DIVISION OF WASTE MANAGEMENT AND ENVIRONMENTAL PROTECTION
TECHNICAL EVALUATION REPORT
RELATED TO UTAH RADIOACTIVE MATERIAL LICENSE UT2300478
ENERGYSOLUTIONS, LLC

1.0 BACKGROUND

On December 13, 2010, Energy*Solutions*, LLC notified the State of Utah's Division of Radiation Control (UT DRC) of its discovery of 15 shipments consisting of 23 containers that exceeded Class A limits (Chalk, 2010). The containers were accepted and disposed of at Energy*Solutions*' low-level radioactive waste disposal facility located in Clive, Utah. The error was the result of a problem with Energy*Solutions*' Electronic Waste Information System which is used to calculate the classification of waste shipments sent to the disposal facility and in the classification of waste by the generators who shipped waste to the disposal facility. On February 24, 2011, UT DRC issued a Notice of Violation to Energy*Solutions* (Lundberg, 2011a*)*. The Notice of Violation identified violations relating to the management of waste that exceeds the Class A limits and the requirement to immediately notify the UT DRC of waste shipments where there may be a violation of applicable rules or license conditions. The Notice of Violation found that the corrective actions, proposed by Energy*Solutions*, to prevent the recurrence of the receipt of waste that exceeds Class A limits are appropriate. The Notice of Violation also required Energy*Solutions* to provide:

(i) an analysis of dose estimates to radiation workers if the subject waste is removed,
(ii) a calculation showing the impact on performance of the facility if the waste is left in place,
(iii) details of how the waste will be located and removed if ordered by the State of Utah, and
(iv) a cost estimate and time table to remove the subject waste.

On April 7, 2011, Energy*Solutions*' responded, as required in the Notice of Violation, with a comparison of whether to leave the subject waste in place (i.e., no action) or remove the subject waste from the disposal cells followed by return of the subject waste to its generators (McCandless, 2011). Energy*Solutions*' analysis indicated the additional impacts to radiation workers and the general population from waste removal far exceed the projected doses from increases to future groundwater concentrations as a result of leaving the waste in place. After reviewing Energy*Solutions*' analysis, the UT DRC in a letter dated July 7, 2011 agreed with Energy*Solutions* and concluded that there is no added benefit to public health, the environment, or the State of Utah to remove the waste (Lundberg, 2011b).

On December 20, 2011, UT DRC requested routine technical assistance from the U.S. Nuclear Regulatory Commission (NRC), per Management Directive 5.7, regarding the aforementioned enforcement action against Energy*Solutions*, LLC (Lundberg, 2011c). Specifically, UT DRC requested NRC to comment on Energy*Solutions*' position on leaving the waste in place and the UT DRC concurrence of that position. The results of the NRC review are described in the following sections.

2.0 DOSE EVALUATION

NRC staff performed a high-level peer review of the Energy*Solutions*' response to the Notice of Violation (McCandless, 2011) which considered two alternatives and the UT DRC review of the response (Lundberg, 2011b). The alternatives considered by Energy*Solutions* include leaving the subject waste in place (i.e., no action alternative) and removing the subject waste from the disposal lifts and returning the targeted lifts to the respective generators (i.e., extraction alternative). Energy*Solutions* evaluated radiological doses to radiation workers and the general public from the subject waste for the two alternatives considered.

2.1 Source Term

Energy*Solutions* identified that over the course of 15 separate shipments there were 23 containers of low-level radioactive waste that exceeded the Class A limits specified in R313-15-1009 of the Utah Administrative Code (UAC), which are compatible with the requirements specified in Section 61.55 of Title 10 of the *Code of Federal Regulations*. Based on information reported by Energy*Solutions* in Table 1-1, 18 of the 23 containers exceeded the allowable Class A limits for radionuclides in Table I of R313-15-1009 (McCandless, 2011). The remaining five of the 23 containers exceeded the allowable Class A limits for radionuclides in Table II of R313-15-1009. The 18 containers that exceed the Class A limits of Table I are, therefore, properly classified as Class C waste. The five containers that exceed the Class A limits of Table II are, therefore, properly classified as Class B waste.

Further, the 23 containers were disposed on various dates from 2001 through 2010 at the Clive facility in 19 separate disposal lifts. The lifts are located in both the Class A and Mixed Waste disposal cells with 13 in the Class A cell and six in the Mixed Waste cell. All 19 disposal lifts were targeted for potential removal and return to the generator in the extraction alternative that Energy*Solutions* considered in its response to the Notice of Violation.

2.2 Exposure Scenarios

Energy*Solutions* estimated potential radiological exposures to both radiation workers and the general public from the subject waste in response to the Notice of Violation. Potential radiological exposures were evaluated for two alternatives: (i) an extraction alternative in which the subject waste is removed and returned to the generators, and (ii) a no action alternative in which the subject waste is left in place.

2.2.1 Radiation Workers

Energy*Solutions* evaluated potential radiological doses for a suite of radiation workers for the extraction alternative during the specific actions required for removal and return of the subject waste. These actions include: (i) surveying and staking the target lifts, (ii) excavation of any overlying lifts or cover material and the subject waste in the target lift, (iii) transfer of the subject waste to intermodal shipping containers, (iv) return of the excavated waste to generators, (v) replacement of the overlying lifts and cover material in the excavation, and (vi) compaction of the target and overlying lifts and any cover material. External exposure to radiation from the waste was evaluated for all the actions. Inhalation of dust was evaluated for excavation, transfer, replacement and compaction activities. Ingestion of dust was evaluated for the excavation

activity. Energy*Solutions* estimated the time each of 11 radiation worker positions comprising 41 individuals would spend in proximity to the excavated waste. Energy*Solutions* lists the radiation workers for which exposures were estimated for the extraction alternative in Table 2-3 of its response to the Notice of Violation (McCandless, 2011). The exposure times vary depending on the task performed. Energy*Solutions* also describes the exposure times for each activity involved in extraction in Section 2.3.2 of its response (McCandless, 2011).

For the no-action alternative, Energy*Solutions* expects no further contact by workers with the subject waste; therefore, no additional worker doses were projected. Energy*Solutions* examined the worker exposures for the time period of disposal of the subject waste and reportedly found no statistically-significant increase in comparison to exposures during normal operations, but did not appear to supply information to corroborate the finding in the documentation NRC reviewed.

2.2.2 Members of the Public

For the extraction alternative, Energy*Solutions* estimated potential radiological exposure to an offsite rancher/industrial worker at the Clive site boundary from windblown contaminated dust during various activities associated with extraction. Pathways evaluated include external exposure to radiation from contaminated dust blown from the site as well as inhalation of the contaminated windblown dust. Energy*Solutions* assumed an exposure time of 175 hours per year (Energy*Solutions*, 2011)

A rancher/industrial worker is reportedly considered the most likely receptor because: (i) the site is zoned as a “Hazardous Industrial District” by the Tooele County Commission which prohibits future residential housing in the vicinity of the Clive site (NRC, 1993); (ii) the area around the site is used for cattle and sheep grazing and recreation (NRC, 1993); and (iii) the lack of potable water at the site reportedly makes the surrounding area an unlikely location for residential, commercial, or industrial developments (Baird et al., 1990); and (iv) exposure to individuals at offsite locations other than the site boundary (e.g., Interstate-80 rest stops or the Knolls Recreation Area) is expected to be minimal due to either the large distances from the site or the exposure time would be brief. While Energy*Solutions* provides support for its basis for the selection of an offsite rancher/industrial worker, NRC notes that many cited references are approaching almost two decades in age. Using more current information to confirm that previous support remains appropriate may be warranted, particularly as it relates to land use and demographic information.

For the no-action alternative, Energy*Solutions* relies on a projection of potential radionuclide concentrations in groundwater at a compliance location for a period of 500 years after closure to comply with the site’s groundwater discharge permit in lieu of estimating doses to a receptor. Energy*Solutions* indicated that other pathways will not exceed the dose limits to members of the public because of limited erosion and infiltration as well as naturally poor classification of the groundwater in the vicinity of the site. Energy*Solutions*’ response to the Notice of Violation did not discuss the rationale for demonstrating compliance with the groundwater discharge permit over a 500 year time period to protect the general public, therefore, NRC staff is deferring to UT DRC acceptance of this approach for demonstrating protection of the general public from potential releases of radioactivity from the Clive site. NRC staff notes that many of the subject waste containers contain longer-lived radionuclides, such as those listed in Table I of R313-15-1009, which are expected to persist for significantly longer than 500 years, and it is not clear how these impacts are accounted for in this approach.

2.3 Mathematical Models

Energy*Solutions* estimated external, ingestion, and inhalation doses to radiation workers and members of the public using various models to represent the exposure scenarios described in the previous section for both the extraction and no-action alternatives.

2.3.1 Radiation Workers

Energy*Solutions* evaluated the potential external radiological exposures to radiation workers from the extraction scenario using Grove Engineering's Microshield®, Version 8.03. Energy*Solutions* estimated ingestion and inhalation doses in Microsoft Excel® using Equations 2-1 and 2-2 in their documentation of the analysis responding to the Notice of Violation. The estimations of ingestion and inhalation doses relate radioactivity concentrations in the waste, uptake of waste, and factors converting activity to exposure. NRC staff concurs with the UT DRC finding regarding the acceptability of these calculations to estimate potential exposures to radiation workers for the extraction alternative.

As described in Section 2.2.1, for the no-action alternative Energy*Solutions* expects no further contact by workers with the subject waste; therefore, no additional worker doses were projected.

2.3.2 Members of the Public

Energy*Solutions* evaluated the potential external and inhalation doses to the rancher/industrial worker scenario described in Section 2.2.2 for the extraction alternative in Microsoft Excel® using Equations 2-5 through 2-9 in their documentation of the analysis responding to the Notice of Violation. The estimation of external dose accounts for suspension of contaminated dust, the airborne radionuclide concentration associated with windblown dust, deposition velocity of the dust, the time over which the receptor is exposed, and factors converting activity to exposure. The calculation for inhalation accounts for suspension of contaminated dust, the airborne radionuclide concentration associated with windblown dust, the receptor's inhalation rate, the time over which the receptor is exposed, and factors converting activity to exposure. NRC staff concurs with the UT DRC finding regarding the acceptability of these calculations to estimate potential exposures to the designated receptor for the extraction alternative.

For the no-action alternative, Energy*Solutions* estimated the travel times for water to migrate from the target lifts to the compliance point. Travel time estimations included vertical migration from the target lifts to the water table and horizontal migration to the compliance point. For any travel times less than 500 years, Energy*Solutions* estimates radionuclide concentrations in groundwater at the compliance point. However, estimates indicate none of the target lifts have water travel times less than 500 years. NRC staff concurs with the UT DRC finding that the calculations are appropriate for estimating travel times from the target lifts to the point of compliance.

2.4 Estimated Doses

Table 1 lists the results of Energy*Solutions*' analyses that were summarized by UT DRC (Lundberg, 2011b).

Table 1. Estimated average additional doses to radiation workers and members of the public for extraction and no-action alternatives.

Alternatives	Average Additional Dose† for All Radiation Workers mSv/person (mrem/person)	Additional Dose† to Public mSv/year (mrem/year)
Remove Waste (i.e., Extraction)	1.94 (194)	0.012 (1.2)
Waste Stays in Place (i.e., No-Action)	0 (0)	--‡

† 'Additional dose' considers potential exposures from future actions or performance and does not account for doses actually incurred from the previous actions associated with the disposal of the waste containers exceeding Class A limits.
‡ Dose to the public was not estimated for the no-action alternative. Rather compliance with the site's groundwater discharge permit was evaluated. For a summary of the analysis see Sections 2.2.2, 2.3.2, and 2.4.2.

2.4.1 Radiation Workers

Energy*Solutions* summarizes estimated doses summed over the actions anticipated for the extraction alternative in Table 2-5 of its response to the Notice of Violation (McCandless, 2011). See Section 2.2.1 for a summary of the actions required for the extraction alternative. Estimated doses range from 0.0234 mSv/person (2.34 mrem/person) for the Director of Engineering to 5.29 mSv/person (529 mrem/person) for the Operators and QC Technicians. Energy*Solutions* reports that the dose per worker averaged over all radiation workers is 1.94 mSv/person (194 mrem/person).

As described in Section 2.2.1 above, for the no-action alternative Energy*Solutions* expects no further contact by workers with the subject waste; therefore, no additional worker doses were projected. Further, Energy*Solutions* examined the worker exposures for the time period of disposal of the subject waste and reportedly found no statistically-significant increase in comparison to exposures during normal operations, but did not appear to supply information to corroborate the finding in the documentation NRC reviewed.

2.4.2 Member of the Public

For the extraction alternative, Energy*Solutions* reports the estimated exposures to the general public in Figure 2-10 of its response to the Notice of Violation (McCandless, 2011). External exposure to radiation from contaminated windblown dust is the significant exposure pathway resulting in an estimated dose of 0.012 mSv/year (1.2 mrem/year) for the rancher/industrial worker receptor. Energy*Solutions* estimates that the dose contribution from inhalation of contaminated dust is $1x10^{-6}$ mSv/year ($1x10^{-4}$ mrem/year).

For the no-action alternative, Energy*Solutions* estimated water travel times from the target lifts where the waste exceeding Class A limits was disposed to the compliance point. Energy*Solutions* summarizes the estimated travel times in Table 3-2 of its response to the Notice of Violation (McCandless, 2011). For ground water travel times to the compliance location that are less than 500 years, concentrations of radionuclides in groundwater must be estimated. However, travel times for all target lifts exceeded 500 years. Therefore, Energy*Solutions* does not expect that radionuclides from the subject waste will be measureable within the compliance location well water before the 500-year time limit promulgated as part of the site's groundwater discharge permit.

3.0 STATE OF UTAH FINDINGS

The State of Utah documented the findings of its review of Energy*Solutions*' response to the Notice of Violation from DRC (Lundberg, 2011b). The UT DRC agreed with Energy*Solutions* and concluded that there is no added benefit to public health, the environment, or the State of Utah to remove the waste. Specifically, the UT DRC noted findings regarding Energy*Solutions*' Dose Evaluation and Facility Performance Evaluation. These specific findings are summarized below.

3.1 Dose Evaluation Findings

Specifically, the UT DRC determined the following regarding the dose evaluation:

- the formulas used by Energy*Solutions* to develop their dose estimates were appropriate;
- the computer program Microshield® is an appropriate program to use;
- the assumptions that Energy*Solutions* used to develop the dose estimates were appropriate; therefore,
- the dose estimates for radiation workers and the public are appropriate.

As noted in the summary of Energy*Solutions*' dose evaluation described in Section 2.0, NRC staff generally concurs with the UT DRC's findings regarding estimated doses for radiation workers and members of the public for the extraction alternative. NRC staff notes in Section 2.2.1 that, while doses incurred as a result of the subject waste disposal are common to both alternatives, Energy*Solutions* provided no basis in the documents that NRC reviewed to support the statement that workers received no significant increase during the disposal of the waste containers exceeding Class A limits. However, NRC staff expects that this information can be confirmed via inspection by the UT DRC. Therefore, NRC staff defers to the UT DRC finding regarding doses received as a result of disposal of the subject waste.

3.2 Facility Performance Findings

Findings made by the UT DRC related to Energy*Solutions*' evaluation of the Clive facility's performance for the no-action alternative are:

- the formulas used by Energy*Solutions* to develop their infiltration estimates were appropriate;
- the assumptions that Energy*Solutions* used to develop the infiltration estimates were appropriate; therefore,
- the infiltration estimates are appropriate.

NRC staff did not perform a review of infiltration estimates because the basis for infiltration rates is not documented in the documents the UT DRC asked NRC staff to review. Therefore, NRC staff defers to the UT DRC findings regarding infiltration.

UT DRC also noted that Energy*Solutions*' performance assessment demonstrates compliance with the facility's radioactive material limits and groundwater discharge permit. NRC staff notes in Section 2.2.2 that it defers to the UT DRC regarding the acceptability of demonstrating protection of the public via the compliance with the groundwater discharge permit for 500 years. Information supporting the acceptability of this approach to demonstrate compliance with the performance objective for protection of the public was not available in either the Energy*Solutions*' analysis (McCandless, 2011) or the UT DRC findings (Lundberg, 2011b).

Finally, NRC staff notes that the Notice of Violation (Lundberg, 2011b) requested analyses addressing the 10 CFR Part 61 performance objectives for protection of the general population (Section 61.41), and individuals during operations (Section 61.43), but it did not request analyses addressing the remaining two performance objectives for protection of inadvertent intruders (Section 61.42) and stability of the disposal site (Section 61.44). Based on the classification of the subject waste containers, Energy*Solutions* has disposed of Class B and Class C waste.

Part 61 also contains technical requirements in Subpart D that are pertinent to the disposal of waste. Class B and C wastes are designated as such because they contain higher radioactivity than Class A waste. Therefore, Class A waste, which is considered relatively innocuous compared to Class B and C wastes should, to the extent practicable, be segregated from Class B and C wastes, per Sections 61.52(a) and 61.55(a)(2). All classes of waste must meet minimum requirements for waste characteristics, specified at Section 61.56(a), to facilitate handling and to provide protection of the health and safety of personnel at the disposal site. However, Class B and C waste forms or containers should be designed to be stable, i.e., maintain gross physical properties and identity, over 300 years. Stability ensures that the waste does not affect overall stability of the site through slumping, collapse, or other failure that would result in water infiltration. Stability also plays a role in limiting exposures to an inadvertent intruder since it provides a recognizable and non-dispersible waste. Therefore, Class B and C wastes must also meet the more rigorous stability requirements for waste characteristics that are specified at Section 61.56(b).

Further, Class C waste can present unique long-term hazards to an inadvertent intruder after closure. Section 61.52(a)(2) requires Class C waste must be disposed of so that the top of the

waste is a minimum of 5 meters below the top surface of the cover or must be disposed of with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 years. Assessments demonstrating compliance with the performance objectives for protection of the inadvertent intruder and stability of the disposal facility could include demonstration of compliance with the specific technical requirements of Subpart D associated with disposal of Class B and C wastes.

4.0 REFERENCES

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