticality Following Disposal of Uranium at Low-Level Waste Facilities," Vol. 1. The use of silicon in the analysis was significant because silicon has a very low neutron-capture cross section and silicon dioxide (sand) is often a major constituent in the soil or backfill materials used at LLW facilities. In waste disposal environments, elements such as iron, calcium, and sodium, would also be expected to be present in the waste. These elements are primarily neutron absorbers, reducing k_{eff} and making the SNM waste less likely to cause a criticality accident. The staff asked an RAI about local soil compositions, which can vary significantly, and cause large changes in reactivity. As discussed in Section 3.2 of this SER, bounding moderating and reflecting media were considered; taking local soil impurities into account will tend to increase the concentration of neutron absorbing elements, which will therefore reduce $k_{eff.}$

USACE considered the possibility that a burial trench could be excavated containing waste with a concentration of fissile nuclides exceeding the 10 mg ^{235}U/L limit. USACE has mentioned that there were burial logs generated at the time of operation of the burial trenches indicating that some waste consignments involved individual items with ^{235}U mass contents as high as 130 g ^{235}U. However, due to the associated large potential volume of waste material associated with the items described in the burial logs, it is expected that buried wastes and contaminated soils with elevated ^{235}U concentration of up to a few tens of grams ^{235}U FGE/L would be encountered on an infrequent and intermittent basis.

Due to USACE's acknowledgement that the burial logs may have inaccurate information about the anticipated fissile nuclide loading, it is necessary to rely on administrative actions to fulfill the requirements noted above. For that, USACE has established strict Criticality Safety Controls (CSCs) to ensure the thorough identification and careful removal of all Non-NCS Exempt Materials prior to exhuming NCS Exempt Material.

USACE established that prior to removal of soil/waste material from a trench at the SLDA site, it will perform a comprehensive in-situ radiological survey and visual inspection of the soil/waste material to identify potential items or regions containing Non-NCS Exempt Materials. USACE has described the in-situ radiological survey in detail. They will employ High Resolution Gamma Spectroscopy (HRGS) instruments to provide gamma ray measurements of the surface area of interest based on a survey technique similar to the Multi Agency Radiation Survey and Site Investigation Manual (MARSSIM) protocol. An effective average fissile nuclide concentration limit of 0.4 g ^{235}U FGE/L will be used to identify items with elevated levels of fissile nuclides contamination. According to USACE, a limit of 0.4 g ^{235}U FGE/L is a factor of 29 lower than the maximum safe fissile concentration for an infinitive system comprising only ^{235}U and water (11.6 g ^{235}U FGE/L), and is a factor of 3½ times lower than the minimum infinitive sea concentration of 1.4 g ^{235}U FGE/L for a fictitious bounding medium consisting in of only SiO_2 and ^{235}U. In response to an RAI, USACE stated that its survey method will have an acceptable detection threshold and a fissile material concentration uncertainty of 15%. Based on the above, this effective average 0.4 g ^{235}U FGE/L concentration limits affords a large margin of safety.

3.2 Criticality Safety of Non-NCS Exempt Materials

USACE's Hazard Identification Report presented a detailed evaluation of the hazards associated with the SLDA Remediation Project Activities which include handling, transit, and buffer storage of Non-NCS Exempt Material, as well as the evaluation and assay of Non-NCS Exempt Material.

USACE chose the *What-If/NCS Parameter List* analysis method for the hazards analysis. This evaluation technique is a brainstorming approach in which a group or team familiar with the site equipment and processes ask questions or voice concerns about possible undesirable events. The *NCS Parameter List* consists of list of physical characteristics that are important to criticality safety and helps to add a systematic nature to the process by ensuring all applicable hazards are addressed. NRC staff reviewed the evaluation technique mentioned above and concluded that the events and identified control strategies provide for reasonable assurance of safety with regard to event scenarios associated with these activities.

For scenarios thus identified, USACE documented the basis for criticality safety in a series of NCSAs. In the NCSA for material transit and buffer storage, the applicant explained in detail operational procedures for the exhumed non-NCS Exempt Material. USACE established a control that, prior to removal of soil/waste from a trench on the SLDA site, comprehensive in-situ radiological surveys and visual inspections of the materials will be performed to identify potential items exceeding the 0.4 g ^{235}U FGE/L limit. The in-situ radiological survey will normally use instruments that provide gamma ray measurements of the surface area of interest. Any items thus removed will be carefully exhumed and placed into geometrically controlled Hot Spot Containers (HSCs), which will be transported and stored in geometrically controlled Isolation Containers (ICs). ICs are limited to less than 350 g ^{235}U total mass. These measures were designed to establish and maintain limits on the mass and volume of exhumed fissionable materials and maintain to a safe spacing between them to limit neutron interaction. Due to the limits in place, the staff concludes that USACE has demonstrated there are large margins of safety in the normal condition and there is considerable tolerance to fault under abnormal conditions.

In the Nuclear Criticality Safety Calculation (NCSC) for ICs during packaging, handling, and storage, USACE described its use of the MCNP computer code to analyze normal and postulated abnormal configurations of ICs and exhumed SLDA items. The results presented in this NCSC were based on ICs containing 350 g-^{235}U FGE in high density polyethylene (HDPE). Sensitivity studies involving several different moderating media (e.g., water, soil, sand, and HDPE alone and in various mixtures with water) demonstrated that HDPE represents the most conservative assumption for moderation. The studies also demonstrated that sand (SiO_2) represents the most conservative assumption for reflection material. USACE modeled several different configurations of fissionable material within the ICs. The most conservative arrangement occurs when the fissionable material is concentrated in a small spherical volume at the center of the IC, at nearly optimal moderation. While the dimensions of this region increase as the volume increases, the material density decreases and the hydrogen-to-fissile (H/X) ratio deviates from optimum into the over-moderated range. Thus, the net effect is a reduction in the system reactivity. The staff considers this obvious for the case of a single IC, but USACE's sensitivity studies also show this to be the case for an infinite planar array of ICs. Individual ICs were modeled with varying reflection conditions, and square and hexagonal arrays of ICs were

modeled with varying reflection and spacing conditions. The staff concluded that USACE's calculations assumed the most conservative geometry, moderation and reflection, and spacing conditions that could be expected to occur under normal or credible abnormal conditions. The staff also performed its own confirmatory calculations, using the SCALE computer code, and confirmed the adequacy of USACE's limits. Based on these calculations, USACE established a mass limit of 350 g ^{235}U FGE per IC, and a surface-to-surface (S2S) spacing limit of 36". (These limits result in an areal density of 0.48 g ^{235}U FGE/cm^2, which only exceeds the single-parameter areal density limit of 0.4 g ^{235}U/cm^2 from ANSI/ANS-8.1-1998 slightly. These single-parameter limits are based on very conservative assumptions.)

The NCSC also analyzed abnormal conditions (the results of which were confirmed by the staff in its confirmatory calculations), considering the possible overloading of the ICs and/or failure to adhere to the required spacing. As long as each IC adheres to the 350 g ^{235}U FGE mass limit, an infinite planar hexagonal array of ICs with S2S = 0" (the closest possible arrangement) will still be adequately subcritical. (While the staff did not have access to the validation report, it established a subcriticality condition of $k_{eff} + 2\sigma \leq 0.95$. The materials and geometries being modeled are those commonly encountered in the nuclear fuel industry, and thus use of a limit on k_{eff} that has been traditionally employed in fuel facility applications was appropriate.) The calculations demonstrated that even with all the ICs double-batched (up to 700 g ^{235}U FGE), an infinite array of ICs at the required S2S = 36" would remain adequately subcritical. Thus, there is no single failure of mass or spacing limit that can result in criticality, and therefore the staff concludes that the handling and storage of ICs meets the double contingency principle.

3.3 Criticality Safety of Materials Processing Building (MPB), Waste Water Treatment Facility (WWTF), and Associated Auxiliary Systems

In the NCSA for the WWTF and the MPB ventilation system, USACE provided an overview of the WWTF design and associated operations. The WWTF was designed to collect and treat water from various operations associated with site remediation activities. These sources include waste excavation activities, the Final Site Survey (FSS) pad, the MPB, and decontamination activities. The water thus collected will include water drained from waste materials, rain, dust control activities, and decontamination/cleaning activities. The water will be collected in sumps or catch basins and pumped to the WWTF.

The WWTF collects waste water from a variety of sources in the unfavorable geometry (200,000 gallon) ModuTanks, following which it is pumped through an Inclined Plane Clarifier (IPC) and series of filters before being stored in additional large geometry tanks prior to discharge. The main concern with this area is the potential for highly concentrated (greater than 11.6 g ^{235}U FGE/L) fissile solution to accumulate in unfavorable geometry tanks and vessels. The safety basis for this operation is on limiting the concentration of fissile material in the incoming water streams. USACE has stated in its response to RAIs that it will have no in-line monitoring or periodic sampling to verify the low concentration. Rather, it considers low concentration to be assured on the basis of assumptions about the low fissile material concentration in the trenches (and a qualitative determination that it is extremely unlikely this will be significantly concentrated by any mechanism) and the fact that multiple streams of water are being combined prior to entry into the WWTF tanks. USACE provided the following equation in support of determining the maximum concentration in runoff water:

$$\frac{C_W}{CF_{SOIL}} = \frac{1}{\rho_{SOIL} K_d}$$

where C_W and CF_{SOIL} are the concentration of soluble fissile material in the runoff water and the concentration of fissile material in the soil respectively, ρ_{SOIL} is the density of the soil, and K_d is the sorption coefficient. In response to an RAI, USACE stated that the sorption coefficient is "specific to the SLDA." The assumed value was taken from document NUREG-1613, "Draft Environmental Impact Statement Decommissioning of the Babcock & Wilcox Shallow Land Disposal Area in Parks Township, Pennsylvania." However, the staff noted that the NCSA (NSA-TR-SLDA-10-19) refers to the chosen value as an 'average' coefficient, and that the assumed maximum concentration depends on not exceeding the fissile material concentration in the soil. USACE stated that it does not plan to monitor the fissile material concentration in the runoff water because it considers exceeding a safe concentration in the ModuTanks to be incredible. For the reasons stated above, the staff therefore considers reasonable assurance of safety to be met in performing the following commitment:

Commitment #1

USACE shall sample waste water streams from active trench excavations, prior to collection in the ModuTanks or other unfavorable geometry vessels. Sampling shall consist of dual independent samples and analyses, and shall be performed daily, to verify bounding assumptions and conditions in the applicable nuclear criticality safety calculations and assessments to ensure the tanks will remain subcritical.

In the event the bounding assumptions and conditions are found to be invalid, the transfer of solution to the tanks shall cease until provisions for continuous waste water stream monitoring can be established.

The staff also questioned the possibility of concentration mechanisms subsequent to entry into the WWTF. For example, the applicant has stated that the ModuTanks are large, open-topped tanks. In response to an RAI concerning the possibility of introducing precipitating agents into the ModuTanks, USACE stated that this would have to be a deliberate act and cited the site security. However, it has not demonstrated the absence of readily available precipitating agents that could be introduced into the tanks by accident. USACE has established that it will sample the ModuTanks once every 200,000 gallons (where they expect the majority of the setting to take place).

In addition, the downstream IPC represents an area where fissile material could be expected to accumulate, as do the several downstream filters. The first potential accumulation point is the IPC itself, a large, unfavorable geometry piece of equipment. USACE has also established a frequency for sampling the settled solids in the IPC once every 400,000 gallons. It stated that when running at full capacity, this may result in sampling once every 2-3 weeks. While no firm technical basis for this was provided, the staff notes that sampling results will be monitored and, if sampling results indicate a higher concentration than expected, the sampling frequency will be increased as needed to ensure subcriticality. Based on this assurance, the proposed sampling frequency is acceptable to the staff.

There is also the possibility of carryover of fissile material from operations in the MPB (e.g., from dropped ICs) into the MPB ventilation system. USACE has stated that it has no plans to periodically survey or sample such unfavorable geometry process equipment for the long-term accumulation of fissionable material. For unfavorable geometry equipment that relies on concentration and/or mass control, standard industry practice would normally involve dual independent sampling, and possibly in-line monitoring, of incoming liquid streams, and measures such as periodic non-destructive assay (NDA) over any locations where fissile material could accumulate undetected. For the reasons stated above, the staff therefore considers reasonable assurance of safety to be met by performing the following commitment:

Commitment #2

USACE shall perform non-destructive assay (NDA) on unfavorable geometry equipment in the Materials Processing Building in contact with special nuclear material, including the building ventilation system (HEPA filters, ductwork). The NDA shall be performed at least monthly while the equipment is operating, and waste containing special nuclear material is within the building, to verify bounding assumptions and conditions in the applicable nuclear criticality safety calculations and assessments to ensure the process will remain subcritical.

Additionally, USACE shall sample the settled solids in the Inclined Plate Clarifier, a component in the Waste Water Treatment Plant, at a frequency of 1 sample per 400,000 gallons of water processed to verify bounding assumptions and conditions in the applicable nuclear criticality safety calculations and assessments to ensure the process will remain subcritical.

In the event the bounding assumptions and conditions are found to be invalid, the frequency of NDA or sampling shall be increased as needed to protect against accumulation of a minimum critical mass, or other appropriate controls established.

The NRC's technical conclusions stated in this SER are only valid for the process as described in the documents reviewed. Should process modifications be needed under these conditions, the acceptability of those modifications is not ensured.

3.4 Criticality Accident Alarm System (CAAS) and Emergency Planning and Response

Under the standards of 10 CFR 70.24(a), a criticality detection and alarm system is normally required for facilities involving special nuclear material in excess of 700 g ^{235}U, 450 g Pu, etc., and half those quantities if graphite, heavy water, or beryllium are present. Since greater than those quantities are likely to be exhumed, handled, and stored at the SLDA site, the site would normally require such a CAAS system. Exemptions are frequently granted under 10 CFR 70.17 if such an exemption is "authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest." USACE submitted several technical basis documents to justify its request for approval of planned activities without having coverage by a CAAS system meeting the criteria in 10 CFR 70.24(a).

In addition, 10 CFR 70.24(a)(3) and (b)(1) and (2) require emergency procedures to evacuate affected areas, perform radiation surveys, and provide for medical and decontamination facilities to protect health and safety in the event of a criticality accident. 10 CFR 70.22(i)(1) requires

either an evaluation showing that the dose from criticality to a member of the public will be less than 1 rem, or a formal emergency plan for protecting health and safety.

The staff reviewed USACE's proposed activities against the above standards that would normally be applied to a fuel facility licensed under 10 CFR Part 70.

With regard to CAAS omission, USACE's technical basis is essentially that the criticality accident sequences satisfy the predetermined probabilistic criterion established in its CAAS Omission Evaluation Procedure. This criterion is that the risk score is no more than -6, which the applicant qualitatively assigned a probability of “not credible.” The applicant further clarified in an RAI response that the basis for CAAS omission is that criticality is “not credible.”

The staff reviewed the CAAS omission technical basis documents and the CAAS omission procedure to determine if it agreed with USACE's assessment. The staff noted that the technical basis documents made repeated references to “credible criticality accident event sequences,” as do the various NCSAs. Merely having an assigned risk score of -6 has not been accepted as sufficient to qualify an event sequence as “not credible” under NRC fuel facility guidance. NUREG-1520, Rev. 1, Section 3.4.3.2(9), states that an assessment of “not credible” must not depend on any facility features that could credibly fail to function or could be rendered ineffective as the result of a change. The criterion of 10^{-6}/yr applies only to external hazards, such as natural phenomena, over which a licensee has no control. USACE's response to the RAI stated that the basis for determining that criticality is “not credible” depends upon the “NCS controls established.” Thus, USACE's criteria are not in accordance with the NRC’s guidance for determining than an accident sequence is “not credible.” The staff also reviewed the specific accident sequences contained in the technical basis documents, and determined that the risk scoring depended largely upon administrative controls and initiating and enabling events (e.g., likelihood that a hotspot with elevated fissile nuclide concentration is encountered). While the use of such controls and events in scoring risk is permissible, reliance on these items renders a determination that the sequence is “not credible” problematic. Administrative controls tend to be much less reliable than engineered controls. Initiating and enabling events depend upon assumptions about the mass and concentration of materials being exhumed and likely to be present in runoff water. However, the uncertainty in what will be encountered—especially in light of USACE's acknowledgement that the burial logs may contain inaccuracies—makes reliance on these factors for risk scoring questionable. Therefore, the staff concludes that the presence of administrative controls and initiating and enabling events relying on assumptions that have large uncertainties argues against these sequences being “not credible.”

The staff also noted that the criticality calculations were such that large arrays of ICs could be made to exceed the $k_{eff} + 2\sigma = 0.95$ criterion. While the number of failures would exceed what is required to comply with the double contingency principle, multiple failures of administrative mass and/or spacing controls could lead to a critical configuration. Thus, based on calculations criticality cannot be dismissed as “not credible.” The presence of unfavorable geometry tanks and accumulation points (e.g., ventilation, IPC) requiring periodic monitoring also means that, based on the nature of the processes and equipment, criticality cannot be dismissed as “not credible.”

The staff has determined that the proposed activities are very low risk, due to the low masses and concentrations expected to be encountered, and limited nature of material processing, though they have not been demonstrated to be “not credible.” There is therefore a benefit to having a system for detecting criticality and alerting personnel to take appropriate protective measures. The staff finds that the reduced risk warrants relaxing the requirements that would

normally be required under 10 CFR 70.24. Omission of a CAAS system meeting all of these requirements (and those contained in the endorsed industry standard on CAAS, ANSI/ANS-8.3-1997) is therefore warranted, provided USACE's employ alternate compensatory measures to protect workers and the public, as specified in the condition below (i.e. Commitment #3).

With regard to emergency planning, USACE acknowledged that it had not assessed the dose to individuals at the property boundary. The staff observed that the trenches and location of the planned MPB are in very close proximity to the property boundary, several public roads (Kiskimere Road, Mary Street, and Eisenhower Street), and a small community on the other side of Mary Street. The staff estimated the distances involved and used a source term of 10^{19} total fissions from NUREG/CR-6410, "Nuclear Fuel Cycle Facility Accident Analysis Handbook." While assuming 10^{19} fissions is conservative, there is considerable spread in the fission yield of historical criticality accidents, and this is meant to bound that history. The staff then evaluated the doses resulting from this source term at the estimated distance using the Nuclear Criticality Slide Rule (NUREG/CR-6504). The results, while a very rough estimate, show that a dose exceeding the 1 rem criterion in 10 CFR 70.22(i) and the 12 rad "excessive radiation dose" defined in ANSI/ANS-8.3-1997. (While 10 CFR Part 70 does not define the evacuation area, ANSI/ANS-8.3-1997, which has been endorsed by the NRC in Regulatory Guide 3.71, uses a 12 rad "excessive radiation dose" to define the area of the Immediate Evacuation Zone.) The staff therefore considers measures necessary to protect workers and members of the public to be protected from the consequences of an accidental criticality. Therefore, reasonable assurance of safety to be met by performing the following commitment:

Commitment #3

USACE shall utilize personal alarming dosimeters in areas handling special nuclear material, and area radiation monitors in the Material Processing Building, to detect and protect against the consequences of a criticality accident. USACE shall maintain emergency procedures for the protection of workers and members of the public in response to an indication of criticality from these dosimeters and monitors. Procedures shall specify thresholds for distinguishing between routine radiation exposures and exposures indicating possible criticality, and shall include provisions for the prompt evacuation of workers and notification of offsite authorities, assessment of personnel exposures, decontamination and proper medical attention, and incident recovery and re-entry.

4 CONCLUSION

NRC staff reviewed NCSA documents mentioned in Section 3.1 of this SER, NCSAs, and supporting calculations for the SLDA remediation operations. Within the documents reviewed, NRC staff determined that, in general, USACE had provided enough information to justify the SLDA Remediation Work Plan. Analyses providing for subcriticality of operations were thorough and comprehensive. Staff observed that these analyses contained appropriate limits on controlled parameters for all credible accident sequences leading to inadvertent criticality. Staff did note that there is considerable uncertainty about the types and quantities of material to be excavated, as well as the likely concentration of incoming waste streams to the MPB. Due to this uncertainty, staff determined that it is necessary for USACE to verify the assumptions in its analyses. Therefore, staff has suggested and USACE has agreed to perform the sampling of

incoming waste water streams and non-destructive assay of areas where fissionable material could accumulate over time into unfavorable geometries.

While material processing is limited, and concentrations are expected to be very low (though subject to the uncertainties mentioned above), USACE's analysis concluded that criticality is credible. Therefore, given the involved uncertainties and the possibility of criticality, the staff has suggested and USACE has agreed to perform detection of inadvertent criticality, and subsequent protection of workers and members of public from the consequences of inadvertent criticality.

Staff finds, subject to these conditions (i.e. Commitments # 1, 2 and 3), that the SLDA Remediation Work Plan will provide for adequate protection of workers and the public from the consequences of inadvertent criticality.

REFERENCES

ANSI/ANS-8.1-1998, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," American Nuclear Society, 1998.

ANSI/ANS-8.3-1997, "Criticality Accident Alarm System," American Nuclear Society, 1997.

NUREG/CR-6505, "The Potential for Criticality Following Disposal of Uranium at Low-Level Waste Facilities," Vol. 1 and 2, June 1997.

NUREG-1613, "Draft Environmental Impact Statement Decommissioning of the Babcock & Wilcox Shallow Land Disposal Area in Parks Township, Pennsylvania," August 1997.

NUREG/CR-6410, "Nuclear Fuel Cycle Facility Accident Analysis Handbook," USNRC, March 1998.

"Demonstration of Subcriticality of Large Arrays of Isolation Containers for the Shallow-Land Disposal Area (SLDA) Review," dated June 9, 2011 (ML111600012).

NUREG/CR-6504, Vol. 1 and 2, "An Updated Nuclear Criticality Slide Rule," Oak Ridge National Laboratory, April 1998.

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