State of Utah

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Lieutenant Governor

Department of
Environmental Quality

Amanda Smith
Executive Director

DIVISION OF SOLID AND
HAZARDOUS WASTE
Scott T. Anderson
Director

July 1, 2014

Sean McCandless
Director of Permitting and Compliance
EnergySolutions, LLC
423 South 300 West, Suite 200
Salt Lake City, Utah 84101

RE: Depleted Uranium Performance Assessment (DUPA)
Clive Facility
Round 3 Interrogatories
DRC Radioactive Materials License 2300249

Dear Mr. McCandless:

The Department of Environmental Quality has completed the Round 3 Interrogatory of the Depleted Uranium Performance Assessment for the EnergySolutions Clive LLRW Disposal Facility, Utah LLRW Disposal license – Condition 35 (RML UT 2300249), pertaining to:
Compliance Report, Revision 1 (November 8, 2013), including Final Report, Version 1.2 (Appendix A), and Appendices 1–18 to Appendix A (Version 1.2 of the GoldSim model, received June 6, 2014). A critique of the responses to the Round 2 Interrogatories (received on June 17, 2014) will be incorporated into the Safety Evaluation Report.

The interrogatories are enclosed. We understand that the complete documentation for the proposed permit amendment will be submitted by July 8, 2014. We appreciate your cooperation.

If you have any questions, please call me at (801) 536-0215.

Sincerely,

Helge Gabert, Project Manager DU Contract
Division of Solid and Hazardous Waste

HG/STA/tjm

(Over)

c: Rusty Lundberg, Director, DRC
Myron Bateman, EHS, MPA, Health Officer, Tooele County Health Department
Jeff Coombs, EHS, Environmental Health Director, Tooele County Heal

UTAH DIVISION OF RADIATION CONTROL: ENERGY*SOLUTIONS* CLIVE LLRW DISPOSAL FACILITY:

UTAH LLRW DISPOSAL LICENSE – CONDITION 35 (RML UT 2300249)

COMPLIANCE REPORT (JUNE 1, 2011) INCLUDING FINAL REPORT, VERSION 1.0 (APPENDIX A) AND APPENDICES 1–17 TO APPENDIX A AND COMPLIANCE REPORT, REVISION 1 (NOVEMBER 8, 2013) AND REVISED DU PA (JUNE 5, 2014) INCLUDING FINAL REPORT VERSION 1.2 AND APPENDICES 1–18

ROUND 3 INTERROGATORIES

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ABBREVIATIONS AND ACRONYMS

ACAP	Alternative Cover Assessment Program
ALARA	as low as reasonably achievable
Am	americium
amsl	above mean sea level
ASTM	American Society for Testing and Materials
bgs	below ground surface
BLM	Bureau of Land Management
BP	before present
BWCS	Babcock & Wilcox Conversion Services, LLC
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
Ci	curie(s)
Ci/g	curie(s) per gram
CLSM	controlled low-strength material
cm	centimeter(s)
cm/s	centimeter(s) per second
cm^2/s	square centimeter(s) per second
cm/yr	centimeter(s) per year
CO_2	carbon dioxide
Cs	cesium
CTC	Cover Test Cell
DEQ	(Utah) Department of Environmental Quality
DF	decontamination factor
DOE	U.S. Department of Energy
DOT	department of transportation
DRC	(Utah) Division of Radiation Control
DU	depleted uranium
DUF_6	depleted uranium hexafluoride
DUO_2	depleted uranium dioxide
DUO_3	depleted uranium trioxide
DWR	(Utah) Division of Water Rights
DWUR	drinking water unit risk
E_H	reduction potential, redox potential
E/P	escape/production
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ES	Energy*Solutions*
ET	evapotranspirative
FEP	feature, event, and process
FHWA	Federal Highway Administration

FRV1	*Final Report for the Clive DU PA Model version 1.0*, June 1, 2011 (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)
FRV1.2	Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2,* NAC-0024_R1, June 5, 2014.
ft	foot/feet
g	gram(s)
g/cm^3	gram(s) per cubic centimeter
GDP	gaseous diffusion plant
gpm	gallon(s) per minute
GW	groundwater
GWPL	groundwater protection limit
GWQDP	groundwater quality discharge permit
HI	hazard index
HQ	hazard quotient
I	iodine
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEM	Integrated Environmental Management, Inc.,
IHI	inadvertent human intruder
in/yr	inch(es) per year
IRIS	Integrated Risk Information System
K	hydraulic conductivity
K_d	soil/water partition coefficients
K_s	saturated hydraulic conductivity
K_{sa}	as-built hydraulic conductivity
K_{si}	in-service hydraulic conductivity
kg	kilogram(s)
km	kilometer(s)
ky	thousand years
kya	thousand years ago
LANL	Los Alamos National Laboratory
lb	pound(s)
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
LLRW	low-level radioactive waste
M	molar
m	meter/meters
m/s	meters per second
m^2/s	square meters per second
MCL	maximum contaminant level
MDA	minimum detectable activity
Mg	megagram(s)
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter

mm	millimeter(s)
mm/kr	millimeter(s) per thousand years
mm/yr	millimeter(s) per year
mrem	millirem
mrem/yr	millirem per year
mSv	millisievert
MT	metric tonne
MTU	metric tonne unit
mV	millivolt
My	million years
nCi/g	nanocurie(s) per gram
NNSS	Nevada National Security Site
NOAA	National Oceanic and Atmospheric Administration
Np	neptunium
NRC	U.S. Nuclear Regulatory Commission
OHV	off-highway vehicle
OMB	Office of Management and Budget
ORGDP	Oak Ridge Gaseous Diffusion Plant
PA	performance assessment
PAWG	Performance Assessment Working Group
pCi/cm^3	picocurie(s) per cubic centimeter
pCi/g	picocurie(s) per gram
pCi/L	picocurie(s) per liter
pCi/m^2-s	picocurie(s) per square meter per second
PGA	peak ground acceleration
PGDP	Paducah Gaseous Diffusion Plant
PORTS	Portsmouth Gaseous Diffusion Plant
ppb	part(s) per billion
PRA	probabilistic risk assessment
psf	pound(s) per square foot
Pu	plutonium
Ra	radium
RfD	reference dose
RFI	request for information
RMS	root mean square
Rn	radon
SNL	Sandia National Laboratories
Sr	strontium
SRS	Savannah River Site
SWCA	SWCA Environmental Consultants
Tc	technetium
TDS	total dissolved solids
TEDE	total effective dose equivalent
U	uranium
U_3O_8	triuranium octaoxide

UAC	Utah Administrative Code
UDEQ	Utah Department of Environmental Quality
UDOT	Utah Department of Transportation
UF_6	uranium hexafluoride
µg/L	microgram(s) per liter
UO_2	uranium dioxide
UO_3	uranium trioxide
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UZ	unsaturated zone
WIPP	Waste Isolation Pilot Plant
yr	year

CATEGORIZATION OF INTERROGATORIES

Cell and Cover Design: 27, 70, 71, 81, 84, 93, 109, 121, 150, 154, 155, 160, 162, 168, 171, 173, 175, 179, 189, 191, 192

Geochemistry: 54, 55, 64, 65, 66, 67, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149

Groundwater: 8, 20, 96, 97, 105, 106, 114, 117, 135, 156, 163, 182, 193

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Waste: 17, 23, 25, 30, 31, 32, 48, 49, 50, 51, 52, 89, 95, 113, 157, 158, 159, 161, 166, 167, 170, 174, 176

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INTRODUCTION

This document continues SC&A's review of the Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011 (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011) (FRV1), and Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013 (together referred to as the Depleted Uranium (DU) Performance Assessment (PA)).

All of the Round 1 Interrogatories are included here for completeness. Those Round 1 Interrogatories where the response from Energy*Solutions* (ES) was judged to be acceptable are so noted. Those interrogatories for which responses were judged not to be acceptable are renumbered so that the ending numerals are changed from xy/1 to xy/2. For each of the Round 2 Interrogatories, the ES response is summarized briefly and the SC&A Rebuttal is provided.

In addition, two new interrogatories (Interrogatory CR R313-25-19-183/2: Meat Ingestion and Interrogatory CR R313-25-19-184/2: GoldSim Skips Stability Calculations) were added. These have been discussed informally with ES previously and were included in the Round 2 Interrogatories, dated May 27, 2014, to ensure the completeness of the review record.

On June 5, 2014, ES submitted revised PA documents (collectively referred to FRV1.2), which included revisions related to ES responses to Round 1 Interrogatories and new material related to use of an evapotranspirative (ET) cover rather than a rock-armored cover on the Federal Cell. These documents were posted on the Utah Department of Environmental Quality (DEQ)/ Division of Radiation Control (DRC) website, http://www.radiationcontrol.utah.gov/EnSolutions/depleteduranium/performassess/duperfass.htm , under the locator Update June 6, 2014. This new and revised material has been reviewed to prepare the Round 3 Interrogatories included in this document. For those interrogatories addressed by this new material, the document summarizes the ES response and provides an V1.2 Critique, noting whether the interrogatory has been resolved. For those that remain open, the ending numerals in the interrogatory were renumbered to xy/3. When an V1.2 Critique is provided, it should be understood that this is commentary in addition to (not in lieu of) the SC&A Rebuttal. In addition, five new Round 3 Interrogatories have been added based on the revised DU PA documents submitted on June 5, 2014.

ROUND 3 INTERROGATORIES

INTERROGATORY CR R313-25-19-01/3: INTERGENERATIONAL CONSEQUENCES

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

No changes were made to Sections 4.1.2.11 and 6.4 of FRV1.2 with regard to the implication that either an undiscounted value of $1,000 per person-rem or a discounted value of $2,000 per person-rem may be used, and the text continues to include discount factors of 3% and 7%. No discussion on the U.S. Nuclear Regulatory Commission's (NRC's) position on intergenerational impacts, as defined in NUREG/BR-0058, has been added to Sections 4.1.2.11 and 6.4.

While ES has added text describing intergenerational consequences, it continues to use the out-of-date $1,000 per person-rem value. Contrary to ES's interpretation, the NRC has not supplemented the $1,000 per person-rem non-discounted value with a $2,000 per person-rem discounted value. Rather, as indicated in NUREG/BR-0058, Revision 4, the NRC has superseded the $1,000 per person-rem with the value of $2,000 per person-rem for all benefit/cost analyses, including intergenerational non-discounted analyses. Thus, we continue to take issue with the cost values presented in FRV1.2 Section 6.4. That said, doubling the costs in FRV1.2 Table 10 would not change any of the conclusions of the as low as reasonably achievable (ALARA) analysis (i.e., "the ALARA costs involved are very small").

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2*, NAC-0024_R1, June 5, 2014.

U.S. Nuclear Regulatory Commission, *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission*, NUREG/BR-0058, Office of Nuclear Regulatory Research, Revision 4, September 2004.

INTERROGATORY CR R313-25-8(5)(A)-02/1: DEEP TIME

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES added the noted revisions to the FRV1.2 Executive Summary. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-03/3: DEEP TIME – SEDIMENT AND LAKE CONCENTRATIONS

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

Refer also to R313-19-13(2)(a)(i)(B): *(a) Exempt concentrations: (i) Except as provided in Subsection R313-19-13(2)(a)(iii) a person is exempt from Rules R313-19, R313-21 and R313-22 to the extent that the person receives, possesses, uses, transfers, owns or acquires products or* *materials containing: (B) diffuse sources of natural occurring radioactive materials containing less than 15 picocuries per gram radium-226.*

INTERROGATORY STATEMENT:

1. Explain why FRV1 does not provide any health and environmental concentration limits for future lake water or sediments for comparison.
2. Resolve discrepancies between the concentration values given in Table 14 and the concentrations shown in FRV1 Figure 13.
3. Provide the basis for presenting only the U-238 sediment concentrations (rather than the full U-238 decay series), as well as the basis for concluding that these concentrations are "small."
4. Indicate why the soil criteria in 40 CFR Part 192 should not apply to the deep time assessment.

BASIS FOR INTERROGATORY:

FRV1 Section 5.1.1, page 43, describes how the deep time model did not consider doses to receptors from future lake water and sediments but instead only predicted lake water and sediment concentrations. The report should provide appropriate environmental regulatory lake water and sediment concentration limits that can be used for compliance comparisons. Alternatively, the report should explain and justify why such health and environmental protection concentration limits are not needed.

FRV1 Section 5.1.8, page 45, describes how, after a future lake erodes the embankment and re-distributes the depleted uranium (DU) waste among lake sediments, the DU contaminants migrate into the lake water via diffusion. However, it does not mention how DU waste contaminants could enter the lake via a groundwater pathway. This apparent omission should be explained and justified, including why it is a conservative approach (protective of health and the environment).

FRV1 Section 6.5.2, page 81, provides in Table 14 and Figure 13 the U-238 lake sediment concentrations derived from successive lake events. However, the values given in Table 14 and shown in Figure 13 do not always agree. For example, the mean concentration in Table 14 is 1,500 or 1,600 picocuries per gram (pCi/g), but Figure 13 shows the mean concentration as always less than 1,000 pCi/g.

Section 7.1, page 84, states in the first full paragraph, "*Despite these possible conservatisms in the deep-time model, the lake water and lake sediment concentrations are small*." The full U-238 decay series is not provided and no other basis is given for concluding that the concentrations are "*small*." When considered in the context of regulations such as 40 CFR 192.12(a), the concentrations are not in fact small.

40 CFR 192.12(a) states the following:

> *The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than—*
>
> > *(1) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and*

> *(2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.*

Although 40 CFR 192.12 was developed specifically for the cleanup of uranium mill tailings sites under Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978, the U.S. Environmental Protection Agency (EPA) has used the criteria in 40 CFR Part 192 when setting remediation goals at Comprehensive Environmental Response, Compensation, and Liability Act sites with radioactive contamination, and those criteria could be considered applicable to this facility.

A similar limit is included in Utah regulation R313-19-13(2)(a)(i)(B), which requires a radioactive material license for diffuse sources containing more than 15 pCi/g of Ra-226.

ES RESPONSE:

In its response, ES focused on various aspects of the future uranium sediment and lake concentrations.

REBUTTAL:

In response to the request to explain why FRV1 does not provide any health or environmental concentration limits for future lake water or sediments for comparison, ES stated that: "*The purpose of the deep time analysis is to provide a* 'qualitative analysis with simulations.' *Although the intent of this requirement could be debated, calculating doses in deep time is neither required nor informative.*" We agree that calculating doses is not required by the current regulations. Nonetheless, we feel that once concentrations are provided (either in the water or sediment or both), those concentrations will be converted into doses (if not by ES, then perhaps by the Utah DEQ or by a third party). Additionally, in order to provide perspective, it is difficult to envision a "qualitative analysis" that does not compare the deep time concentrations provided by ES to some metric (e.g., a similar regulation, background concentrations, occupational exposures). If ES declines to provide the "metric," then in order to support the conclusions of the ES "qualitative analysis," DEQ will define it.

In response to the request to resolve discrepancies in concentration values, ES states that it will make corrections as indicated and that these revisions will be available with the next version of the GoldSim model for the DU PA. We look forward to reviewing the revised report.

In response to the request to provide a basis for presenting only the U-238 sediment concentrations, as well as the basis for concluding that these concentrations are small, ES stated that it will include information on other radionuclides in the revised PA. Any determination of the adequacy of the ES response will await a review of that submittal.

In response to the request to indicate why the soil criteria in 40 CFR Part 192 should not apply to the deep time assessment, the explanation by ES does not recognize a similar regulatory concentration (15 pCi/g Ra-226) for a radioactive materials license exemption under R313-19-13(2)(a)(i)(B). Similar to 40 CFR Part 192, this state rule is designed to protect the public from the adverse health effects of radon exposure. As stated above, if ES declines to compare the deep time concentrations to some "metric," then DEQ will perform that comparison, and the 15 pCi/g Ra-226 "metric" will be used in the "qualitative analysis."

V1.2 CRITIQUE (ROUND 3):

As part of its response to this interrogatory, ES stated that in FRV1.2 (1) discrepancies between Table 14 and Figure 13 would be resolved, (2) concentrations for radionuclides in addition to U-238 would be provided, and (3) a clarification for why the uranium concentrations are considered "small" would be provided. However, a review of FRV1.2 indicates that none of these modifications have been made. Specifically, FRV1.2 Table 12, page 77, shows a peak U-238 sediment concentration of 1,530 pCi/g, whereas FRV1.2 Figure 12, page 78, shows the U-238 sediment concentration peaking at under 1.0e03 pCi/g. FRV1.2 Section 6.5 presents water and sediment concentrations (Tables 11 and 12, pages 76 and 77) for only U-238. Rather than clarifying why the U-238 concentrations are "small," a paragraph added to the FRV1.2 Executive Summary states that background concentrations are about 1 pCi/g, implying that the Clive DU PA Model results are "large" relative to background. The FRV1.2 Executive Summary goes on to argue that, based on "*other conservatisms*" and "*deterministic runs*," the Clive DU PA Model concentrations should be reduced to background levels. However, since "*other conservatisms*" and "*deterministic runs*" were not identified or provided, that argument is considered unsubstantiated.

We continue to disagree with ES on the need to present the results of the qualitative analysis in the form of doses rather than concentrations, and on the usefulness of the 40 CFR Part 192 Ra-226 ground concentration as a comparison metric.

In its June 17, 2014, Round 2 response to this interrogatory, ES provided a quote from NUREG-1573 as part of its justification for not determining doses during the deep time analysis. With regards to the ES interpretation of "qualitative analysis" for future model predictions beyond 10,000 years after facility closure, we refer to NUREG-1573, which states the following:

> *However,* ***it should be noted that for performance assessments carried out beyond 10,000 years, it may be necessary to ensure that the disposal of certain types of waste will not result in markedly high doses to individuals*** *living at any time in the future.* ***Potentially high doses relative to the performance objective could occur within a timeframe longer than 10,000 years, from disposing of large quantities of uranium*** *or transuranics, or possibly by mobile long-lived radionuclides at arid sites with long ground-water travel times.* ***If, at 10,000 years, a radionuclide shows evidence of breakthrough below a peak, the calculation should be continued, assuming the same set of conditions, processes, and events considered significant over the initial 10,000 years, until the radionuclide's peak dose is reached regardless of when that occurs*****.** ***For example, a uranium-238 (^{238}U) inventory resulting in a ^{226}Ra dose at 10,000 years may indicate a potential ^{226}Ra dose in excess of the performance objective beyond 10,000 years.*** *The PAWG recommends that assessments beyond 10,000 years not be used for determining regulatory compliance with the performance objective. However, as a basis for making judgments about the magnitude of the estimated dose relative to the performance objective and its time of occurrence beyond the regulatory compliance period, such assessments may provide an important contribution to the site environmental evaluation. If, after considering the magnitude and time of the dose, and associated uncertainty, the*

regulatory authority decides that the dose is unacceptably high, either inventory limits would have to be imposed or the problem waste is not suitable for disposal as LLW at the site. [page 3-16, second paragraph; emphasis added]

Basedon this text from NUREG-1573, it is clear that the Performance Assessment Working Group (PAWG) is not recommending that doses not be calculated beyond 10,000 years. Thus, the request to ES to supply a deep time dose estimate does not invalidate the express purpose for the qualitative deep time analysis.

We also note that the June 17, 2014, ES response failed to address the need to evaluate future soil/sediment concentrations of Ra-226 near the disposal facility and compliance with the 15 pCi/g concentration requirements of R313-19-13(2)(a)(i)(B).

REFERENCES:

Code of Federal Regulations, Title 40, *Protection of Environment*, Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2*, NAC-0024_R1, June 5, 2014.

U.S. Nuclear Regulatory Commission, *A Performance Assessment Methodology for Low-level Radioactive Waste Disposal Facilities; Recommendations of NRC's Performance Assessment Working Group*, Office of Nuclear Material Safety and Safeguards, NUREG-1573, October 2000.

INTERROGATORY CR R313-25-8(4)-04/1: REFERENCES

Round 1 Interrogatory Response is satisfactory.

INTERROGATORY CR R313-25-7(2)-05/2: RADON BARRIER

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

Refer also to R313-25-7(4): *Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

INTERROGATORY STATEMENT:

Explain why the model does not consider the effects of a compromised radon barrier.

BASIS FOR INTERROGATORY:

The FRV1 Executive Summary, page 2, states, "*The model does not consider the effects of enhanced infiltration or radon diffusion from a compromised radon barrier*." The effects of a compromised radon barrier should be considered, since the durability of the radon barrier over time is problematic. As described in FRV1, plant roots and burrowing animals are active at the Clive site and could compromise the radon barrier by creating "short-circuit" pathways. This issue is particularly sensitive since the performance assessment (PA) model must predict future site/embankment performance for more than 10,000 years, as called for in R313-25-8(5)(a).

ES RESPONSE:

In its response, ES stated the following:

> *SCWA has conducted detailed analysis demonstrating negligible degradation of the Evapotranspirative Cover's radon barrier from animal borrow and root penetration (Energy*Solutions*, 2013d).*
>
> …
>
> *The sensitivity of cover infiltration to changes in radon barrier integrity has been evaluated (Energy*Solutions*, 2014) for the ET cover design. These analyses demonstrated that an increase of 3 orders of magnitude in radon barrier hydraulic conductivity resulted in no increase in infiltration. Therefore, no further assessment of the impact of a compromised radon barrier is necessary in the model.*
>
> …
>
> *…The ET cover design reduces predicted infiltration by two orders of magnitude compared with the rock armor mulch.*
>
> …
>
> *A compromised radon barrier need not be modeled at this time because the ET Cover design will limit infiltration down to the radon barrier. With no infiltration down to that level, the naturalization of the radon barrier will have no effect on performance.*
>
> …
>
> *…what is required would be refined modeling of closure cover performance using probabilistic cover parameters and multiple model simulations designed so that the output from the multiple simulations can be abstracted into the probabilistic performance assessment model.*

REBUTTAL:

In addition to the regulatory requirements listed above, note also that NRC's NUREG-1573, Appendix D, page D-1 (Section D-2, item 1), states that: "*The use of Probabilistic Risk Assessment (PRA) technology should be increased in all regulatory matters to the extent* *supported by the state of the art in PRA methods and data and in a manner that complements NRC's deterministic approach and supports NRC's traditional defense-in-depth philosophy.*"

The radon barrier sensitivity analysis that ES has performed only evaluates the sensitivity of infiltration rates to changes in radon barrier integrity. This exercise involved holding the hydraulic conductivity (K) values of all soil materials overlying the radon barrier constant at proposed as-built values, and changing the hydraulic conductivity values of the upper and lower radon barriers. Due to the high evapotranspiration rates and low permeability of the soils overlying the radon barriers, the infiltration rates were shown to be insensitive to the permeability of the radon barriers. Although this analysis provides some insight into the behavior of the system under static, artificial conditions, the analysis needs to be extended to more realistic future conditions. As described in NUREG/CR-7028 (Benson et al. 2011), cover-system soils that are in service degrade over a period of several years because of a number of natural degradative processes, and the hydraulic conductivity values of these soils tend to rise to values found in a specific, identified range. Depending on the as-built hydraulic conductivity of the soils when the embankment is constructed, the in-service hydraulic conductivity values several years later typically range from one to three orders of magnitude greater than the as-built values.

DRC has asked ES to adjust the hydraulic conductivity and van Genuchten alpha values of all shallow soil materials overlying the radon barrier to values within the range recommended by NUREG/CR-7028 or values correlated with this range. DRC provided ES with a possible log-alpha/log-K_s correlation, based on NRC values in Table 6.1 of NUREG/CR-6346 (NRC 1996). The log-alpha/log-K_s correlation was $\log(\text{alpha}) = 0.42 * \log(K_s) - 1.8853$. The R^2 value for this equation was 0.91. ES has not reported on the results of this experiment, conducted several weeks ago, except to mention to John Hultquist (manager of the DRC License Section) in a conversation (based on his verbal report to DRC staff) that ES performed the exercise but did not accept the results. A simple equation relating alpha to K_s is also provided by Guarracino (2007). He shows, using a well-known soil database, that a strong correlation exists between van Genuchten alpha values and hydraulic conductivities for the soil classes in this database, and he provides the theoretical basis for this correlation. Additional information is found in SC&A's comments in Interrogatory CR R313-25-7(2)-189/3: Modeling Impacts of Changes in Federal Cell Cover-System Soil Hydraulic Conductivity and Alpha Values.

It has been demonstrated very effectively in NUREG/CR-7028 that, based on some of the largest studies ever undertaken to date of alternative cover systems, representing many years of careful research, the hydraulic conductivities of nearly all cover-system shallow soil materials of low to moderate as-built hydraulic conductivity tested have dramatically increased over the as-built values within several years after emplacement in an actual cover system. A number of processes are believed to be responsible for this. NUREG/CR-7028 unequivocally states that, for these relatively shallow soils, "*saturated hydraulic conductivity of earthen barrier and storage layers will increase over time*…." Often, increases reported are of two or three orders of magnitude.

Relatively few studies have been conducted on long-term performance of cover systems for containment facilities. NUREG/CR-7028 states that "*The most comprehensive of these studies is the Alternative Cover Assessment Program (ACAP), which evaluated the performance of 27 different final cover profiles at 12 locations in 8 states in the US (Albright et al. 2004).*" This is the focus of much of NUREG/CR-7028, although considerable additional information is also referenced through the 112 different citations in the text and the corresponding 112 references provided at the end of that document. Twenty-seven test sections were exhumed at the ACAP sites, providing invaluable information on cover-system soil degradation, with increases in hydraulic conductivity, over time. The study found that nearly all soils at the sites studied underwent dramatic increases in hydraulic conductivity within several years after being emplaced. As noted in NUREG/CR-7028, "*Larger changes were observed for soils with lower as-built saturated hydraulic conductivity and soils with a greater proportion of clay particles in the fines fraction.*"

Such a characterization appears to be applicable to the proposed upper radon-barrier clay soil at the Federal Cell, which would consist of a soil "*with lower as-built saturated hydraulic conductivity*," and which includes "*a greater proportion of clay particles in the fines fraction.*" Lesser fractional changes would be expected for other coarser textured soils in the cover system, such as the more-shallow soils mentioned previously, but it is important that changes in hydraulic conductivity and alpha values of these soils should still be considered. NUREG/CR-7028 speaks of as-built hydraulic conductivity (K_{sa}) of each studied soil layer and compares it with the in-service hydraulic conductivity (K_{si}) years after cover construction. It reports that "*for sites with lower K_{sa}, the in-service hydraulic conductivity can be more than 10,000 times higher than K_{sa}.*" Figure 6.8 from NUREG/CR-7028 below shows some of these changes:

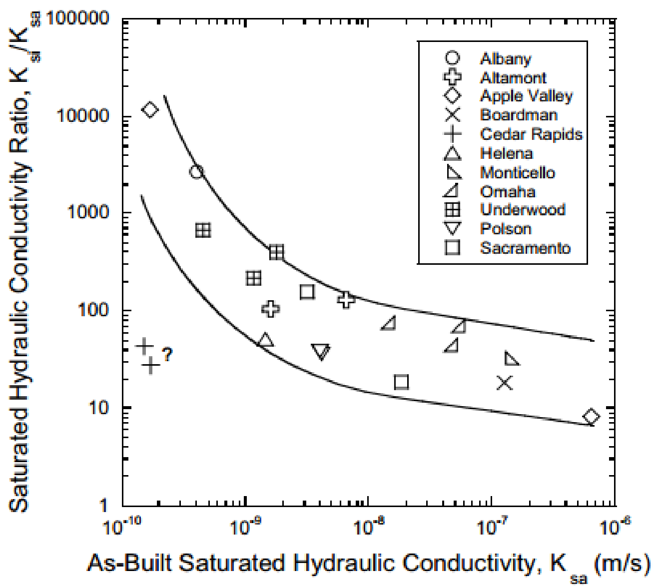

Figure 6.8 from NUREG/CR-7028 (Benson et al. 2011)

This graph shows the ratio of in-service to as-built hydraulic conductivity values for a number of important alternative cover system sites. The ratio is plotted against as-built hydraulic conductivity, expressed in meters per second (m/s) (not centimeters per second (cm/s)). The upper radon barrier, with a relatively small as-built hydraulic conductivity of $5x10^{-10}$ m/s (equivalent to $5x10^{-8}$ cm/s), can thus be expected to have an in-service hydraulic conductivity value in the range of 100 to 1,800 times as great as the as-built value. Even soils with small to moderate as-built hydraulic conductivity values increased in hydraulic conductivity value while in service, by, on average, one to two orders of magnitude. NUREG/CR-7028 found that these increases in hydraulic conductivity, as carefully measured using field tests, occurred for all soils found within about 10 feet of the ground surface.

NUREG/CR-7028 found that "*the saturated hydraulic conductivity of in-service storage and barrier layers that were evaluated is sensitive to scale. Saturated hydraulic conductivities determined from testing conventional small-scale specimens (< 76-mm diameter) in the laboratory are appreciably lower (more than 1000x in some cases) than the actual field hydraulic conductivity.*" This is significant because the hydraulic conductivities assumed in the PA model are based on testing in a laboratory setting of conventional small-scale soil specimens (core samples), the hydraulic conductivities of which may be orders of magnitude smaller than actual field-scale hydraulic conductivities.

ES also stated that the "*compromised radon barrier need not be modeled at this time because the ET Cover design will limit infiltration down to the radon barrier. With no infiltration down to that level, the naturalization of the radon barrier will have no effect on performance*." However, once the K values in the soil units overlying the radon barriers are changed, the infiltration rates may be found to be sensitive to the K of the radon barriers.

Furthermore, the demonstration of the long term integrity of the radon barrier/cover system is particularly important since the cover design does not have the multiple independent and redundant layers of defense to compensate for potential human and mechanical failures that are typical of NRC's defense-in-depth strategy.

In summary:

1. The ES response began by referring to two documents (Energy*Solutions* 2013b and Energy*Solutions* 2014), which obviously were not included in FRV1. ES needs to integrate the information from these two documents into the revised report. Then DRC can review and comment on how that information is being used in the DU PA.
2. The ES response indicates that the ET cover would reduce infiltration by two orders of magnitude compared with the rock armor mulch cover. The revised GoldSim DU PA model (v1.199) provided by ES on May 5, 2014 (Rogers 2014), does not support this statement. The original mean infiltration rate (VerticalFlow_BelowCap) was about 0.12 cm/yr, whereas with the ET cover the rate is about 0.04 cm/yr—reduced by only a factor of three.
3. The ES response indicates that the ET cover design will limit infiltration down to the radon barrier. However, the response does not address what impact (if any) burrowing animals, plant roots, gullies, and similar mechanisms would have on the radon diffusion upwards to the surface.
4. Finally, in its response ES described the cover performance modeling that is required. DRC looks forward to receiving and reviewing this refined modeling effort.

REFERENCES:

Albright, W., C. Benson, G. Gee, A. Roesler, T. Abichou, P. Apiwantragoon, B. Lyles, and S. Rock, *Field Water Balance of Landfill Final Covers*, J. Environmental Quality, Vol. 33, No. 6, pp. 2317–2332, 2004.

Benson, C.H., Albright, W.H., Fratta, D.O., Tinjum, J.M., Kucukkirca, E., Lee, S.H., Scalia, J., Schlicht, P.D., and Wang, X., *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, Volume 1, NUREG/CR-7028, NRC Office of Nuclear Regulatory Research, December 2011.

Energy*Solutions*, *State of Utah Radioactive Material License Renewal Application, Revision 1 (UT 2300249)*, March 6, 2013 [Energy*Solutions* 2013b].

Energy*Solutions*, *Evapotranspirative Infiltration Sensitivity to Changes in Radon Barrier Hydraulic Conductivity*, Energy*Solutions* Technical Memorandum to the Utah Division of Radiation Control, March 31, 2014.

Guarracino, L., *Estimation of saturated hydraulic conductivity Ks from the van Genuchten shape parameter α*, Water Resources Research, Vol. 43, Issue 11,W11502, Nov 15, 2007.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2*, NAC-0024_R1, June 5, 2014.

Rogers, Vern C., *DU PA – ET Cover GoldSim Files*, email to H. Gabert, Utah Division of Radiation Control and W.C. Thurber, S. Cohen & Associates, May 2, 2014.

U.S. Nuclear Regulatory Commission, *Hydrologic Evaluation Methodology for Estimating Water Movement Through the Unsaturated Zone at Commercial Low-Level Radioactive Waste Disposal Sites*, NUREG/CR-6346, Office of Nuclear Regulatory Research, January 1996.

U.S. Nuclear Regulatory Commission, *A Performance Assessment Methodology for Low-level Radioactive Waste Disposal Facilities; Recommendations of NRC's Performance Assessment Working Group*, Office of Nuclear Material Safety and Safeguards, NUREG-1573, October 2000.

INTERROGATORY CR R313-25-7(2)-06/1: GULLY MODEL ASSUMPTIONS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

This interrogatory requested a cross-reference in the Executive Summary to the discussion on gully model assumptions in the Erosion Modeling report. The FRV1.2 Executive Summary does not cross-reference any of the appendices to FRV1.2, including the Erosion Modeling report (Appendix 10 to FRV1.2). However, the paragraph in question was removed in its entirety from the FRV1.2 Executive Summary, page 3, so the cross-reference is no longer applicable. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(4)(B)-07/2: APPLICABILITY OF NRC HUMAN INTRUSION SCENARIOS

PRELIMINARY FINDING:

Refer to R313-25-8(4)(b): *Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.*

INTERROGATORY STATEMENT:

Identify the intrusion barriers in the disposal cell design and explain why typical NRC intrusion scenarios usually underestimate the performance of the disposal system and under what unusual circumstances the performance of the facility/site will not be underestimated. Evaluate other suggested scenarios in addition to the usual NRC intrusion scenarios.

BASIS FOR INTERROGATORY:

The FRV1 Executive Summary, page 3, states that typical NRC intrusion scenarios do not adequately describe likely human activities in the arid west and will usually underestimate the performance of the disposal system. That is, we presume that modeling usual human intrusion scenarios will result in higher doses because such scenarios might not be reasonable in the arid West. The Dose Assessment report lists the exposure scenarios but does not explain why underestimation of performance the disposal system is usual.

Energy*Solutions* should explain and justify why each of the typical NRC intrusion scenarios were omitted from examination in FRV1, and identify the embankment features that constitute the intrusion barriers for the Clive facility.

In addition to the usual NRC intruder scenarios, Energy*Solutions* should also evaluate the following scenarios:

1. Future industrial occupation of Energy*Solutions*' abandoned buildings outside of Section 32.
2. Nearby or on-site industrial occupation for renewable energy development (e.g., solar farm, wind turbines).
3. Excavation for a transcontinental utility pipeline.
4. Surface mining of clay, sand, and gravel.

ES RESPONSE:

In its response, ES stated that: "*While an unlimited number of hypothetical inadvertent intruder scenarios could be developed, Division requirements limit such development to include,* 'Identification of the known natural resources at the disposal site whose exploitation could result in inadvertent intrusion into the wastes after removal of active institutional control.*' UAC R313-25-7(8).*"

REBUTTAL:

We do not agree with the ES interpretation that UAC R313-25-7(8) limits consideration of intruder scenarios to those involving known natural resources. As stated in Interrogatory CR R313-25-20-82/1: Limitation on Inadvertent Intruder Scenarios:

> *Section 1.3.2.2, page 1-13, of the 2013 Compliance Report, Revision 1, states the following:*
>
> > While an unlimited number of inadvertent intruder scenarios can be developed, Division requirements limit such developments to include, 'Identification of the known natural resources at the disposal site whose exploitation could result in inadvertent intrusion into the wastes after removal of active institutional control.' UAC R313-25-7(8).
>
> *DRC does not agree with this interpretation of the regulation. The full section of R313-25-7, of which R313-25-7(8) is a sub-section, describes specific technical information that the applicant must provide:* "The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:…." *Nothing in the regulatory language suggests that DRC plans to limit intrusion scenarios to those related to the exploration and exploitation of natural resources. Certainly, if there are known natural resources, DRC will likely wish to ensure the consideration of intruder scenarios involving their exploration and exploitation. More to the point, the definition of "inadvertent intruder" does not limit the DRC Director to only considering discovery and exploitation of natural resources. Instead, as stated in UAC R313-25-2—*
>
> Inadvertent intruder *means a person who may enter the disposal site after closure and engage in activities unrelated to post closure management, such as agriculture, dwelling construction, or other pursuits which could, by disturbing the site, expose individuals to radiation.*
>
> *Hence, the emphasis is not only on natural resources but also on human activities and pursuits at the disposal site after facility closure.*

Interrogatory CR R313-25-8(4)(b)-07/1 requested evaluation of four scenarios, one of which included surface mining of clay, sand, and gravel. We do not find in the ES response to this interrogatory any compelling arguments as to why this scenario for inadvertent human intrusion should be excluded, particularly since it involves known natural resources. Since R313-25-8(1)(a) recognizes NUREG-0782[1] as a fundamental supporting document for the low-level radioactive waste rules at 10 CFR Part 61, it is reasonable to expect that the PA model report should at least consider the same intrusion scenarios the NRC staff used in 1981. These include intruder construction, intruder discovery, intruder agriculture, and intruder well. If any of these

[1] Details on intruder analysis used by NRC staff can be found in Volumes 2 and 4 of NUREG-0782.

are omitted from the PA analysis, ES needs to discuss and justify why they should not be included.

REFERENCES:

Code of Federal Regulations, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Nuclear Regulatory Commission, *Draft Environmental Impact Statement on 10 CFR Part 61 Licensing Requirements for Land Disposal of Radioactive Waste*, Office of Nuclear Material Safety and Safeguards, NUREG-0782, September 1981.

INTERROGATORY CR R313-25-8(4)(A)-08/1: GROUNDWATER CONCENTRATION ENDPOINTS

Round 1 Interrogatory Response is satisfactory, as it pertains to dose predictions to ranch workers, hunters, and off-highway vehicle (OHV) enthusiasts. With regard to ES statements about a lack of sensitivity for Tc-99 groundwater concentration results, DEQ will make its conclusions after several other interrogatories are resolved. These include CR R313-25-8(5)(a)-31/2: Tc-99 Content in the Waste and Inclusion in the Sensitivity Analysis, CR R313-25-7(9)-48/2: Source and Composition of DU Waste, CR R313-25-7(1–2)-90/2: Calibration of Infiltration Rates, CR R313-25-8(4)(d)-155/2: Cover Performance for 10,000 Years, and CR R313-25-8(5)(a)-163/2: Groundwater Compliance for 10,000 Years.

INTERROGATORY CR R313-25-19-09/1: DEFINITION OF ALARA

Round 1 Interrogatory Response is satisfactory.

INTERROGATORY CR R313-22-32(2)-10/3: EFFECT OF BIOLOGICALS ON RADIONUCLIDE TRANSPORT

PRELIMINARY FINDING:

Refer to R313-22-32(2): *The Executive Secretary may, after the filing of the original application, and before the expiration of the license, require further statements in order to enable the Executive Secretary to determine whether the application should be granted or denied or whether a license should be modified or revoked.*

INTERROGATORY STATEMENT:

Provide support for the statement that the severity of the *"…effect* [of plants, ants, and burrowing mammals] *on radionuclides transport might be small."*

BASIS FOR INTERROGATORY:

FRV1 Section 4.1.2.8, page 32, states that the severity of the effect of plants, ants, and burrowing mammals on radionuclide transport might be "*small*" because the impact will be limited largely to the top several meters. However, no discussion is provided to support this qualitative judgment of "*small*" effects. For example, what if burrowing occurs in gullies? We also note that the verb "*might*" typically connotes a considerable degree of uncertainty.

ES RESPONSE:

In its response, ES discussed how the effects related to such transport would decline as a function of depth.

REBUTTAL:

The interrogatory had asked ES to support its statement that the effect of plants, ants, and burrowing mammals on radionuclide transport might be small. The response instead discussed how the effects related to such transport would decline as distance from the ground surface increases. However, this response does not satisfy the interrogatory with regard to how the effect of plants, ants, and burrowing mammals on radionuclide transport itself was determined to be small.

V1.2 CRITIQUE (ROUND 3):

While ES speculates that the effect of biointrusion (e.g., by ants) on radionuclide transport might be small, Gaglio et al. (2001) demonstrated in one study that "*infiltration rates of water into soils with ant nests was approximately eight times faster than soils without ant nests.*"

Higher rates of infiltration are also induced by other types of biointrusion. Biointrusion can, in some instances, dramatically increase downward water movement. Dwyer et al. (2007), for example, state that "*biointrusion can lead to increased infiltration and preferential flow of surface water through the cover system as well as contribute to the change in the soil layer's hydraulic properties.*"

Laundre (1993) shows that burrowing by ground squirrels can increase the amount of snowmelt infiltration into soils in the spring by as much as 34%. Hakonson (1999) indicates that pocket gophers can increase rates of infiltration by 200 to 300%. Breshears et al. (2005) report that burrows made by pocket gophers in simulated landfills dramatically increased infiltration rates (i.e., by about one order of magnitude). Badger burrows at the Hanford site are reported to have captured much runoff and allowed the runoff to infiltrate into soils deeper than elsewhere on site. Measurements by researchers of moisture in soils under the burrows after artificial rainfall events demonstrated this impact: "*These measurements confirmed that larger mammal burrows can and do cause the deep penetration of precipitation-generated runoff at Hanford*" (Link et al., 1995).

The PA should account for greater infiltration through the cover system as a result of biointrusion by animals in general.

Biointrusion by plant roots can also damage cover systems, increase infiltration, and hasten migration of contaminants. This is done by increasing the hydraulic conductivity of cover-system soils penetrated by roots. This can be especially problematic at radon barriers. Waugh and Smith (1988) indicate that at a U.S. Department of Energy (DOE) low-level waste (LLW) site at Burrell, Pennsylvania, the hydraulic conductivity increased by two orders of magnitude at locations where roots penetrated the radon barrier. This is yet another reason why in-service hydraulic conductivity values of all near-surface (i.e., within 10 feet of ground surface) cover-system soils should be increased in modeling over as-built values to values within the ranges given by NRC guidance in NUREG/CR-7028.

Higher rates of infiltration are typically associated with higher contaminant transport rates. Infiltration should be minimized (see UAC R313-25-24(3) and (4)). ES should account in its modeling for greater infiltration through the cover system at the Federal Cell embankment due to biointrusion by plant roots and by animals. One way to achieve this would be to simultaneously increase all cover-system soil hydraulic conductivities to values in ranges provided in NUREG/CR-7028. These values are designed to account for changes in soil hydraulic conductivity occasioned collectively by biointrusion activity and other types of soil disturbance.

REFERENCES:

Breshears, D.D., J.W. Nyhan, and D.W. Davenport, *Ecohydrology monitoring and excavation of semiarid landfill covers a decade after installation*, Vadose Zone Journal, Vol. 4, pp. 798–810, 2005.

Dwyer, S.F., R.E., Rager, and J. Hopkins, *Cover System Design Guidance and Requirements Document*, LA-UR-06-4715, EP2006-0667, Environmental Programs-Environmental Restoration Support Services, Los Alamos National Laboratory, New Mexico, April 2007.

Gaglio, M.D., W.P. Mackay, D. Padilla, R. Webb, and D.V. LeMone, *The effectiveness of biobarrier layers within protective ET covers at preventing penetration of waste sites by the harvester ant* Pogonomyrmex salinus *Olsen (Hymenoptera: Formicidae)*, Waste Management Conference, February 25–March 1, 2001, Tucson, Arizona, 2001.

Hakonson, T.E., *The effects of pocket gopher burrowing on water balance and erosion form landfill covers*, J. Environ. Qual., Vol. 28, pp. 659–665, 1999.

Link, S.O., L.L. Cadwell, K.L. Petersen, M.R. Sackshewsky, and D.S. Landeen, *Role of Plants and Animals in Isolation Barriers at Hanford, Washington*, Battelle, 1995.

Laundre, J.W., *Effects of small mammal burrows on water infiltration in a cool desert environment*, Oecologia (Berlin), Vol. 94, pp. 43–48, 1993.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Benson, C.H., Albright, W.H., Fratta, D.O., Tinjum, J.M., Kucukkirca, E., Lee, S.H., Scalia, J., Schlicht, P.D., and Wang, X., *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, Volume 1, NUREG/CR-7028, NRC Office of Nuclear Regulatory Research, December 2011.

INTERROGATORY CR R313-25-20-11/1: INADVERTENT HUMAN INTRUDER

Round 1 Interrogatory Response will be evaluated after resolution of Interrogatory CR R313-25-8(4)(B)-07/2: Applicability of NRC Human Intrusion Scenarios.

INTERROGATORY CR R313-25-20-12/2: SELECTION OF INTRUSION SCENARIOS

PRELIMINARY FINDING:

Refer to R313-25-20: *Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed.*

INTERROGATORY STATEMENT:

Address inadvertent human intruder exposure scenarios that are likely to result in the greatest doses to members of the public.

BASIS FOR INTERROGATORY:

FRV1 Section 4.1.2.10.1, page 37, addresses only ranching and recreational scenarios for exposure. While each of these scenarios is likely, neither one is a scenario in which the greatest radioactive doses would likely occur, should the scenario come to pass. The PA should consider other likely scenarios in which the doses would likely be far greater. This will be more protective of inadvertent intruders and members of the public. At a minimum, these scenarios must include an industrial scenario, in which industrial activities, such as industrial waste disposal, are conducted on site. This may involve construction and use of buildings with basements, as well as use of groundwater from onsite wells for dust suppression, and other activities. The scenario may also involve digging of earthen materials for onsite cover use or some other beneficial purpose. Another scenario that should be considered is mining for sand and clay onsite (e.g., for road construction). Both types of activities have historically taken place on and/or near the site.

The following activities have been or are currently undertaken at or near the Clive site in an industrial setting and could serve as a basis for an inadvertent human intruder exposure scenario:

1. Drilling of wells – Personnel at industrial sites including the Clive site and a number of adjacent or nearby sites have drilled wells to moderate depths (e.g., several hundred feet); an inadvertent intruder in the future may likewise drill one or more wells and be exposed to radioactivity in cuttings, drilling mud, or gas emanating from a borehole.
2. Pumping of groundwater from wells – A number of wells at or near the Clive site have been pumped in the past to recover groundwater. The groundwater may be used for washing, cleaning, dust control, cooling, scrubbing, or other industrial purposes, as it historically has been used in the region. Any radioactivity within the groundwater (e.g., radon, Ra-226) may

potentially be involved in a dose (via inhalation, skin contact, or other routes) to inadvertent intruders as receptors on the site.

3. Mining of clay and sand – This has been performed at Clive as well as at the Grassy Mountain facility and other nearby areas. Mining directly from embankments at the facility, such as for materials for road construction or waste embankments, could result in direct exposures to radioactivity without inadvertent intruders necessarily becoming aware of the hazard.
4. Development of areas where, because of ponding, leaking pipes, bad casing protection in wells, or some other reason, water locally infiltrates and results in mounding below the surface, as occurs at several places on the Clive site – This, in turn, may encourage rooting by deep-rooted plants that transpire water from the water table and capillary fringe and export radioactive substances to the surface.
5. Digging of foundations, basements of buildings, or roadcuts – This may potentially provide exposure to radioactive substances to one or more inadvertent intruders, not only during the time of digging but also at subsequent times when basements are used.

ES should also justify why other industrial pursuits were not considered, including, but not limited to, aquaculture for biofuels production and solar energy farms.

ES RESPONSE:

In its response, ES stated that: "*As explained in the response to Interrogatory CR R313-25-8(4)(B)-07/1, likelihood of maximum dose is not a criterion for inadvertent intruder scenario selection within the Depleted Uranium Performance Assessment.*"

REBUTTAL:

Although correct, the statement above does not address the main point of the interrogatory, namely that several inadvertent intruder scenarios should be considered, similar to the need to consider surface mining of clay, sand, and gravel, as mentioned in the comments on Interrogatory CR R313-25-8(4)(b)-07/1: Applicability of NRC Human Intrusion Scenarios. ES should also address the remaining scenarios or explain and justify why they are not relevant.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7-13/1: REFERENCE FOR LONG-TERM CLIMATIC CYCLES

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES added the noted references to FRV1.2 Section 4.1.2.13, page 47. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(4)(D)-14/2: SEDIMENT MIXING

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d)): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Clarify the statement *"probably leads to conservative results"* to indicate those cases in which conservative results would not be obtained.

BASIS FOR INTERROGATORY:

FRV1 Section 4.1.2.13, page 42, states that "*an assumption that the sediments completely mix is expedient, and probably leads to conservative results*." Section 3.4, pages 10–11, of the Deep Time Assessment report discusses the sedimentation accumulation rate but does not discuss the mixing of sediments. More information is needed on cases in which conservative results would not be obtained in order to permit full evaluation of the conservatism of the approach.

ES RESPONSE:

In its response, ES described its deep time conceptualization of sediment mixing in future lakes. The response focused on sediment mixing and lake cycles.

REBUTTAL:

ES did not address the situation in which sediments from the first lake are not yet covered and mixed with sediments from the second lake. During the teleconference on April 9, 2014, ES committed to evaluate a deep time scenario in which in situ DU waste is not scoured by pluvial lake wave action and is left at or near the ground surface after the lake recedes, which should address this concern. We await the results of that evaluation. For subsequent lakes, complete mixing ensures that the DU would be near the ground surface, rather than buried beneath a layer of newly deposited sediment.

REFERENCES:

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R317-6-6.3(Q)-15/2: URANIUM CHEMICAL TOXICITY

PRELIMINARY FINDING:

Refer to R317-6-6.3(Q): *Ground Water Quality Protection Regulations – Applications Requirements for a Ground Water Discharge Permit – Other Information Required.*

INTERROGATORY STATEMENT:

Provide the spatial compliance points for uranium chemical toxicity.

BASIS FOR INTERROGATORY:

FRV1 Section 5.1.1, page 43, identifies compliance points for the dose assessment and the groundwater protection limits (GWPLs), but not for uranium toxicity. The Geochemical Modeling report discusses geochemical modeling related to uranium but does not address toxicity. Spatial compliance points for uranium chemical toxicity are needed.

ES RESPONSE:

In its response, ES stated that: "*Ingestion of groundwater at the Clive site is not identified as a potential exposure pathway, so dose and risk from uranium toxicity are not evaluated for this pathway, and there are no GW compliance points for uranium toxicity*."

REBUTTAL:

As discussed in several interrogatories (e.g., Interrogatory CR R313-25-8(4)(a)-96/2: Current and Future Potability of Water), ES has not provided convincing evidence that ingestion of groundwater is not a potential exposure pathway. Consequently, ES needs to provide a revised response to this interrogatory.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(A)-16/2: RADON PRODUCTION AND BURROWING ANIMALS

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a)): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Discuss the relationship between burrowing animals in the cover system and the radon escape/production ratio, if any. Provide the values used in the Conceptual Site Model with regard to the waste form, porosity, and surface area and escape/production ratios for both the Savannah River Site (SRS) and gaseous diffusion plant (GDP) waste sources of DU.

BASIS FOR INTERROGATORY:

FRV1 Section 6.2.2, page 67, should discuss the relationship between burrowing animals and the radon escape/production ratio, if any. For example, gullies where the rip rap has been disturbed might be more accessible to burrowing animals and would represent a shorter pathway to the waste.

Section 9.2.3, page 51, of the Conceptual Site Model report describes the relationship between the waste form, porosity, and surface area and the escape/production ratios. Energy*Solutions* should provide the values used in the model for both the SRS and GDP waste sources of DU.

ES RESPONSE:

In its response, ES indicated that there was "*no relationship between the radon E/P ratio and animal burrowing*." It also referred to Table 5.1 of the Model Parameters report (Appendix 16, page 18, to FRV1) as the place where the escape/production (E/P) ratio values are defined.

REBUTTAL:

The E/P ratio is applied at the source of the radon; that is, in the waste. With ES now committed to burying the waste below the surface, burrowing animals would not be able to go that deep and could not bring in more moisture or turn the soil into fine powder. Once the radon has been produced, its travel to the surface could be affected by burrowing animals, but the E/P ratio is not involved in that transport and that effect is the subject of other interrogatories. Thus, since it addresses both questions in the interrogatory, the ES response is satisfactory.

V1.2 CRITIQUE (ROUND 3):

No changes were required to FRV1.2. Therefore, this interrogatory is closed.

REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R317-6-6.3(Q)-17/1: URANIUM PARENTS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES removed the reference to uranium parents in FRV1.2. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-18/3: SEDIMENT ACCUMULATION

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Resolve the discrepancy between the values for sediment accumulation cited in FRV1 and the Deep Time Assessment report.

BASIS FOR INTERROGATORY:

FRV1 Section 6.5, page 78, states that sediment accumulated at a rate of about 17 meters per 100 ky. Section 6.3, page 24, of the Deep Time Assessment report states that the sedimentation rate for large lakes (i.e., lakes that reach the elevation of the Clive site) has a log-normal distribution, with a geometric mean of 120 millimeters/ky and a geometric standard deviation of 1.2. This geometric mean is equivalent to 12 meters per 100 ky. The differing values cited in FRV1 and the Deep Time Assessment report should be reconciled. Lower sedimentation rates could lead to less isolation of the waste from the surface environment upon lake recession.

ES RESPONSE:

In its response, ES clarified the sediment accumulation processes described in FRV1 and those presented in the Deep Time Assessment report (Appendix 1 to FRV1).

REBUTTAL:

ES stated: "*However, recent research suggests that it is unlikely that a lake will inundate Clive in the current 100ky glacial cycle.*" As stated with regard to Interrogatory CR R313-25-8(4)(d)-122/2: Size of Pluvial Lakes, ES must consider climatic change intervals that are localized to the Great Basin and not rely on global cycles. Inundation of the Clive site (at an elevation of about 4,270 feet or about 70 feet above the level of the modern Great Salt Lake) could occur as a result of a "small" or "intermediate" lake forming during one of these shorter term climate cycles. This has been discussed in other interrogatories. For example, in response to Interrogatory CR R313-25-8(5)(a)-44/1: Occurrence of Intermediate Lakes, ES indicated that it will add the statement that: "*Intermediate lakes are assumed to be smaller lakes that reach and exceed the altitude of Clive….*"

ES also stated that: "*Aeolian sedimentation rates at Clive are expected to be between 0.1 and 3 mm/yr during the current inter-pluvial period based on analogue measurements at dry pluvial lake sites throughout the world and in the arid SW United States.*" However, ES did not provide a reference for this statement, which appears to be flawed. If these accumulation rates were correct, the entire Great Basin would now be covered by an average of 1 to 3 meters of Aeolian sediment that has been accumulating since the onset of the Holocene, masking significant areas of bedrock, shorelines, and other subtle geomorphic features. Aeolian material almost certainly forms the substrate for desert soils in this part of the world, but this mantling material has thicknesses of tens of centimeters, not meters. Many places of the Great Basin have no mantling Aeolian material whatsoever.

Cursory efforts located the following summary table indicating Aeolian accumulation rates about one order of magnitude lower than that indicated in ES' response. The data do not appear to support the idea that the ES site will be covered by a thick layer of dust before the onset of the next shallow lake cycle.

Table 9.1 Annual dust deposition rates on land (after Middleton, 1997 and Goudie, 1995)

References	Location	Deposition rate ($t\ km^{-2}\ a^{-1}$)	Deposition rate ($mm\ 1000\ a^{-1}$)[a]
Sahara			
Mediterranean region			
Löye-Pilot *et al.* (1986)	Corsica	14	16
Yaalon and Ganor (1975)	Israel	22–83	25–93
Goossens (1995)	Negev	15–30	10–20
Bücher and Lucas (1975)	Pyrenees	18–23	20–26
Pye (1992)	Crete	10–100	11–112
Harmattan plume			
Maley (1980)	S Chad	109	122
McTainsh and Walker (1982)	N Nigeria	137–181	154–203
Drees *et al.* (1993)	SW Niger	200	100–150
USA			
Smith *et al.* (1970)	High Plains	65–85	73–96
Péwé *et al.* (1981)	Arizona	54	61
Gile and Grossman (1979)	New Mexico	9.3–125.8	10–141
Muhs (1983)	California	24–31	27–35
Reheis and Kihl (1995)	California/Nevada	4.3–15.7	5–18
Middle East			
Safar (1985)	Kuwait	100	112
Behairy *et al.* (1985)	W Saudi Arabia	13–109	15–122
Miscellaneous			
Inoue and Naruse (1991)	Japan	3.5–6	4–7
Tiller *et al.* (1987)	SE Australia	5–10	6–11
Kukal (1971)	Caspian Sea	39.5	44

[a] Calculated on bulk density of dust of 0.89 g cm^3 where not derived in original reference.

Source: Goudie et al. 1997

V1.2 CRITIQUE (ROUND 3):

Text similar to that given in the ES response was added to Section 3.3, pages 13–15, of the Deep Time Assessment report (Appendix 13 to FRV1.2). However, since the concerns identified above remain, this interrogatory remains open.

Note that there are two Oviatt et al. 1994 references in the list on page 44 of the Deep Time Assessment report. ES needs to modify the text so that it is clear which one is being referenced at which locations.

REFERENCES:

Goudie, A.S., I., Livingstone, S. Stokes, *Aeolian environment, sediments, and landforms*, Wiley Interscience, 1997.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., Deep Time Assessment for the Clive DU PA, Clive DU PA Model v1.2, NAC-0032_R1, June 5, 2014. (Appendix 13 to FRV1.2)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(5)(A)-19/1: REFERENCE FOR SEDIMENT CORE RECORDS

Round 1 Interrogatory Response is satisfactory.

INTERROGATORY CR R317-6-2.1-20/2: GROUNDWATER CONCENTRATIONS

PRELIMINARY FINDING:

Refer to R317-6-2.1: *The following Ground Water Quality Standards as listed in Table I are adopted for protection of ground water quality.*

Refer also to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Explain why groundwater concentrations are not identical with and without the formation of gullies in the cover system.

BASIS FOR INTERROGATORY:

FRV1 Section 7.1, page 83, states that *"Once gullies are involved, the doses increase (ground water concentrations do not change noticeably)."* If groundwater concentrations are not identical with and without the gullies (i.e., if they change, even if it is not *"noticeable"*), the text should explain why.

ES RESPONSE:

In its response, ES stated the following:

> *As is noted in Section 7.1 of Appendix A of the Report,* "once gullies are involved, the doses increase (groundwater concentrations do not change noticeably)." *Since proximity to waste dominates projected doses, the thinning of the cover due to gullies and the possibility of bringing waste to the surface increase the resulting doses. Additionally, the addition of gullies also results in local changes to the*

> *cover system. However, when modeled across the entire Federal Cell cover, minor local changes in infiltration result in extremely minor variations in point-of-compliance groundwater concentrations.* [emphasis added]

REBUTTAL:

It is unclear why the formation of gullies that would erode through the barriers and focus surface water would result in only minor local changes in infiltration. Furthermore, it is unclear where the PA models increased recharge (due to gully formation) to demonstrate that the groundwater concentrations do not change.

The ES response also referenced doses due to the thinning cover. It may be true that the radon dose is so much higher than the potential groundwater dose (increases in groundwater concentrations are insignificant), but that does not explain why the groundwater concentrations are conceptualized so that they do not increase when the cover is compromised.

ES should provide more information to explain and reconcile these concerns.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2*, NAC-0024_R1, June 5, 2014.

INTERROGATORY CR R313-25-8(4)(D)-21/2: INFILTRATION RATES

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d)): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Explain why infiltration rates may be overestimated.

BASIS FOR INTERROGATORY:

FRV1 Section 7.2, page 85, states that *"Infiltration rates might be overestimated…."* The text should discuss and justify why the estimates for infiltration rates may be too high.

ES RESPONSE:

In its response, ES stated that FRV1 Section 4.1.2.4.1 already states that: "*These model comparisons* [Meyer et al.1996, Khire et al. 1997, Albright et al. 2002] *indicate that the vertical flow rates through the CAS cell calculated using the HELP model are likely to be overestimated in the PA Model.*" ES will revise the text in FRV1 Section 7.2, page 85, to cross-reference Section 4.1.2.4.1 with regard to the possibility of overestimating infiltration rates.

REBUTTAL:

Previous ES infiltration modeling for the facility used the unsaturated flow model UNSAT-H to overcome such HELP model overestimation. ES should explain and justify why HYDRUS, with its variable saturation equations, could not eliminate the flux overestimation problem. Note that SC&A is currently investigating the reasonableness of the recharge rates predicted by HYDRUS.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7-22/1: DEFINITION OF FEPS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES made the proposed revisions to Sections 4.1.1 and 4.1.2, page 5, of the revised FEP [Feature, Event, and Process] Analysis report (Appendix 1 to FRV1.2). Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(2)-23/1: CANISTER DEGRADATION AND CORROSION

Round 1 Interrogatory Response is satisfactory.

V1.2 CRITIQUE (ROUND 3):

ES has added the indicated cross-references to the revised FEP Analysis and Conceptual Site Model reports (Appendices 1 and 2 to FRV1.2). Therefore, this interrogatory is closed.

INTERROGATORY CR R313-15-101(1)-24/3: UTAH REGULATIONS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

Section 1.3 of FRV1.2 should have been revised to cite UAC R313-25-9(5)(a) as the source for the quotation on page 18. However, this revision was not made. Revisions were also not made to Section 4.2.1, page 22, of the Conceptual Site Model report.

ES had also stated that governing Utah rules would be cited in Sections 1 and 1.3 of the Conceptual Site Model report. No such changes have been made to Section 1, and there is no Section 1.3 in either FRV1 or FRV1.2.

INTERROGATORY CR R313-25-7(9)-25/1: DISPOSITION OF CONTAMINANTS IN UF_6

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES has revised Section 6.2 of the Conceptual Site Model report (Appendix 2 to FRV1.2) as proposed. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(4)(A)-26/2: RADON DIFFUSION IN THE UNSATURATED ZONE

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Clarify whether diffusion of radon in the air phase in the unsaturated zone is included in the PA model. If it is not, justify why its omission is protective of human health and the environment. Also, describe and justify what site-specific investigation was performed at Clive to determine the applicable air phase tortuosity model.

BASIS FOR INTERROGATORY:

Section 6.6, page 26, of the Conceptual Site Model report states that *"The transport of radon in both the saturated and unsaturated zones will be included in the PA model."* Section 7.1.1.1, page 27, states that *"Diffusion in the air phase within the UZ below the facility will not be modeled, since the only diffusive species would be radon…."* The text should resolve these apparently contradictory statements.

Page 6 of the *Implementation of Diffusion in GoldSim* attachment to the Embankment Modeling report explains that three different models returned three different values for air phase tortuosity and then states that "*Which model is most appropriate for a given material is a matter of site-*

specific investigation." The text should describe and justify what site-specific investigation was performed at Clive to determine the applicable air phase tortuosity model.

ES RESPONSE:

The ES response stated:

> *The text in Section 6.6, page 26, of the Conceptual Site Model white paper is being modified…to clarify that the transport of radon in the saturated and in the unsaturated zone from the waste to the ground surface is included in the PA model, resolving the apparent inconsistency.*
>
> …
>
> *No site-specific investigation of air phase tortuosity was performed,…. The analysis is therefore dependent on models proposed in the literature.*

REBUTTAL:

The PA should also indicate which processes are being modeled by GoldSim for the transport of radon, particularly in the unsaturated zone (e.g., diffusion, advection).

V1.2 CRITIQUE (ROUND 3):

Section 6.6, page 31, of the Conceptual Site Model report (Appendix 2 to FRV1.2) now states: "*The transport of radon in the saturated zone and in the unsaturated zone from the waste to the ground surface is included in the Clive DU PA Model. Radon transport is controlled by the emanation factor, diffusion, advection, and partitioning parameters that will be incorporated into the transport modeling.*" Therefore, this interrogatory is closed. However, other interrogatories that question the saturated and unsaturated radon diffusion and advection transport models remain open.

REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, NAC-0018_R1, June 5, 2014. (Appendix 2 to FRV1.2)

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model*, May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(A)-27/3: DIFFUSION PATHWAY MODELING

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Clarify how the PA model accounts for the impact of diffusion pathways.

BASIS FOR INTERROGATORY:

Section 7.1.3.1, page 28, of the Conceptual Site Model report states that *"Over time, cracks, fissures, animal burrows, and plant roots can also provide preferential diffusion pathways that reduce the effectiveness of the engineered barrier."* Although the Embankment Modeling report outlines how diffusion in air and water is to be implemented in GoldSim models that include diffusion in the unsaturated zone, neither this appendix nor the Air Modeling report discusses how diffusion pathways reduce the effectiveness of the radon barrier. The text in Section 7.1.3.1 should indicate how the PA model accounts for such pathways reducing the effectiveness of the engineered barrier, particularly with respect to the potential release of radon to the surface. If such preferential pathways are not included in the PA, the text should discuss and justify why this modeling aspect was not included.

ES RESPONSE:

In response, ES stated that it will modify the text of the Conceptual Site Model report (Appendix 2 to FRV1) to state in part the following: "*Over time, cracks, fissures, animal burrows, and plant roots can also provide preferential pathways that reduce the effectiveness of the engineered barrier. These effects are difficult to quantify and are not modeled in the Clive DU PA Model v1.0. Efforts at quantification could be included as part of future cover modeling as part of PA maintenance.*"

REBUTTAL:

It is not clear what is meant by PA maintenance and whether quantification will in fact be included in a forthcoming revised PA report. DEQ is not aware of any formal plans by ES for PA maintenance. Any such plans should be described.

In addition, "*difficult to quantify*" is not a sufficient reason for not performing the modeling if it is necessary. In response to this interrogatory, ES should provide modeling that quantitatively accounts for these processes and effects, taking into account NRC guidance such as that in NUREG/CR-7028. Alternatively, it should explain why DRC should not require ES to perform the quantification effort now, rather than in the future.

V1.2 CRITIQUE (ROUND 3):

ES stated on page 29 of its response to the Round 2 Interrogatories that "*no further revision or PA maintenance is planned to version 1.2 of the Modeling Report.*" Therefore, ES should provide modeling that quantitatively accounts for these processes and effects, taking into account NRC guidance such as that in NUREG/CR-7028. Note that Section 7.1.3.1, page 38, of the revised Conceptual Site Model report (Appendix 2 to FRV1.2) states that: "*efforts at quantification could be included as part of future cover modeling as part of PA maintenance.*" In keeping with its Round 2 response, ES needs to modify this statement.

In its Round 1 responses to four other interrogatories (i.e., 28, 78, 155, and 162), ES stated that "*PA Maintenance*" would address the issue. ES should revise the Round 1 responses to those four interrogatories to indicate how the information is to be provided without further model revision or PA maintenance.

REFERENCES:

Benson, C.H., Albright, W.H., Fratta, D.O., Tinjum, J.M., Kucukkirca, E., Lee, S.H., Scalia, J., Schlicht, P.D., and Wang, X., *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, Volume 1, NUREG/CR-7028, NRC Office of Nuclear Regulatory Research, December 2011.

Energy*Solutions*, *RML UT2300249 – Condition 35 Compliance Report Responses to Round 2 Interrogatories*, June 17, 2014.

Neptune and Company, Inc., *Atmospheric Transport Modeling for the Clive DU PA,* May 28, 2011. (Appendix 8 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, NAC-0018_R1, June 5, 2014. (Appendix 2 to FRV1.2)

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model,* May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(A)-28/3: BIOTURBATION EFFECTS AND CONSEQUENCES

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Provide references to support the statement that bioturbation and homogenization of the radon barriers will probably occur very slowly relative to the 10,000-year time frame for the PA, and address other effects and consequences of biointrusion and bioturbation.

BASIS FOR INTERROGATORY:

Section 8.3, page 45, of the Conceptual Site Model report describes processes that drive potential changes in evapotranspiration and lateral drainage as the cap evolves. The third bullet states, "*On balance, the evidence suggests that bioturbation and homogenization of the radon barriers will probably occur very slowly relative to the 10,000-year time frame for the PA.*" However, the text provides no supporting references or justification for this claim. In addition, homogenization of the radon barriers is not the only result of biointrusion and bioturbation. Reduction of the diffusion path length should also be considered. The text should be expanded to address other results, and any assertions made should be well explained and justified.

In addition, Section 3.1.6, page 3-5, of the 2013 Compliance Report, Revision 1, states, "*Burrowing animals at the site include jackrabbits, mice, foxes, and ants.*" This statement needs to be reconsidered since jackrabbits do not burrow, per se. Black-tailed jackrabbits (*Lepus califonicus*) found at the site cannot properly be described as burrowing mammals: "*Jackrabbits are not true rabbits at all, but are actually hares…hares use only forms or surface nests, whereas most rabbits retreat to burrows when alarmed*" (McAdoo and Young 1980). The PA should clarify the information about jackrabbits on or near the site.

Potential bioturbation effects from other burrowing animals that are not referenced in Section 3.1.6 should also be considered. For example, SWCA Environmental Consultants (SWCA) (2012) states that (1) coyote burrows, while not seen in the limited number of plots studied at the site, were observed near or close to the plots, indicating the potential for coyotes to burrow in an embankment on the site, (2) badger burrows were observed in two of the plots, (3) badgers themselves were photographed moving about during the sampling event, and

(4) burrowing owls were also observed on site and photographed. Coyotes and badgers are documented to dig more deeply than the planned Class A South rip rap cover system depth of 5.5 feet (Lindzey 1976, McKenzie et al. 1982, Hampton 2006). SWCA (2012) reports that "*the presence of the badgers…in the study area indicates the potential for large volume soil bioturbation within the existing vegetation communities and soil types.*"

Kit foxes, which are found in western Utah, either create or use dens as deep as 2.5 meters (8.2 feet) (Tannerfeldt et al. 2003, referencing O'Neal et al. 1987). This is considerably deeper than the design depth of the top of the radon barrier at the site and considerably deeper than the design depth of the top of the bulk waste. The DU PA should definitely account for fox burrowing into bulk Class A waste.

SWCA (2012) reports on the species of ground squirrels observed onsite: *Spermophilus spp*. Suter (1993) and Suter et al. (1993) report ground squirrel burrowing to depths of at least 1.4 meters (4.6 feet) but do not mention species. If ground squirrels get into bulk Class A waste, they may become surficially contaminated by radioactive particles and may spread these radioactive particles to other parts of the environment. Additionally, radioactive materials consumed by the ground squirrels may subsequently adversely impact the environment via excretion of ground squirrels' urine, feces, or other bodily fluids, or through decomposition.

The PA mentions mice but does not provide sufficient detail about deer mice. According to the SWCA (2011, 2012), 83 deer mice and one kangaroo rat were trapped during a single biological survey on site. This indicates the potential for extensive burrowing on site.

Arthur et al. (1986, 1987; see also Bowerman and Redente 1998) note that deer mice penetrated an Idaho National Environmental Laboratory cover system having a thickness of 2.4 meters (7.9 feet). Many of the mice are reported to have received relatively high radiation doses, some of which are said to have been lethal.

Landeen and Mitchell (1981) found that other types of mice (i.e., pocket mice) at the Hanford site burrowed about 79% deeper in disturbed soils than in native soils. This indicates that, for combinations of some mammals and some soils, biointrusion may be deeper in disturbed soils than in undisturbed soils.

Based on the foregoing, it appears that the potential for biointrusion exists for both kangaroo rats and deer mice at the site. Kangaroo rats are noted in field observations to have burrowed down to soil depths of at least 1.75 meters (5.7 feet). It is not known how species variation affects burrowing depth. Deer mice can burrow down to at least 2.4 meters (7.9 feet). These are depths for sites at which actual field samples are relatively few. Therefore, greater depths of burrowing could be expected if an entire population of sites were to be evaluated. Furthermore, as reported for one species in one soil type by Landeen and Mitchell (1981), burrowing depths may possibly be greater in disturbed soil. All of this indicates the potential for deer mice and kangaroo rats to burrow below the cover system at the Federal Cell. Therefore, the PA should comprehensively describe and model such burrowing.

Many seeds, smaller plants, and burrowing mammals may be able to penetrate a rock armor cover by migrating through the large interstices or voids existing between its cobbles. Larger, stronger, fossorial mammals, such as badgers, may be able to remove some or all of the smaller cobbles by digging or burrowing. Dwyer et al. (2007) suggest that to prevent a mammal of concern from moving a cobble, the cobble should weigh at least 1.5 times more than the animal. The PA should account for this in the model and also document the potential for deep burrowing by badgers.

A rock armor cover may or may not by itself provide adequate protection from biointrusion, especially for extremely strong animals like badgers. Hakonson (1986) is one of the very few careful studies undertaken on this topic. The cover system needs to provide a high level of protection from intrusion by burrowing animals, including ground squirrels. The PA should account for this in the model and in the descriptions.

ES RESPONSE:

In its response, ES stated the following:

> *Detailed analysis conducted by SCWA demonstrating negligible degradation of the Evapotranspirative Cover's radon barrier from animal borrow and root penetration has previously been conducted (Appendix C of Energy*Solutions*, 2013d).*
>
> …
>
> *The sensitivity of cover infiltration to changes in radon barrier integrity has been evaluated (Energy*Solutions*, 2014) for the ET cover design. These analyses demonstrated that an increase of 3 orders of magnitude in radon barrier hydraulic conductivity resulted in no increase in infiltration. Therefore, no further assessment of the impact of a compromised radon barrier is necessary in the model.*
>
> …
>
> *…The ET cover design reduces predicted infiltration by two order of magnitude compared with the rock armor mulch.*
>
> …
>
> *…As part of PA maintenance, the model will be updated with separate distributions for soil movement by small mammals (…) which occur frequently on the site, and large mammals (…) which occur in much lower densities at Clive and the surrounding area.…*

REBUTTAL:

1. The ES response began by referring to two documents (Energy*Solutions* 2013d and Energy*Solutions* 2014), which obviously were not included in FRV1. ES needs to integrate the information from these two documents into the revised report. Then DEQ can review and comment on how that information is being used in the DU PA.
2. The ES response indicates that the ET cover would reduce infiltration by two orders of magnitude compared with the rock armor mulch cover. The revised GoldSim DU PA model (v1.199) provided by ES on May 5, 2014 (Rogers 2014), does not support this statement. The

original mean infiltration rate (VerticalFlow_BelowCap) was about 0.12 cm/yr, whereas with the ET cover the rate is about 0.04 cm/yr—reduced by only a factor of three.

3. The ES response indicates that an increase in the radon barrier hydraulic conductivity resulted in no increase in infiltration. However, the response does not address what impact (if any) burrowing animals, plant roots, gullies, and similar mechanisms would have on the radon diffusion upwards to the surface.
4. Finally, in its response ES indicated that the "mammal burrowing model" would be updated at an unspecified time in the future, as part of PA maintenance. DEQ looks forward to receiving and reviewing this refined modeling effort. ES should provide a schedule for the completion of PA maintenance.

V1.2 CRITIQUE (ROUND 3):

This interrogatory remains open for the following reasons: (1) none of the information from Energy*Solutions* 2013d and Energy*Solutions* 2014 has been incorporated, (2) the ET cover appears not to perform as claimed in the ES responses to the Round 1 Interrogatories, (3) FRV1.2 Section 7.1, page 83, specifically states that the "*impact of gullies has not been fully developed in terms of their effect on biotic activity, radon transport, or infiltration*," and (4) there is no indication when/if the updated "mammal burrowing model" will be ready for review.

The ES response to Round 1 Interrogatories states that "*Detailed analysis conducted by SWCA demonstrating negligible degradation of the Evapotranspirative Cover's radon barrier from animal borrow and root penetration has previously been conducted (Appendix C of Energy*Solutions*, 2013d)*." However, DRC staff members reviewing that document indicate that it is still in the process of review and that they have many interrogatories and concerns pertaining to it.

ES also stated in its response that "*The sensitivity of cover infiltration to changes in radon barrier integrity has been evaluated (Energy*Solutions*, 2014) for the ET cover design. These analyses demonstrated that an increase of 3 orders of magnitude in radon barrier hydraulic conductivity resulted in no increase in infiltration*." However, hydraulic conductivities of all cover-system soil layers were not changed simultaneously, with corresponding correlated changes in van Genuchten alpha values. Hence, the conclusion, "*Therefore, no further assessment of the impact of a compromised radon barrier is necessary in the model*," is also flawed. See also Interrogatories CR R313-25-7(2)-05/2: Radon Barrier, CR R313-25-8(4)(a)-112/2: Hydraulic Conductivity, and CR R313-25-7(2)-189/3: Modeling Impacts of Changes in Federal Cell Cover-System Soil Hydraulic Conductivity and Alpha Values.

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Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

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INTERROGATORY CR R313-25-8(5)(A)-29/2: LIMITATION TO CURRENT CONDITIONS OF SOCIETY AND THE ENVIRONMENT

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

Refer also to R313-25-23(3): *Within the region where the facility is to be located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives of R313-25.*

INTERROGATORY STATEMENT:

Explain and justify why Bureau of Land Management (BLM) restrictions should be included in the inadvertent intruder analysis, given the likelihood that they will change over the compliance period of the PA (i.e., 10,000 years). Explain why other future land uses and FEPs were omitted.

BASIS FOR INTERROGATORY:

Section 10.3.1, page 57, of the Conceptual Site Model report states that *"Inputs for developing exposure parameter values under the ranching scenario include…restrictions related to BLM leases…."* The document should explain why it is appropriate to include BLM restrictions, given the potential for BLM policies to change over the next 10,000 years or more.

Section 11, page 62, of the Conceptual Site Model report states that the model will use current conditions of society and the environment to project future conditions, and that potential receptors are based on present-day use of the general area. This approach should be explained and justified, given the performance modeling objective of R313-25-8(5)(a) of 10,000 years or more.

Section 4.2, page 7, of the FEP Analysis report suggests that certain land use assumptions be eliminated for calculation of future human exposures (i.e., urban settlement, residential use, farming, and aquaculture). The text should explain and justify why seawater aquaculture could not be undertaken at Clive and future industrial land uses should not be considered in the PA model.

Table C, page 43, of the FEP Analysis report eliminates many FEPs. Energy*Solutions* should provide further explanation and justification for their exclusion. These include the following:

1. Resource extraction (quarrying and surface mining; FEP ID 910, page 45) – It is difficult to conceive that this will not happen in the future, in light of historic and current surface mining activities of clay, sand, and gravel resources near Clive by both government and private entities.
2. Water resource management (FEP ID 611, page 46) – In the case of future industrial land use, the text should explain why groundwater supply wells could not be a resource to support an industrial pursuit.

ES RESPONSE:

In its response, based on the NRC PAWG guidelines (NUREG-1573), which states in part that: "*The applicant should apply a current conditions philosophy to determine which pathways are to be evaluated. That is to say that current regional land use and other local conditions in place at the time of the analysis will strongly influence pathways that are considered to be significant*," ES concluded that it is appropriate to include in the DU PA a recreational scenario based on current BLM practices. ES also concluded that the exclusion of activities such as seawater aquaculture and water resource management is consistent with such a current conditions philosophy.

REBUTTAL:

We concur with this position. However, as indicated elsewhere in this document, we are not convinced that it is appropriate to exclude as human intrusion scenarios mining of sand, clay, and gravel, or exploration drilling for resources, or extraction of deeper lying groundwater for a variety of beneficial uses. ES needs to address these scenarios. Further, NUREG-1573 also provides guidance for the PA model developer when a proposed disposal site currently lacks residents, as follows:

> *Finally, with respect to the portion of this question concerning how the critical group approach would be implemented if there were no residents near a candidate disposal site, the PAWG expects that the LLW disposal facility developer would identify some analog site, of comparable geology and climate, and define the critical group in terms of the analogue site. Again, the LLW disposal facility developer needs to document the technical basis for his or her decision-making - regarding how both the analogue site was selected and the critical group subsequently defined.* [page B-60]

ES should also consider this information as it selects the various human intrusion scenarios for the 10,000-year compliance period PA analysis. We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

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INTERROGATORY CR R313-25-8(5)(A)-30/1: INCLUSION OF SRS-2002 DATA IN THE SENSITIVITY ANALYSIS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

The questioned text remains unchanged in Section 3.3, page 18, of the Waste Inventory report (Appendix 4 to FRV1.2) (i.e., still states that the effect "*has been tested…and is reported*" rather than "*will be tested…and will be reported*"). However, the FRV1.2 Sensitivity Analysis report (Appendices 15(I) and (II) to FRV1.2) does evaluate the sensitivity of the Clive DU PA Model results to the activity concentration in the SRS DU waste, so use of the past tense is appropriate. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-31/3: TC-99 CONTENT IN THE WASTE AND INCLUSION IN THE SENSITIVITY ANALYSIS

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Indicate whether (and where) the expectation that the concentration of Tc-99 will be a sensitive parameter was tested. Alternatively, explain and justify what other evidence is available that led to this conclusion. Perform additional characterization of the SRS waste proposed for disposal in terms of Tc-99 content and provide the results for agency review, or explain and justify why additional sampling and laboratory analysis are not needed.

BASIS FOR INTERROGATORY:

Section 3.3, page 19, of the Waste Inventory report states that *"Given the mobility of ^{99}Tc and the width of the input distribution defined above, it is reasonable to expect that concentration of ^{99}Tc will be a sensitive parameter."* The text should indicate whether this expectation was tested and, if so, where the results are reported. Alternatively, the text should explain and justify what other evidence is available that led to this conclusion.

Note that FRV1 Section 6.1.1, page 55, states that *"In the case of ^{99}Tc there are concerns over both the inventory concentration distribution, the concentration of ^{99}Tc in the GDP waste, and the infiltration modeling. The ^{99}Tc inventory concentration distribution is derived from three datasets that suggest very different concentrations. Consequently, the input distribution covers more than one order of magnitude of possible ^{99}Tc concentrations. With more data or better information, it is reasonable to expect that this uncertainty could be reduced."*

Also note that the three sources of waste characterization data (i.e., Beals et al. 2002, GEL Laboratories 2010, Johnson 2010) include a total of 217 individual Tc-99 laboratory results. Unfortunately, as noted in Section 2.2.2, page 5, of the Waste Inventory report, the SRS samples were taken from a set of 3,300 drums, and it is not known if this is the same drum population as the more than 5,000 drums now in storage at Energy*Solutions*. Further, Section 2.2, page 4, of the Waste Inventory report states that the SRS DU waste stream consists of 36,000 drums. Therefore, it would appear that additional sampling and analysis are required to adequately characterize the SRS waste proposed for disposal. Energy*Solutions* should explain how this additional characterization will be done and provide results for agency review, or explain and justify why additional sampling and laboratory analysis are not needed.

ES RESPONSE:

In its response, ES stated that: "*Further explanation is being provided in an updated sensitivity analysis results section or appendix to the main report. And, since the issue of inventory of Tc-99 is considered important here, further analysis is being performed to show how the dose results change as a function of changes in only the Tc-99 concentrations.*"

REBUTTAL:

We look forward the updated results regarding Tc-99 inventory and its effects on dose results. We presume the new analyses will include, among other considerations, an indication of the sensitivity of Tc-99 content to compliance with the GWPL and doses from groundwater over 10,000 years.

V1.2 CRITIQUE:

In its Round 1 response, ES stated that a questioned statement would be removed, and this was done in the revised Waste Inventory report (Appendix 4 to FRV1.2). However, as noted above, ES stated that further analysis is being performed to show how the results change as a function of Tc-99 concentrations. The only relevant information we could find in the revised PA documents is the results of a global sensitivity analysis for 500 years in Appendices 15(I) and 15(II). Contrary to the ES response, this information does not show how dose results change as a function of changes only in the Tc-99 concentration, nor does it provide any indication as to how the sensitivity changes over longer timeframes.

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Neptune and Company, Inc., *Machine Learning for Sensitivity Analysis of Probabilistic Environmental Models*, NAC-0029_R1, June 5, 2014. (Appendix 15(I) to FRV1.2)

Neptune and Company, Inc., *Sensitivity Analysis Results for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0030_R0, June 5, 2014. (Appendix 15(II) to FRV1.2)

INTERROGATORY CR R313-25-8(4)(A)-32/3: EFFECT OF OTHER POTENTIAL CONTAMINANTS ON PA

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

The revised Sensitivity Analysis Results report (Appendix 15(II) to FRV1.2) shows that the effect of other potential contaminants to the intruder doses is trivial. However, based on new groundwater utilization scenarios, this may not be the case for intruder and member of the public doses.

INTERROGATORY CR R315-101-5.3(6)-33/1: CLARIFICATION OF THE PHRASE "PROOF-OF-PRINCIPLE EXERCISE" AND SENSITIVITY TO URANIUM ORAL REFERENCE DOSE FACTORS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES made changes similar to those proposed in its response to the interrogatory in Section 3.4.5, page 26, of the revised Dose Assessment report (Appendix 11 to FRV1.2), referring to the effect of "*science policy uncertainty*." ES also added the following paragraph:

> *A discrete distribution is used to represent the uranium oral RfD based on current EPA science policy associated with EPA's Superfund Program and Office of Water. A uranium oral RfD of 0.0006 mg/kg-day is associated with the derivation of the final uranium drinking water maximum contaminant level (MCL) as defined on page 76713 of Federal Register, Volume 65, No. 236, December 7, 2000 (Section I.D.2d). A uranium oral RfD of 0.003 mg/kg-day for soluble salts of uranium is published in the Integrated Risk Information System (IRIS) supporting the Superfund Program. A 50/50 probability is assigned to these oral RfDs to determine in the Sensitivity Analysis whether selecting one or the other of these published values is a significant contributor to uncertainty in the uranium Hazard Index in any exposure scenario.*

Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-34/3: INTENT OF THE PA

With the following edits (in ***bold****), the Round 1 Interrogatory Response is satisfactory:*

"The role of PA in a regulatory context is often restricted to the narrow use of evaluating compliance. In the present case, the Clive DU PA ***GoldSim*** *Model ~~v1.0~~ can be used to evaluate compliance—and inform a PA document that presents the argument that demonstrates compliance—with 10 CFR 61 Subpart C and the corresponding provisions of the Utah Administrative Code****, including (1) quantitative PA modeling for at least 10,000 years and (2) complete additional PA simulations for a 1,000,000 year timeframe****. In addition to that role, however, and because of the long-term nature of the analysis, the intent of the Model is not necessarily to estimate actual long-term human health impacts or risks from a closed facility. Rather, the purpose is to provide a robust analysis that can examine and identify the key elements and components of the site, the engineered system, and the environmental setting that could contribute to potential long-term impacts. Because of the time-scales of the analysis and the associated uncertainty in knowledge of characteristics of the site, the waste inventory, the engineered system and its potential to degrade over time, and changing environmental conditions, a critical part of the PA process is also the consideration of uncertainty and evaluation of model and parameter sensitivity in interpretation of PA modeling results."*

V1.2 CRITIQUE (ROUND 3):

ES added the revision to FRV1.2 Section 2.1, page 24, as indicated in its responses to the Round 1 Interrogatories; however, the edits recommended above were not incorporated.

INTERROGATORY CR R313-25-19-35/1: REFERENCE FOR COST PER PERSON-REM

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES added the reference to DOE 1997 to FRV1.2 Section 1.3, page 19. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(4)(A)-36/1: ANT NEST EXTRAPOLATIONS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES added references to Neptune (2006), the Biological Modeling report (Appendix 9 to FRV1.2), and SWCA (2013) to FRV1.2 Section 4.1.2.8.2, page 40. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-37/2: DISTRIBUTION AVERAGING

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of* *concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Describe the means of capturing "*the appropriate systems-level effect*" from the use of differential equations and multiplicative terms in the PA and describe what specific steps, model inputs, and model assumptions were modified for this purpose.

BASIS FOR INTERROGATORY:

FRV1 Section 5.2, page 45, discusses distribution averaging and states the following:

> *In addition, these types of models are characterized by differential equations and multiplicative terms. Averaging is a linear construct that does not translate directly in non-linear systems. Again, care needs to be taken to capture the appropriate systems-level effect when dealing with differential equations and multiplicative terms.*

The text should clarify what *"care"* was taken in the PA to *"capture the appropriate systems-level effect"* and identify and justify what specific steps, model inputs, and model assumptions were modified for this purpose.

ES RESPONSE:

In its response, ES stated the following:

> *References is* [sic] *being provided to the model inputs for which additional "care" was taken. The text is being revised to provide clarity in the intent here.*
>
> …
>
> *Consideration has been given during model development to appropriate upscaling for each parameter. Sometimes simple averaging is applied, but sometimes greater consideration needs to be given to the response, and adjustments are made to get closer to a linear response in the immediate dependent variable.*

REBUTTAL:

This is a complex topic, and DRC believes that more information is needed to understand how distribution averaging is actually implemented in GoldSim:

1. ES described a scaling process that is specific to a given model cell. Provide additional details and numerical examples of specific parameters in support of these statements contained in the response: "*Data that represent points in time and/or space cannot be used*

directly in this type of model. The data range and variance is too broad for the large spatial or temporal effects that are being modeled."

2. Provide a more detailed description, with examples of how the input parameter distributions are applied when calculating an average response for cells with linear response, and the types of modifications required for cells with non-linear response.
3. Describe how the final model outputs are calculated using the cell-specific averages.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0,* June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(5)(A)-38/3: FIGURES 5 AND 11 IN FRV1

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Correct the caption for Figure 5 to reflect the nature of the plots and describe how Figure 5 demonstrates compliance with R313-25-8(5)(a).

BASIS FOR INTERROGATORY:

In FRV1 Section 6.1.1, page 56, the caption for Figure 5 appears to be incorrect. The figure provides plots of calculated Tc-99 concentrations as a function of time for each realization; they are not *"mean peak"* values. We believe that the caption should read, *"Tc-99 concentrations as a function of time for all realizations."*

In addition, explain and justify why a 500-year simulation for the groundwater pathway, shown in Figure 5, complies with the minimum 10,000-year mandate in R313-25-8(5)(a).

On Figure 11 in the Conceptual Site Model report, the exposure media column (far right) omits offsite groundwater as a means of possible human exposure. This point is important, since R313-25-8(5)(a) requires Energy*Solutions* to simulate disposal facility performance for 10,000 years. The figure should be revised to include offsite groundwater as a pathway.

ES RESPONSE:

In response to those portions of the comment dealing with the groundwater pathway, ES stated:

> *The reason there is no groundwater drinking water exposure pathway shown on Figure 11 is that this exposure pathway is not credible. Groundwater salinities are such that the water is not potable, and it is not considered a drinking water source by the State of Utah. While water from the deeper aquifer near the mountain front is treated and used, water from the shallow, upper-unconfined aquifer is not used for anything, including dust suppression. As such, the lack of potable groundwater sources is exemplified by the fact that there is no current use of groundwater for this purpose, despite the presence of industry (including the Clive Site itself) and a permanent resident at the rest area on Interstate 80. Drinking water requirements for persons at these and other locations in the basin are satisfied using water delivered by truck.*
>
> *Since groundwater is not a source of drinking water, the drinking water exposure pathway does not exist, and groundwater concentrations are not evaluated for this purpose. There is therefore no need to evaluate groundwater concentrations for 10,000 years.*

REBUTTAL:

We find this position to be reasonable with regard to the unconfined aquifer. However, groundwater is being extracted for beneficial uses in the Clive area, presumably from the confined aquifer that lies below the shallow unconfined aquifer. For example, ES uses groundwater from a local well to suppress dust.

Several deep wells have been drilled near Clive, Utah. A log for one well just west of the Clive turnoff from Interstate 80 was drilled in 1969 to a depth of 350 feet for the Cox Construction Company. The intended use was for highway construction sprinkling and compaction (see http://waterrights.utah.gov/cblapps/wrprint.exe?wrnum=16-545). The location is said to have been S 2100 ft E 1100 ft from NW cor, Sec 18, T 1S, R 11W, SLBM. The well is reported to have produced groundwater during a pumping test in 1969 at a rate of 600 gpm over 10 hours of testing (click on Well Log link at http://waterrights.utah.gov/cgi-bin/docview.exe?Folder=welllog427264). The well is now associated with Utah water right 16-722, with a well whose location is said to be at S 1900 ft W 1400 ft from NE cor, Sec 18, T 1S, R 11W, SLBM. The well log shown on the Utah Water Rights website is the same as that for the well previously described for water right 16-545. Groundwater pumped from the well is reported to be used for dust suppression and control and truck washdown (http://www.waterrights.utah.gov/cblapps/wrprint.exe?wrnum=16-772). The well reportedly had produced about 15,313,800 gallons of groundwater by 2008.

Another well, located about 3 miles east of the Clive low-level waste disposal facility, is related to Utah groundwater right 16-190 by Skull Valley Company for water for livestock (see http://www.waterrights.utah.gov/cblapps/wrprint.exe?wrnum=16-190). The depth is 293 feet, with water down at 263 feet. The flow is given as only 0.0377 cfs. Another reference shows a map for the Grassy Mountain Facility, northwest of Clive, with wells called the North USPCI

Water Supply Well and the South USPCI Water Supply Well (Hansen, Allen and Luce, Inc., 2010). USPCI also drilled a well west of the Clive facility (http://www.waterrights.utah.gov/cblapps/wrprint.exe?wrnum=16-796). That well was drilled in 1992, and a well test was conducted then with an air lift yield of 0.134 cfs. Repairs were attempted in 1997, along with pumping at 350 gpm, before the well was abandoned.

The ES response has not addressed the possibility that drawdown associated from these or similar wells located just off-site at Clive could pull contamination from the Federal Cell through the underlying unsaturated and saturated zones via discontinuities in the confining layer into the confined aquifer from where it could be pumped to the surface. Water from the deeper aquifer would probably be too saline for domestic uses without treatment but could be used for dust suppression and similar purposes.

It is also possible that this water could be treated by techniques such as reverse osmosis and be used as drinking water as is currently happening at the nearby Delle Auto Truck Stop. We understand that water quality at this location is governed by state regulations since, as defined in R209-100(4), (1) "*A public drinking water system is a system, either publicly or privately owned, providing water for human consumption and other domestic uses, which: (b) Serves an average of at least 25 individuals daily at least 60 days out of the year….*" It is also our understanding that regulation of small sources that do not meet the test of a public water system as described in R309-100-4 are regulated by local health organizations. In the case of Tooele County, the county health department requires that for any culinary water use, the water user needs to pay for what the County Health Department refers to the "full chemical test" based on EPA standards. These EPA standards do not include "radiologicals," unlike the situation with public drinking water systems. Thus, the water user would not know about potential exposure to radioactive contaminants. In the case of reverse osmosis treatment, the contaminants would partition between the treated water and the wastewater creating multiple exposure pathways.

V1.2 CRITIQUE (ROUND 3):

A recent ES submission to the DRC, "*2013 Groundwater Withdrawal Survey, Part LH. 13 GWQDP No. UGW450005*," indicates that its water-right 16-722 with a 10-inch-diameter underground well at S 1900 ft W 1400 ft from NE co, Sec 18, T1S, R11W, SLBM is capable of producing groundwater at a rate of 0.72 cfs and that it produced 2,941,200 gallons of groundwater in 1993 alone. The well reportedly had produced about 15,313,800 gallons of groundwater by 2008.

As previously mentioned, pumping from deeper wells has the potential to pull down groundwater from shallow depths to the screens of deeper wells with continued pumping over time. This is a regular occurrence in many parts of the world, as observed by DRC staff members over years of consulting with companies dealing with industrial contamination. This occurrence could, over some period of time, drive contaminants into a deeper, more productive aquifer. Therefore, the PA needs to include investigation of deeper aquifers, analysis of potential hydraulic connections between shallow aquifers and deeper aquifers, protection of groundwater in the shallow aquifer from radioactive contamination, analysis of inadvertent intruder uses of deeper groundwater, and estimation of potential inadvertent intruder doses.

Deeper wells penetrating shallow aquifers also provide potential for leakage along casing or through fractured or incomplete annular seals. This may provide a conduit for preferential flow and contaminant migration down to a deeper aquifer. We recognize that drilling regulations require boreholes to be sealed. In Tooele County, borehole sealing inspections are performed by the county health department. However, failure to properly seal the annular space is not unusual in well drilling. A thorough investigation of the potential for deeper drilling at the site, along with studies of other, related aspects of deeper groundwater at the site, are integral parts of complying with applicable rules and guidance in developing the PA. Thus far, ES has presented to the DRC no reliable information for deeper aquifers (e.g., >500 feet deep) on site, either as to hydraulic head, hydraulic conductivity, flow rate, or water quality. ES needs to obtain all of this information before the PA can be approved. This is consistent with Utah rule UAC R313-25-3(5):

> *The plan approval siting application shall include hydraulic conductivity and other information necessary to estimate adequately the ground water travel distance.*

Likewise, UAC R313-25-3(6) states the following:

> *The plan approval siting application shall include the results of studies adequate to identify the presence of ground water aquifers in the area of the proposed site and to assess the quality of the ground water of all aquifers identified in the area of the proposed site.*

Similar requirements also apply when a candidate seeks a license under Utah Environmental Quality Code 19-3-305(1), which calls for the following:

- identification of "*the presence of any groundwater aquifers in the area of the proposed site*"
- assessing "*the quality of the groundwater of all aquifers identified in the area of the proposed site*"
- providing "*reports on the monitoring of vadose zone and other near surface groundwater*"
- supplying "*reports on hydraulic conductivity tests*"
- giving "*any other information necessary to estimate adequately the groundwater travel distance*"
- including a site description involving geologic, geochemical, geotechnical, hydrologic and ecologic information and description for aquifers on site

Since none of these tasks has yet been completed for the deeper gravel strata, layers, or zones of the confined aquifer (e.g., at 450–700 feet) on site, this remains to be done as part of the PA, or, at the very least, prior to a new or modified license being signed. This is one of the critical deficiencies of the current PA.

The groundwater exposure pathways discussed in this interrogatory need to be examined and the results compared to the R313-25-19 groundwater dose limit. Obtaining this information will require, among other things, drilling of deeper wells (e.g., down to 600–700 feet) in the area upgradient or to the sides of the waste area and conducting pumping tests, or, possibly slug tests, in the deeper wells to assess hydraulic conductivity. Pumping tests should be employed if the hydraulic conductivity is $1x10^{-3}$ cm/s or higher.

After the additional information discussed here is provided, disposition of this and related interrogatories can be addressed. These include the following:

- Interrogatory CR R313-25-8(4)(a)-96/3: Current and Future Potability of Water
- Interrogatory CR R313-25-8(4)(a)-97/3: Need for Potable and/or Industrial Water
- Interrogatory CR R313-25-8(4)(a)-105/3: Human Use of Groundwater
- Interrogatory CR R313-25-8(4)(a)-106/3: Desalination Potential
- Interrogatory CR R313-25-8(5)(a)-163/3: Groundwater Compliance for 10,000 Years
- Interrogatory CR R313-25-19-182/2: Groundwater Exposure Pathways

REFERENCES:

Energy*Solutions*, *2013 Groundwater Withdrawal Survey, Part LH. 13 GWQDP No. UGW450005*, 2013.

Hansen, Allen and Luce, Inc., *Clean Harbors Grassy Mountain, LLC, Tooele County, Utah Landfill Cells 6b and 7 Closure Design Modifications for Vertical Expansion, Design Engineering Report (Hal Project No 064 82 100),* December 2010. Retrieved October 2013 from http://www.hazardouswaste.utah.gov/CFF_Section/Docs/Grassypermit/Att_VI-3_B6_7.pdf.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of EnergySolutions, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Utah Division of Water Rights, *Searching for Water Right Records*, Utah Department of Natural Resources, http://www.waterrights.utah.gov/wrinfo/query.asp.

INTERROGATORY CR R313-25-8(5)(A)-39/1: FIGURE 6 CAPTION

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES corrected the caption for FRV1.2 Figure 6, page 62, as noted. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-40/3: FIGURES 7, 8, 9, 10, AND 11

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

FRV1.2 Section 6.1.2 now includes a reference to "*Appendix 19, Sensitivity Analysis Results.*" However, the correct appendix is Appendix 15(II), and the appropriate section within the appendix is not cited. In addition, the appendix is not cited in FRV1.2 Sections 6.2.2 or 6.3.2.

INTERROGATORY CR R315-101-5.3(6)-41/3: TABLE 7

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

Two tables are no longer provided in FRV1.2 Section 6.3.1, page 70. The text has been revised as follows:

> *The uranium HI results are summarized in Table 6, which shows the statistics for mean uranium HI for all receptors.*
>
> *The HIs for uranium are extremely small relative to threshold of 1.0, indicating essentially no possibility of observing health effects from uranium toxicity. Similar to the dose results presented above, this indicates that disposal of DU waste below grade, at the bottom of the embankment, is protective of human health and the environment. These values are in compliance with the regulatory standards.*

The title of the associated table is as follows:

> *Table 6. Peak uranium hazard index: statistical summary*

However, the text refers to "mean uranium HI" and the table title to "peak uranium HI," so the original issue with consistency ("mean" vs. "peak") appears to be unresolved.

We also note that until the other intruder scenarios requested in these interrogatories have been addressed, it cannot be assumed that the HIs are small relative to the 1.0 threshold.

INTERROGATORY CR R315-101-5.3(6)-42/1: HAZARD QUOTIENT IN TABLES 7 AND 8

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES renamed FRV1.2 Section 6.3, page 69, as indicated. The text (pages 69–70) was revised as noted, with some additions:

> *Uranium hazard indices (HIs) within 10,000 yr are calculated for each receptor scenario as the sum of hazard quotients (HQs) for the ingestion exposure pathways defined in Table 1. A HQ is the ratio of the average daily dose (i.e., chemical intake) of a chemical to the corresponding reference dose for that chemical, where a reference dose is an estimate of daily exposure likely to be without appreciable risk of adverse health effects. The uranium HI values are*

> *compared to EPA's standard HI threshold of 1.0, a level that indicates that the average daily dose is below the dose associated with health effects.*

Other than in the text quoted above, the tern "hazard quotient" or "HQ" is no longer used in FRV1.2. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-19-43/1: PEAK DOSE IN TABLE 11

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES changed the title of the table (now Table 8) on page 73 of FRV1.2 as proposed. It no longer differentiates between gully scenarios. ES also added Table 9, "*Cumulative receptor population: statistical summary,*" and the following explanation:

> *These population doses represent the sum of the doses to all hypothetical individuals in each year over the 10,000-yr simulation. Table 9 below shows statistics of the average number of cumulative individuals at 10,000 years for the total population as well as the different receptor types.*
>
> *One measure for evaluating the population dose levels shown in Table 8 is by comparing these doses with radiation doses related to natural sources. Average annual individual background doses related to ubiquitous natural background radiation in the United States is approximately 3.1 mSv (310 mrem) (NCRP, 2009). For the total population of about 3 million individuals, natural background radiation dose is therefore approximately 930,000 rem, a level that is many orders of magnitude higher than the population doses shown in Table 8.*

The significance of the new material would be more clear if ES explained that 3 million individuals is the population of the State of Utah. Otherwise, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-44/2: OCCURRENCE OF INTERMEDIATE LAKES

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Clarify the number meant by the term *"handful"* when referring to the occurrence of intermediate lakes. Describe intermediate lakes in terms of past or future total surface area and potential inundation of the Clive site.

BASIS FOR INTERROGATORY:

FRV1 Section 6.5.1, page 79, states that *"intermediate lakes only occur a handful of times."* The text should indicate what number is meant by the term *"handful."* It should also describe intermediate lakes in terms of past or future total surface area and potential to inundate the Clive site. The text should describe the duration of time each of the past lakes persisted and their frequency.

ES RESPONSE:

In its response, ES discussed the occurrence of intermediate lakes and the relevance of whether the shore reaches the elevation at the Clive site. Specifically, ES stated that: "*Intermediate lakes are modeled as a Poisson process with a rate of 0 to 7.5 lakes per 100 ky. … Please refer to the following existing sections in the Deep Time Assessment white paper for further details regarding timing.*"

REBUTTAL:

We are troubled by ES' ongoing statements concerning carbonate sedimentation in lakes: "*Intermediate lakes are assumed to be smaller lakes that reach and exceed the altitude of Clive, but are not large enough that carbonate sedimentation can occur [at Clive]*." Similar statements also appear in ES responses to other interrogatories, such as Interrogatory CR R313-25-8(4)(d)-126/1: Shallow Lake Cycles.

There seems to be a sense in the PA that lacustrine carbonate sedimentation is restricted to the deep, distal (profundal) portions of large lakes. Evidence, however, indicates that this is not correct. Other than the very near shore, fine-grained carbonate sedimentation is a function of water chemistry and can occur in lakes, large or small, at virtually all depths. Provo age (~15.5–13.5 kya) marl in Lake Bonneville is common at paleodepths as shallow as 5 to 10 meters. Modern sediments of the Great Salt Lake have carbonate concentrations as great as 70% (Eardley, 1938; 1966). Preliminary research on a small lake (< 1 km^2 area, 50 meters maximum depth) in upstate New York found that fine-grained carbonate constitutes approximately 75% of the bottom sediment (Takahashi et al., 1968). Further, calcium carbonate tufa deposits have been mapped in Gilbert-age lake sediments on the Greyback Hills, a short distance northwest of Clive (Doelling et al. 1994, page 13).

Given the importance of sediment characteristics to the mobility and sequestration of radionuclides, more serious consideration needs to be given to this issue. For example, radium is often precipitated with the carbonates, which could significantly impact the concentrations in the lake water.

V1.2 CRITIQUE (ROUND 3):

As ES noted in its responses to the Round 2 Interrogatories (Energy*Solutions* 2014), statements on carbonate sedimentation have been changed in the revised Deep Time Assessment report (Appendix 13 to FRV1.2). Also, text has been adding to state that the model is not dependent on the dynamics of carbonate deposition and that it conservatively assumes all waste is precipitated with and incorporated into local sediments during lake recession. The deep time model is a non-mechanistic model that assumes that all of the radioactivity is within the water (within solubility limits) when the lake is present, and once the lake is gone, all the radioactivity is within the sediments. The model does not take credit for the dynamic removal of radioactivity (e.g., radium) by precipitation, which is conservative for the lake water concentration and does not affect the sediment concentration. Therefore, this interrogatory is closed.

REFERENCES:

Doelling, H.H., B.J. Solomon, and S.F. Davies, *Geologic Map of the Greyback Hills Quadrangle, Tooele County, Utah*, Utah Geological Survey, Map 166, 1994.

Eardley, A.J., *Sediments of the Great Salt Lake*, American Association of Petroleum Geologists Bulletin, Vol. 22, pp. 1305–1411, 1938.

Eardley, A.J., *Sediments of the Great Salt Lake*, in Great Salt Lake Utah, Geological Society of Utah Guidebook No. 20, pp. 105–120, 1966.

Energy*Solutions*, *RML UT2300249 – Condition 35 Compliance Report Responses to Round 2 Interrogatories*, June 17, 2014.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0032_R1, June 5, 2014. (Appendix 13 to FRV1.2)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0,* June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Takahashi, T., W. Broeker, Y.H. Li, D. Thurber, *Chemical and isotopic balances for meromictic lake*, Limnology and Oceanography, pp. 272–292, 1968.

INTERROGATORY CR R313-25-7(2)-45/1: INACCURATE CROSS-REFERENCE

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES corrected the reference from Figure 7 to Figure 5 in FRV1.2 Section 4.2.2, page 23, which appears to be correct. There is no Table 4 in either the original or revised version of the Conceptual Site Model report (Appendix 2 to FRV1.2). Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(1)-46/1: TORNADOS

Round 1 Interrogatory Response is satisfactory.

V1.2 CRITIQUE (ROUND 3):

Resolution of this interrogatory required no changes to FRV1.2. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(1)-47/1: SELECTION OF BIOME

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES revised the figure (now Figure 10) in the Conceptual Site Model report (Appendix 2 to FRV1.2) as proposed. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(9)-48/3: SOURCE AND COMPOSITION OF DU WASTE

PRELIMINARY FINDING:

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

INTERROGATORY STATEMENT:

Clarify the source of the DU waste considered in the analysis and how the PA accounts for potentially different radionuclide species compositions. Address concerns with the three sources of information on the characteristics of the DU waste.

BASIS FOR INTERROGATORY:

With regard to the reported inventory, Section 9.1.1, page 47, of the Conceptual Site Model report states that *"Based on laboratory analysis of the contents of DU waste (including all radionuclides in the containers), the species in the disposed inventory include (Beals et al. 2002; Energy*Solutions *2009b; Johnson 2010):…."* However, it is not clear which waste this statement refers to – all DU waste expected to be disposed of, including in the future; all DU waste currently disposed of; DU waste from SRS; or DU waste from the GDPs. Each of these will have different DU-waste species compositions.

In addition, detailed review of these three information sources has resulted in the following concerns:

1. Beals et al. (2002) – This DOE SRS report dated November 19, 2002, provided 33 DU sample results for 14 analytes (Tc-99, Am-241, Ra-226, Cs-137, Sr-90, I-129, Pu-239, Pu-240 (also Pu-239+420, Pu-241[2], Pu-242), Np-237, U-238, U-235+236, U-234[3]).

[2] SRS analyzed only three DUO_3 waste samples for Pu-242.
[3] The report notes on page 22 that no U-233 concentrations were observed during mass spectrometry in the selected samples.

- Few SRS samples. Section 2.2.2, page 5, of the Waste Inventory report indicates that 33 SRS samples were collected from a population of 3,300 drums at SRS (1% sampling rate). The text should explain and justify why these 33 samples are representative of the 36,000 SRS DU drums in need of disposal, as cited on page 4 of the Waste Inventory report.
- SRS reporting of minimum detectable activity (MDA) limits. Several nuclides were expressed in terms of the MDA value for each sample and not by sample activity concentrations (e.g., Ra-226 in Table 7, Sr-90 in Table 9, and I-129 in Table 10 of Beals et al. (2002)). Reliable, representative activity concentration data are needed for at least two of these: Ra-226 is needed for estimation of short-term radon emanation from the disposal cell, and I-129 is needed because it is a mobile isotope in groundwater and is easily leached from the DU waste. The text should provide activity concentration data for these two isotopes in the SRS DU waste or explain and justify why these are not needed or could be conservatively replaced by an analog nuclide. For any future Ra-226 sampling and analysis, the MDA should be ≤15 pCi/g.
- Lack of SRS uranium isotope activity concentration data. We agree that the SRS uranium data cannot be reconciled into activity concentrations for input into the PA model because they were reported in units of atom% and activity% and not in units of activity per mass (pCi/g) or activity per volume (pCi/cm^3). As a result, the total numbers of uranium data from the three data sources used in FRV1 have been reduced from 59 to only 26 samples (all collected by Energy*Solutions*), thus making the uranium activity data statistically weaker than many of the other DU waste analytes considered.
- Lack of SRS reconciliation of uranium data. Energy*Solutions* should explain why it did not ask DOE to resolve the problem with uranium analysis reporting units. Alternatively, Energy*Solutions* should ask SRS to collect new representative samples and provide adequate analytical results for the uranium isotopes to be disposed in Utah.

2. Energy*Solutions* 2009b – These data were summarized in Tables 14 and 15 of the Waste Inventory report and include 26 different DU waste samples collected at Clive in January 2010 (11 samples) and April 2010 (15 samples). These were analyzed for five different analytes (Tc-99[4], total uranium, U-238, U-235+236, and U-233+234). Section 2.2.1, page 5, of the Waste Inventory report indicates that these samples were taken from a small portion of the 5,408 SRS drums now in storage at Clive.
   - Few Energy*Solutions* samples. Energy*Solutions* should explain and justify why the 26 Energy*Solutions* samples are representative of the 5,408 DU drums in Clive storage now and of the 36,000 SRS drums in total needing land disposal, for all analytes reported.
   - Artificial Neptune uranium isotope data. Given the concern that the 26 Energy*Solutions* uranium samples are not statistically representative of the 5,408 DU drums in storage at Clive or the 36,000 drums of SRS DU needing burial, the artificially generated Neptune

[4] No Energy*Solutions* sampling for Tc-99 was done in the April 2010 sampling event (see Table 4 of the Waste Inventory report). Therefore, only 11 Tc-99 samples are available from this report, compared to the other analytes reported.

uranium concentration data also raise concerns. Energy*Solutions* should explain and justify how mathematical generation of uranium isotope concentrations for the DU waste from only 26 Energy*Solutions* samples can be reliable, representative, and produce conservatively high uranium concentrations for the PA model. This concern should be addressed in terms of individual artificial data values, the mean population concentration, and the full range of possible concentrations (distribution) for each of the uranium isotopes in question.

3. Johnson 2010 – This document includes Utah Division of Radiation Control (DRC) sampling and analytical results for 173 samples for Tc-99 only (see Tables 9 and 16 of the Waste Inventory report). No other analyte was sampled or analyzed in this work. In determining the number of samples from the 5,300 SRS drums at Clive at the time needed for statistical power, the state relied on EPA Resource Conservation and Recovery Act waste sampling guidance (EPA 2002). Therefore, it should be explained why 33 samples or less, as collected by SRS and Energy*Solutions*, could be statistically meaningful and representative of the entire SRS DU waste inventory of 36,000 drums needing disposal.

The text should clarify and justify the DU waste sources and analytical data considered and indicate how the PA model accounts for the potentially different species compositions and isotopic distributions for both the SRS DUO_3 waste and future DU waste from GDPs.

ES RESPONSE:

In its response, ES stated the following:

> *The Division's concerns about the representativeness of the samples used to characterize the waste inventory are understandable. However, none of the inventory distributions are sensitive, and they are all as "wide" as they can be given the data. To this end, the following actions are proposed.*
>
> - *Specific sensitivity analysis (one-at-a-time) is being developed for select dose rates and hazard quotients focusing on inventory distributions as inputs. Initially, this effort will analyze data from existing model runs (after implementing the ET cover). This would provide information about the relative impacts of the inventory amounts and identify conditions where greater certainty is needed. This item relates to the comments raised in CR R313-25-8(5)(a)-30/1, CR R313-25-8(5)(a)-31/1 and CR R313-25-8(4)(a)-32/1.*
> - *This sensitivity analysis will include evaluating the effect of ignoring some data sources.*

REBUTTAL:

We look forward to reviewing the new data demonstrating the sensitivity of the waste composition to PA results. In addition, although it would be ideal to use the actual quantitative method of employing the scaling factors, this seems like an appropriate way to quantify I-129. Given the high dose conversion factor, it is very important to use a conservative approach for I-129. With regard to the statement about a lack of model sensitivity, DEQ will evaluate this after

ES completes PA modeling for the groundwater pathway for a time period of at least 10,000 years.

V1.2 CRITIQUE (ROUND 3):

ES has provided useful information showing that the I-129 concentration is grossly overstated (see footnote 1 in the revised Waste Inventory report (Appendix 4 to FRV1.2). However, ES has not performed the proposed actions described in its response to the Round 1 Interrogatory.

REFERENCES:

Beals, D.M., S.P. LaMont, J.R. Cadieux, C.R. Shick, Jr., and G. Hall, *Determination of Trace Radionuclides in SRS Depleted Uranium (U),* WSRC-TR-2002-00536, Westinghouse Savannah River Company, Aiken, SC, November 19, 2002.

Energy*Solutions*, *Radioactive Waste Profile Record,* EC-0230, Rev. 7, plus attachments (Form 9021-33), Clive, Utah, 2009 [Energy*Solutions* 2009b].

Johnson R., State of Utah, Department of Environmental Quality, Memorandum, *Subject: Savannah River Depleted Uranium Sampling,* April 6, 2010.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0023_R1, June 5, 2014. (Appendix 4 to FRV1.2)

U.S. Environmental Protection Agency, *RCRA Waste Sampling Draft Technical Guidance, Planning, Implementation, and Assessment*, EPA 530-D-02-002, August 2002.

INTERROGATORY CR R313-25-7(9)-49/3: COMPOSITION OF MATERIAL MASS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

Section 2.2.2, page 6, of the revised Radioactive Waste Inventory report (Appendix 4 to FRV1.2) states that: "*The mass of the empty drums is assumed to be approximately 108 Mg, so the total waste mass is 3577 Mg of drummed waste – 108 Mg drum mass = 3469 Mg of DU waste which is a mix of uranium isotopes and contaminants, and where the uranium is assumed to be in the form of DUO_3.*" We interpret this to mean that the mass of 3,469 Mg refers to DUO_3 containing 83.6% DU. This interpretation does not appear to be reflected in Table 1, where the total mass of SRS DUO_3 is listed as 3,577 Mg. This is also the mass listed in the Table 39, page 26, of the Model Parameters report (Appendix 16 to FRV1.2).

INTERROGATORY CR R313-25-7(9)-50/3: SAMPLES COLLECTED

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES did not implement the proposed correction.

INTERROGATORY CR R313-25-7(9)-51/3: NATURE OF CONTAMINATION

Round 1 Interrogatory Response is satisfactory, in that ES will review and evaluate 17 additional documents on waste contaminants and concentrations. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

We could not ascertain that any significant amendments to the text of the revised Waste Inventory report (Appendix 4 to FRV1.2) were made based on the ES review and evaluation of the 17 cited documents, although several were added to the reference list. ES did state the following in Section 1.0, pages 2–3, of the Waste Inventory report:

> *However, these studies and reports do not provide specific information on concentrations that can be used directly to develop input probability distributions. Until adequate information concerning DU inventory is received from the GDPs, which may not happen until the DU oxide product has been produced and sampled, the actinides and fission products are assumed to be in relative concentrations in the DUF_6 waste equal to those in the SRS DUO_3 waste, as shown in Table 2. This is only a rough approximation and will need to be revised as data from the GDP waste are provided.*

Our reading of the usefulness of these documents is different. We believe that they contain data on concentrations of contaminants that can be used in performance assessment. ES needs to explain why the data, particularly those contained in Hightower et al. (2000), cannot be used to characterize contaminant concentrations of species such as Tc-99.

This concern is discussed more fully in Interrogatory CR R313-25-7(9)-89/3: Contamination Levels in DUF_6.

REFERENCES:

Hightower, J.R., L.R. Dole, D.W. Lee, G.E. Michaels, M.I. Morris, D.G. O'Conner, S.J. Pawel, R.L. Schmoyer, L.D. Trowbridge, and V.S. White, *Strategy for Characterizing Transuranics and Technetium Contamination in Depleted UF6 Cylinders*, ORNL/TM-2000/242, UT-Battelle, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 2000.

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0023_R1, June 5, 2014.

INTERROGATORY CR R313-25-7(9)-52/1: MEASUREMENT TYPES FOR SAMPLING EVENTS

Round 1 Interrogatory Response is satisfactory.

INTERROGATORY CR R313-25-7(9)-53/1: SUBSCRIPTS IN EQUATION 1

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES implemented the proposed changes. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(9)-54/1: PARTITIONING IN THE SENSITIVITY ANALYSIS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text, particularly changes to be made to Section 6 of the DU PA model report (FRV1).

V1.2 CRITIQUE (ROUND 3):

The noted change (with the exception of the cross-reference to Section 6) was made in FRV1.2 Section 3.2.2, page 15. The Sensitivity Analysis report (Appendices 15(I) and (II) to FRV1.2) does evaluate the sensitivity of the Clive DU PA Model results to the activity concentration in SRS DU waste. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-55/2: URANIUM ISOTOPE DISTRIBUTIONS

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Indicate whether analyses were conducted to determine if the uranium isotope distributions significantly affected the results of the PA.

BASIS FOR INTERROGATORY:

Section 3.2.3, page 16, of the Waste Inventory report states, *"If, given these relatively broad distributions, the uranium isotopes are not sensitive to any PA model endpoint, then the need to refine these distributions will be less."* The text should indicate whether any analyses were conducted to determine if the uranium isotope distributions significantly affected the results of the PA. The response should be prepared after all other interrogatories related to the Waste Inventory report have been resolved.

ES RESPONSE:

In its response, ES stated that the statistical analysis examined how the results varied due to the uranium distribution given in the Waste Inventory report (Appendix 4 to FRV1).

REBUTTAL:

ES does not appear to have answered the interrogatory. ES stated that the statistical analysis examined how the results varied due to the uranium distributions given in the Waste Inventory report, but it did not state how that distribution (or impacts) would vary if the uranium isotope distribution varies. The uranium isotopic distributions should be revised if any of the literature being reviewed under Interrogatory CR R313-25-7(9)-51/1: Nature of Contamination uncovers relevant new data.

V1.2 CRITIQUE (ROUND 3):

The revised Sensitivity Analysis report (Appendices 15(I) and (II) to FRV1.2) evaluates the sensitivity of the Clive DU PA Model results to the activity concentration in SRS DU waste, including the uranium isotopic distribution. No scenario doses show sensitivity to the uranium isotopic distribution, and the uranium isotopic distributions were not further revised. Therefore, this interrogatory is closed.

REFERENCES:

Neptune and Company, Inc., *Machine Learning for Sensitivity Analysis of Probabilistic Environmental Models*, NAC-0029_R1, June 5, 2014. (Appendix 15(I) to FRV1.2)

Neptune and Company, Inc., *Sensitivity Analysis Results for the Clive DU PA, Clive DO PA Model v1.2*, NAC-0030_R0, June 5, 2014. (Appendix 15(II) to FRV1.2)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(9)-56/1: INTERPRETATION OF BOX PLOTS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES added the proposed text to Section 3.3, page 16, of the revised Waste Inventory report (Appendix 4 to FRV1.2) and to the references. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(9)-57/1: DASHED LINES IN FIGURE 4

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES edited the caption to Figure 4 on page 21 of the revised Waste Inventory report (Appendix 4 to FRV1.2) as proposed. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(9)-58/1: REFERENCE FOR PERSONAL COMMUNICATION

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

The Stapleton reference was added to the reference list. The text citations to the Stapleton reference in Section 3.5.2.3, page 25, were updated to indicate the correct month, which is sufficient since the full reference is included in the reference list. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(2)-59/2: BATHTUB EFFECT

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

INTERROGATORY STATEMENT:

Clarify why, after the upper flow barriers are compromised, water will not collect above the clay liner and drive infiltration rates above those predicted by models.

BASIS FOR INTERROGATORY:

Section 4.1, page 5, of the Unsaturated Zone Modeling report states, *"Since the upper filter layer is assumed to have been silted up and is therefore ineffective at diverting infiltrating water, it is assigned a lateral flow of 0 cm/yr (0 in/yr)."* The document should clarify why, after the upper flow barriers are compromised, water will not collect above the top clay liner ("bathtub effect") and provide a driving force to increase the infiltration rates above those predicted by HELP and UNSAT-H.

ES RESPONSE:

In its response, ES stated that: "*For this review of the model, which includes the rip-rap design, it is assumed that the 'top clay liner' referred to in the Interrogatory is the top clay liner below the waste zone and not one of the radon barriers*.

REBUTTAL:

The ES response was developed for the rip-rap design and therefore may not be appropriate for the newly proposed ET cover design. In addition, other interrogatories requested examination of the effects of pedogenesis, biointrusion, and other phenomena on the permeability of the radon barrier. We appreciate ES' forthcoming efforts to reexamine the potential for ponding within the waste as part of the ET cover design. We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(3)-60/2: MODELED RADON BARRIERS

PRELIMINARY FINDING:

Refer to R313-25-7(3): *Descriptions of the principal design criteria and their relationship to the performance objectives.*

INTERROGATORY STATEMENT:

Provide additional justification for the modeled post-installation upper and lower radon barriers.

BASIS FOR INTERROGATORY:

Sections 5.1.5 and 5.1.6, page 27, of the Unsaturated Zone Modeling report describe hydraulic conductivity values for the modeled post-installation field permeability of the upper ($5x10^{-8}$ cm/s) and lower (5×10^{-6} cm/s) radon barriers. However, the values used for the lower barrier are orders of magnitude lower than those indicated as being appropriate in NRC guidance, such as NUREG/CR-7028. The text should provide additional justification for the model parameters chosen, with emphasis on natural phenomenon including, but not limited to, frost damage, burrowing insects and animals, and desiccation.

ES RESPONSE:

In its response, ES referred to its responses to Interrogatory R313-25-7(2)-05/1: Radon Barrier, Interrogatory CR R313-25-8(5)(a)-176/1: Representative Hydraulic Conductivity Rates, and Interrogatory CR R313-25-8(4)(a)-108/1: Biointrusion.

REBUTTAL:

Refer to the Rebuttals for Interrogatories R313-25-7(2)-05/1; R313-25-8(5)(a)-176/1; and R313-25-8(4)(a)-108/1.

Additional explanation is needed in the sensitivity analysis of infiltration rates to the hydraulic conductivity of the radon barriers underlying the ET cover (Energy*Solutions* 2014). In particular, it is unclear why a decrease in the hydraulic conductivity of the upper radon barrier leads to an increase in infiltration at the top of the waste. This is counterintuitive and appears to be inconsistent with the results of the earlier Whetstone analyses (presented in the 2014 sensitivity analysis). In that study of infiltration through a rock armor cover, an increase in the hydraulic conductivity by two orders of magnitude increased the infiltration rate from 0.143 to 0.676 inches per year. Furthermore, a more detailed review of the HYDRUS modeling will be performed as part of the revised PA review.

DRC staff members also raised multiple concerns during their review of the Class A West cell ET cover proposal. These concerns must be resolved before such a cover can be considered on the DU embankment.

In addition, the reference to Benson, et al., 2011 in the response does not refer to Benson, et al., 2011 provided in the references in Section 3 of the response document. Rather, it refers to NUREG/CR-7028, which was not included in Section 3.

REFERENCES:

Benson, C.H., Albright, W.H., Fratta, D.O., Tinjum, J.M., Kucukkirca, E., Lee, S.H., Scalia, J., Schlicht, P.D., and Wang, X., *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, Volume 1, NUREG/CR-7028, NRC Office of Nuclear Regulatory Research, December 2011.

Benson, L.V., S.P. Lund, J.P. Smoot, D.E. Rhode, R.J. Spencer, K.L. Verosub, L.A. Louderback, C.A. Johnson, R.O Rye, R.M. Negrini, *The Rise and Fall of Lake Bonneville Between 45 and 10.5 ka, Quaternary International*, Vol. 235, pp. 57–69, 2011.

Energy*Solutions*, *Evapotranspirative Infiltration Sensitivity to Changes in Radon Barrier Hydraulic Conductivity*, Energy*Solutions* Technical Memorandum to the Utah Division of Radiation Control, March 31, 2014.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(A)-61/2: MASS-BALANCE INFORMATION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Provide the mass-balance information for both the flow and contaminant transport from the model simulations.

BASIS FOR INTERROGATORY:

Section 8.0, page 30, of the Unsaturated Zone Modeling report should provide the mass-balance information for both the flow and contaminant transport from the model simulations. A mass balance is an application of the conservation of mass to the analysis of physical systems. In numerical models, as a result of numerical approximations (truncation and rounding errors), the conservation of mass is not always ensured; thus, it needs to be verified for each application. (Silling, 1983; ASTM, 2002). This information should be submitted for review by the Utah Department of Environmental Quality.

ES RESPONSE:

In its response, ES stated the following:

> *The mass balance of water flow is not in question, since it is up to GoldSim to assure that all flows are properly accounted for.…*
>
> …
>
> *The mass balance of contaminants (radionuclides) is determined internally by the GoldSim software as part of its proprietary solution algorithms.…The modeler and the user are not privy to the internal mass balance calculations,….*

REBUTTAL:

The fact that mass balance is not externally tracked and reported in GoldSim does not provide a level of confidence that mass is being adequately tracked. Although modeling precision can be made progressively tighter to see if the solution converges to the same values, this does not necessarily indicate good mass balance since this approach will only check over the temporal and spatial discretization internally defined by GoldSim. It is also unknown whether mass is conserved within the mass-flux links of the process-level models (unsaturated to saturated zone) and the external pathway function. The inability to independently verify that mass is conserved is a major limitation of the GoldSim code. Notwithstanding this, ES should provide references to the code developer's test problems that demonstrate that mass is conserved.

DRC notes that it is "*strongly recommended*" in the GoldSim Containment Transport User's Guide that the GoldSim user "*specifically enforce media flow balances by specifying pathway* *flow rates and media volumes and masses in a manner that is physically consistent with the mechanics of the system being modeled*" (page 229). ES should describe how this has been accomplished in the DU PA model and indicate where it is documented.

DRC also notices that GoldSim "*provides a warning message* [to the Run Log] *if the absolute difference between the inflow and the outflow* [of a pathway] *exceeds 1E-10 m3/sec AND the ratio of the absolute difference to the inflow exceeds 1E-6.*" ES should indicate whether it has used this feature to determine whether mass balance is being maintained in the DU PA model. If it has, ES should indicate the results of that determination and where they are reported.

REFERENCES:

American Society for Testing and Materials, *Standard Guide for Describing the Functionality of a Groundwater Modeling Code*, D6033-96, reapproved 2002.

GoldSim Technology Group, *GoldSim Containment Transport Module User's Guide*, Version 6.3, July 2013.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Silling, S.A., *Final Technical Position on Documentation of Computer Codes for High-Level Waste Management*, NUREG-0856, NRC Office of Nuclear Material Safety and Safeguards, June 1983.

INTERROGATORY CR R313-25-7(2)-62/2: NUMERICAL TESTING OF RUNGE-KUTTA METHOD

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

INTERROGATORY STATEMENT:

Provide a reference for the statement about numerical testing with regard to the Runge-Kutta method and describe the bases for the conclusion that stable solutions were produced.

BASIS FOR INTERROGATORY:

Section 8.3, page 37, of the Unsaturated Zone Modeling report states, *"Numerical testing demonstrated that the geometric zoning produces stable solutions for the top slope and side slope models with the Runge-Kutta method up to flow rates of 5 cm/year."* The text should provide a specific reference with regard to this numerical testing work and describe the bases for the conclusion that stable solutions were produced.

ES RESPONSE:

In its response, ES stated the following:

> *The Runge-Kutta solution method applied to this problem was extensively tested and verified, using test models in both GoldSim and Microsoft Excel. A more extensive documentation of this testing will be provided as an appendix to a revision to the Unsaturated Zone Modeling white paper.*

REBUTTAL:

On May 9, 2014, ES (Energy*Solutions* 2014) provided a draft revision to the Unsaturated Zone Modeling report (Neptune 2014). We expected that the revised report would provide more extensive documentation of the testing of the Runge-Kutta solution method. Instead, a search of the report found no mention of the term "Runge-Kutta." DRC anticipates that ES will restore and expand upon the description of the Runge-Kutta solution method in the final version of the revised Unsaturated Zone Modeling report (Appendix 5 to FRV1), as ES had indicated in its Round 1 response. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

An appendix has been attached to the Unsaturated Zone Modeling report (Appendix 5 to FRV1.2) describing the development and testing of the Runge-Kutta method. This appendix provides a description of the testing and implementation of the Runge-Kutta method that is adequate for estimating volumetric water content of the waste, clay liner, and unsaturated zone below the waste. Therefore, this interrogatory is closed.

REFERENCES:

Energy*Solutions*, *WHITE PAPER: Unsaturated Zone Modeling V2*, email from Vern C. Rogers to Helge Gabert, Utah Division of Radiation Control, May 9, 2014.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA – Revision 2 – Draft*, NAC-0015_R2, May 8, 2014.

INTERROGATORY CR R313-25-8(4)(A)-63/2: AIR-PHASE ADVECTION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.

INTERROGATORY STATEMENT:

Provide additional explanation and justification for the exclusion of air-phase advection from the PA model.

BASIS FOR INTERROGATORY:

Section 9.2.1, page 49, of the Unsaturated Zone Modeling report states that *"Air-phase advection is not included in the Clive DU PA Model. It is assumed that the advective flux of gases is negligible compared to the diffusive gas flux."* The document should provide additional justification for this statement, since it is a major assumption in predicting radon flux back to the surface. If a total pressure gradient exists in a soil as a result of external forces (e.g., atmospheric pumping or diurnal temperature changes), gases, especially when considering dispersion, will experience net flow from points of higher to lower pressure. Furthermore, it has been shown that relatively small gradients in total pressure can result in advective gas fluxes that are much larger than diffusive gas fluxes (Thorstenson and Pollock, 1989; Massmann and Farrier, 1992; Weisbrod et al., 2009; Ganot et al., 2012).

ES RESPONSE:

In its response, ES stated the following:

> *Temperature gradients due to daily thermal cycles were shown to be sufficient to induce convective venting. The aperture of the fracture tested was large and thermal gradients in the Negev Desert are steep. The significance of the process at the Clive site for contaminant gas transport and drying of the cover would have to be determined. Air flow should be measured or simulated for apertures considered to be representative of expected cracks in the proposed cover at Clive under site specific atmospheric conditions to determine the relevance of this process to the Clive site.*

REBUTTAL:

Since the degree of movement of radon will have a significant impact on dose estimates, ES should investigate transport from all potentially significant processes. We look forward to reviewing the revised report.

REFERENCES:

Ganot, Y., M.I. Dragila, and N. Weisbrod, *Impact of thermal convection on air circulation in a mammalian burrow under arid conditions*, Journal of Arid Environments, Vol. 84, pp. 51–62, 2012.

Massmann, J. and D.F. Farrier, *Effects of atmospheric pressures on gas transport in the vadose zone*, Water Resour. Res., Vol. 28, pp. 777–791, 1992.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Thorstenson, D.C., and D.W. Pollock, *Gas transport in unsaturated porous media: The adequacy of Fick's law*, Rev. Geophys., Vol. 27, pp. 61–78, 1989.

Weisbrod, N., M.I. Dragila, U. Nachshon, and M. Pillersdorf, *Falling through the cracks: The role of fractures in Earth-atmosphere gas exchange*, Geophys. Res. Lett., 36, L02401, doi:10.1029/2008GL036096, 2009.

INTERROGATORY CR R313-25-8(4)(A)-64/3: YUCCA MOUNTAIN STUDIES

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

Refer also to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Consider more recent Yucca Mountain information in preparing the Geochemical Modeling report.

BASIS FOR INTERROGATORY:

The Geochemical Modeling report uses data developed for the Yucca Mountain Site Characterization Project's Total System Performance Assessment to define solubilities for several species. The source document cited is LA-13262-MS (LANL, 1997). However, more recent Yucca Mountain studies on solubilities exist that should be considered, such as ANL-WIS-MD-000010.

ES RESPONSE:

In its response, ES stated that: "*SNL* [Sandia National Laboratories] *(2007) discusses solubility for almost all of the elements in the Clive PA model and models in detail the solubility of Am, Np, Pa, Pu, Th, and U. Some of the solubility values in SNL (2007) are presented in look up tables with pH and partial pressure of* CO_2 *as variables.*"

REBUTTAL:

These solubility values are based on the assumption that these ions are dissolving from pure solutions. However, it is more likely that the ions are present as solid-solutions within the uranium solid phases. The PA should explain whether the differences between solubility of a pure phase versus that of a solid-solution have been considered in the models.

The phase diagrams in Figures 1‒3 below were generated to illustrate the solubility of uranium versus redox potential in the presence and absence of carbonate using Geochemist Workbench with the Lawrence Livermore National Laboratory (LLNL) v8r6+ database. The diagrams were generated using the dissolved ion concentrations from Tables 5 and 6 in the Geochemical Modeling report (Appendix 6 to FRV1), with and without carbonate included and with the pH fixed at 7. The E_H and total uranium were varied, and the diagrams are shown in a pourbaix format with the dominant species shown in each region. Under reducing conditions, formation of U(IV) minerals limits the solubility of uranium through formation of uraninite.

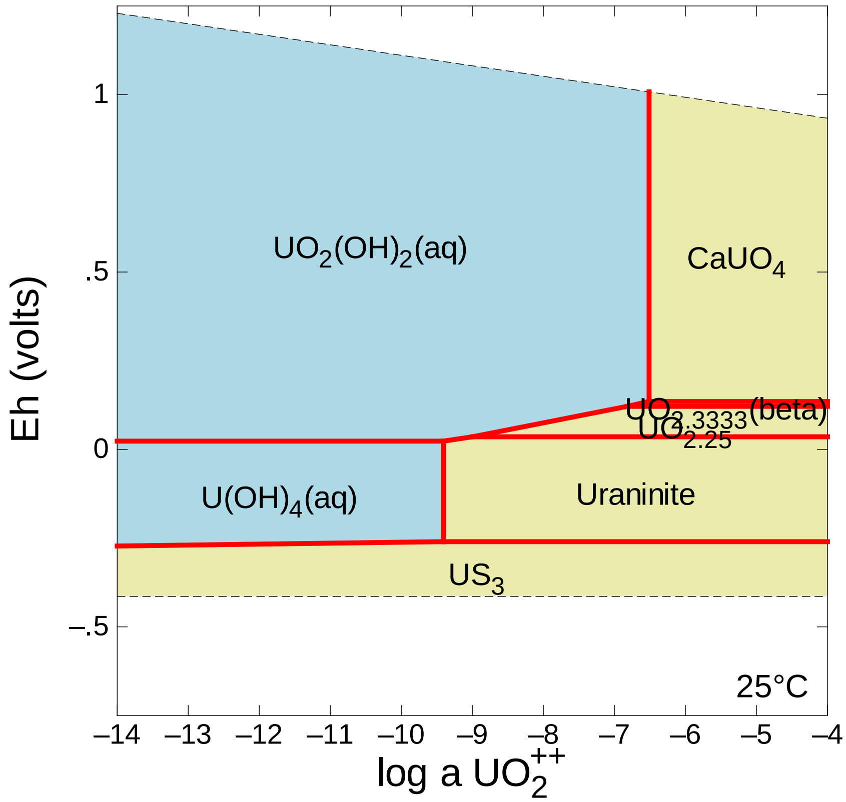


Figure 1. E_H-activity diagram demonstrating uranium speciation and solubility in the absence of carbonate. Note yellow regions indicate formation of a solid phase. Model generated using Geochemist Workbench and LLNL v8r6+ database.

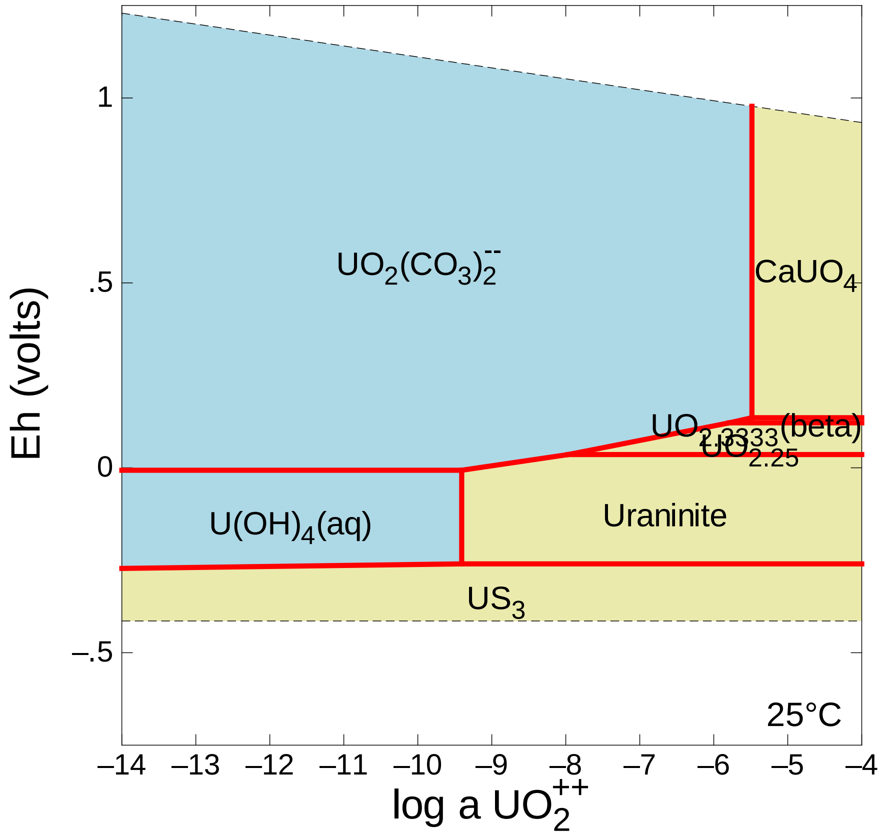


Figure 2. E_H-activity diagram demonstrating uranium speciation and solubility in the presence of approximately 100 mg/L carbonate. Note yellow regions indicate formation of a solid phase. Model generated using Geochemist Workbench and LLNL v8r6+ database.

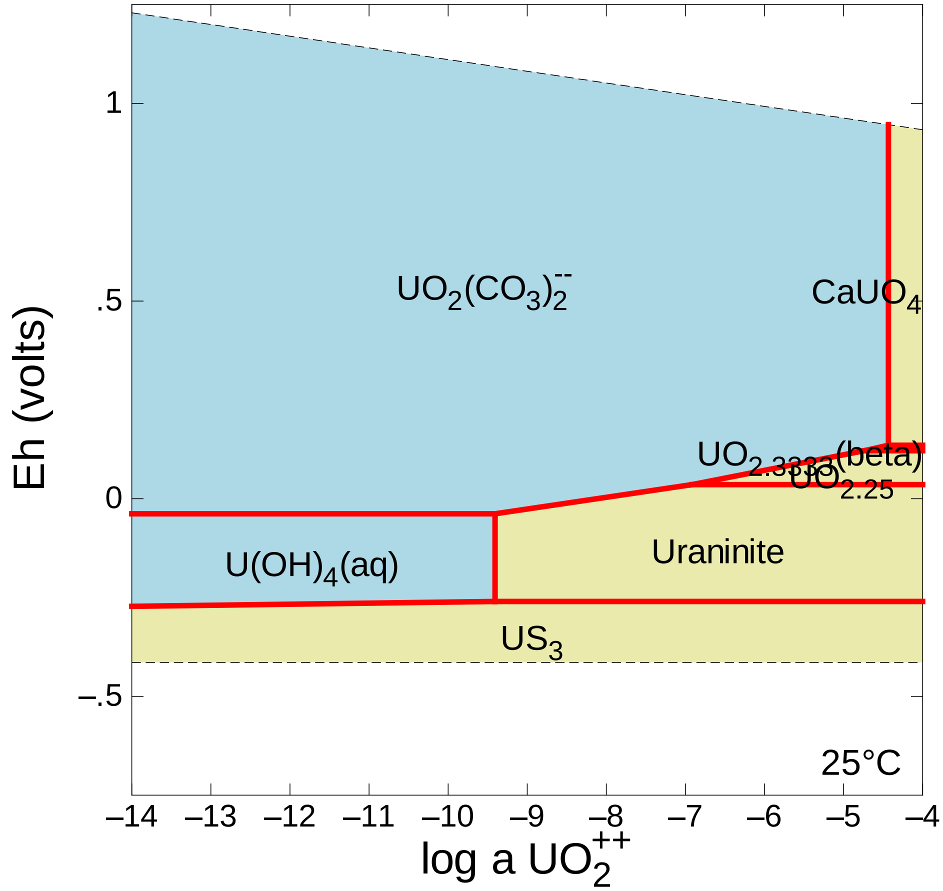


Figure 3. E_H-activity diagram demonstrating uranium speciation and solubility in the presence of approximately 350 mg/L carbonate. Note yellow regions indicate formation of a solid phase. Model generated using Geochemist Workbench and LLNL v8r6+ database.

The last line of Table 2-64/1 provided in the response presents uranium solubility data from SNL (2007). The uranium concentrations reported in Table 2-64/1 seem to only include the solubility of U(VI) phases and do not consider the potential formation of U(IV) phases, which will have significantly decreased solubility. The PA should indicate whether the geochemical model considers the potential formation of uraninite or other U(IV) phases and the expected redox conditions of the waste. Not considering the U(IV) phases if they are indeed forming will result in a very overly conservative estimate of aqueous uranium concentrations.

Also relevant to the overall prediction of the solubility of uranium is that the solubilities listed in Table 10 of the Geochemical Modeling report (Appendix 6 to FRV1) represent the output of a Visual MINTEQ model of U_3O_8 solubility. Given the low solubilities of uranium reported in Table 10, it is clear that oxidation of U(IV) to U(VI) was not considered. This must be done by "coupling" the U(IV)/U(VI) reaction within Visual MINTEQ before running the model. It appears that the intent of the modeling exercises examining schoepite and U_3O_8 solubility in Tables 8–10 was to give boundaries of uranium solubility. However, it is unrealistic to run a model with a relatively high E_H/pH condition (such as pH 8, E_H 200 mV in Table 10) and not allow for the oxidation of reduced species. Therefore, the reported low solubility values in Table 10 are not reliable for use as the source term in reactive transport models. The table and figure below show the reported values from Table 10 as well as two columns of output from additional Visual MINTEQ runs. In the first column, data from Tables 5, 6, and 10 of the Geochemical Modeling report (Appendix 6 to FRV1) were used as noted in an attempt to reproduce the reported total dissolved uranium concentrations shown in Table 10. This was done by running the model with the U(IV)/U(VI) system "uncoupled," as was apparently done for the model output shown in Table 10. However, the final column in the table below shows the total uranium concentration in a Visual MINTEQ model with the U(IV)/U(VI) reaction coupled. Oxidation of U(IV) to U(VI) is therefore allowed and the expected total dissolved uranium concentrations are significantly higher. Since the redox chemistry of the waste disposal site in this work is variable, it is recommended that redox coupled solubility calculations be used when defining the source concentrations in reactive transport models. The specific E_H and pH ranges expected under the various geologic conditions considered in the reactive transport models must be used in this source term analysis.

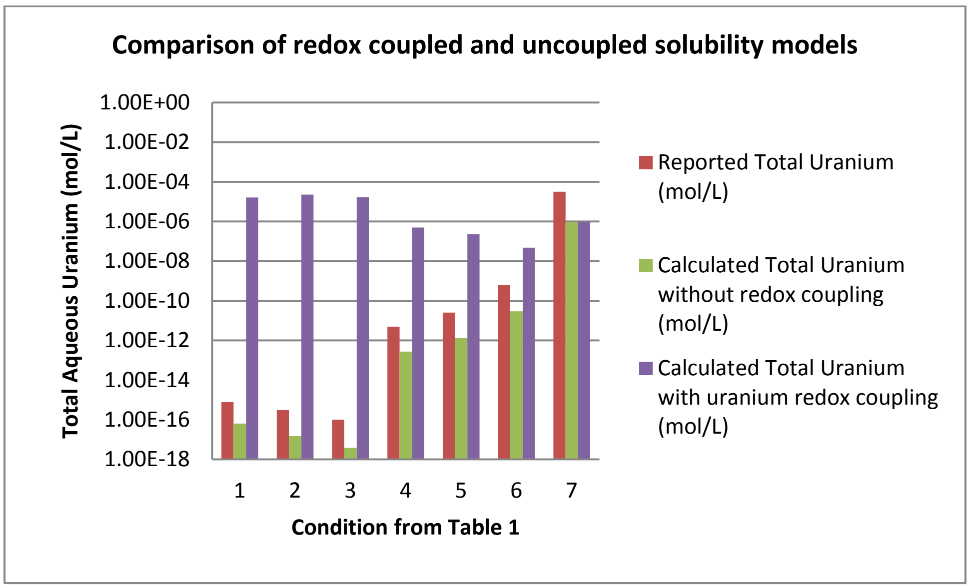


Table 3. Ion concentrations, pH, and E_H values for various uranium solubility models using Visual MINTEQ. Reported values from Table 10 of the Geochemical Modeling report (Appendix 6 to FRV1) are provided. Models with and without redox coupling were performed using the reported pH, E_H, and ion concentrations shown with each condition.

Condition	pH	E_H	Total CO_3^{-2}	Br^- mg/L	F^- mg/L	Cl^- mg/L	NO_3^- mg/L	SO_4^{-2} mg/L	Ca^{2+} mg/L	Mg^{2+} mg/L	K^+ mg/L	Na^+ mg/L	Reported Total Uranium, Appendix 6, Table 10 mol/L	Calculated Total Uranium Without Redox Coupling mol/L	Calculated Total Uranium With Uranium Redox Coupling mol/L
1	6.5	200	190	20	4.2	24094	1.5	3079	552	793	509	15162	7.85E-16	6.49E-17	1.62E-05
2	7	200	190	20	4.2	24094	1.5	3079	552	793	509	15162	3.00E-16	1.51E-17	2.23E-05
3	8	200	300	20	4.2	24094	1.5	3079	552	793	509	15162	1.00E-16	3.76E-18	1.68E-05
4	7.3	-10	190	20	4.2	24094	1.5	3079	552	793	509	15162	4.98E-12	2.74E-13	4.84E-07
5	7.3	-40	190	20	4.2	24094	1.5	3079	552	793	509	15162	2.52E-11	1.30E-12	2.24E-07
6	7.3	-100	190	20	4.2	24094	1.5	3079	552	793	509	15162	6.45E-10	2.93E-11	4.74E-08
7	7.3	-300	190	20	4.2	24094	1.5	3079	552	793	509	15162	3.18E-05	9.44E-07	9.44E-07

V1.2 CRITIQUE (ROUND 3):

Table 2, page 2, of the revised Geochemical Modeling report (Appendix 6 to FRV1.2) lists U_3O_8 with an expected low solubility. ES should indicate whether U_3O_8 allowed to oxidize to schoepite or some other oxidized phase within this model. If U_3O_8 represents a significant amount of the waste and is able to oxidize to a more soluble form, the modeled aqueous uranium concentrations could be significantly underestimated. Section 5.1.14.1, page 24, states that: "*The solubility of U_3O_8 is also incorporated into the GoldSim model.*" However, Section 5.1.14.3, page 29, includes a "Note" on the Goldsim model that indicates that the model cannot include both UO_3 and U_3O_8. The text implies, but does not clearly state, that U_3O_8 was ignored (since UO_3 is the primary control of solubility). If this is indeed the case, then all of the discussion of U_3O_8 is superfluous. The section could be shortened to one statement that the solubility of U_3O_8 is orders of magnitude lower than UO_3 (with proper references), so UO_3 is considered the dominant phase.

In addition, the headings in Table 4, page 3, note that these are solubility values in salt water. ES should provide the parameters for this "salt water," as this could be quite a wide range.

REFERENCES:

Bechtel SAIC Company, LLC, *Dissolved Concentration Limits of Radioactive Elements*, ANL-WIS-MD-000010, Revision 05, for U.S. Department of Energy, July 2005, retrieved September 2013 at www.osti.gov/scitech/servlets/purl/883412.

Los Alamos National Laboratory, *Summary and Synthesis Report on Radionuclide Retardation for the Yucca Mountain Site Characterization Project*, LA-13262-MS, 1997.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Geochemical Modeling for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0025_R1, June 5, 2014. (Appendix 6 to FRV1.2)

Sandia National Laboratories, *Dissolved Concentration Limits of Elements with Radioactive Isotopes*, ANL-WIS-MD-000010, Revision 06, September 2007. Available from http://pbadupws.nrc.gov/docs/ML0907/ML090770267.pdf.

INTERROGATORY CR R317-6-6.3(Q)-65/3: COLLOID TRANSPORT

PRELIMINARY FINDING:

Refer to R317-6-6.3(Q): *Ground Water Quality Protection Regulations – Applications Requirements for a Ground Water Discharge Permit – Other Information Required.*

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.

INTERROGATORY STATEMENT:

Discuss the potential for other types of colloids and colloidal-forming constituents in the waste (e.g., ligands). Explain how these phenomena might affect K_d coefficients in GoldSim and justify how and why the K_d values used are representative of or conservatively low for the actual site conditions.

BASIS FOR INTERROGATORY:

Section 5.0, page 17, of the Geochemical Modeling report states that *"The potential for colloidal transport of actinides at the Clive facility is not incorporated into the PA model."* To support this decision, the text then refers to actinide intrinsic colloids, which comprise one type of colloid. The text should discuss the potential for the actinides and progeny to form colloids with other constituents in the waste (e.g., ligands). In addition, it should explain how these phenomena might affect radionuclide soil-water partitioning (K_d) coefficients in the GoldSim modeling effort. In light of these possible factors, Energy*Solutions* should justify how and why the K_d values used are representative of or conservatively low for the actual site conditions.

In addition, Section 5.0, page 18, of the Geochemical Modeling report states the following:

> *Retention of colloids is favored at high ionic strength, low pH and in impermeable rock. The high ionic strength conditions in the saturated zone at Clive are counter to conditions considered favorable for colloid transport.*

The text should provide citations for the statement that retention of colloids is favored in solutions of high ionic strength. The text should also discuss any specific conditions under which exceptions may occur.

ES RESPONSE:

In its response, ES indicated that it will rely primarily on the influence of ionic strength collapsing the double layer and causing aggregation of the colloids, which will limit their mobility.

REBUTTAL:

ES described what seems to be an appropriate way of addressing colloids. However, changes in ionic strength can generate mobile colloids. ES should review Cheng and Saiers (2009) and Ryan and Elimelech (1996) and revise the report to discuss potential impacts on the PA model.

V1.2 CRITIQUE (ROUND 3):

ES added text in Section 2.0 of the Geochemical Modeling report (Appendix 6 to FRV1.2) describing the conditions expected at the site and those of mobile colloids. However, the logic of not including something because it is complex is not sufficient. Since the presence of colloids is "*unknown and currently speculative*" (page 6), it seems the best way to determine the potential for colloid transport would be to measure for pore water colloid concentrations at the site or gather data from a similar site.

Note that the reference in Section 3.0, page 10, to the figure is missing, as is the reference to the section number in Section 4.1 on page 13.

REFERENCES:

Cheng, T., and J.E. Saiers, *Mobilization and transport of in situ colloids during drainage and imbibition of partially saturated sediments*, Water Resources Research, Vol. 45, 2009.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Geochemical Modeling for the Clive DU PA, Clive DU PA Model v1.2,* NAC-0025_R1, June 5, 2014. (Appendix 6 to FRV1.2)

Ryan, J. N., and M. Elimelech, *Colloid mobilization and transport in groundwater*, Colloids and Surfaces A: Physicochemical and Engineering Aspects, Vol. 107, No. 1, 1996.

INTERROGATORY CR R313-25-8(4)(A)-66/2: COLLOID RETENTION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.

INTERROGATORY STATEMENT:

Provide references from technical, peer-reviewed publications to support the statement that retention of colloids is favored in solutions of high ironic strength.

BASIS FOR INTERROGATORY:

Section 5.0, page 18, of the Geochemical Modeling report states that "*Retention of colloids is favored at high ionic strength, low pH and in impermeable rock. The high ionic strength conditions in the saturated zone at Clive are counter to conditions considered favorable for colloid transport.*" The text should provide citations from technical, peer-reviewed publications for the statement that retention of colloids is favored in high ionic strength solutions.

ES RESPONSE:

In its response, ES provided citations that support the conclusion that the retention of colloids is favored in high ionic strength solutions.

REBUTTAL:

An evaluation of the simulation of colloidal transport will be conducted after the DRC staff reviews the additional references provided by ES in response to this interrogatory. ES should forward the references that are cited in the response as soon as possible.

REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(A)-67/3: SOLUBILITY AND SPECIATION OF RADIONUCLIDES

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.

INTERROGATORY STATEMENT:

Consider the solubility and speciation work with radionuclides in high ironic strength brines performed to support the Waste Isolation Pilot Plant. If it is not relevant, explain how solubility and speciation in high ionic strength brines are addressed.

BASIS FOR INTERROGATORY:

Section 5.0, page 18, of the Geochemical Modeling report states the following:

> *In many cases the solubility of radionuclide species used in the transport model was based to some extent on the data provided in the proposed Yucca Mountain Project (LANL 1997) and the Nevada National Security Site (NNSS, formerly the Nevada Test Site) (Sandia 2001) modeling.*

The discussion should also include the solubility and speciation work with radionuclides in high ionic strength brines that has been performed (and is currently ongoing) to support the Waste Isolation Pilot Plant (e.g., LCO-ACP-08 and LCO-ACP-10). If this information does not correlate directly to the Clive shallow groundwater, Energy*Solutions* should explain how it addresses solubility and speciation in high ionic strength brines.

ES RESPONSE:

In its response, ES stated that it will review the documents related to the Waste Isolation Pilot Plant (WIPP) suggested in the interrogatory and will incorporate a discussion of the relevance of the geochemistry of the WIPP into the Geochemical Modeling report (Appendix 6 to FRV1).

REBUTTAL:

We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

Section 5.0, page 20, of the revised Geochemical Modeling report (Appendix 6 to FRV1.2) states that: "*The high ionic strength brine found in the shallow aquifer at Clive can increase the solubilities of some actinides (DOE 2009) and this influence was incorporated into the decision making for solubility selection and modeling.*" The interrogatory asked ES to "*Consider the solubility and speciation work with radionuclides in high ironic strength brines performed to support the Waste Isolation Pilot Plant. If it is not relevant, explain how solubility and speciation in high ionic strength brines are addressed*." The added text does not sufficiently explain how the high ionic strength systems were treated. This is not a trivial problem and should be addressed.

The same paragraph also states: "*However, the three locations do also have very different mineralogy and soil properties that can influence the ion-exchange and sorption constraints in this model.*" ES should clarify whether it is implying that the ionic strength will change across the site, and if so indicate the expected range. Only an average value was given (0.73 M) on page 9 of the report based on the data in Table 8.

In addition, Table 11, page 28, of the Geochemical Modeling report lists only U(VI) aqueous species. ES should clarify whether any U(IV) species were considered; we assume that they were in order to calculate the solubilities of U_3O_8 without redox coupling within Visual MINTEQ (as previously discussed). Therefore, Table 11 should also list the U(IV) species. Although not necessary, it would significantly strengthen the case being made with this model if the stability constants for each species and the reference for the constant were reported as well.

REFERENCES:

Borkowski, M., J.F. Lucchini, M.K. Richmann, and D.T. Reed, *Actinide (III) Solubility in WIPP Brine: Data Summary and Recommendations*, LCO-ACP-08, Revision 0, LANL/ACRSP Report, LA-UR-09-03222, Los Alamos: Los Alamos National Laboratory, 2009.

Los Alamos National Laboratory, *Summary and Synthesis Report on Radionuclide Retardation for the Yucca Mountain Site Characterization Project*, LA-13262-MS, 1997.

Lucchini, J.-F., H. Khaing, M. Borkowski, M.K. Richmann, and D.T. Reed, *Actinide (VI) Solubility in Carbonate-free WIPP Brine: Data Summary and Recommendations,* LCO-ACP-10, LANL\ACRSP Report, LA-UR-10-00497, Los Alamos: Los Alamos National Laboratory, 2010.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Geochemical Modeling for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0025_R1, June 5, 2014. (Appendix 6 to FRV1.2)

Sandia National Laboratories, *Compliance Assessment Document for the Transuranic Wastes in the Greater Confinement Disposal Boreholes at the Nevada Test Sites*, Volume 2: *Performance Assessment*, Version 2.0, 2001.

U.S. Department of Energy, *Title 40 CFR Part 191 Subparts B and C Compliance Recertification Application for the Waste Isolation Pilot Plant*, Waste Isolation Pilot Plant, SOTERM-2009, Appendix SOTERM-2009 Actinide Chemistry Source Term, 2009.

INTERROGATORY CR R313-25-8(4)(A)-68/2: DISTRIBUTION OF HYDRAULIC GRADIENTS

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in

isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.

INTERROGATORY STATEMENT:

Provide any factors considered when developing the magnitude and distribution of hydraulic gradients from off-normal conditions.

BASIS FOR INTERROGATORY:

Section 3.3, page 4, of the Saturated Zone Modeling report should discuss any factors taken into consideration when developing the distribution of hydraulic gradients from off-normal conditions. These could include impacts by increased infiltration due to climatic changes; gully erosion; plant or animal penetration of the cover system; or accumulation of snow melt and stormwater runoff in clay, sand, and gravel pits already authorized by Tooele County in areas adjoining Section 32 that remain unreclaimed upon facility closure.

ES RESPONSE:

In its response, ES stated the following:

> *Monthly averages of the site-wide hydraulic gradient from 1999 through 2010 were calculated by Energy*Solutions *from water level measurements. These data were used to establish a distribution for the mean site-wide gradient. The influence of any off-normal conditions occurring during the time period of the water level measurement data would be included in this data.*

REBUTTAL:

The original interrogatory asked ES to consider four possible events or phenomena that could increase local hydraulic gradient. In its response, ES made reference to conditions at Clive between 1999 and 2010. Unfortunately, three of the requested events did not occur during this time period, namely climate change, gully erosion, and biodegradation of the radon barrier. Further, ES' claim that the hydraulic gradient was not a sensitive parameter needs to be revisited after ES increases the modeling time interval from 500 to more than 10,000 years. ES should provide the missing information; we look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Saturated Zone Modeling for the Clive DU PA*, May 28, 2011. (Appendix 7 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(A)-69/2: LONGITUDINAL DISPERSIVITY

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Provide the longitudinal dispersivity value used in the model and references for any studies or calculations that demonstrate the GoldSim model grid spacings are sufficiently small. Provide the mass-balance information for both the flow and contaminant transport from the model simulations. Indicate the length and location of the horizontal domain used for groundwater flow and transport modeling in the GoldSim simulations.

BASIS FOR INTERROGATORY:

Section 4.2, page 11, of the Saturated Zone Modeling report states that *“Only longitudinal dispersion will be considered for this discussion because of the geometry of the transport pathway.”* The longitudinal dispersivity value used in the model must be provided and justified. Energy*Solutions* should also provide any studies (e.g., grid convergence) or calculations that demonstrate the GoldSim model grid spacings are sufficiently small.

The text must also provide the mass-balance information for both the flow and contaminant transport from the model simulations.

The Saturated Zone Modeling report should be revised to indicate the length of the horizontal domain used for groundwater flow and transport modeling in the GoldSim simulations. The text should also indicate whether this model distance was fixed and if so describe where this domain is located relative to the proposed DU waste source term, nearby point of compliance monitoring well(s), the DU disposal cell’s buffer zone, and outer boundaries of property owned and controlled by Energy*Solutions*.

ES RESPONSE:

In its response, ES indicated that text will be clarified in a number of sections with respect to dispersivity and mass balance.

REBUTTAL:

The ES response generated the following questions:

1. Omission of Horizontal Dispersivity Calculations: Since longitudinal dispersion would decrease the time it takes for the contaminant to reach the compliance point, ES should explain how this omission produces a result that is either conservative (protective of the environment) or is representative of Clive site conditions. We note the offer by ES to perform sensitivity testing of the model to evaluate dispersivities. ES should provide this information in its next report revision and ensure that the model used simulates a time period of 10,000 years or more.
2. Unconfined Aquifer Dimensions: A review of the schematic in Figure 1 of the Saturated Zone Modeling report (Appendix 7 to FRV1) indicates that the saturated horizontal pathway had a constant aquifer thickness (model cell height). ES should explain how this geometry will provide conservative or representative model results given that a large groundwater recharge mound is found along the south and southwest margins of the proposed Federal Cell, thereby increasing the unconfined aquifer thickness there. Conversely, a thinner aquifer on the north side of the disposal cell should increase shallow aquifer velocity. ES should also explain whether instantaneous full vertical mixing, which will dilute the plume, makes sense over a travel distance of 232 feet.
3. Mass Balance: ES should provide evidence to support the statement that the model author (operator) ensured that all flows are properly accounted for. ES should provide the criteria used to determine what magnitude or ratio of mass balance was deemed satisfactory. We appreciate the insight on how DEQ may examine this issue for itself. We are particularly concerned that the model properly accounts for the mass entering the saturated zone from the unsaturated zone.
4. Grid Spacing: Although the grid spacing appears reasonable, ES should calculate and present the Peclet number since that is the more traditional approach to guide space discretization. Ideally, the number should be less than 2.

We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Saturated Zone Modeling for the Clive DU PA*, May 28, 2011. (Appendix 7 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(2)-70/3: GULLY SCREENING MODEL

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

Refer also to R313-25-23(2): *The disposal site shall be capable of being characterized, modeled, analyzed and monitored.*

INTERROGATORY STATEMENT:

Explain and justify why a more sophisticated erosion model than the initial screening-type gully model is not needed and why gully formation is restricted to locations only on the cover system and does not include other locations.

BASIS FOR INTERROGATORY:

Section 4.0, pages 4–5, of the Erosion Modeling report states the following:

> *The purpose of the initial gully model in the Clive PA model is to determine whether gullies and fans are significant contributors to dose and whether a more sophisticated erosion model is needed. A simple screening-type gully model was developed with the advice of Dr. Willgoose.*

Similarly, FRV1 Section 4.1.2.9, page 36, states the following:

> *The gully model is a simplistic model of gully erosion and landscape evolution. For example, the model assumes that 1) a gully forms instantly and doesn't change with time, 2) that between 1 and 20 gullies only are allowed to form, and 3) that gullies do not interact with other model processes such as biotic transport (e.g., no plants grow in a gully). This stylized model was used to provide a basis for discussion of whether or not gully formation is an important consideration in this waste disposal system, and to evaluate the consequences of human activities that inadvertently cause doses to future humans.*

FRV1 Section 6.2.1 shows that the presence of gullies increases the peak mean dose to a rancher from 4.37 mrem/yr total effective dose equivalent (TEDE) in Table 3 (page 59) to 20.9 mrem/yr TEDE in Table 4 (page 61). This increase is due to thinning of the cover layers (cap and fill materials) and possible direct exposure of the DU waste. Based on this information, it would appear that gully formation is an important consideration in evaluating the long-term performance of the waste disposal system. Therefore, the report should explain why a more sophisticated erosion model is not needed, including justification for how and why the assumed 1 to 20 gullies can be reconciled with the actual number of gullies expected to form during a minimum of 10,000 years. The text should explain why gully formation is restricted to locations only on the cover system and why a gully could not form in a nearby excavation, away from the disposal cell, and by head-cutting processes that later erode the side and top slope areas of the cover. If a more sophisticated erosion model is developed, the report needs to describe the new model, including how it will be implemented in the PA and its effect on the peak mean dose to a rancher or to any other member of the public in any other relevant scenarios.

ES RESPONSE:

In its response, ES stated that: "*The results of the SIBERIA modeling for the borrow pit are being abstracted and adapted to the disposal mound in the model of the ET Cover. Because of the slope differences, this will over-estimate sediment transport offsite, and will over-estimate depth of gullies formed. This will be included in the next version of the model and the report. Further erosion modeling needs will be evaluated after that model and report are reviewed.*"

ES also stated that: "*The impact of gullies on the dose assessment is minimal for the below-grade scenario.*"

REBUTTAL:

The PA must consider gully erosion and its effects on infiltration, radon emanation, and groundwater contamination. ES should ensure that the model includes an analysis of the effects of gully formation on cover system infiltration, radon emanation, and groundwater contamination. We look forward to reviewing this response when the revised ET cover report is available.

V1.2 CRITIQUE (ROUND 3):

Section 2.1, page 3, of the revised Erosion Modeling report (Appendix 10 to FRV1.2) states that: "*However, sheet erosion is not included in the Clive DU PA Model since the top slope of the cover is nearly horizontal and since the side slope will not have DU waste buried beneath it.*" However, the Executive Summary of FRV1.2, page 3, states that: "*The impact of sheet and gully erosion in the Model is evaluated by the application of results of landscape evolution models of hillslope erosion loss and channel development conducted for a borrow pit at the site.*" The documents should clarify whether or not sheet erosion is included in the Clive DU PA Model. As noted above, ES should ensure that the model includes an analysis of the effects of gully formation on cover systems infiltration, radon emanation, and groundwater contamination, as well as other factors such as changes in cover-system soil hydraulic conductivity over time.

REFERENCES:

Neptune and Company, Inc., *Erosion Modeling for the Clive PA*, May 28, 2011. (Appendix 10 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Erosion Modeling for the Clive DU PA Model, Clive DU PA Model v1.2*, NAC-0017_R1, June 5, 2014. (Appendix 10 to FRV1.2)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2,* NAC-0024_R1, June 5, 2014.

INTERROGATORY CR R313-25-8(4)(A)-71/1: BIOTIC PROCESSES IN GULLY FORMATION

Round 1 Interrogatory Response is satisfactory, provided that the results of the SIBERIA modeling are reflected in the radon flux and other dose models.

INTERROGATORY CR R313-25-8(4)(A)-72/1: DE MINIMIS DOSE VALUE

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES added the following text to Section 3.3.3, page 17, of the revised Dose Assessment report (Appendix 11 to FRV1.2):

> *Note that NRC was required under Section 10 of the Low-Level Waste Policy Amendments Act of 1985 to "establish standards for determining when radionuclides in waste streams were in sufficiently low concentrations or quantities as to be below regulatory concern, thereby potentially exempting them from NRC Low-Level Waste regulation" (NRC, 2007; NUREG-1853, Section 3.5). The* de minimus *risk level discussed above is in no way related to establishing concentrations or quantities "below regulatory concern" in disposed waste. Rather, this level is employed to support a methodology for meaningful evaluation of collective radiation dose in relation to the ALARA assessment endpoint of the Performance Assessment.*

However, NRC 2007 was not added to the reference list. Assuming that this minor editorial change is made, this interrogatory is closed.

INTERROGATORY CR R313-25-19-73/1: ALARA CONCEPT

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES revised Section 1.0, page 5, of the Decision Analysis report (Appendix 12 to FRV1.2) to incorporate International Commission on Radiological Protection (ICRP) Publication 101b (ICRP 2006):

> *The ALARA concept was first described in publication in ICRP (1973), following similar concepts that date back to ICRP publications at least as early as 1959 (ICRP, 1959). Updates have been provided by the ICRP in both 1977 (ICRP, 1977), and more recently in 2006 (ICRP, 2006). In this latest report, the ICRP*

> *focuses more on expanding the optimization process. This includes evaluating different relatively homogeneous population groups, stakeholder involvement in addressing receptor scenarios, site-specific evaluation of exposure, intergenerational equity, and many other aspects. The ICRP report provides a comprehensive list of factors that should be considered for optimization. However, the ICRP stops short of describing a methodology for implementation, even suggesting that full quantification of all relevant factors is not possible. However, with modern decision analysis methods this need not be the case (e.g., Keeney, 1992; Gregory et al., 2012). The Office of Management and Budget (OMB, 1992) also provides a road map for applying a decision analysis approach to policy analysis that could be adapted to PA. Another obstacle that is recognized in ICRP, 2006, is that lack of regulatory support for such an approach. However, the ALARA principle exists in both DOE and NRC regulations and guidance, decision analysis methods exist to implement the intended optimization, and there appears to be some traction now with both DOE and NRC regarding decision analysis methods for optimization, or ALARA.*
>
> *In terms of the ALARA analysis performed for the Clive DU PA, it does not achieve all that the ICRP calls for. This is primarily because the regulatory support for doing so does not clearly exist. However, as ICRP has made clear, this is an approach that will help focus decision-making on finding optimal solutions. To implement this approach to ALARA a paradigm shift is needed in the industry, starting with the regulators, so that the focus is on optimal use of the Country's limited disposal resources as opposed to somewhat arbitrary compliance decisions. ICRP (2006) recognizes this same need. For the current PA the approach has included evaluation of specific relatively homogeneous receptor groups, and has included a metric for evaluating potential costs for the simulated doses. It has not engaged many of the other recommendations of the ICRP.*

However, ICRP Publication 101b is not discussed in Section 2.0 of the report, although a discussion of DOE guidance (DOE 1997) was added. Nevertheless, we believe that the discussion of ICRP101b in Section 1 is sufficient. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-74/1: TAILORED DISCUSSION OF SENSITIVITY ANALYSIS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the expanded discussion.

V1.2 CRITIQUE (ROUND 3):

ES added Appendix 15(II) to more fully describe the output of the sensitivity analysis and provide more context when certain types of input (such as inventory) are not identified as sensitive. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(9)-75/1: BRANCHING FRACTIONS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES has added the reference to Section 11.0, page 57, of the revised Model Parameters report (Appendix 16 to FRV1.2) as proposed. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(10)-76/1: QUALITY ASSURANCE PROJECT PLAN SIGNATURE PAGE

Round 1 Interrogatory Response is satisfactory.

V1.2 CRITIQUE (ROUND 3):

Resolution of this interrogatory did not require any changes to FRV1.2. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(10)-77/1: QUALITY ASSURANCE PROJECT PLAN PAGE NUMBERING

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised plan.

V1.2 CRITIQUE (ROUND 3):

ES added page numbers to the Quality Assurance Project Plan (Appendix 17 to FRV1.2). Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(10)-78/2: GOLDSIM MODEL CALIBRATION

PRELIMINARY FINDING:

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

Refer also to R313-25-23(2): *The disposal site shall be capable of being characterized, modeled, analyzed and monitored.*

INTERROGATORY STATEMENT:

Describe the role of model calibration in substantiating that GoldSim adequately simulates the physical, chemical, and biological processes at the Clive site.

BASIS FOR INTERROGATORY:

The PA Quality Assurance Project Plan describes quality assurance for modeling services and the development of the GoldSim model. However, the only GoldSim model calibration appears to be that done to counteract numerical dispersion on air diffusion in Section 9.4.3, pages 55–56, of the Unsaturated Zone Modeling report. The Quality Assurance Project Plan should discuss the role that model calibration has taken in substantiating that GoldSim adequately simulates the physical, chemical and biological site processes. The purpose of the model calibration is to make sure that the model is simulating the actual field parameters correctly. For example, soil layer water content should be measured in the field and the assigned infiltration rate in the model should yield the measured water content.

ES RESPONSE:

In its response, ES explained why calibration was not conducted. It then went on to explain that "*global sensitivity analysis*" was used to check model results against expectations, stating that when model results do not match expectations, "*the sensitivity analysis will very quickly indicate that there is something not quite right, and the model is investigated for the unexpected results..…This cycle of model building and sensitivity analysis will continue throughout the PA Maintenance program.*"

REBUTTAL:

Since we could identify very little of this type of information within the published literature, it would provide some measure of confidence in the GoldSim DU PA model if ES provided DRC with documentation of any of the results of any "global sensitivity analysis" that has been performed on the GoldSim DU PA model. We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Quality Assurance Project Plan Performance Assessment Model Clive, Utah*, undated. (Appendix 17 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(10)-79/1: CRITICAL TASKS AND SCHEDULE

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES added completion dates to Table 2 on page 4 of the Quality Assurance Project Plan (Appendix 17 to FRV1.2). Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(10)-80/2: TESTING OF GOLDSIM ABSTRACTIONS

PRELIMINARY FINDING:

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site* *characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

Refer also to R313-25-23(2): *The disposal site shall be capable of being characterized, modeled, analyzed and monitored.*

INTERROGATORY STATEMENT:

Provide information on the verification and benchmarking exercises that were designed to test the GoldSim abstractions against results obtained from process-level analytical and/or numerical models.

BASIS FOR INTERROGATORY:

Appendix B, Section 2.6, page 8, of the PA Quality Assurance Project Plan provides a general description of model validation/verification and benchmarking. However, specific written information should be given on the verification and benchmarking exercises that were designed to test the GoldSim abstractions against results obtained from process-level analytical and/or numerical models. This should include, but not be limited to, all such testing results related to all of the simulated fate and transport pathways, input/output links to external models (e.g., HELP, atmospheric modeling), probabilistic components, and dose assessments.

ES RESPONSE:

In its response, ES stated the following:

> *Neptune uses a process for the model validation/verification and benchmarking described in this Interrogatory to test the GoldSim abstractions against results obtained from process-level analytical and/or numerical models. For the DU PA Model v1.0, model verification primarily consisted of reasonableness checking and did not include formal model benchmarking processes.*

REBUTTAL:

Since we could identify very little of this type of information within the published literature, it would provide some measure of confidence in the GoldSim DU PA model if ES provided DRC with documentation of any of the model validation/verification and benchmarking that Neptune has conducted. We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Quality Assurance Project Plan Performance Assessment Model Clive, Utah*, undated. (Appendix 17 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(2) AND 7(6)-81/2: COMPARISON OF DISPOSAL CELL DESIGNS

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

Refer to R313-25-7(6): *Descriptions of the construction and operation of the land disposal facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and ground water access to the wastes. The description shall also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances which might affect meeting the performance objectives of R313-25.*

INTERROGATORY STATEMENT:

Provide a detailed annotated comparison of (1) the design of the Class A South embankment design[5] described in FRV1 and upon which the DU PA dated June 1, 2011, was based, (2) the Division-approved Class A West embankment design discussed in the 2013 Compliance Report (Revision 1, 2013) and (3) the Federal Cell design now proposed for DU disposal. The comparison should include design features and design criteria that are common to the three cells, as well as those that are different among the three designs. The comparison should include such factors as physical dimensions, materials used, types of waste, infiltration rates, depth of waste burial, waste depth compared to native grade, design life of the cell, liner and cover system specifics and other assumptions used in groundwater modeling, such as soil layer porosity and permeability, soil/water partition coefficients (K_d values) and solubilities. Explain and justify why the Class A West Cell design is relevant and applicable to the new DU disposal cell to be constructed in the far southwest corner of Section 32.

Also explain and justify why current construction specifications and quality assurance/quality control requirements used at the Class A West Cell (or any other Clive disposal cell) have relevance to the DU PA, now that DU Waste disposal is to be examined for at least 10,000 years.

Provide a single, stand-alone engineering design report, including drawings and construction specifications, for the cell where DU waste will be disposed. Include detailed cross-sections to clearly identify the specific below-grade depth interval that the DU waste will occupy, as well as

[5] At a minimum, this would include both *Amendment Request Class A South/11e.(2) Embankment*, Revision 0, dated January 4, 2008 (Energy*Solutions* 2008), and *Class A South/11e.(2) Embankment Revised Application & Response to Completeness Review*, dated June 9, 2009 (Energy*Solutions* 2009).

design elevations for all pertinent site and disposal embankment features. If Energy*Solutions* plans to implement any evapotranspirative cover design for the DU cell, provide specific, discrete, and detailed engineering plans and specifications for the cell where this disposal will take place. Explain the current status in obtaining approval from DRC of an evapotranspirative cover design for the Class A West Cell.

Describe the types, forms, and locations of intruder barriers that will be provided for the DU waste in the disposal cell selected. Elaborate on how these barriers can and will endure across deep time periods (i.e., at least 10,000 years).

BASIS FOR INTERROGATORY:

Sections 1.2, 2.2, 2.3, 2.5, and 3.1.3 of the 2013 Compliance Report, Revision 1, and the Embankment Modeling report make frequent reference to the division-approved Class A West embankment and the fact that it is similar to the Federal Cell. By inference, the Federal Cell should perform the same as the Class A West embankment. For example, Section 1, page 1-1, of the 2013 Compliance Report, Revision 1, states the following:

> *As is illustrated in Figure 1-1, Energy*Solutions *has evaluated a new Federal Cell, using the Division-approved and licensed Class A West Embankment cover design, as the ultimate destination for the large volumes of depleted uranium.*

Although Energy*Solutions* speaks of a "*new Federal Cell, using the Division-approved and licensed Class A West Embankment cover design*," the licensee should make clear that no design has yet been submitted for the Federal Cell, and that, although the proposed Federal Cell may use a design for a cover that is similar to that approved for the Class A West embankment cell, no design for the Federal Cell embankment has yet been submitted to nor approved by DRC. The Federal Cell will have a different location, different dimensions, different geometry, different waste, and different waste containers within it as compared to the Class A West embankment cell. Moreover, its performance must be demonstrated for 10,000 years.

Energy*Solutions* should more explicitly identify proposed elevations, or heights above and depths below native grade. Depths given in the PA below the base of the top slope engineered cover are not sufficient for review when the elevation of the base of the top slope engineered cover is not given explicitly or clearly.

Section 1.3.2.3, page 1-16, of the 2013 Compliance Report, Revision 1, states, "*Since there is no change being proposed for construction of the Federal Cell for ultimate disposal of depleted uranium in the types of waste or necessary administrative controls that will be managed,…*." Energy*Solutions* should explain and justify this statement. The types of waste are considerably different.

Section 1.3.2.4, page 1-17, of the 2013 Compliance Report, Revision 1, refers to the Class A West Embankment and states, "*As such, this depleted uranium Performance Assessment model of a Federal Cell using the Division-approved Class A West Embankment cover design does not trigger the need to conduct additional stability analysis*." However, the nature, containerization and geometry of most of the DU waste and containers proposed for disposal in the Federal Cell are highly different from those of most other waste disposed of at the Class A West cell, and it may affect stability differently. Moreover, site dimensions differ. Energy*Solutions* should justify its claim using an appropriate stability analysis.

Section 1.3.2.5, page 1-17, of the 2013 Compliance Report, Revision 1, states, "*Part I.C.1 of the* [Ground Water Quality Discharge Permit UGW450005] *specifies that GWPLs shall be used for the Embankment.*" However, the permit does not refer directly to the Federal Cell embankment.

Section 2.1, page 2-1, of the 2013 Compliance Report, Revision 1, states that "*Depleted uranium waste will be disposed below native grade in the permanent near surface engineered disposal Federal Cell….*" Energy*Solutions* needs to also place below native grade radon protection layers, which would lie above the DU waste. Otherwise, destruction of the above-ground portion of the cell would simply provide for easier exposure to radioactivity from the DU waste.

Because information on the various designs is located piece-meal in several documents, it is not possible to develop a coherent view of the differences and similarities of the designs. This lack of transparency is further complicated by reference to an alternative evapotranspirative cell. It is not clear whether or not some of the favorable PA outcomes cited in the 2013 Compliance Report, Revision 1, are attributable to that alternative design.

ES RESPONSE:

In its response, ES provided a series of drawings for the Federal Cell to clarify its design and placement of significant quantities of DU therein. It also referred to the responses to Interrogatories CR R313-25-7(6)-84/1: Below-Grade Disposal of DU, and CR R313-15-1009(2)(B)(I)-158/1: Waste Packaging.

REBUTTAL:

None of the ES responses provided the requested comparison between the Class A West Cell and the Federal Cell cover designs. It is our belief that such a comparison of the structural design and expected performance of the cells with rock-armor and/or ET cover systems is needed to enable DRC to compare proposed and existing designs and ensure that the proposed designs comply with R313-25-7(2) and (6).

At present, only a rock-armor cover system has been approved for the Class A West cell, and the proposed ET cover system for that cell is undergoing DRC review and has not yet been approved. ES should compare the proposed Federal Cell with all alternative cover systems that have been proposed for the Class A West cell, or with an approved cover system only.

The proposed Federal Cell that contains the DU waste must have an approved design such that its cover system is fully integrated with, or completely isolated from, the existing 11e.(2) cover system, as appropriate, based on applicable federal and state laws and regulations. ES should show how the proposed ET cover system, based on soil, will be integrated with, or isolated from, the existing 11e.(2) rock-armor cover system. ES should describe how the design of that part of the Federal Cell containing DU waste will meet all potentially applicable DOE and NRC regulations, including types of wastes disposed of and connection, or lack of connection, with nearby waste cells, and also types of influence, or lack of influence, on or by other nearby waste cells, including the existing 11e.(2) cell.

At this time, DRC does not expect ES to provide a “stand-alone engineering design report,” as was requested in the original interrogatory. However, a more complete description of structural design and performance is requested, particularly in the design of features of the proposed cell contrasting with features of existing cells. We look forward to reviewing the revised information.

REFERENCES:

Energy*Solutions*, *Amendment Request Class A South/11e.(2) Embankment*, Revision 0, January 4, 2008.

Energy*Solutions*, *Class A South/11e.(2) Embankment Revised Application & Response to Completeness Review*, June 9, 2009.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model*, May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-20-82/2: LIMITATION ON INADVERTENT INTRUDER SCENARIOS

PRELIMINARY FINDING:

Refer to R313-25-20: *Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed.*

INTERROGATORY STATEMENT:

Explain and justify why the language of R311-25-7(8) limits the types of intrusion scenarios to be considered.

BASIS FOR INTERROGATORY:

Section 1.3.2.2, page 1-13, of the 2013 Compliance Report, Revision 1, states the following:

> *While an unlimited number of inadvertent intruder scenarios can be developed, Division requirements limit such developments to include, ‘Identification of the known natural resources at the disposal site whose exploitation could result in inadvertent intrusion into the wastes after removal of active institutional control.’ UAC R313-25-7(8).*

DRC does not agree with this interpretation of the regulation. The full section of R313-25-7, of which R313-25-7(8) is a sub-section, describes specific technical information that the applicant must provide: “*The following information is needed to determine whether or not the applicant* *can meet the performance objectives and the applicable technical requirements of R313-25:…."* Nothing in the regulatory language suggests that DRC plans to limit intrusion scenarios to those related to the exploration and exploitation of natural resources. Certainly, if there are known natural resources, DRC will likely wish to ensure the consideration of intruder scenarios involving their exploration and exploitation. More to the point, the definition of "inadvertent intruder" does not limit the DRC Director to only considering discovery and exploitation of natural resources. Instead, as stated in R313-25-2—

> Inadvertent intruder *means a person who may enter the disposal site after closure and engage in activities unrelated to post closure management, such as agriculture, dwelling construction, or other pursuits which could, by disturbing the site, expose individuals to radiation.*

Hence, the emphasis is not only on natural resources but also on human activities and pursuits at the disposal site after facility closure.

We agree that the inadvertent intruder requirements in the rules of the NRC and Utah DRC are in some ways confusing and open to interpretation. The NRC staff has also acknowledged the confusion and attempted to add clarity in several writings, including in SECY-08-0147 (NRC 2008):

> *…since the requirement to conduct an inadvertent intruder analysis similar to that conducted to develop the § 61.55 waste classification tables is not specifically identified in Part 61 and may not be well understood.… applicants or licensees could misinterpret the regulations to only require compliance with the concentration limits in the waste classification tables for ensuring protection of the intruder….* [p. 6]

> *At the time of development of Part 61, it was envisioned that LLW in a disposal facility would decay, in a maximum of 500 years, to activity levels that would not pose a significant risk to an inadvertent intruder, and that there would not be significant quantities of long-lived isotopes which would pose unacceptable long-term risks to the public from releases from the facility.…The disposal site included a buffer zone around the disposal area, where the disposal area circumscribed the disposal units (NRC, 1982). An appropriate buffer zone was expected to extend approximately 100 m (330 feet [ft]) from the disposal area, although buffer zones up to 1,000 m (3,300 ft) were considered.* ***A receptor engaging in activities on the disposal site, rather than outside the buffer zone, was regarded as the inadvertent intruder. A receptor engaging in activities at the edge of the buffer zone was regarded as a member of the public.*** [Enclosure 1, p. 4; emphasis added]

We also acknowledge that the NRC is currently revising 10 CFR Part 61 and that upon completion of that effort there may be better clarity in what constitutes the "inadvertent intruder" and how to best protect that person(s). In the meantime, we suggest that the Division and Energy*Solutions* meet to discuss this issue in detail and establish a path forward.

ES RESPONSE:

In its response, ES took the position that inadvertent intruder scenarios are limited by UAC-25-7(8) to those related to known natural resources.

REBUTTAL:

As described in the discussion of Interrogatory CR R313-25-8(4)(b)-07/2: Applicability of NRC Human Intrusion Scenarios, and Interrogatory CR R313-25-20-12/2: Selection of Intrusion Scenarios, we do not accept that position. ES must provide arguments as to why the proposed inadvertent intruder scenarios should not be included, or else include them in the DU PA. We look forward to reviewing the revised report.

REFERENCES:

Code of Federal Regulations, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

U.S. Nuclear Regulatory Commission, *NRC Response to Commission Order CLI-05-20 Regarding Depleted Uranium,* SECY-08-0147, October 7, 2008.

INTERROGATORY CR R313-25-20-83/2: INTRUDER-DRILLER AND NATURAL RESOURCE EXPLORATION SCENARIOS

PRELIMINARY FINDING:

Refer to R313-25-20: *Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed.*

INTERROGATORY STATEMENT:

Explain why a lack of subsurface mineral resources renders the intruder-driller scenario inapplicable. Evaluate inadvertent intrusion at locations within the facility's buffer zone and determine all exposure pathways and doses to a member of the public.

Explain the reason for excluding the intruder-driller scenario from this PA, taking into account the fact that the guidance in NUREG/CR-4370 refers to an intruder drilling for water, not mineral resources, and the fact that such a scenario was included in a prior site-specific PA.

BASIS FOR INTERROGATORY:

Section 1.3.2.2, page 1-14, of the 2013 Compliance Report, Revision 1, states, "*However, lacking the precursory subsurface mineral resources (NRC 1986, Section 4.2.1), the intruder-driller scenario is inapplicable to the Federal Cell*." The text refers to NUREG/CR-4370 (NRC, 1986) as the basis for the argument for inapplicability. However, the intruder-driller scenario as described in NUREG/CR-4370, Section 4.2.1, refers to a scenario that involves drilling for water; it is not related to subsurface mineral resources:

> *It is assumed in this scenario that, some time after the end of operations at the disposal facility, institutional controls temporarily break down and an intruder inadvertently decides to have a house built on the disposal facility. In order to do so, however, he must first install a well to secure an adequate supply of water for his living needs.*

This discrepancy with the argument given in the 2013 Compliance Report needs to be explained or corrected.

In addition, the intruder-driller scenario was included in a prior PA submitted by Energy*Solutions* related to waste disposal at the Clive Facility (October 8, 2012). That report stated the following:

> *That potable groundwater is not present below the floor of the Great Salt Lake Desert where the disposal site is located is common knowledge today. However, there is a very remote but finite chance that someone in the future might drill a well to determine whether potable groundwater exists at the Clive, UT site. Even if this were to occur, it is also highly unlikely that a drilling rig would be sited upon the rip rap cap of the embankment, rather than on the flat-lying landscape surrounding the disposal facility. Nevertheless, the initiating scenario of intruder-drilling suggested as an example in NRC (1986) is evaluated in the IHI dose assessment*. [Appendix B, p. 23]

An explanation should be provided for excluding the intruder-driller scenario from this PA, when it was included in a prior related PA. The analysis should also include the exploitation of other natural resources that may be available near the disposal site. At a minimum, it should evaluate inadvertent intrusion at locations within the facility's buffer zone and determine all exposure pathways and doses to a member of the public.

Furthermore, the Federal Cell geology is similar to the geology of the rest of the site, which contains valuable clay and sand used in construction of waste cells for the facility. These are of great value to the facility as they prevent a need to import similar construction materials from a distance and thus materially reduce costs. Workers at the Utah Test and Training Range have dug for and have used local native soils for disposal at Landfill No. 5 and for other applications. Clean Harbors Grassy Mountain Facility, north of the Clive low-level waste disposal facility, uses local native soils for various purposes. Intruders on the Clive site in the future may likewise dig for clay and/or sand for a variety of purposes, possibly including disposal of waste or creating basements for buildings. Thus, the assumption that the Federal Cell's geology holds no mineral resources of value is not accurate.

The site also contains natural resources other than minerals. Saline water is a potentially valuable resource, in that it can help grow beneficial halophytic plants or algae for cooking oils, and may contain minerals of value, such as lithium. Sunshine in the West Desert is also an important natural resource in great abundance at the site. It may be harvested in the future, such as to create large amounts of solar energy at solar farms in and about the Clive area. Solar farms are currently being implemented throughout the country, including nearby areas in the region. It is reported, for example, that a massive solar farm is currently being planned in the region at a location near Delta, Utah (see, for example, Maffly 2013).

The fact that the Federal Cell's current practices and county zoning limit use of the area to industrial purposes means that the site can indeed be used for industrial purposes, even if someone in the future happens to be aware of the zoning laws, and if they are still enforced. Thus, an inadvertent intrusion scenario related to industrial use should therefore be developed.

Recreational pursuits can also be considered, but these are not believed to be nearly as likely to cause significant, chronic dose to inadvertent intruders as the intruder-industrial or the intruder-resource-user scenarios, which need to be analyzed in the PA.

ES RESPONSE:

In its response, ES referred to its response to Interrogatory CR R313-25-8(4)(b)-07/1: Applicability of NRC Human Intrusion Scenarios.

REBUTTAL:

ES did not explain why drilling to explore for water had been included in a previous PA (Energy*Solutions* 2012) based on "*a very remote but finite chance that someone in the future might drill a well to determine whether potable groundwater exists at the Clive, UT site*," but was excluded here. ES also did not address the possibility of mineral exploration. Additional findings relevant to this topic are found in the discussion of Interrogatory CR R313-25-8(5)(a)-29/2: Limitation to Current Conditions of Society and the Environment. ES needs to address these issues as well as those found in Interrogatory CR313-25-8(4)(b)-07/2 before this interrogatory can be closed. We look forward to reviewing the revised report.

REFERENCES:

Energy*Solutions*, *Utah Low-Level Radioactive Material License (RML UT2300249) Updated, Site Specific Performance Assessment*, October 8, 2012.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Maffly, Brian, *Massive solar farm to be planted near Delta*, The Salt Lake Tribune, September 19, 2013, access at www.sltrib.com/sltrib/news/56893328-78/state-energy-solar-utah.html.csp.

U.S. Nuclear Regulatory Commission, *Update of Part 61 Impacts Analysis Methodology*, NUREG/CR-4370, Volume 1, *Methodology Report*, January 1986.

INTERROGATORY CR R313-25-7(6)-84/3: BELOW-GRADE DISPOSAL OF DU

Refer to R313-25-7(6): *Descriptions of the construction and operation of the land disposal facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder* *barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and ground water access to the wastes. The description shall also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances which might affect meeting the performance objectives of R313-25.*

Refer also to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Explain how Figure 1-2 demonstrates that the entire inventory of DU can be disposed below grade. Provide calculations demonstrating that below-grade disposal will be achieved in the Federal Cell and that the burial depth is sufficient to protect the DU waste.

Indicate the drum/cylinder dimensions and orientation after placement on the respective waste lifts. Indicate the container packing arrangement (e.g., cubic, rhombic, octhahederal) and the minimum, maximum, and average distance that will be left between DU containers. Explain how a degraded embankment would continue to adequately control radiation dose to a member of the public and describe the types, forms, and locations of intruder barriers and how they will endure for a period of 10,000 years or more.

BASIS FOR INTERROGATORY:

Section 1, page 1-3, of the 2013 Compliance Report, Revision 1, states the following:

> *…depleted uranium will be disposed below grade to enhance assurance of continued isolation under geologic-time events such as the return of a large lake inundating Clive. Figure 1-2 below demonstrates that the entire depleted uranium inventory evaluated can be disposed in such a manner.*

Figure 1-2, page 1-4, shows that the below-grade capacity of the Federal Cell is 44,712 DU cylinders (21,962 cylinders in a single layer and 22,750 cylinders in a double layer). However, Table 1 of the Waste Inventory report indicates that 57,122 cylinders are available for disposal, and the B&W Conversion Services deconversion Web site states that more than 63,000 cylinders are stored at Paducah and Portsmouth. These values are higher than the Federal Cell capacity of 44,722 cylinders cited in Figure 1-2.

The report should indicate the drum/cylinder dimensions and orientation after placement on the respective waste lifts. It should also indicate the container packing arrangement (e.g., cubic, rhombic, octhahederal) and the minimum, maximum, and average distance that will be left between DU containers.

In addition, Table 1 of the Embankment Modeling reports an average original grade elevation of 4,272 feet above mean sea level and an average elevation at the bottom of the waste of

4,264.17 feet above mean sea level. Thus, the distance from the original grade to the bottom of the waste is 7.83 feet (4,272-4264.17). Figure 1-2 of the 2013 Compliance Report, Revision 1, shows that a double stack of DU cylinders is 7.3 feet high. This means that the double stack of DUF_6 cylinders would be only a few inches below grade. Energy*Solutions* should indicate whether this very small increment is consistent with its definition of below grade, and justify whether that small amount of below-grade cover will prevent the DU waste from being impacted by an encroaching pluvial lake, or prevent excessive radiological exposure to a receptor located above the cover (e.g., in a houseboat).

Energy*Solutions* should also explain and justify how, after an erosion event has occurred and the pluvial lake has receded, the degraded embankment would continue to adequately control radiation dose to a member of the public. At a minimum, this analysis must include evaluation of the degraded radon controls, prevention of stormwater erosion, and increased infiltration and contaminant leachate discharges to groundwater.

Energy*Solutions* should also describe the types, forms, and locations of intruder barriers that will be provided for the DU waste in the disposal cell selected. Detail should be provided on how these barriers can and will endure across deep time periods of at least 10,000 years.

ES RESPONSE:

In its response, ES stated the following:

> *In order to address the current round of interrogatories, the model is being revised to replace the rip-rap cover with an ET cover. This will have a significant effect on infiltration (lowering infiltration) so that disposal of DU below grade is not expected to adversely impact groundwater. In addition, an erosion model is being included that addresses both sheet and gully erosion based on the properties of the ET cover. Upon this evaluation, a more informed response can be provided concerning the potential effects of erosion on waste buried below grade…. The aeolian deposition rates should be considered as part of the relatively near-term erosion modeling and the deeper time modeling. In both cases the* [Aeolian] *deposition seems likely* [to] *enhance site stability.*

ES also stated the following:

> *NRC has confirmed that depleted uranium, even in significant quantities, is Class A LLRW. Thus, there is no requirement for an intruder barrier, let alone a demonstration that it could persist for 10,000 years or more.*

REBUTTAL:

We look forward to reviewing the new material on the cover system discussing its potential impacts on infiltration and groundwater, and the potential effects of erosion on below-grade disposal and on the effects of aeolian deposition on near-term and deep time modeling. ES should ensure that these revisions are consistent with and resolve other related DEQ concerns in Interrogatories CR R313-25-8(5)(a)-18/2: Sediment Accumulation and CR R313-25-8(4)(d)-159/2: Embankment Damage by Lake Formation.

In response to the request under this interrogatory to "*describe the types, forms, and locations of intruder barriers,*" ES responded that "*there is no requirement for an intruder barrier,…*" and did not provide additional information. However, in response to a similar question in Interrogatory CR R313-25-8(4)(b)-07/1: Applicability of NRC Human Intrusion Scenarios, ES responded that the "*intruder barriers of Energy*Solutions *Federal Cell are the same as its licensed Low Level Radioactive Waste Disposal facility, which are those defined in UAC R313-25-2….*" ES should clarify these apparent conflicting statements. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES contends that there is no requirement for an intruder barrier, let alone one that will last for 10,000 years. The latter is, in fact, not required. However, intruder barriers, coupled with natural soil and groundwater conditions, must be such so as to prevent doses to the general public above standards over a 10,000-year period, based on UAC R313-25-9(5)(a).

Barriers for wastes do degrade over time. Concrete, for example, may only last decades to centuries. Yet some radionuclides last much longe than concrete. For example, Tc-99 has a half-life of over 200,000 years. Defense against undue radioactive exposure to inadvertent intruders and other members of the general public over the long-term future may involve such factors as design of embankments and selection of surrounding site hydrogeological conditions, which may be more important in the long run than specific containers used as intruder barriers.

DU and associated waste as proposed for disposal in the Federal Cell contain radionuclides that will increase in concentration over time, ultimately even beyond Class B and C limits. This was not considered when NRC devised the Draft Environmental Impact Statement for 10 CFR Part 61, which created the radioactive waste classification system over 30 years ago. Rather than provide definitive statements as to whether DU waste can be disposed of, NRC has left this issue up to individual states to decide. Therefore, with this unanalyzed condition at hand, it becomes important for the State of Utah to pay close scrutiny to whether or not disposal of blended and processed waste under the cover system proposed may pose any hazards that need to be addressed. Development of a rigorous PA, supported fully by available scientific and engineering knowledge, is therefore required.

ES errs in assuming that regulations do not require that Class A waste be disposed of with intruder barriers. UAC R313-25-8(6) specifies that minimum requirements for disposal of radioactive waste include designs for types of intruder barriers that the Licensee will be constructing. The definition of intruder barrier is given in UAC R313-25-2:

> "Intruder barrier" *means a sufficient depth of cover over the waste that inhibits contact with waste and helps to ensure that radiation exposures to an inadvertent intruder will meet the performance objectives set forth in R313-25, or engineered structures that provide equivalent protection to the inadvertent intruder.*

The DRC staff does not find adequate justification by ES that a minimum of 4.5 feet of cover (as proposed in the PA) above the temporary cover provides "*a sufficient depth of cover over the waste that inhibits contact with waste and helps to ensure that radiation exposures to an* *inadvertent intruder will meet the performance objectives set forth in R313-25*." Greater depth of cover at the embankment than currently proposed is needed in order to meet site-specific performance objectives, including prevention of excessive radioactive doses to inadvertent intruders and other members of the general public.

REFERENCES:

B&W Conversion Services, LLC, *The DUF6 Process*, accessed January 3, 2014. (www.bwconversionservices.com/our-process)

Code of Federal Regulations, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model*, May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(A)-85/1: UNCERTAINTY DISTRIBUTIONS ASSIGNED TO DOSE CONVERSION FACTORS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES added the text provided under the heading "Brief Review of Relevant Literature" in the response to Round 1 Interrogatories to Section 3.4.3, pages 21–22, of the revised Dose Assessment report (Appendix 11 to FRV1.2). Although Section 3.4.4, page 26, does not appear to have been modified, the new information provided in Section 3.4.3 is adequate. Changes similar to those proposed were made to Section 4.4, pages 30–31, of the Dose Assessment report. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(5)(A)-86/3: CONSEQUENCES OF SEDIMENTATION ON DISPOSAL CELL

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such* *performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

The deep time assessment needs to consider the relative rates of progeny in-growth and pluvial lake sedimentation. It should be determined if there are points in time when individual exposures can be greater than at the time of peak activity, due to the influence of sedimentation on reducing surface concentrations of contamination or of wavecutting increasing access to waste and doses received by receptors.

BASIS FOR INTERROGATORY:

FRV1 Section 4.1.2.13, page 42, asserts that "*Overall sediment concentrations decrease over time because the amount of waste does not change other than through decay and ingrowth, whereas more sediment is added over time*." This statement is misleading. In-growth of uranium progeny is an important consideration that was not included in the deep time assessment. The PA should qualitatively discuss relative rates of radionuclide in-growth and net sediment accumulation over long periods of geologic time (e.g., until peak doses are attained for all radionuclides potentially having a human health consequence, which may be longer than 1 My years). The PA should also assess how geological changes through time may affect net rates of sediment accumulation (considering relative rates of sediment erosion as well as deposition). At the time that wave action cuts into the embankment, some or all of the low-level waste (including DU) in the embankment or in wave-cut sediments may be present in a form that has relatively high concentrations of progeny and that allows for human exposure prior to the redistribution of sediment throughout the lake. Human exposure during this intermediate time is not analyzed in the model or text. This scenario needs to be considered in the model and documented in the text.

ES RESPONSE:

In its response, ES focused on the time frame that individual doses are evaluated (i.e., 10,000 years), and on the conceptualization for the mixing of sediments in the deep time assessment.

REBUTTAL:

ES did not address expanding the current limited deep time model to address "other" exposure pathways. Such pathways include wave-cutting increasing access to waste, which could occur if waves were to remove the top portion of the embankment, followed by retreat of the lake, leaving non-dispersed DU exposed. ES should construct a PA analysis scenario to simulate possible dose effects for this situation.

V1.2 CRITIQUE (ROUND 3):

In its responses to Round 2 Interrogatories (Energy*Solutions* 2014), ES stated that with "*the current disposal configuration placing all depleted uranium waste below grade, the dispersal mechanisms previously considered in the Deep Time component of version 1.0 of the Model are no longer applicable*." This statement only strengthens the argument for evaluating additional pathways. For example, a lake removes the entire embankment but leaves the below-grade DU in place. Although some sediment would cover the DU, it would not be as thick or as robust as the embankment. Thus, an individual who stands on the sediment directly above the DU would be exposed at a much higher level than an individual who stands on top of the embankment.

REFERENCES:

Energy*Solutions*, *RML UT2300249 – Condition 35 Compliance Report Responses to Round 2 Interrogatories*, June 17, 2014.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R315-101-5.3(6)-87/2: ORAL TOXICITY PARAMETERS

PRELIMINARY FINDING:

Refer to R315-101-5.3(6): *Identification of toxicity information gathered for all identified hazardous constituents for carcinogenic, slope factors and weight-of-evidence classification, noncarcinogenic effects, chronic reference doses (RfDs) and critical effects associated with RfDs from, in order of preference, the Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, Environmental Criteria and Assessment Office (ECAO), or other scientifically accepted listings. The source and date of the toxicological information must be identified and be acceptable to the Director.*

INTERROGATORY STATEMENT:

The approach used in the Dose Assessment report with regard to oral toxicity should be revised based on the established drinking water standard for uranium and a review of recent literature on hazards from uranium ingestion. The report should also explain how the oral toxicity factors used in the PA were derived, as they may understate risk.

BASIS FOR INTERROGATORY:

As is noted in Section 3.4.5, page 25, of the Dose Assessment report, the term "*proof-of-principle exercise*" relates to the potential non-radiation-related toxicity of DU. EPA published oral toxicity criteria for natural uranium in relation to the Superfund Program (EPA, 2002) and in relation to drinking water standards (EPA, 2000). Given the five-fold difference between these criteria, the DU PA employed both to determine the sensitivity of uranium health effects results to differences in these criteria. Specifically, Table 1 of the Dose Assessment report indicates that a discrete distribution was used as input for this parameter, where 50% of the realizations were assigned an oral RfD of 0.0006 mg/kg-day and 50% were assigned 0.003 mg/kg-day.

It is noteworthy that the drinking water standard for uranium is 30 µg/L (EPA, 2000). The Dose Assessment report should explain how it derived a drinking water standard expressed as 0.003 mg/kg-day. Assuming a 70-kilogram adult drinks 2 liters per day, the maximum contaminant level (MCL) for uranium of 30 µg/L is converted into units of mg/kg-day as follows:

$$30\ \mu g/L \times 1E\text{-}3\ mg/kg \times 2\ L/day \div 70\ kg = 8.5E\text{-}4\ mg/kg\text{-}day$$

This calculation yields lower results than cited in EPA's drinking water standards (R317-6-2, Table 1).

Inspection of the IRIS Web site (EPA, 2002) reveals that Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997 and that, as of December 1998, EPA was reassessing uranium under the IRIS program. Hence, the MCL is the EPA standard currently applicable for the control of exposures to uranium in drinking water, which includes consideration of both the chemical and radiological toxicity of uranium ingestion. Since the radiological risks associated with uranium are explicitly addressed elsewhere in the PA, the question is whether the discrete distributions delineated in Table 1 of the Dose Assessment report represent a valid characterization of the uncertainty in the non-radiological risks associated with the ingestion of uranium in the form of DU oxide in water (and presumably food).

A vast body of literature has been compiled on the chemical toxicity of DU, especially following the Persian Gulf War in 1990–1991, where DU munitions were introduced into the battlefield in a significant way (Briner, 2010). Briner (2010) cites nearly 400 authoritative reports that address the toxicity of DU as of the time of publication of his article in the *International Journal of Research in Public Health*. The article emphasizes the inhalation of fine airborne particles of DU and not DU in drinking water. However, the article and the literature cited in the article address the chemical toxicity of DU once it is absorbed into the bloodstream, and the article does cite literature where rats were administered DU in drinking water. The article provides a detailed description the toxic effects of both acute and chronic uptakes of DU, which are not repeated here. However, it is worth noting that chronic low uptakes of DU that do not produce classic signs of renal toxicity and failure are suspected of producing other detrimental effects as a result of protracted low-level exposures at subclinical levels, similar in many respect to exposure to lead. For example, exposures to pregnant experimental animals at levels that were not observed to cause renal damage resulted in neurodevelopmental effects, smaller litter size, small offspring, increased offspring mortality, skeletal abnormalities, and a number of behavioral changes indicative of neurodevelopment effects.

In light of the extent of the relatively recent published literature, it might be prudent to survey the published literature to confirm that the non-radiological effects associated with chronic intakes of DU are bounded by the drinking water standards as adopted for use in the PA. Also, it appears that the discrete distributions adopted in the PA for uranium non-radiological toxicity are somewhat arbitrary and require reconsideration. Since IRIS does not currently report a value for oral toxicity, the approach taken in the Dose Assessment report of equal weighting of IRIS data and the drinking water standards is questionable and understates the oral toxicity risk.

ES RESPONSE:

In its response, ES provided a detailed discussion of the sources of RfD for uranium toxicity. ES also stated that: "*Since the ingestion of groundwater is not a dose pathway, the dose assessment report is correct.*"

REBUTTAL:

The discussion of RfD for uranium toxicity provided by ES is adequate. However, we do not agree that ingestion of groundwater is not a pathway. See, inter alia, Interrogatory CR R313-25-8(4)(a)-96/2: Current and Future Potability of Water.

REFERENCES:

Briner, W., *The Toxicity of Depleted Uranium*, Int. J. Res. Public Health, Vol. 7, No. 1, pp. 303–313, January 25, 2010.

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Integrated Risk Information System*, Office of Research and Development and National Center for Environmental Assessment, Electronic Database, entry for Uranium, natural (CASRN 7440-61-1), available online at www.epa.gov/iris/subst/0259.htm, last updated August 9, 2002, accessed January 16, 2014.

U.S. Environmental Protection Agency, *National Primary Drinking Water Regulations; Radionuclides; Final Rule*, Federal Register, Volume 65, No. 236, December 7, 2000.

INTERROGATORY CR R313-25-20-88/2: COLLECTIVE DOSE AND ALARA

PRELIMINARY FINDING:

Refer to R313-25-20: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

INTERROGATORY STATEMENT:

Confirm that the population (collective) doses over 10,000 years presented in FRV1 Table 11 are not in error, underestimating those doses by about a factor of 10. If the doses are correct, explain and justify why it should stand as written.

BASIS FOR INTERROGATORY:

FRV1 Section 6.4, Section 3 of the Dose Assessment Report, and Section 2 of the Decision Analysis report analyze compliance with 10 CFR 61.41 with respect to the requirement that "*Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*" The analysis describes (1) the regulatory requirements and guidelines pertaining to an ALARA analysis of the design and operation of the facility, (2) the criteria used in the PA for judging compliance with cost/benefit criteria used to perform an ALARA analysis (i.e., $1,000 per person rem averted), (3) the methods used to perform such an analysis, and (4) the calculation of the collective dose over a 10,000-year time period. The PA appropriately addresses the applicable regulatory requirements and guidelines, selects an appropriate cost/benefit criterion, and uses appropriate mathematical models and assumption to derive collective doses. The detailed analysis in the PA provides a high level of assurance that the doses are very small. However, the actual quantitative analysis of the collective doses, expressed in units of person rem, appears to have underestimated dose by about a factor of 10. It appears that a calculation error has been made, and the values for the population (collective) doses over 10,000 years, as provided in FRV1 Table 11, page 76, should be re-evaluated.

ES RESPONSE:

In its response, ES stated that: "*It is acknowledged that an error was made in calculation of collective doses. This error is being addressed in the next version, and is being coupled with the revised ET Cover design that is being incorporated into the next revision (hence all values will change, and will be reported correctly.*"

REBUTTAL:

The ES response commits to resolve this issue in the next report revision. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES corrected the error that had been made in the calculation of the collective doses in FRV1.2 Section 6.4. Therefore, this interrogatory is closed.

REFERENCES:

Code of Federal Regulations, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Neptune and Company, Inc., *Decision Analysis Methodology for Assessing ALARA Collective Radiation Doses and Risks*, May 30, 2011. (Appendix 12 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2*, NAC-0024_R1, June 5, 2014.

INTERROGATORY CR R313-25-7(9)-89/3: CONTAMINATION LEVELS IN DUF_6

PRELIMINARY FINDING:

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal.*

INTERROGATORY STATEMENT:

Review the basis for setting contamination levels in the DU PA and consider the substantial amount of contamination information available from the GDPs in lieu of surrogate data based on DU from SRS. Direct particular attention to contamination remaining in the heels of the DUF_6 cylinders. Describe in the PA how Energy*Solutions* will ensure that the cylinders shipped to Clive do not contain contaminated heels resulting from introduction of recycled uranium into the GDP process streams.

Revise the PA report to do the following:

1. Incorporate the new technical literature information for nuclide activity in the GDP DU waste.
2. Explain and justify why the already buried nuclear inventory for Clive was not included in the DU PA model, as required by R313-25-8(5)(a).

BASIS FOR INTERROGATORY:

In the DU PA, contamination in the DUF_6 associated with recycled uranium processed through the GDPs was estimated using surrogate assays from DUO_3 produced at SRS. Based on information specifically from the GDPs, it appears that the contamination in the DUF_6 and its containment cylinders may have been significantly underestimated.

Table 1 of the Waste Inventory report assumes that there were 686,500 MT of DUF_6 stored in 57,122 cylinders at the GDPs, based on information available from the Depleted Uranium Hexafluoride Information Network (DOE 2014). On page 24, the report further assumes that between 1,946 and 2,619 cylinders contained contamination from recycled uranium, based largely on information derived from Henson (2006). Figure 6 indicates that the number of contaminated cylinders was assigned a normal distribution, with the 1^{st}, 50^{th}, and 99^{th} percentiles being 1,946, 2,266 and 2,619 cylinders, respectively.

The Tc-99, plutonium, and Np-237 contents of the contaminated DUF_6 stored at the GDPs were assumed to be the same as the contaminated DUO_3 from SRS. Using several sets of assays of the SRS DUO_3, Table 5 shows a mean Tc-99 concentration of 23.8 nCi/g U for the contaminated oxide. Table 6 shows a mean Np-237 concentration of 5.68 pCi/g U and a mean plutonium (Pu-238, Pu-239, Pu-440, and Pu-241) concentration of 5.87 pCi/g.

The specific activity of Tc-99 is 1.7E-02 Ci/g (IEM 2014) or 1.7E+07 nCi/g Tc-99. Thus, the mean Tc-99 concentration in the contaminated cylinders would be 13.9 E-07 g Tc/g U (23.8 nCi/g U ÷ 1.7 E+07 nCi/g Tc). The average mass of uranium in a cylinder is 8.17 MTU (686,500 x 238/352 MTU ÷ 57,122 cylinders). If the mean estimate is 2,266 contaminated cylinders, then the mean total amount of Tc-99 in the DUF_6 inventory would be 25,700 g Tc (2,266 × 8.17 MTU × 10^6 g U/MTU × 13.9 E-07 g Tc/g U) or 25.7 kg Tc-99. Expressed in total activity of GDP DU waste to be shipped to Clive, over the coming years, this would equate to a total of 436.9 Ci Tc-99 to be disposed.

The specific activity of Np-237 is 6.9E-04 Ci/g Np (IEM 2014) or 6.9 E+08 pCi/g Np, fixing the neptunium concentration at 0.82 E-08 g Np/g U (5.68 pCi/g U ÷ 6.9 E+08 pCi/g Np) or 8.2 parts per billion (ppb). The total Np-237 inventory would be 152 g (2,266 × 8.17 MTU × 10^6 g U/MTU × 8.2 E-09 g Np/g U).

Based on the mix of plutonium isotopes in Table 6 and their specific activities, the total mass of plutonium is 0.4 g.

However, the DU PA did not consider, for example, a study by Hightower et al. (2000) characterizing the contamination in DUF_6 cylinders from processing at the GDPs. Information in Table C.2 of Appendix C to that report indicates that approximately 98,400 MTU as recycled UO_3 was delivered to the GDPs. Of this, about 95,600 MT UF_6 was fed into the cascades. Included in the recycled uranium was 872 kg of Tc-99 delivered to the UF_6 feed preparation facilities at the GDPs, of which 804 kg were delivered to the cascades, 709 kg were fed into the cascades, and 95 kg remained in the cylinder heels. Table 1 provides details on the composition of the feed cylinder heels (Hightower et al. 2000, Appendix C, Table C.6).

Table 1. Estimated Upper Bound Quantities of Pu-239, Np-237, and Tc-99 Remaining as Heels in Reactor Returns Feed Cylinders

Plant	Pu (g)[a]	Np (kg)[b]	Tc (kg)[c]
ORGDP	21	0.73	21
PGDP	2.9	11.1	57
PORTS	No data	No data	17
Total	24	11.8	95

a – 99.9% of Pu remains in feed cylinder
b – 60% of Np remains in feed cylinder
c – 20% of Tc remains in feed cylinder

Hightower et al. (2000) (Appendix C, Table C-9, page C-9) concluded that the **bounding** concentrations for these contaminants based on the limits of detection in the DUF_6 tails were as follows:

- Pu – 0.01 ppb U
- Np – 5 ppb U
- Tc-99 – 10 ppb U

Conservatively assuming that each of the contaminants is at the bounding concentration, Table 2 presents the estimated quantities in the heels and in the DUF_6 tails. Note that the plutonium content is in grams, while the Np-237 and Tc-99 contents are in kilograms.

Table 2. Contaminants in DUF_6

DUF_6 (MT)	Tc-99 in Heels (kg)	Tc-99 in DUF_6 (kg)	Np in Heels (kg)	Np in DUF_6 (kg)	Pu in Heels (g)	Pu in DUF_6 (g)
95,600	95	0.65[a]	11.8	0.33	24	0.65

a – 95,600 MT DUF_6 × 238/352 MTU/MT DUF_6 × 10 parts Tc/10^9 parts U × 10^3 kg/MT = 0.65 kg

As shown in Table 3, the quantity of Tc-99 estimated in Table 2 is a factor of 3.7 higher than that used in the DU PA ([95 kg in heels + 0.65 kg in DUF_6] ÷ 25.7 kg in DU PA). If the DUF_6 cylinders are cleaned as part of the de-conversion process, then it should be possible to substantially reduce the mass of the heels. Results of tests when washing the cylinders with an acidic solution indicated that contamination in the rinse solution was reduced by factors of 400–500 after four rinses (Hightower et al. 2000, Appendix C, page C-7).

Table 3. Contaminants in DU PA Versus Contaminants Based on Hightower et al. (2000)

Contaminant	DU PA	Hightower	Hightower w/o heels
Tc-99 (kg)	25.7	95.65	0.65
Np-237 (kg)	0.15	12.1	0.33
Pu (g)	0.4	24.6	0.65

However, current practice at the de-conversion plants is **not** to wash the emptied tails cylinders but rather to add potassium hydroxide to neutralize the heels. The neutralized residue is left in the cylinder and any liquid is assumed to absorbed in the de-converted uranium oxide.

If the heels are eliminated by washing, then Tc-99 would be reduced by a factor of 40 as compared to the DU PA, but Np-237 would still be a factor of 2 higher than the value in the DU PA and the plutonium would be a factor of 1.6 higher.

The quantities of contaminants listed in Table 3 above from the DU PA include only those contaminants from the GDPs. Table 4 below estimates the contaminants in the drummed SRS UO_3 already stored at Clive based on the following assumptions:

- Number of drums – 5,408
- Mass of SRS DUO_3 – 3,577 MT (2,977 MTU)
- Tc-99 activity concentration – 23,800 pCi/g
- Np-237 activity concentration – 5.68 pCi/g
- Pu activity concentration – 5.87 pCi/g

Table 4. Mass of Contaminants in SRS DUO_3

Contaminant	Activity Concentration (pCi/g U)	Mass of SRS UO_3 (MTU)	Specific Activity (pCi/g)	Mass of Contaminant (g)
Tc-99	23,800	2,977	1.7E+10	4,196
Np-237	5.68	2,977	6.9E+08	24.7
Pu	5.87	2,977	various	0.07

Note that all calculated masses in Table 4 are in grams. Comparing Tables 3 and 4, it can be seen that the SRS DUO_3 accounts for about 16% of the total Tc-99 mass included in the DU PA modeling.

Energy*Solutions* should revise the PA report to (1) incorporate the new technical literature information for nuclide activity in the GDP DU waste and (2) explain and justify why the already buried nuclide inventory for Clive was not included in the DU PA modeling analysis, as required by R313-25-8(5)(a).

ES RESPONSE:

In its response, ES stated that: "*The average concentration of DU historically disposed by Energy*Solutions *prior to January 2010 is 1,988 pCi/g (which is less than the 5-percent limit promulgated in UAC R313-25-8(2)(c) of 1.8E+4 pCi/g – as clarified by the Division on May 24, 2010).*"

REBUTTAL:

We note that the correct regulatory citation should actually be UAC R313-25-8(5)(c). However, we do not understand why that regulation addresses the main point of the interrogatory. R313-25-8(5)(a) specifies concentrated DU and other wastes as separate materials. The question remains as to why the PA did not include "*other wastes*" as required by R313-25-8(5)(a). This issue needs to be resolved if ES is to demonstrate compliance with R313-25-8(5)(a). We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

After reviewing additional literature, ES did not make any changes in the initial approach to quantifying contamination in the GDP DU. Rather, ES chose to continue to use data from SRS DUO_3 as a surrogate for contaminant species such as technetium, neptunium, and plutonium in the GDP DU. As outlined in this interrogatory, this approach appears to be non-conservative in the case of Tc-99. Using the SRS data as a surrogate for the GDP DU, it can be estimated that the total mass of Tc-99 is 25.7 kg. Using data from Hightower et al. (2000), the mass of Tc-99 is estimated to be 95.6 kg.

ES needs to demonstrate that a nearly four-fold increase in Tc-99 concentration will have no significant impact on compliance with the GWPLs or groundwater pathway doses to at least 10,000 years.

REFERENCES:

Henson Technical Projects, LLC, *Contents Categorization of Paducah DUF6 Cylinders Using Cylinder History Cards – Phase II*, DUF6-G-G-STU-003, Draft for UDS Review, Uranium Disposition Services, LLC, Lexington, KY, September 30, 2006 (file: DUF6-G-G-STU-003 Henson 2006.pdf).

Hightower, J.R., L.R. Dole, D.W. Lee, G.E. Michaels, M.I. Morris, D.G. O'Conner, S.J. Pawel, R.L. Schmoyer, L.D. Trowbridge, and V.S. White, *Strategy for Characterizing Transuranics and Technetium Contamination in Depleted UF6 Cylinders*, ORNL/TM-2000/242, UT-Battelle, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 2000.

Integrated Environmental Management, Inc., *Specific Activities*, available at *www.iem-inc.com*, accessed January 16, 2014, followed by searching for "specific activities."

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Department of Energy, *Depleted UF_6 Storage*, available at http://web.ead.anl.gov/uranium/mgmtuses/storage/index.cfm, accessed January 16, 2014.

INTERROGATORY CR R313-25-7(1–2)-90/2: CALIBRATION OF INFILTRATION RATES

PRELIMINARY FINDING:

Refer to R313-25-7(1–2): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.

INTERROGATORY STATEMENT:

Explain how the infiltration rates predicted with HELP/UNSAT-H and HYDRUS were calibrated against actual field data. Explain and justify which infiltration rate should apply to the DU disposal embankment (Federal Cell) at Clive, addressing radon barrier damage via frost heave, root penetration, animal burrowing, insect burrowing, and desiccation.

BASIS FOR INTERROGATORY:

According to Rogers (2007), the measured infiltration through the test cell averaged 0.0267 cm/yr (including the first year of monitoring data). At that time, the modeled infiltration rate was assigned a value an order of magnitude higher at 0.265 cm/yr. However, as discussed in a memorandum from a DRC staff member to the Director, there is evidence that the observed flux, at least up until that time, was not from infiltration (Edwards and Bishop 2011). If fully saturated, the cover system at the test cell (having very low-permeability radon barrier soil layers) would permit infiltrating water under a unit head to move through it in about 11 years. If not fully saturated (which it would not be under desert conditions), then the time for fluid migration would be much greater. At the time of review, the cover test cell had been in service about 11 years. The fluids observed, including those in the first year, were likely merely water added during construction and expressed during compaction. Whetstone (2007) predicted a net infiltration of 0.277 cm/yr and 0.287 cm/yr for the top and side slopes of the Class A South cell, respectively. For the Class A West cell, however, Whetstone (2011**)** predicted net infiltration rates of 0.09 cm/yr and 0.168 cm/yr for the top and side slopes, respectively. Since the modeled configurations all consist of the traditional rock-armored cover system, it is unclear why there is significant variability in the predicted infiltration rates.

Energy*Solutions* should explain and justify which infiltration rate should apply to the DU disposal embankment (Federal Cell) at Clive, addressing radon barrier damage via frost heave, root penetration, animal burrowing, insect burrowing, and desiccation.

Section 6.0 of the Quality Assurance Project Plan notes the following:

> *The quality objective for the model is to provide results that are consistent with the site characteristics, the waste characteristics, and the CSM. If data are available, the demonstration of consistency will be supported by available site monitoring data and other field investigations.*

The importance of model calibration is further stressed by conclusions reached in the Executive Summary, page xii, of NUREG/CR-6836:

> *For the numerical model [HYDRUS-2D] inputs and results, the largest source of uncertainty arose from the need to input estimated potential evapotranspiration. The uncertainty is propagated through the model's approach for calculating actual evapotranspiration (i.e., assumptions in plant water uptake and root distribution). Additional sources of uncertainty for the modeling results were due to incomplete knowledge of soil hydraulic properties.*

ES RESPONSE:

In its response, ES detailed its work associated with the ET cover design.

REBUTTAL:

We look forward to reviewing the new ET cover design for the Federal Cell and the related PA model results. Some of the information we expect to see regarding the new ET cover for the Federal Cell includes the following:

- Cover layer characteristics: Characteristics include thickness, types of soil texture, particle gradation specifications, moisture retention characteristics, slope angle, slope length, upgradient drainage areas, slope runoff coefficients, leaf area index, and soil porosity and saturated permeability.
- Effects of aging on hydraulic conductivities of cover materials.
- Duration of model simulations: ES should ensure that all infiltration and contaminant transport models simulate cover performance for at least 10,000 years or more, as called for in Interrogatory CR R313-25-8(4)(d)-155/1: Cover Performance for 10,000 Years.
- Coordination of interrogatory resolution: When describing the ET cover design, ES should coordinate responses to other related interrogatories, including the following:
  - CR R313-25-7(2)-05/1: Radon Barrier
  - CR R313-25-7(3)-60/1: Modeled Radon Barriers
  - CR R313-25-7(1)-100/1: Groundwater Recharge from Precipitation
  - CR R313-25-8(4)(a)-112/1: Hydraulic Conductivity
  - CR R313-25-8(4)(d)-153/1: Impact of Pedogenic Process on the Radon Barrier
  - CR R313-25-8(5)(a)-176/1: Representative Hydraulic Conductivity Rates

We look forward to reviewing the revised report. Additional information related to this topic and the ET cover system will be presented in an upcoming interrogatory on the promised ES ET cover system report.

REFERENCES:

Edwards, D., and C. Bishop, Memorandum to Rusty Lundberg, Director, Utah Division of Radiation Control, through John Hultquist and Phil Goble, *Review and Audit of Energy*Solutions*' Cover Test Cell (CTC) Corrective Action Plan and Related Documents*, October 28, 2011.

Neptune and Company, Inc., *Quality Assurance Project Plan Performance Assessment Model Clive, Utah*, undated. (Appendix 17 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Rogers, V., *EnergySolutions*, Letter to D. Finerfrock, Utah Department of Environmental Quality, *Subject: Radioactive License No: UT2300249 – Comments on Draft License Renewal,* September 21, 2007.

U.S. Nuclear Regulatory Commission, *Comparing Ground-Water Recharge Estimates Using Advanced Monitoring Techniques and Models*, NUREG/CR-6836, Office of Nuclear Regulatory Research, September 2003.

Whetstone Associates, Inc., *Energy*Solutions *Class A South Cell Infiltration and Transport Modeling*, December 7, 2007.

Whetstone Associates, *Energy*Solutions *Class A West Disposal Cell Infiltration and Transport Modeling*, November 28, 2011.

INTERROGATORY CR R313-25-7(2)-91/1: DESIGN CRITERIA FOR INFILTRATION

Information related to this topic and the ET cover system will be presented in an upcoming interrogatory related to the ES ET cover system report.

V1.2 CRITIQUE (ROUND 3):

The interrogatory asked that ES "*Include specific design criteria for infiltration into the Class A South Cell (subsequently called the Federal Cell) and explain how the Utah groundwater protection levels will be met for 10,000 years. Explain and justify which infiltration rate will apply to the DU disposal cell and how a 500-year PA analysis for the groundwater pathway is compliant with R313-25-8(5)(a) in terms of both model prediction time and determination of peak dose.*" The Conceptual Site Model report (Appendix 2 to FRV1.2) and the Embankment Modeling report (Appendix 3 to FRV1.2) have been revised to address the design of the proposed Federal Cell ET cover. The Conceptual Site Model report includes an explanation and justification for the infiltration. The issues related to the 500-year compliance time are presented in Interrogatory CR UGW450005 Part I.D.1-180/2: Compliance Period. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-20-92/2: INADVERTENT INTRUDER DOSE STANDARD AND SCENARIOS

PRELIMINARY FINDING:

Refer to R313-25-20: *Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed.*

Refer also to R313-25-8(4)(b): *Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided. Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.*

INTERROGATORY STATEMENT:

1. Justify why 25 mrem/yr should not be used as the dose limit for inadvertent intruders and instead why a 500 mrem/yr limit should be applied for inadvertent intruder analysis in unrestricted areas.
2. Include analysis in the PA for additional inadvertent intruder scenarios.

BASIS FOR INTERROGATORY:

1. Section 1.3.2.2, pages 1-15 to 1-16, of the 2013 Compliance Report, Revision 1, discusses the use of an intruder dose limit for inadvertent intruder analysis of 500 mrem/year.

We agree that when the NRC promulgated the 10 CFR Part 61 low-level radioactive waste (LLRW) rules in 1982 that the dose limit for the members of the public in unrestricted areas

(10 CFR Part 20) was 500 mrem/yr. However, the NRC did not consider the shallow land disposal of large quantities of concentrated DU waste in the original 10 CFR Part 61 rulemaking. Consequently, it appears that use of a 500-mrem/yr dose limit in this case is without regulatory support.

Since its original promulgation of 10 CFR Part 61, the NRC has amended its rules in 10 CFR Part 20 to reduce the dose limit for exposure in unrestricted areas to 25 mrem/yr TEDE (see current 10 CFR 20.1402).[6] This same limit is reflected in the Utah rule at R313-15-402.

We also agree that the NRC license termination rules allow a 500 mrem/yr dose to public in unrestricted areas, should certain conditions be met. The corresponding Utah requirement is found in R313-15-403. Unfortunately, this Utah flexibility is restrained by R313-15-401(1), which imposes a key limiting criteria, in that "*For low-level waste disposal facilities (Rule R313-25, the criteria apply only to ancillary surface facilities that support radioactive waste disposal activities*." Our current interpretation of these rules leads us to find that a 500 mrem/yr dose standard in inadvertent intruder analysis should not be applied to the actual disposal embankment. However, we are willing to consider additional Energy*Solutions* arguments to the contrary.

We also recognize the draft NRC rule changes for the Unique Waste Streams initiative at 10 CFR Part 61, which propose a 500 mrem/yr inadvertent intruder dose limit. Unfortunately, that draft rule has yet to be approved by the Commission, opened for public comment, or promulgated. Therefore, final NRC rulemaking is many months away, if not a year or more.

Further, the DRC Director has an obligation to determine a DU inadvertent intruder dose limit for the Clive facility that is legally defensible under current state rules. Currently, we believe that this dose limit should be 25 mrem/yr. In light of the above findings by the Utah Department of Environmental Quality (DEQ), Energy*Solutions* should explain and justify why the modern 25 mrem/yr value should not be used and instead the 500 mrem/yr limit be applied for inadvertent intruder analysis in unrestricted areas.

Alternatively, if Energy*Solutions* is intent on pursuing a 500 mrem/yr inadvertent intruder dose limit, at least three options are available, including, but not limited to, petitions before the Utah Radiation Control Board for the following:

- Exemption from the 25 mrem/yr dose limit for members of the public in unrestricted areas.
- Exemption from the current requirements in R313-25-401(1) that would, in turn, allow the Director to apply a 500 mrem/yr inadvertent intruder dose limit, should the conditions of R313-15-403 be met.
- Rulemaking to modify applicable requirements in either R313-15 or R313-25.

2. In addition, the PA model should include additional inadvertent intruder analysis to account for the following new intruder scenarios, and Table 3-3 of the 2013 Compliance Report,

[6] For more information, see NRC RCPD 13-005, Enclosure, pages 9 and 27, as transmitted by email from Donald Saah (NRC) to Craig Jones (Utah Division of Radiation Control) on March 15, 2013.

Revision 1, should be revised (or new tables provided) to describe peak inadvertent intruder dose under these new scenarios:

- Industrial Occupation of Energy*Solutions* Abandoned Structures Outside of Section 32 – where person(s) occupy or use buildings and facilities Energy*Solutions* plans to leave behind after site closure that border on the buffer zone.
- Nearby Industrial Occupation, Renewable Energy Development – where at some future time one or more persons build new structures on or near Section 32 to develop and operate waste disposal facilities, or alternative energy projects, such as solar farms and wind turbine farms, or to conduct saline aquaculture for bio-diesel.
- Excavation of a Transcontinental Pipeline – where a private company digs trenches for a transcontinental pipeline (or other utility) near the disposal embankment.
- Mining or Harvest of Soil and Gravel Materials – including removal of engineered gravels found in the Federal Cell cover system, or harvest of native clay, silt, or sand materials near the Clive disposal site.

ES RESPONSE:

In its response, ES argued that the appropriate standard for inadvertent intruder exposure is 500 mrem/yr rather than the 25 mrem/yr standard suggested by the State of Utah.

Specifically, ES stated the following:

> *As noted above, NRC is close to publishing the proposed amendments to Part 61, and based on SECY-13-0075, will propose a 500 mrem/yr dose limit:*
>
> > "The proposed rule should clearly indicate that the intruder assessment should be based on intrusion scenarios that are realistic and consistent with expected activities in and around the disposal site at the time of site closure. ... A further protective analysis...should strive to minimize radiation dose with the goal of keeping doses below a 500 mrem/yr analytical threshold."[4]
>
> *It is true that there is not yet a final rule; however, the indications are very clear that NRC will propose a 500 mrem/yr dose limit for inadvertent intrusion, and for that limit to be reduced to 25 mrem/yr in the final rule will require a major change in direction after the proposed rule is published. If DRC requires a 25 mrem/yr dose limit for inadvertent intruders in the PA, it will most likely be inconsistent with the NRC rule without any basis to demonstrate why the NRC rule would be inadequate to protect the inadvertent intruder.*

REBUTTAL:

It is our understanding that the Utah DEQ Director has determined that the acceptable level is a policy decision of DEQ/DRC.

REFERENCES:

Code of Federal Regulations, Title 10, *Energy*, Part 20, *Standards for Protection against Radiation*.

Code of Federal Regulations, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

U.S. Nuclear Regulatory Commission, RCPD 13-005, Enclosure, pages 9 and 27, as transmitted by email from Donald Saah (NRC) to Craig Jones (Utah Division of Radiation Control), March 15, 2013.

INTERROGATORY CR R313-25-22-93/2: STABILITY OF DISPOSAL SITE AFTER CLOSURE

PRELIMINARY FINDING:

Refer to R313-25-22: *The disposal facility shall be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate, to the extent practicable, the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.*

INTERROGATORY STATEMENT:

1. Include long-term PA analysis for a scenario where wave-cut action from a pluvial lake breaches the Federal Cell cover system and DU waste. Alternatively, redesign the Federal Cell to locate the DU waste and its overlying radon barrier at an elevation that is below the native ground surface.
2. Revise the consideration of the span of time used in the PA modeling to go beyond the time period for which the disposal embankment maintains its designed condition and function, and explain and justify why the span of time used in the PA modeling for engineering design requirements was adequate to comply with the requirements of R313-25-8(4) and (5).

BASIS FOR INTERROGATORY:

1. Section 1.3.2.4, pages 1-16 to 1-17, of the 2013 Compliance Report, Revision 1, does not mention the effect of pluvial lakes on the Clive site. Because the current design may place part of the DU waste at an elevation that is above native ground surface, the amendment application and PA model should be revised to include long-term PA analysis for a scenario where wave-cut action from a pluvial lake breaches the Federal Cell cover system and DU waste. Alternatively, Energy*Solutions* may redesign the Federal Cell to locate the DU waste and its overlying radon barrier at an elevation that is below the native ground surface.
2. We agree that there is a limit to how long engineered structures will withstand natural forces. We do not disagree with your suggestion that this period might be as long as 1,000 years. However, we disagree that the Division should continue its past practice of limiting the PA

analysis to the time period for which the disposal embankment maintains its designed condition and function. Because the disposal of large quantities of DU unique waste is a scenario completely outside the original assumptions underlying the NRC's 10 CFR Part 61 rulemaking in the early 1980s, it is now appropriate for Energy*Solutions* to re-tool its PA analysis.

Pursuant to R313-25-8(4)(a), the PA "*…analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes*." Hence, once the engineered embankment has failed, the site characteristics must come to bear to ensure "*…exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19*." The same requirement is set forth in 10 CFR 61.13(a).

This concept is further reinforced in NUREG-1573, Section 1.2, page 1-2, where the NRC states the following:

> *The* natural site *in which an LLW disposal facility is located consists of: (a) the geosphere and hydrosphere (i.e., geologic and hydrogeologic systems, including surface water); (b) the surrounding atmosphere; and (c) the biosphere. The natural characteristics of an LLW disposal site should promote disposal site stability and attenuate the transport of radionuclides away from the disposal site into the general environment. Although engineered barriers can be used to improve or enhance disposal site performance, the natural (geologic) setting must be relied on, in the long term, for safety.*

NUREG-1573, page 1-3, states the following:

> Engineered barriers *(both physical and chemical) are man-made structures or devices designed to improve or enhance the site's natural ability to isolate and contain waste, and to minimize releases of radionuclides to the environment. The engineered barrier system operates in conjunction with the characteristics of the natural site to form an integrated waste disposal system.*

The PA analysis should be revised accordingly, and the text should explain and justify why the span of time used in the PA modeling was adequate to comply with the requirements of R313-25-8(4) and (5).

ES RESPONSE:

In its response, ES described the assessment of a further lake cycle in the Deep Time Assessment report (Appendix 13 to FRV1) and provides the assumptions for the lake erosion scenario.

REBUTTAL:

See DEQ comments on the ES responses to the following interrogatories:

- CR R313-25-8(5)(a)-03/1: Deep Time – Sediment and Lake Concentrations
- CR R313-25-8(5)(a)-86/1: Consequences of Sedimentation on Disposal Cell
- CR R313-25-8(4)(d)-129/1: Lake Erosion

- CR R313-25-8(4)(d)-131/1: Potential Wave Energy

We look forward to reviewing the revised report.

REFERENCES:

Code of Federal Regulations, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Nuclear Regulatory Commission, *A Performance Assessment Methodology for Low-level Radioactive Waste Disposal Facilities; Recommendations of NRC's Performance Assessment Working Group*, Office of Nuclear Material Safety and Safeguards, NUREG-1573, October 2000.

INTERROGATORY CR R313-25-3(8)-94/1: ULTIMATE SITE OWNER

Round 1 Interrogatory Response is satisfactory. We look forward to receiving the written agreement for ownership between ES and DOE.

INTERROGATORY CR R313-25-8(4)(A)-95/2: ESTIMATION OF I-129 CONCENTRATIONS

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

Refer also to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

INTERROGATORY STATEMENT:

Consider an alternative approach to estimating I-129 concentrations in the waste and revise the PA accordingly. Alternatively, explain and justify why a proxy nuclide already in the PA model report could be used to account for the I-129 activity/dose in the environment near the Clive facility.

BASIS FOR INTERROGATORY:

FRV1 Section 6.1.1, page 55, states that I-129 was not detected or identified in any sample, which suggests that I-129 does not exist in the SRS inventory. The text also states that the detection limit was used to create the I-129 inventory distribution. If fission occurred (and the presence of Tc-99 confirms that fission did occur), then, as a fission product, I-129 will be present. That said, using the detection limit to create an I-129 inventory may be too conservative. Considering that the SRS data (Beals et al. 2002, p. 4) involved a 1% sampling rate (33 samples) of a population of 3,300 drums, and that a total of 26,000 drums of SRS DU need disposition, a better method to estimate the I-129 inventory may be to use an I-129 to Tc-99 spent fuel ratio that is available from general industry documentation. For example, the I-129 to Tc-99 ratios given in EPRI NP-4037 could be used to estimate the DU I-129 inventory from the measured DU Tc-99 inventory. This better practice is important in that both Tc-99 and I-129 are mobile isotopes in water environments.

ES RESPONSE:

In its response, ES indicated that DOE and its contractors have written a number of reports regarding the fate of reactor return uranium which ES is examining for more information. ES is also evaluating the use of ratios to develop a distribution for I-129 and revising the Waste Inventory report (Appendix 4 to FRV1) to address this issue of scaling and the distributions used in the PA model.

REBUTTAL:

We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES added footnote 1 in the revised Waste Inventory report (Appendix 4 to FRV1.2) describing the high level of conservatism in estimating I-129 concentrations. Therefore, this interrogatory is closed.

REFERENCES:

Beals, D.M., S.P. LaMont, J.R. Cadieux, C.R. Shick, Jr., and G. Hall, *Determination of Trace Radionuclides in SRS Depleted Uranium (DU)*, WSRC-TR-2002-00536, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC, 2002.

Electric Power Research Institute, *Radionuclide Correlations in Low-Level Radwaste*, EPRI NP-4037, June 5, 1985.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(A)-96/3: CURRENT AND FUTURE POTABILITY OF WATER

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Demonstrate that there will only be non-potable water at the Clive site for 10,000 years, considering the potential for desalination, reverse osmosis, and other water treatment activities and the potential for higher groundwater quality in deep aquifers. Provide reliable evidence that (1) groundwater near Clive will not improve in quality in the future, (2) currently available treatment technology cannot render Clive groundwater useable for municipal or industrial purposes, (3) no potable or treatable groundwater exists at Clive in deeper aquifers, and (4) there is no current or future treatment technology that could render saline waters suitable for culinary or industrial use.

BASIS FOR INTERROGATORY:

In numerous places, the Conceptual Site Model report mentions the current lack of shallow potable water at the Clive site (e.g., Section 3.1, page 7; Section 3.4, page 11; Section 4.2.3, page 19; and Section 10.3, page 57). However, this may not be the case over the next 10,000 years, especially given the potential for water treatment technologies such as desalination and reverse osmosis, and/or tying in to sources of water to the east via pipeline.

Research by DRC (2014) shows that public water supply systems registered with the Utah Division of Drinking Water, including four facilities in Tooele County, near Clive, already rely on reverse osmosis treatment to supply culinary and industrial water from brackish and saline groundwater.

Energy*Solutions* has argued that all water resources near Clive are non-potable. However, there may be exceptions to this claim. For example, deep groundwater resources have been shown to be of better quality than the shallow aquifer, as noted by Bingham Environmental (1991). Bingham Environmental (1991) shows that three sets of nested monitoring wells do or have existed in Section 32, including (1) GW-19A and GW-19B, (2) I-1-30, I-1-50, and I-1-100, and (3) I-3-30, I-3-50, and I-3-100 (Figure 2). Upward native hydraulic gradients were observed in these well nests in 1991 (Bingham Environmental 1991, p. 26). However, downward gradients have been observed in GW-19A and GW-19B transiently since that time during mounding after high precipitation events and/or pond leakage. The table below summarizes historic and recent total dissolved solids (TDS) sampling and analysis from two nested well groups. Review shows that in 1991 TDS groundwater concentration in wells completed at depths of almost 100 feet below ground surface (bgs) had half the TDS concentration of those in the shallow aquifer. Further, in 2012, the shallow monitoring well GW-19A had a TDS content that was three times higher than nearby 1991 deep well sample in GW-19B.

Well	**Screen Interval, feet bgs**	**1991 TDS mg/L[a]**	**2012 TDS mg/L[b]**
GW-19A	18–28	45,000	69,000
GW-19B	~78–98	23,000	
I-1-30	25–35[c]	n/a	n/a
I-1-100	90–100[c]	21,000	n/a

[a] Bingham Environmental 1991, Appendices A and C
[b] Energy*Solutions* 2013
[c] DRC Summary Spreadsheet HYDROSTR.XLS (2000)

Therefore, it is possible that deeper aquifers near Clive could produce water for beneficial municipal and industrial uses and that, periodically, because of high precipitation events or pond or other leakage, could be locally impacted by the shallow aquifer. In order to support its current claims regarding lack of useable groundwater resources near Clive, both today and in the future, Energy*Solutions* should provide reliable evidence that (1) groundwater near Clive will not improve in quality in the future, (2) currently available treatment technology cannot render Clive groundwater useable for municipal or industrial purposes, (3) no potable or treatable groundwater exists at Clive in deeper aquifers, and (4) there is no current or future treatment technology that could render saline waters suitable for culinary or industrial use.

ES RESPONSE:

In its response, ES stated the following:

> *Energy*Solutions *acknowledges the technical feasibility of treating saline waters at effectively any initial salinity. However, technical feasibility does not equate to probability of implementation. Within the west desert, there are numerous sources of surface and ground water for treatment that are of higher initial quality. In addition, regardless of the future ability to treat groundwater, there is not viable way to produce significant quantities of water from the upper, unconfined aquifer beneath Clive.*
>
> *Furthermore, treatment of groundwater is a scenario that crosses from inadvertent to deliberate intrusion. Utah drinking water quality standards, as well as all state and federal standards, include criteria for radionuclides. If the need and technology for groundwater treatment is present, one must presume that a*

technical context recognizing the potential presence and hazards of radioactive constituents is also present.

REBUTTAL:

We find the position on limited yield to be reasonable with regard to the shallow unconfined aquifer. However, groundwater is being extracted for beneficial uses in the Clive area presumably from the deeper confined aquifer. For example, ES uses or has used groundwater from a local well to suppress dust and decontaminate equipment and waste containers.

Several deep wells have been drilled near Clive, Utah. A log for one well just west of the Clive turnoff from Interstate 80 was drilled in 1969 to a depth of 350 feet for the Cox Construction Company. The intended use was for highway construction sprinkling and compaction (see http://waterrights.utah.gov/cblapps/wrprint.exe?wrnum=16-545). The location is said to have been S 2100 ft E 1100 ft from NW cor, Sec 18, T 1S, R 11W, SLBM. The well is reported to have produced groundwater during a pumping test in 1969 at a rate of 600 gpm over 10 hours of testing (click on Well Log link at http://waterrights.utah.gov/cgi-bin/docview.exe?Folder=welllog427264). The well is now associated with Utah water right 16-722, with a well whose location is said to be at S 1900 ft W 1400 ft from NE cor, Sec 18, T 1S, R 11W, SLBM. The well log shown on the Utah Water Rights website is the same as that for the well previously described for water right 16-545. Groundwater pumped from the well is reported to be used for dust suppression and control and truck washdown (http://www.waterrights.utah.gov/cblapps/wrprint.exe?wrnum=16-772). The well reportedly had produced about 15,313,800 gallons of groundwater by 2008.

Another well, located about 3 miles east of the Clive low-level waste disposal facility, is related to Utah groundwater right 16-190 by Skull Valley Company for water for livestock (see http://www.waterrights.utah.gov/cblapps/wrprint.exe?wrnum=16-190). The depth is 293 feet, with water down at 263 feet. The flow is given as only 0.0377 cfs. Another reference shows a map for the Grassy Mountain Facility, northwest of Clive, with wells called the North USPCI Water Supply Well and the South USPCI Water Supply Well (Hansen, Allen and Luce, Inc., 2010). USPCI also drilled a well west of the Clive facility (http://www.waterrights.utah.gov/cblapps/wrprint.exe?wrnum=16-796). That well was drilled in 1992, and a well test was conducted then with an air lift yield of 0.134 cfs. Repairs were attempted in 1997, along with pumping at 350 gpm, before the well was abandoned.

The ES response has not addressed the possibility that drawdown associated from these or similar wells located just off site at Clive could pull contamination from the Federal Cell through the underlying unsaturated zone and water table via discontinuities in the confining layer into the confined aquifer, from where it could be pumped to the surface and put to beneficial use. Although water from the deeper aquifer would probably be too saline for direct domestic use without treatment, it could be used for dust suppression and similar industrial purposes.

It is also possible that this deep groundwater could be treated by techniques such as reverse osmosis and be used as drinking water, as is currently happening at the nearby Delle Auto Truck Stop. This is also the case at Aragonite, a commercial hazardous waste incinerator owned by Clean Harbors, located about 4 miles east of Clive, where two deep wells exist (between 700 and 800 feet bgs) (Earthfax 1999). Both of these deep wells, located directly to the northeast of the

Aragonite facility, are currently being pumped to supply drinking water to approximately 100 employees through a reverse osmosis system. Therefore, a drinking water scenario in an industrial setting from a deep well in the confined aquifer outside the facility's boundaries should be considered.

It is our understanding that local health organizations regulate small sources that do not meet the test of a public water system as described in R309-100-4. In the case of Tooele County, the county health department requires that for any culinary water use, the water user needs to pay for what the department refers to as the "full chemical test" based on EPA standards. These EPA standards do not include "radiologicals." Thus, the water user would not necessarily know about potential exposure to radioactive contaminants. In the case of reverse osmosis treatment, the contaminants would partition between the treated water and the wastewater byproduct, creating multiple exposure pathways.

Another pathway that should be examined is the flow of contaminants from the unconfined aquifer to the confined aquifer through the annulus between borehole and the well casing. We recognize that drilling regulations require boreholes to be sealed. In Tooele County, borehole sealing inspections are performed by the county health department. However, failure to properly seal the annular space is not unusual in well drilling.

Both of these groundwater exposure pathways need to be examined and the results compared to the R313-25-19 groundwater dose limit.

V1.2 CRITIQUE (ROUND 3):

Pumping of groundwater from the deeper aquifer with subsequent reverse osmosis treatment also takes place at the Clean Harbors – Aragonite facility, a commercial hazardous waste incinerator owned by Clean Harbors located about 4 miles east of Clive, where two deep wells exist (between 700 and 800 feet bgs) (Earthfax, 1999). Both of these deep wells, located directly to the northeast of the Aragonite facility, are currently being pumped and put through a reverse osmosis system to supply groundwater to meet industrial needs and to help meet the sanitation requirements of approximately 100 employees. Safe yield pumping rates for the two wells are listed in the State of Utah Public Water System Inventory Report (UTAH23067) as 138 gpm and 25 gpm. Tank sizes are 572,000 gallons and 22,500 gallons. According to Clean Harbors – Aragonite Environmental Manager Lonnie Brown (personal communication with DRC Staff member David Edwards, January 2014), employees at the facility formerly consumed the potable reverse osmosis-treated groundwater. The State of Utah water right (16-757) also lists the use of the groundwater for culinary purposes for 150 employees. Therefore, the PA should consider and mdel a drinking water scenario in an industrial setting using water from a deep well in the confined aquifer outside the facility's boundaries. This is needed to satisfy UAC R313-25-20, which requires a licensee to show that "*No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater.*"

There is neither statutory nor regulatory basis for excluding groundwater at a LLW waste disposal facility from consideration as a potential exposure pathway simply because the groundwater, like most other water used for public drinking supply, needs to be treated before it is rendered potable. Anderson and Sloan (2001) state that, of drinking water systems in the

United States, more than 98% use disinfection via chlorine-based compounds for treatment. Other forms of treatment are also used, depending on need. Brackish or saline groundwater, if not contaminated by radionuclides (some of which cannot be fully removed via reverse osmosis), can be treated via reverse osmosis to greatly reduce TDS and therefore be made drinkable. In fact, as noted above, brackish or saline groundwater in the region near Clive has been regularly treated and used for a variety of uses at several regional facilities, and one of these uses has been consumption.

REFERENCES:

Anderson, R., and J. Sloan, *Water systems protected from bioterrorism agents*, The United States Conference of Mayors, Washington, DC, December 3, 2011, retrieved March 2014 from http://www.usmayors.org/usmayornewspaper/documents/12_03_01/water_protected.asp, 2001.

Bingham Environmental, *Hydrogeological Report Envirocare Waste Disposal Facility South Clive, Utah*, October 9, 1991.

Earthfax Engineering, Inc., *Drinking Water Source Protection Plan for Safety Kleen (Aragonite), Inc. Test and Production Wells*, September 1999.

Edwards, D., *Regional Use of Reverse Osmosis Technology in Areas near Clive, Utah to Treat Saline or Brackish Groundwater*, Memorandum to Rusty Lundberg, Laura Lockhart, John Hultquist and File, Utah Department of Environmental Quality, Division of Radiation Control, January 16, 2014.

Energy*Solutions*, *2012 Annual 11e.(2), LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, March 1, 2013.

Hansen, Allen and Luce, Inc., *Clean Harbors Grassy Mountain, LLC, Tooele County, Utah Landfill Cells 6b and 7 Closure Design Modifications for Vertical Expansion, Design Engineering Report (Hal Project No 064 82 100)*, December 2010. Retrieved October 2013 from http://www.hazardouswaste.utah.gov/CFF_Section/Docs/Grassypermit/Att_VI-3_B6_7.pdf.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011).

Utah Department of Environmental Quality, *Public Water System Inventory Report, Clean Harbors-Aragonite (UTAH23067)*, Division of Drinking Water, 2013.

Utah Division of Radiation Control, Summary Spreadsheet HYDROSTR.XLS (last revised March 20, 2000), compiled from 12 different ES hydrologic reports between January 1992 and June 1997. (Included in Edwards 2014.)

Utah Division of Water Rights, *Searching for Water Right Records*, Utah Department of Natural Resources, http://www.waterrights.utah.gov/wrinfo/query.asp.

INTERROGATORY CR R313-25-8(4)(A)-97/3: NEED FOR POTABLE AND/OR INDUSTRIAL WATER

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Add a discussion of various existing and historical examples of the waste industry in the Clive area and explain how they address the potential need for potable and/or industrial water in the area. Provide reliable evidence to substantiate claims that no moderate- or high-yield aquifers exist at depth near Clive and evaluate economic considerations for current and future beneficial uses of deep groundwater.

BASIS FOR INTERROGATORY:

Section 3.1, page 7, of the Conceptual Site Model report states the following:

> *While the site is zoned for hazardous waste disposal by Tooele County, the lack of potable water at this site makes the surrounding area an unlikely location for any residential, commercial, or industrial developments (Baird et al. 1990).*

However, a number of industrial developments currently exist on and near the site, including the Energy*Solutions* low-level waste disposal facility, that are dedicated to various aspects of the waste industry. Other industrial facilities are, or have been, located nearby. The Division of Drinking Water (Edwards 2014) has indicated that a number of facilities to the west of the Great Salt Lake use regional groundwater having relatively high TDS content and treat it to make it potable. The treated groundwater has been used for drinking at some of these facilities. Appropriate treatment technology for saline water exists. It is simply a matter of whether sufficient economic incentive for it to be used exists at a given time.

DRC recognizes previous Energy*Solutions* arguments that aquifers at Clive are of such low yield that they could never serve for a major water supply. However, in 1996, Envirocare's construction contractor, Broken Arrow Inc., drilled a deep supply well near the southern margin of Section 29, at a distance of 500 feet from the northern margin of the Clive disposal site (Section 32) (DWR 2014, water right number 16-816). This supply well was installed to a depth of 620 feet bgs and found two significant water-bearing gravel layers at depths of 487–495 and 505–545 feet bgs (DWR 2014, well log number 11293). Therefore, it is possible that high-yield water-bearing strata can be found at Clive. Based on TDS groundwater quality evidence (Bingham Environmental 1991, HYDROSTR.XLS, and DRC summary spreadsheet TDS - Clive GW Monitoring Wells.xlsx in Edwards 2014), it is possible that higher water quality could exist at depths greater than any of the wells historically drilled in either Sections 29 or 32. If present, this deep groundwater could be called on for beneficial municipal and industrial uses. Energy*Solutions* should provide reliable evidence to substantiate its recent claims that no moderate- or high-yield aquifers exist at depth near Clive and evaluate economic considerations for current and future beneficial uses of deep groundwater.

ES RESPONSE:

In its response, ES stated the following:

> *Historic consideration of the nature and uses of Clive's native groundwaters is well documented (Energy*Solutions*, 2014b). Industrial facilities in the west desert use groundwater from recharge zones adjacent to the Cedar Mountains and the Grayback Hills. Drinking water is trucked to these sites from Grantsville. See also the response to Interrogatory CR R313-25-8(4)(a)-96/1.*

REBUTTAL:

As discussed under Interrogatory CR R313-25-8(4)(a)-96/2: Current and Future Potability of Water, ES fails to mention a nearby well that has been used for dust suppression and equipment decontamination.Assuming that this water is obtained from the deeper confined aquifer, it could become contaminated from pollution in the overlying water table aquifer and cause exposure to surface workers. Likewise, future treatment of the deep confined aquifer could render this water beneficial for other industrial applications and drinking water. These possibilities need to be examined.

V1.2 CRITIQUE (ROUND 3):

ES fails to discuss groundwater head, hydraulic conductivity, hydraulic gradient, or groundwater water quality in the higher yielding deeper gravel zones of the confined aquifer at the site (e.g., at 450–700 feet). These deeper gravel zones of the confined aquifer are clearly observable in well logs for the Broken Arrow wellbore drilled in Section 29, just to the north of the Clive facility, and the two Clean Harbors – Aragonite groundwater production wells, located 4 miles to the east, which produce from similar deeper gravel zones. The gravel zones in both the Broken Arrow Well and the two Clean Harbors – Aragonite groundwater production wells appear to have sediment particles similar in size, and they may originate from similar higher-elevation sources. Furthermore, on April 11, 2005, ES submitted a modeling report discussing two proposed deep water wells on the site. The accompanying letter from Dan Shrum to Dane Finerfrock, also dated April 11, 2005 (Shrum, 2005), referred to modeling of a requested "*production well screened from 550 to 600 feet below ground surface (bgs), pumped at 200 gallons per minute, 24 hours per day, 4 months per year...*" on site. While this particular well was never drilled, ES' request supports the concept that an inadvertent intruder might consider drilling a deep well on site and pumping it at considerably higher rates than the shallow aquifer is capable of yielding. It is important for ES to study the hydrogeology of the deeper gravel zones and to model potential hydraulic connections between these when the deeper gravel zones are pumped at relatively high rates.

As discussed under Interrogatory CR R313-25-8(4)(a)-96/3: Current and Future Potability of Water, ES fails to mention a nearby well that has been used for dust suppression and equipment decontamination.

Interrogatories CR R313-25-8(5)(a)-38/3: Figures 5 and 11 in FRV1 and CR R313-25-8(4)(a)-96/3 further show that groundwater from the deeper parts of the confined aquifer has been used historically for drinking at the Clean Harbors – Aragonite incinerator facility. Also, groundwater treated by reverse osmosis is currently used by Delle Auto Truck Stop for drinking purposes. If the shallow aquifer becomes contaminated, then the deeper aquifer, which contains groundwater with potentially beneficial uses for citizens of the state, may become contaminated by groundwater from the shallow, unconfined aquifer after the deeper portions of the confined aquifer are pumped for a sufficiently long time. ES must therefore investigate the deeper portions of the confined aquifer and the drinking of groundwater from the deeper portions of the confined aquifer as an exposure pathway by which receptors might receive radioactive doses. It is assumed that groundwater obtained from the deeper confined aquifer could become contaminated from pollution in the overlying water table aquifer and cause exposure of surface workers. Likewise, future treatment of the deep confined aquifer could render this water beneficial for other industrial applications and drinking water. These possibilities need to be examined in the PA.

REFERENCES:

Baird, R.D., M.K. Bollenbacher, E.S. Murphy, R. Shuman, and R.B. Klein, *Evaluation of the Potential Public Health Impacts Associated with Radioactive Waste Disposal at a Site Near Clive, Utah*, Rogers and Associates Engineering Corporation, Salt Lake City Utah, 1990.

Bingham Environmental, *Hydrogeological Report Envirocare Waste Disposal Facility South Clive, Utah*, October 9, 1991.

Edwards, D., *Regional Use of Reverse Osmosis Technology in Areas near Clive, Utah to Treat Saline or Brackish Groundwater*, Memorandum to Rusty Lundberg, Laura Lockhart, John Hultquist and File, Utah Department of Environmental Quality, Division of Radiation Control, January 16, 2014.

Energy*Solutions*, *2013 Annual 11e.(2). LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, Energy*Solutions* Report to the Utah Division of Radiation Control (CD14-0037), February 25, 2014 [Energy*Solutions* 2014b].

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011).

Shrum, D.B., *Request to Install Production Well – Submittal of Revised Modeling*, Letter from Dan Shrum to Dane Finerfrock, April 11, 2005.

Utah Division of Radiation Control, *Summary Spreadsheet HYDROSTR.XLS* (last revised March 20, 2000), compiled from 12 different EnergySolutions hydrologic reports between January 1992 and June 1997.

Utah Division of Water Rights, water rights and well log database at http://waterrights.utah.gov/wrinfo/query.asp. Accessed February 7, 2014.

INTERROGATORY CR R313-25-7(1)-98/1: MONTHLY TEMPERATURES

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

Section 3.2.1, page 7, of the Conceptual Site Model report (Appendix 2 to FRV1.2) has been changed as noted above, with the correction that the MSI reference is MSI 2010, not 2009. However, Section 4.1.2.3.1, page 33, still cites Whetstone 2006, rather than MSI 2010. Once this minor editorial correction is made, this interrogatory is closed.

INTERROGATORY CR R313-25-7(1)-99/1: EVAPORATION

Round 1 Interrogatory Response is satisfactory. ES should update the text as cited in its revised report. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

The text quoted in the Basis for Interrogatory was deleted from Section 3.2.2, page 8, of the Conceptual Site Model report (Appendix 2 to FRV1.2). The remaining text from the ES response was added to Section 3.2.3, page 8, with the exception that the values for average annual pan evaporation and average annual precipitation were also provided in inches, and the reference was changed to MSI 2010. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7(1)-100/2: GROUNDWATER RECHARGE FROM PRECIPITATION

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Address considerations that would affect the amount of groundwater recharge due to precipitation and snow melt, such as concentration of water in topographic depressions, increase in cover-system hydraulic conductivity, and inhibition of evaporation because of large-grain materials.

BASIS FOR INTERROGATORY:

Section 3.2.3, page 8, of the Conceptual Site Model report states that "*Because of the high evaporation rate, the amount of groundwater recharge due to precipitation is likely very small, except during high intensity precipitation events (Adrian Brown, 1997a).*" However, the discussion does not explicitly account for snow storage and subsequent melting, the post-precipitation concentration of water in topographic depressions, drainages, fractures, holes, or burrows in rock or soil cover materials that will likely develop over time and that may locally reduce effective evaporation rates and increase groundwater recharge. It also does not describe how cover-system hydraulic conductivity tends to greatly increase within a relatively short time after cover-system placement due to frost heave and other factors (Benson et al., 2011). Any of these features, processes, or events may potentially result in increased groundwater recharge. Neither does the text account for the inhibition or minimization of evaporation due to the presence of rip rap or natural rock or other large-grain materials at the surface, as has been documented in many technical studies. For example:

- Reith and Caldwell (1990) claim that a rock cover reduces evaporation from a cover system and makes more water present within the cover system.
- Kemper et al. (1994) show that 5 centimeters of gravel placed on top of soil significantly reduced evaporation and increased retention of water in the subsurface to about 80–85% of total precipitation.
- Poesen and Lavee (1994) indicate that the presence of a rock-fragment layer at the surface of a soil acts like a mulch to that soil, inhibiting capillary rise and evaporation. They attribute this to low unsaturated hydraulic conductivity of that rock-fragment layer at low suction values.

Such materials tend to act as a mulch, greatly reducing evaporation rates. The PA should address and resolve these considerations. Alternatively, Energy*Solutions* can provide other technical evidence and explain and justify why it supports the conclusions made in the Conceptual Site Model report.

ES RESPONSE:

In its response, ES indicated that its Revision 1 of the GoldSim model evaluates performance of an ET cover design against the traditional rock armor mulch on the Federal Cell, and that the Conceptual Site Model report (Appendix 2 to FRV1) is being revised.

REBUTTAL:

In the process of modifying the text for the revised report, ES should provide a reference for the quoted text in its response to this interrogatory (Energy*Solutions* 2014, pages 102–103). ES should also document the presence or absence of rip rap on part of the side slopes; if rip rap is present anywhere, the model should be amended to account for reduced evaporation in these areas of rip rap. We look forward to reviewing the revised report.

REFERENCES:

Benson, C.H., W.H. Albright, D.O. Fratta, J.M. Tinjum, E. Kucukkirca, S.H. Lee, J. Scalia, P.D. Schlicht, and X. Wang, *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, NUREG/CR-7028, Volume 1, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, December 2011.

Adrian Brown Consultants, *LARW Infiltration Modeling Input Parameters and Results*, prepared for Envirocare of Utah, Report 3101B.970515, Volume 1, 41 pages plus tables, figures and attachments, May 15, 1997.

Energy*Solutions*, *Responses to 28 February 2014 – Round 1 Interrogatories Utah LLRW Disposal License RML UT 2300249 Condition 35 Compliance Report*, March 31, 2014.

Kemper, W.D., A.D. Nicks, and A.T. Corey, *Accumulation of water in soils under gravel and sand mulches*, Soil Sci. Soc. Am. J., Vol. 58, pp. 56–63, 1994.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Poesen, J. and H. Lavee, *Rock fragments in top soils: significance and processes*, Catena, Vol. 23, pp. 1-28, 1994.

Reith, C.C. and J.A. Caldwell, *Vegetative covers for UMTRA project disposal cells*, Jacobs Engineering Group, Albuquerque, New Mexico, February 1990.

INTERROGATORY CR R313-25-7(1)-101/2: NATURE OF UNITS 1 AND 2

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Indicate how the thickness of Unit 1 is accounted for in the numerical GoldSim model, and describe the nature of the confining unit. Provide information about local downward components of hydraulic gradient at the site that result in groundwater mounding.

BASIS FOR INTERROGATORY:

Section 3.3.1, page 9, of the Conceptual Site Model report states the following:

> *The Envirocare investigation indicates that the total thickness of Unit 1 is at least 75 m (250 ft) (Envirocare, 2004). The deepest borehole at the time of this*

> *investigation was drilled to 250 ft below ground surface (bgs) without encountering bedrock. Unit 1 is saturated beneath the facility and contains a locally confined aquifer.*

Since the PA states that it is uncertain how deep Unit 1 extends, the text should reference a section of the PA describing how the layer thickness is accounted for in the numerical GoldSim model. We note that, in 1996, Envirocare contractor Broken Arrow Inc. drilled a water supply well adjoining Section 29. From review of its boring log, it is clear that bedrock is deeper than 620 feet bgs (DWR 2014, water right number 16-816 and associated well log 11293). From gravity geophysical surveys of nearby Ripple Valley[7] (Baer and Benson 1987, Cook et al. 1964), its unconsolidated deposits in the Clive area appear to be approximately 3,000 feet thick (depth to bedrock).

In addition, it is unclear whether the confining unit mentioned is separate from or includes Unit 2, described as "*clay with occasional lenses or interbeds of silty sand*." Information is missing about how permeable or impermeable this layer is to vertical components of flow, and, if a confining unit does exist (1) the kind of head differences that exist on either side of it, (2) the calculated vertical components of flow resulting from the differences in head and the hydraulic conductivity associated with this confining unit, and (3) how these vertical components of flow compare with horizontal components of flow. Neither is there information about local downward components of hydraulic gradient at the site that result in groundwater mounding. If the text does not discuss these topics specifically, it should provide references to documented analyses that do, either elsewhere in the PA or in other relevant reports.

ES RESPONSE:

In its response, ES indicated that the description of Unit 1 in the Conceptual Site Model report (Appendix 2 to FRV1) is being revised and further describes the hydrogeology at the site.

REBUTTAL:

The ES response is largely satisfactory, providing that DRC finds the promised description in the revised report to be adequate. However, ES should include in the revised report all of the additional text and description provided in its response to this interrogatory. Furthermore, ES should document and explain eh cause of the shallow groundwater mounding in the vicinity of Wells MW-60 and MW-63 in the southern part of Section 32 (see Energy*Solutions*, 2014) and discuss quantitatively its impact throughout time on vertical components of hydraulic gradient. We look forward to reviewing the revised report.

REFERENCES:

Baer, J.L, and A.K. Benson, Results of Gravity Survey, Skull Valley-Ripple Valley, Tooele County, Utah, in Dames and Moore, the Ralph M. Parsons Company, and Roger Foott

[7] Ripple Valley is located about 4 miles north of Section 32 and is found north of I-80 and east of the Greyback Hills.

Associates, Inc., *Site Proposal for the Superconducting Super Collider: Geotechnical Report*, Vol. 2, pp. E1–E8, 1987.

Cook, K.L., M.D. Halverson, J.C. Steep, and J.W. Berg, Jr., *Regional gravity survey of the northern Great Salt Lake Desert and adjacent areas in Utah, Nevada, and Idaho*, Geological Society of America Bulletin, Vol. 75, No. 8, pp. 715–740, 1964.

Envirocare, *Revised Hydrogeologic Report for the Envirocare Waste Disposal Facility Clive, Utah*, Version 2.0, Salt Lake City Utah, August 2004.

Energy*Solutions*, *2013 Annual 11e.(2), LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, February 25, 2014.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Utah Division of Water Rights, water rights and well log database at http://waterrights.utah.gov/wrinfo/query.asp. Accessed February 7, 2014.

INTERROGATORY CR R313-25-7-102/1: SEISMIC ACTIVITY

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES added the proposed discussion to Section 3.3.2, pages 11–13, of the Conceptual Site Model report (Appendix 2 to FRV1.2). Although ES indicated that it would also change Section 6.0 of the FEP Analysis report (Appendix 1 to FRV1.2), no changes to that appendix were made. Because the change to the Conceptual Site Model report is comprehensive, change to the FEP appendix is not needed. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7-103/2: HISTORICAL FLOODING

PRELIMINARY FINDING:

Refer to R313-25-7: *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.

INTERROGATORY STATEMENT:

Discuss historical non-chronic flooding that has occurred on site and how this can potentially impact infiltration, especially once the cover system is compromised by erosion, burrowing, and other events. Discuss flooding that has occurred on the site prior to the human historical record but within the historical geologic record (based on evidence from the field).

BASIS FOR INTERROGATORY:

Section 3.4.1, page 10, of the Conceptual Site Model report states that "*NRC (1993) indicates that no historical (chronic) flooding has occurred in the vicinity of the site.*" The conceptual site model should discuss any historical non-chronic flooding that has locally occurred on site, such as in spring 2011 and previous years, and how this can potentially impact infiltration, especially once the cover system is compromised by erosion, burrowing, and other events. The text should also discuss flooding that has occurred on the site prior to the human historical record but within the historical geologic record (based on evidence from the field). The report should also provide all related technical references that support the discussion.

ES RESPONSE:

In its response, ES indicated that the ability of Clive's exterior berm system and embankments to withstand the impacts of a probable maximum flood has previously been demonstrated and no changes are necessary.

REBUTTAL:

ES does not discuss historical non-chronic flooding at the site, as was requested in the interrogatory. After times of heavy precipitation, water at the site may collect in depressions along the surface in various places. ES should provide details about locations and depths and how the water management system operates to remove the water. Reference to Clive's exterior berm system, as found in the ES LLRW license renewal application dated March 6, 2013, is not appropriate, in that (1) that berm is designed for the active operational life of the facility, and (2) that berm will not persist after facility closure. If it were to, the need for active, ongoing maintenance would be evident; however, such maintenance does not comply the requirements of several state regulations for LLRW, including, but not limited to, R313-25-8(4)(d), R313-25-22, and R313-25-24(1). Consequently, ES should revise its response to address and resolve this interrogatory. We look forward to reviewing the revised report.

REFERENCES:

Energy*Solutions, State of Utah Radioactive Material License Renewal Application, Revision 1, (UT 2300249)*, March 6, 2013

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Nuclear Regulatory Commission, *Final Environmental Impact Statement to Construct and Operate a Facility to Receive, Store, and Dispose of 11e.(2) Byproduct Material Near Clive, Utah*, NUREG-1476, Office of Nuclear Material Safety and Safeguards, 1993.

INTERROGATORY CR R313-25-7(2)-104/3: INFILTRATION IN THE PRESENCE OF RIP RAP OR NATURAL ROCK

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

INTERROGATORY STATEMENT:

1. Realistically quantify the impacts on infiltration or water penetration when the presence of rip rap or natural rock on the embankment cover decreases both evaporation and transpiration. Include technical evidence to support the conclusions made regarding evapotranspiration effects on water infiltration.
2. Specify the total length of the soil zone path used in unsaturated flow modeling and describe the characteristics of the soil involved.
3. Explain and justify how much time will be needed to complete the cover system siltation and establishment of a permanent and viable plant community after closure of the DU cell, including how much of the cover system vertical profile will be in-filled with silts and other Aeolian deposits.
4. Explain and justify why the proposal to use human intervention to help mitigate the effects of future events that could jeopardize the stability of the engineered facility at Clive is congruent with the rule requirement to eliminate active maintenance of the disposal site.

BASIS FOR INTERROGATORY:

1. Section 3.4.2.1, page 10, of the Conceptual Site Model report states that "*An upward gradient is not only due to evaporation of water at the ground surface, it is also driven by the transpiration of plants, which pull water from the ground and release it to the dry atmosphere. The coupled effect of these two processes, or evapotranspiration, serves to keep near-surface soils dry enough that precipitation often does not penetrate to lower soils.*" In light of this statement, the text should discuss possible impacts on infiltration or water penetration within the embankment cover system, and the underlying vadose zone, when the presence of rip rap or natural rock on the embankment cover reduces evaporation to relatively low or even negligible levels (see CR R313-25-7(1)-100/1) and also inhibits plant growth, and thus decreases both evaporation and transpiration to very low values. Realistic quantification of these impacts should be attempted within the model and discussed in the PA

and referenced in this section. Energy*Solutions* should include technical evidence to support the conclusions made regarding evapotranspiration effects on water infiltration. Alternatively, it should explain and justify why the statements should be accepted by the DRC Director as they stand.

2. Section 7.1.1.1, page 27, of the Conceptual Site Model report describes the soil zone used in the unsaturated flow modeling. The text should identify the total length of this path and the characteristics of the soils involved.
3. Section 7.1.4.1, page 32, of the Conceptual Site Model report states, "*It is expected that plants will be the first colonizers of the Clive cap, though that is not expected to occur until the uppermost riprap layer has silted in sufficiently to allow for germination and root establishment*." Energy*Solutions* should explain and justify how much time will be needed to complete the cover system siltation and establishment of a permanent and viable plant community (after closure of the DU cell). It should also explain and justify how much of the cover system vertical profile will be in-filled with silts and other aeolian deposits. This explanation should emphasize the function of the sacrificial soil layer in the cover and the underlying Filter B layer. Energy*Solutions* should explain and justify how this soil development and plant community will be uniformly distributed across the entire DU cell cover system area.
4. Section 7.2.1.6, page 41, of the Conceptual Site Model report states the following:

> *…human intervention could help to mitigate the effects of future events that could jeopardize the stability of the engineered facility at Clive. For example, the disposal cell could be protected by adding more rip-rap material, a seawall, or berm (or other engineered barriers) to prevent the deleterious effects of wave action in the event of future lake formation.*

Energy*Solutions* should explain and justify why this approach is congruent with the requirement in R313-25-7(2) that active maintenance of the disposal site be eliminated. If this concept is to be applied, Energy*Solutions* should explain how that will be accomplished via use of its LLRW surety bond of the State's Perpetual Care Fund for Clive.

ES RESPONSE:

In its response, ES indicated that an ET cover design will be used rather than the rip rap cover specified in the Clive DU PA model, and that the Conceptual Site Model report (Appendix 2 to FRV1) will be revised.

REBUTTAL:

Upcoming report revisions will add new text and better describe the model use. Therefore, the ES response will be evaluated as part of the more detailed review of the HYDRUS modeling during the review of the forthcoming revised PA. With reference to the proposed text for Section 7.2.1.6 of the Conceptual Site Model report, ES should clarify which disposal cell design is being referred to (the rip rap or an ET design). Any rip rap on side slops of an ET cover system should be described.

V1.2 CRITIQUE (ROUND 3):

A number of researchers have shown that the presence of crushed rock, gravel, or other coarse granular or blocky material (e.g., riprap) greatly reduces infiltration compared to the absence of these materials (Hadas and Hillel, 1972; Groenevelt et al., 1989; Reith and Caldwell, 1990; Kemper et al., 1994; Diaz et al., 2005; Albright et al., 2010; and Neptune and Company, 2012). Hadas and Hillel (1972) report that "*soil layering reduces evaporation, especially when a coarse-textured soil overlies a fine-textured soil.*" Reductions in evaporation rates of 80 to 90% for relatively thin layers of some of these materials are referenced in some of these studies. Groenevelt et al. (1989) show that the addition of larger-diameter granular inorganic material to a soil surface substantially reduced evaporation from the soil. With the use of sand, for example, cumulative evaporation from soil, after 38 days, was reduced approximately 83%. Use of scoria rock was almost as effective in reducing evaporation. Reith and Caldwell (1990) claim that a rock cover reduces evaporation from a cover system and makes more water present within the cover system. Kemper et al. (1994) show that 5 cm of gravel placed on top of soil significantly reduced evaporation and increased retention of water in the subsurface to about 80–85% of total precipitation. Diaz et al. (2005) show that reduction in evaporation was related to the thickness of volcanic tephra rock on the ground surface. A 2-cm layer, a 5-cm layer, and a 10-cm layer of tephra rock reduced soil evaporation after 31 days by 52%, 83%, and 92%, respectively. Albright et al. (2010) explain that "*gravel mulches can also form a 'reverse' capillary barrier effect that limits surface evaporation, which may adversely affect the cover water balance....*"

The DRC staff does not consider the remaining evaporation rates after coarse materials have reduced evaporation rates to be significant, at least with respect to evaporation rates in the absence of these materials. The presence of any riprap on the cover system should be accounted for in modeling by an appropriate decrease in evaporation rates, possibly even a rate of zero. ES should justify the rate chosen. ES should also explain and justify how this design will mitigate future pluvial lake flooding at Clive. We look forward to reviewing the revised report.

REFERENCES:

Albright, W.H., C.H. Benson, and W.J. Waugh, *Water balance covers for waste containment principles and practice*, ASCE Press: Reston, Virginia, 2010.

Diaz, F., C.C. Jimenez, and M. Tejedor, *Influence of the thickness and grain size of tephra mulch on soil water evaporation*, Agricultural Water Management, Vol. 74, pp. 47–55, 2005.

Groenevelt, P.H., P. van Straaten, V. Rasiah, and J. Simpson, *Modifications in evaporation parameters by rock mulches*, Soil Technology, Vol. 2, pp. 279–285, 1989.

Hadas, A., and D. Hillel, *Steady-state evaporation through non-homogeneous soils from a shallow water table*, Soil Science, Vol. 113, pp. 65–73, 1972.

Kemper, W.D., A.D. Nicks, and A.T. Corey, *Accumulation of water in soils under gravel and sand mulches*, Soil Sci. Soc. Am. J., Vol. 58, pp. 56–63, 1994.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level*

Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report, June 1, 2011)

Neptune and Company, Inc., *Modeling Report: Fate and Transport of Contaminants from the Class A West Embankment and Exposure to a Post-Closure Traditional Inadvertent Human Intruder at the EnergySolutions Clive, Utah Facility,* prepared for Energy*Solutions,* 2012.

Reith, C.C., and J.A. Caldwell, *Vegetative covers for UMTRA project disposal cells*, Jacobs Engineering Group, Albuquerque, New Mexico, 1990.

INTERROGATORY CR R313-25-8(4)(A)-105/3: HUMAN USE OF GROUNDWATER

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Identify the human uses for which the groundwater at the Clive site is suitable, and consider the potential human uses of the groundwater after treatment.

BASIS FOR INTERROGATORY:

Section 3.4.2.2, page 10, of the Conceptual Site Model report states that the groundwater at the Clive site "*is not suitable for most human uses*." Since the text uses the qualifier "*most*," the document should identify the human uses for which the groundwater is suitable. The report should also consider the potential human uses of the groundwater once it is treated by reverse osmosis or other desalination technologies. Recent advances in this area now make it possible to desalinate seawater and other waters with high TDS where the need is sufficiently great to justify the relatively high cost of desalination. The problem is not a technical one of saline water not being usable by humans; instead, it is an issue of whether there might be a sufficiently strong economic reason under some circumstances to employ the technology to make the water potable for beneficial uses. Systems suitable for single family use are also commercially available at relatively low cost. Water with a TDS value of 40,500 mg/L (Brodeur, 2006; Energy*Solutions*, 2013) is a little more saline than Mediterranean seawater currently being treated via desalination to provide fresh water for 40–80% of Israel's needs (Sales, 2013), but it is less saline than Persian (aka Arabian) Gulf water currently being desalinated to provide potable water for many people in the Gulf States. Cotruvo (2005) gives the value for average TDS for eastern

Mediterranean seawater as 38,600 mg/L and for the Arabian Gulf at Kuwait as 45,000 mg/L. All of these waters are comparable in TDS to Clive's shallow groundwater; deep groundwater at Clive consists of even lower TDS. The Conceptual Site Model report should be revised to reflect this information or explain and justify why these technologies are not appropriate and will not be called on in the future in deserts near Clive.

ES RESPONSE:

In its response, ES stated the following:

> *Energy*Solutions *acknowledges the technical feasibility of treating saline waters at effectively any initial salinity. However, technical feasibility does not equate to probability of implementation. Within the west desert, there are numerous sources of surface and ground water for treatment that are of higher initial quality and production.*
>
> *Furthermore, treatment of groundwater is a scenario that crosses from inadvertent to deliberate intrusion. Utah drinking water quality standards, as well as all state and federal standards, include criteria for radionuclides. If the need and technology for groundwater treatment is present, one must presume that a technical context recognizing the potential presence and hazards of radioactive constituents is also present. In accordance with NRC guidance, the inadvertent intruder must be protected but a deliberate intruder cannot be subject to the same dose protection criteria; since a deliberate intruder by definition knows of the radiological hazard and proceeds to disturb the disposal site regardless.*

REBUTTAL:

Based on the discussion provided under Interrogatory CR R313-25-8(4)(A)-96/2: Current and Future Potability of Water, a member of the general population could drill a well into the confined aquifer and treat the water for domestic and industrial uses. Under current Tooele County regulations, if the domestic uses do not qualify as a public water system, there are no requirements for testing for radioactive contamination. It is also possible that future demand for municipal and industrial water in Utah, combined with currently available treatment technology, could render the deep aquifer useable for drinking water and many other industrial uses. These types of exposure scenarios need to be evaluated.

V1.2 CRITIQUE (ROUND 3):

Locations for groundwater wells at industrial sites are often based on considerations of property ownership and proximity to planned operations rather than on a determination of the optimal location for a well within a large basin, such as in the West Desert. ES itself at one point drilled a borehole for a water well before abandoning the project due to concerns about additional compliance requirements (i.e., the Broken Arrow Well in Section 29; see Utah Water Right 16-816). On another occasion, ES presented a proposal to drill two production wells at the site to provide groundwater for operational use (Whetstone Associates, 2005).

REFERENCES:

Brodeur, J.R., *Mixed Low-Level Radioactive and Hazardous Waste Disposal Facilities*, Energy Sciences and Engineering, Kennewick, Washington, 2006.

Cotruvo, J.A., *Water Desalination Processes and Associated Health and Environmental Issues*, Water Conditioning & Purification, Vol. 47, No. 1, pages 13–17, January 2005, available from www.wcponline.com/pdf/0105%20Desalination.pdf, accessed January 17, 2014.

Energy*Solutions*, *2012 Annual 113.(2), LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, March 1, 2013.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Sales, B., *Water surplus in Israel? With desalination, once unthinkable is possible*, JTA, May 28, 2013 3:46pm, available from www.jta.org/2013/05/28/news-opinion/israel-middle-east/water-surplus-in-israel-with-desalination-once-unthinkable-is-possible#ixzz2fRo3XR7J, accessed September 2013.

Utah Division of Water Rights, *Searching for Water Right Records*, Utah Department of Natural Resources, http://www.waterrights.utah.gov/wrinfo/query.asp.

Whetstone Associates, *Evaluation of Potential Drawdown and Gradient Changes Resulting from Pumping Two Deep Wells at the Envirocare Facility*, prepared for Envirocare of Utah, Inc., April 7, 2005.

INTERROGATORY CR R313-25-8(4)(A)-106/3: DESALINATION POTENTIAL

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Modify the text to reflect the fact that TDS concentrations at Clive are not a barrier to desalination to potable water levels.

BASIS FOR INTERROGATORY:

Section 3.4.2.2, page 11, of the Conceptual Site Model report states that Brodeur (2006) reports that groundwater beneath the Clive site has a TDS content of 40,500 mg/L. This is fairly consistent with mean TDS values in groundwater reported to DRC for monitoring wells at the site, which average 42,237 mg/L (Energy*Solutions*, 2012).

The text also states that "*sea water typically has a TDS content of 35,000 mg/L (35 %o), thus the salinity content at the site is much higher than average sea water*." DRC review of 57 shallow groundwater samples collected at Clive in the 2012 facility annual groundwater sampling event[8] found an average TDS of about 42,000 mg/L, with a range of 10,400–69,000 mg/L. Consequently, average Clive groundwater TDS is 20% higher than typical seawater. However, Energy*Solutions*' statement does not convey the higher values found in various water bodies where desalination along coasts is commonly occurring. Mediterranean seawater has a mean TDS value of about 37,000–39,000 mg/L, and the Persian (aka Arabian) Gulf TDS values are in the range of about 41,000 to 70,000 mg/L in the Persian or Arabian Gulf (e.g., see Khan 2000, Wilf and Klink 2001, Falah et al. 2012, Ladewig and Asquith 2012, Cotruvo 2005). This is an important factor to consider in the PA, since Israel and Persian (aka Arabian) Gulf states often use seawater at these concentrations as the raw water from which potable water is provided for their citizens and industry, showing that the high TDS content of groundwater at Clive does not appear to be a barrier to groundwater use. Although reverse osmosis treatment is expensive, it is feasible.

ES RESPONSE:

In its response, ES stated the following:

> *Section 3.4.2.2 of the Conceptual Site Model report is being revised to acknowledge the technical feasibility and practical improbability of groundwater desalination at Clive.*
>
> *While it is true that desalination occurs in the Persion* [sic] *Gulf and Israel, it is done to fulfill a pressing human need for a dense population. Neither of these currently exists at Clive, nor is it likely to.*
>
> *The text of the CSM document is being changed as follows:*
>
> *[Conceptual Site Model white paper, section 3.4.22:]*
>
> > "The underlying groundwater in the vicinity of the Clive site is of naturally poor quality with high salinity and high TDS, as a consequence, is not suitable for most human uses (NRC, 1993). Brodeur (2006) reports that groundwater beneath the Clive site had a total dissolved solid (TDS) content of 40,500 mg/L (40.5 ‰). The majority of the cations and anions are sodium and chloride, respectively. This is not potable for humans or livestock, nor is it suitable for irrigation. Groundwater is used for dust

[8] DRC Excel Spreadsheet *TDS-Clive GW Monitoring Wells* prepared by David Edwards, February 18, 2014

> control, however, this water is pulled from the deeper aquifer, not the low yielding, shallow-unconfined aquifer found beneath Clive. For comparison purposes, sea water typically has a salinity content three to five times that of the groundwater at the site, thus the salinity content at the site is higher than average sea water."

REBUTTAL:

ES stated that the Conceptual Site Model report (Appendix 2 to FRV1) was being revised to acknowledge the technical feasibility and practical improbability of groundwater desalination at Clive. However, contrary to what ES indicated the proposed revision would acknowledge, the actual ES language does not comment on the technical feasibility of desalination, nor does it recognize that desalination is accomplished in the vicinity of Clive to produce potable water. This needs to be corrected. Further, the probability that Clive groundwater will someday be extracted, treated, and put to beneficial use as drinking and/or industrial water will be a function of economics. Like most Western States, Utah, with a finite quantity of water resources and a growing population, will someday be forced to draw on West Desert groundwater to service future generations. To help DEQ assess groundwater conditions in the deep aquifer in the well near I-80 at the south end of the Greyback Hills, ES should provide comprehensive well completion details, groundwater elevation, and water quality sampling and analysis results for this deep well.

V1.2 CRITIQUE (ROUND 3):

As noted for other interrogatories, desalination is currently accomplished in the vicinity of Clive to produce potable water. It is expected that Utah will be someday forced to draw on water of lesser quality, such as West Desert groundwater, to service future generations. With regard to the comprehensive well completion details requested above, additional on-site and near-site information that will be needed for investigating the hydrogeology of the deeper gravel zones of the confined aquifer will be hydraulic heads, hydraulic conductivities, hydraulic gradients, and water-quality.

REFERENCES:

Brodeur, J.R., *Mixed Low-Level Radioactive and Hazardous Waste Disposal Facilities*, Energy Sciences and Engineering, Kennewick, Washington, 2006.

Energy*Solutions*, *2012 Annual 113.(2), LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, March 1, 2013.

Cotruvo, J.A., *Water Desalination Processes and Associated Health and Environmental Issues*, Water Conditioning & Purification, Vol. 47, No. 1, pages 13–17, January 2005, available from www.wcponline.com/pdf/0105%20Desalination.pdf, accessed January 17, 2014.

Falah, A., R.E. Khatib, and N. Yahfoufi, *Water quality survey of Arabian Peninsula in regions of Dubai in the United Arab Emirates*, Canadian Journal on Chemical Engineering & Technology, Vol. 3, pp. 1–5, 2012.

Khan, W.Z., *Purification of Arabian Gulf high-salinity water by aromatic polyamide hollow fiber membranes*, in Goosen, M.F.A., and W.H. Shayya, Water Management, Purification, and Conservation in Arid Climates – Water Purification, Volume 2, Technomic Publishing Company, Inc., Lancaster, PA, 2000.

Ladewig, B., and B. Asquith, *Desalination Concentrate Management*, Springer, New York, 2012.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Wilf, M. and K. Klink, *Optimization of seawater RO systems design*, Hydranautics, Oceanside, CA, accessed January 2014 from www.membranes.com/docs/papers/06_optimization.pdf.

INTERROGATORY CR R313-25-7(1)-107/2: PREDOMINANT VEGETATION AT THE CLIVE SITE

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Reconcile apparent discrepancies with respect to which type of vegetation predominates at the Clive site and revise the Conceptual Site Model report to be consistent with the research conducted previously by Energy*Solutions* contractors at Clive.

BASIS FOR INTERROGATORY:

Section 3.5.1, page 11, of the Conceptual Site Model report claims that "*Envirocare (2000) and SWCA (2011) confirmed that the predominant vegetation over most of the site is shadscale*."

However, SWCA (2011) indicates that, for the three plots located on or fairly near the Clive site that were studied for the report (two others were located in or near the mountains), the predominant vegetation depends on the plot, and it is not shadscale in the majority of the plots.

In Plot 3, black greasewood dominates among the forbs and shrubs, constituting 4.5% of ground cover, with Mojave seablite, gray molly, and shadscale saltbush constituting 0.3%, 0.2%, and 0.1%, respectively, of soil cover. The total for these four shrubs is thus 5.1% ground cover. Halogeton, a forb, makes up 0.7% of the ground cover. Biological soil crust is said to constitute 84.8% of ground cover. Plant litter covers 6.1% of the soil. Bare ground makes up 2.3% of the surface. Shadscale makes up only $1/10^{th}$ of 1% of ground cover, so it can hardly be called predominant here.

In Plot 4, halogeton dominates among the forbs and shrubs, constituting 3.3% of the ground cover. Shadscale saltbush makes up only 2.3% of the cover.

In Plot 5, located to the west of most current operations, shadscale saltbush does dominate among shrubs and forbs, at 12.5%, but the coverage is relatively small compared to biological soil crust coverage at 70.7%.

SWCA Environmental Consultants, which from June 13–23, 2012, conducted field studies on eight plots in the Clive area that it selected as being ecological analogs to the future embankment cover system at the Clive site, reports the following for all of the studied plots in general (SWCA, 2012):

> *Vegetation: Average plant species cover consisted of 14.3% black greasewood (*Sarcobatus vermiculatus*), 5.9% Sandberg bluegrass (*Poa secunda*), and approximately 3% cover each of shadscale saltbush (*Atriplex confertifolia*) and Mojave seablite (*Suaeda torreyana*). Fourwing saltbush (*Atriplex canescens*) and gray molly (*Bassia americana*) occurred in low densities with 1.6% and 1.3% cover, respectively. Ground cover was dominated by 79.2% average biological soil crust cover.*

Thus, in the area in or fairly near the Clive site, instead of dominating the site as a whole, shadscale saltbush appears to cover from less than 0.3% to 12.5% of the ground, and shadscale saltbush only predominates in one of three plots studied in 2011. Among forbs and shrubs in the 2012 studies, shadscale saltbush came in tied only for third place in terms of ground coverage.

ES RESPONSE:

In its response, ES provided the basis for the assumptions pertaining to the vegetation species surrounding the Clive site.

REBUTTAL:

It is clear that this area has experienced substantial historic disturbance from grazing. This, in combination with stressful climatic and substrate conditions, has left a vascular plant cover that is weedy and ephemeral. This cryptobiotic crust cover, while not comprised of vascular plants, is still a biotic component that likely has substantial importance in the stability of the soil surface.

The PA still needs to address a number of questions pertaining to the plant cover, including the kind of plant community that can be expected beyond 500 years on the ET cover, whether it will be robust and self-sustaining, whether any of the plants will set deep roots, and if so, how deep, and how effective the plant community will be in reducing infiltration.

REFERENCES:

Envirocare, *Assessment of Vegetative Impacts on LLRW*, Salt Lake City, Utah, November 2000.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

SWCA Environmental Consultants, *Field Sampling of Biotic Turbation of Soils at the Clive Site, Tooele County, Utah*, prepared for Energy*Solutions*, January 2011.

SWCA Environmental Consultants, *Vegetated Cover System for the Energy*Solutions *Clive Site: Literature Review, Evaluation of Existing Data, and Field Studies, Summary Report*, prepared for Energy*Solutions*, August 2012.

INTERROGATORY CR R313-25-8(4)(A)-108/2: BIOINTRUSION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Include additional information about biointrusion from SWCA (2012).

BASIS FOR INTERROGATORY:

Section 3.5.2, page 11, of the Conceptual Site Model report discusses local wildlife, which is important with regard to biointrusion. Additional important information relative to biointrusion is found in SWCA (2012). Among the conclusions that can be drawn from SWCA (2012) are that (1) coyote burrows, while not seen in the plots, were observed near or close to the plots, indicating the potential for coyotes to burrow in an embankment on the site, (2) badger burrows were observed in two of the plots, and badgers themselves were seen moving about during the sampling event and were photographed, and (3) burrowing owls were also observed on site and photographed. Coyotes and badgers are documented to dig relatively deeply, more deeply than the planned Federal Cell cover system depth of 5.5 feet (Lindzey, 1976; McKenzie et al., 1982; Hampton, 2006). SWCA (2012) reports that "*the presence of the badgers…in the study area indicates the potential for large volume soil bioturbation within the existing vegetation communities and soil types*." The Conceptual Site Model report should be revised to be consistent with available technical literature and other information generated by Energy*Solutions* consultants.

ES RESPONSE:

In its response, ES stated that: "*new data is being evaluated to determine if changes are needed to the model.*"

REBUTTAL:

We await the results of that evaluation.

REFERENCES:

Hampton, N.L, *Biological Data to Support Operable Unit 7-13/14: Modeling of Plant and Animal Intrusion at Buried Waste Sites*, INEEL/EXT-01-00273, Revision 1, Project No. 23378, Idaho Cleanup Project, January 2006.

Lindzey, F.G., *Characteristics of the natal den of the badger,* Northwest Science, Vol. 50, pp. 178–180, 1976.

McKenzie, D.H., L.L. Cadwell, L.E. Eberhardt, W.E. Kennedy, Jr., R.A. Peloquin, and M.A. Simmons, *Relevance of Biotic Pathways to the Long-Term Regulation of Nuclear Waste Disposal*, NUREG/CR-2675, Pacific Northwest Laboratory, Richland, Washington, 1982.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

SWCA Environmental Consultants, *Vegetated Cover System for the Energy*Solutions *Clive Site: Literature Review, Evaluation of Existing Data, and Field Studies, Summary Report*, prepared for Energy*Solutions*, August 2012.

INTERROGATORY CR R313-25-7(2)-109/1: GEOCHEMICAL DEGRADATION OF RIP RAP

ES notes that this interrogatory is no longer relevant for the top slope of the Federal Cell since the Federal Cell will largely use an ET cover. However, this interrogatory should be addressed in regard to rip rap that will be used on portions of the side slope and on ditches.

INTERROGATORY CR R313-25-8(4)(A)-110/1: RADON TRANSFER FROM WATER

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES made the proposed changes to Section 7.1.3.1, page 38, and Section 9.4.1, page 63, of the revised Conceptual Site Model report (Appendix 2 to FRV1.2). Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-7-111/2: LIKELIHOOD OF LAVA DAM FORMATION

PRELIMINARY FINDING:

Refer to R313-25-7: *The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:*

(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.

INTERROGATORY STATEMENT:

Describe why the future likelihood of lava dam formation is considered small, given that lava dams formed during the Pleistocene and affected Lake Bonneville.

BASIS FOR INTERROGATORY:

Section 7.2.1.4, page 39, of the Conceptual Site Model report describes the formation of lava dams during the Pleistocene and their affect on Lake Bonneville. It states that "*Future changes in the regional hydrology in response to any future lava flows or regional volcanic activity could result in similar implications for future pluvial lake events (i.e., increase or decrease in discharge to the basin).*"

However, Section 2.0, page 3, of the Deep Time Assessment states the following:

> *Other less likely geologic events could also occur in the next 2.1 My. Events such as meteor strikes, and volcanic activity such as Yellowstone could also be considered. However, events other than the cyclic return of large lakes are not considered further in this model because their likelihood is small, and their consequences are likely to be much greater and far reaching for human civilization.*

The text should describe why, if lava dams formed during the Pleistocene affected Lake Bonneville, their future likelihood is considered small.

ES RESPONSE:

In its response, ES cited Nash (1989) and Nash, Oviatt, and Nash (2014).

REBUTTAL:

The cited documents were not included in the reference list in Section 3 of the response document. ES should provide full reference information so that we can review these sources.

REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(A)-112/2: HYDRAULIC CONDUCTIVITY

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Revise the hydraulic conductivity values to be consistent with the values in NUREG/CR-7028. Increase the model's radon barrier permeability by at least two orders of magnitude and re-run the simulations, or provide evidence, explanation, and justification as to why the DRC Director should accept the current assumptions as presented.

BASIS FOR INTERROGATORY:

The modeled saturated hydraulic conductivity values for clay radon barriers at the site of DU disposal, as noted in Table 1 of the Unsaturated Zone Modeling report, are generally much too low for post-construction values (see NUREG/CR-7028). Long-term post-construction hydraulic conductivity values for cover system soils historically tend to be at least one, and generally two or more, order(s) of magnitude **higher** than as-built hydraulic conductivity values. Furthermore, the value used in the model for the less-permeable radon barrier soil is not within the range specified as being realistic for planning in NUREG/CR-7028. The values used in the GoldSim model and described in the text are maintained unrealistically at their as-built values for any modeling past the initial several years. Moreover, the extremely low hydraulic conductivity value claimed for the lower radon barrier actually results from chemical treatment of the soil (with phosphate ion). The resulting decrease in hydraulic conductivity has not been confirmed as continuing for extended periods of time (e.g., hundreds, thousands, tens of thousands, or millions of years). Energy*Solutions* should increase the model's radon barrier permeability by at least two orders of magnitude and re-run the simulations, or provide evidence, explanation, and justification as to why the DRC Director should accept the current assumptions as presented.

ES RESPONSE:

In its response, ES indicated that recent sensitivity analysis shows that the infiltration results are insensitive to changes in radon barrier integrity.

REBUTTAL:

The ES response is not adequate, in that the analysis mentioned does not account for changes in hydraulic conductivity of the surface layer and the evaporative zone. Currently, with presently modeled hydraulic conductivities, the PA model indicates that water does not infiltrate down to the radon barriers at significant rates. As a result, the model currently shows the radon barriers to be insensitive to changes in hydraulic conductivity. However, that may very well change once the PA modeling accounts for changes in hydraulic conductivity of the surface layer and the evaporative zone. Increases in hydraulic conductivity may permit greater rates of infiltration and lesser fractional removal of water via evaporation. Furthermore, a strong correlation exists between van Genuchten alpha values and hydraulic conductivity, as shown by Guarracino (2007). Therefore, the correlated values of alpha should be made also when changes in hydraulic conductivity are made for the surface layer and the evaporative zone in the model.

Also, the interrogatories referenced are in need of additional information and resolution. Therefore, resolution of this interrogatory will also require resolution of several others, including those listed in Interrogatory CR R313-25-7(1–2)-90/1: Calibration of Infiltration Rates.

REFERENCES:

Benson, C.H., Albright, W.H., Fratta, D.O., Tinjum, J.M., Kucukkirca, E., Lee, S.H., Scalia, J., Schlicht, P.D., and Wang, X., *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, NUREG/CR-7028, Volume 1, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, December 2011.

Guarracino, L., *Estimation of saturated hydraulic conductivity Ks from the van Genuchten shape parameter α*, Water Resources Research, Vol. 43, Issue 11,W11502, November 15, 2007.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(5)(A)-113/2: PLACEMENT OF BULK LOW-LEVEL WASTE AMONG DU CANISTERS

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a* *minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Describe modeling and consequent assessment related to the placement of bulk low-level waste between, above, or below the DU canisters.

BASIS FOR INTERROGATORY:

UAC R313-25-8(5)(a) requires that the PA include "*total quantities of concentrated depleted uranium and other wastes*." If Energy*Solutions* would like to place bulk low-level waste between, above, or below DU canisters at some time in the future, then the model's waste source term concentrations should be increased accordingly. This will also entail modeling and quantitative assessment of radioactivity concentrations in environmental media and doses to a member of the public during the 10,000-year compliance period for inclusion in the PA report. Also, additional justification will be needed for why this added waste source term does not alter current Energy*Solutions* findings regarding inadvertent intruders. In addition, new modeling and qualitative assessment of the revised radioactivity concentrations and doses during the remaining, post-10,000-year performance period must be performed under the revised assumption that fill around the DU canisters will comprise low-level waste at Class A limits. This will, of course, potentially increase calculated environmental media concentrations and doses. Section 6.4, page 26, of the Model Parameters report states, in terms of the Inventory\ClassA_LLW_Inventory container, that "*This is a placeholder container. No other LLW inventory is assumed in the model.*" Descriptions of this needed modeling and consequent assessment should be included within the PA. Energy*Solutions* should revise the Model Parameters report and the GoldSim model inputs and re-run the simulations, or provide evidence, explanation, and justification of why this issue is of little consequence and the report can stand as is. Based on the specific plans for waste emplacement, we expect that revisions to the quality assurance/quality control specifications will be required to address how fill around the bulk waste will be treated during disposal.

ES RESPONSE:

In its response, ES stated that: "*Performance assessment for these nuclides is addressed via the ET cover performance assessment currently undergoing DRC review (Energy*Solutions, *2013d).… As such, the condition of the disposal of other Class A low-level radioactive bulk wastes within the Federal Cell is a modeled condition. Therefore, it is unnecessary to repeat this analysis in this Depleted Uranium Performance Assessment.*"

REBUTTAL:

It is not clear how the ES response satisfies the UAC R313-25-8(5)(a) requirement that the PA include "*total quantities of concentrated depleted uranium and other wastes.*" Doses from DU and other wastes (including bulk waste) will sum and must be accounted for in the model quantitatively for 10,000 years and qualitatively (after concentrations are modeled quantitatively) until peak dose is attained. Neither of these requirements is satisfied currently in the PA model.

Among other open questions is (1) how the source term for DU and other wastes will be developed and (2) how relevant engineering requirements related to R313-25-7(2) and (10) will be satisfied, including structural stability of backfill and quality assurance for waste emplacement, respectively. Alternatively, ES could commit not to use bulk low-level radioactive waste as in-fill for DU container disposal. We look forward to reviewing the revised text.

REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License (RML UT2300249) Updated Site-Specific Performance Assessment (Revision 1)*, December 30, 2013.

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-19-114/3: ELEVATED CONCENTRATIONS OF Tc-99

PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

INTERROGATORY STATEMENT:

Discuss the transport of technetium in groundwater at the site, including Tc-99 soil/water partitioning coefficients used in the GoldSim model and results of model predictions for transport of technetium in groundwater at the site for periods of at least 10,000 years. Describe steps that can be taken to limit the presence of technetium in groundwater to concentrations less than or equal to the Utah groundwater protection level of 3,790 pCi/L.

BASIS FOR INTERROGATORY:

Section 4.1.11, page 15, of the Geochemical Modeling report indicates that some of the proposed DU waste contains Tc-99 at elevated concentrations. This includes DU from SRS (see, for example, Table 5 of the Waste Inventory report). Impacted wastes and/or containers also appear to include Tc-99 at elevated concentrations in about 5% of the GDP DU waste canisters. Tc-99 exists under oxic conditions in the subsurface primarily as the TcO^{-4} anion. This species has relatively high solubility and generally very low to even negative partition coefficient values. As a result, Tc-99 will tend to be highly mobile in groundwater. The text should provide a reference to a section(s) of the PA that extensively covers (1) Tc-99 soil/water partitioning coefficients used in the GoldSim model by Energy*Solutions* and (2) results of model predictions for transport of technetium in groundwater at the site for periods of at least 10,000 years. It should also discuss steps that can be taken to limit the presence of technetium in groundwater to concentrations less than or equal to the Utah groundwater protection level of 3,790 pCi/L, specified in Table 1A of Part I.C.1 of the Ground Water Quality Discharge Permit No. UGW450005. The PA should consider waste acceptance criteria that will exclude sources of DU that have elevated concentrations of Tc-99 and thereby limit potential contamination of groundwater at and near the site by this radionuclide. Alternatively, Energy*Solutions* should explain and justify why the DRC Director should accept the PA as it currently stands.

ES RESPONSE:

In its response, ES stated the following:

> *Revision 2 of the GoldSim model is being prepared to evaluate an ET cover design. It is expected that the reduced infiltration afforded by this design will reduce predicted Tc-99 levels in groundwater*.

ES indicated that one strategy to deal with Tc-99 contamination is to locate the Tc-99 contaminated waste higher up in the embankment, then described a second strategy:

> *A second strategy, would be to not dispose of contaminated DU in the first place, especially considering the below grade capacity is considerably exceeded by the DU that needs a disposal option. This approach would still allow for disposal of roughly 95% of the GDP DU, which has no such contamination, and is the first to undergo deconversion at any rate. The deconversion plants in Piketon and Paducah intend to work through their contaminated DUF_6 inventories as the last of their deconversion efforts (personal communication from Jack Zimmerman, Uranium Disposition Services, LLC, to John Tauxe, Neptune and Company, Inc.), and so are unlikely to produce any contaminated DU_3O_8 for at least 20 years.*

REBUTTAL:

We look forward to reviewing the results of the new ET cover design and how it may affect Tc-99 concentrations in the groundwater over 10,000 years or more. These results would need to be integrated in the groundwater exposure scenarios discussed in Interrogatory CR R313-25-8(4)(a)-96/2: Current and Future Potability of Water, and Interrogatory CR R313-25-8(4)(a)-97/2: Need for Potable and/or Industrial Water.

With regard to general strategies for addressing Tc-99, the possibility of locating Tc-99 contaminated waste higher in the embankment is inconsistent with the current approach of burying the DU waste below native grade levels. However, the second strategy has merit, especially since there appears to be inadequate volume below grade to bury all of the DU waste.

V1.2 CRITIQUE (ROUND 3):

In Table 2 of FRV1.2, page 60, the Tc-99 concentration exceeds the 500-year GWPL at the 95th percentile, even with the ET cover. Unless ES provides information on the scenarios involving leakage of contamination into the lower aquifer and extraction of that water for beneficial uses over 10,000 years, the efficacy of the ET cover with regard to demonstrating compliance with R313-25-20 over 10,000 years cannot be determined.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2,* NAC-0024_R1, June 5, 2014.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA,* May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA,* May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

State of Utah, Division of Water Quality, Utah Water Quality Board, Ground Water Quality Discharge Permit No. UGW450005, issued to Energy*Solutions*, LLC, 2013. Available from www.radiationcontrol.utah.gov/EnSolutions/docs/2013/10Oct/SignedfinalPermit.pdf.

INTERROGATORY CR R315-101-5.3(6)-115/1: URANIUM TOXICITY REFERENCE DOSES

Round 1 Interrogatory Response is satisfactory.

INTERROGATORY CR R313-25-8(4)(A)-116/1: Cs-137 DECAY

Round 1 Interrogatory Response is satisfactory.

INTERROGATORY CR R313-25-8(5)(A)-117/2: GROUNDWATER PROTECTION LIMIT FOR Tc-99

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Provide documentation (e.g., a Result Mode GoldSim file) that supports the contention that the Tc-99 GWPL will be met for 10,000 years. In addition, explain why Energy*Solutions* is proposing to include a Tc-99 waste source term concentration limit of 1,720 pCi/g under the side slope, given statements in various places in the PA report that no DU is to be included under the side slopes.

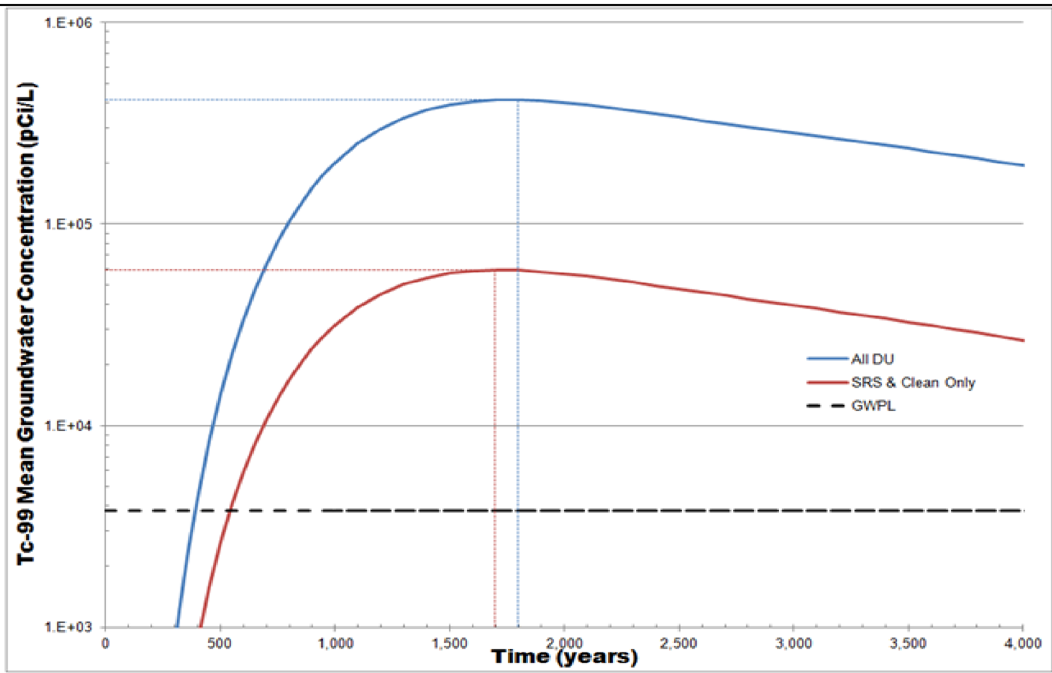
BASIS FOR INTERROGATORY:

Section 3.1.3, page 3-3, of the 2013 Compliance Report, Revision 1, states the following:

> *The infiltration model for the Federal Cell and Division-approved Class A West Embankment covers use GoldSim to demonstrate that the infiltration and radionuclide transport models show that any depleted uranium waste disposed will satisfy all of the groundwater protection criteria, provided that the concentrations of* Tc_{99} *are limited to the concentrations used in the transport modeling. Since the* Tc_{99} *disposal concentrations are already limited to 1,720 pCi/g under the Class A West side slope, Energy*Solutions *proposes the same Federal Cell disposal limitations of 1,720 pCi/g under the side slope and 23,800 pCi/g under the top slope.*

It is not clear that all of the groundwater protection criteria will be satisfied if the stated Tc-99 limits are imposed on the waste. According to Table 5 of the Waste Inventory report, the PA assumes that the mean Tc-99 content is 23,800 pCi/g. This model input waste source term concentration appears to need additional justification and possible revision, as noted in other interrogatories. Section 2.5, page 2-12, of the 2013 Compliance Report, Revision 1, indicates that the DU waste is to be buried at 10 meters. In this case, FRV1 Table 2 shows a peak mean for Tc-99 of 14,400 pCi/L, which is significantly above the GWPL of 3,790 pCi/L.

The figure below shows SC&A's GoldSim simulations comparing Tc-99 concentrations against the GWPL. One case indicates that the Tc-99 GWPL is exceeded after 390 years. We also ran a case where the only source of Tc-99 was the DUO_3 from SRS and determined that the Tc-99 GWPL would be exceeded after 539 years. In another simulation, we decreased the infiltration rate to 0.09 cm/yr (Whetstone 2012, Section 2.4.1) and determined that the Tc-99 GWPL was exceeded in 494 years. Note that none of SC&A's simulations demonstrated that shallow Clive groundwater quality would be protected, below the Tc-99 GWPL, for at least 10,000 years. Based on FRV1 Table 2 and our simulations, it appears that Tc-99 will not meet the established GWPL if the DU is buried at 10 meters.



In addition, Section 2.5, page 2-11 of the 2013 Compliance Report, Revision 1, states that "*no depleted uranium will be placed beneath the Federal Cell's side slopes*." This and similar statements are made in many places in FRV1 and its appendices. However, as noted above, Section 3.1.3, page 3-3, states that "*Energy*Solutions *proposes the same Federal Cell disposal limitations of 1,720 pCi/g under the side slope….*" The reason for including a Tc-99 waste source term concentration limit of 1,720 pCi/g instead of a limit of 0 should be explained.

ES RESPONSE:

> *Revisions underway to the depleted uranium Performance Assessment GoldSim model demonstrate that infiltration into the Federal Cell's evapotranspirative cover will subsequently comply with limitations of Energy*Solutions*' GWQDP.*
>
> *The interrogatory, however, erroneously conflates R313 radiological dose standards with R317 non-degradation standards.*

REBUTTAL:

Limitations on exposures to the general public are established in R313-25-20. Pursuant to R313-25-8(5)(a), these standards must be met for 10,000 years or more for any viable groundwater or other pathway. See our comments on Interrogatory CR R313-25-8(4)(a)-96/2: Current and Future Potability of Water.

We note that ES did not provide a response to our query regarding Tc-99 concentrations in the embankment side slopes. The requested explanation should be provided.

REFERENCES:

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

State of Utah, Division of Water Quality, Utah Water Quality Board, Ground Water Quality Discharge Permit No. UGW450005, issued to Energy*Solutions*, LLC, 2013.

Whetstone Associates, Inc., *Energy*Solutions *Class A West Disposal Cell Infiltration and Transport Modeling,* February 23, 2012.

INTERROGATORY CR R313-25-7(10)-118/1: GOLDSIM RESULTS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES provided the Clive DU PA Model GoldSim file, which gives results consistent with those in FRV1.2. (An exact match is not possible since the FRV1.2 results are based on 10,000 realizations and only 1,000 realizations were run in the test.) Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(4)(A)-119/1: RESUSPENSION AND AIRBORNE PATHWAYS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES made changes to the GoldSim model and is no longer considering the disposal of DU at a depth of 3 meters below the cover system. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(4)(A)-120/3: GULLIES AND RADON

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in

isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Provide justification as to why the presence of gullies in the embankment has no impact on the radon flux at the surface of the embankment, and thus no impact on the general population doses. Alternatively, modify the GoldSim model to have the embankment surface radon flux account for the presence of gullies within the embankment, include the "short-circuiting" of radon migrating upwards though the degraded cap and the release of radon directly to the atmosphere from any gullies that extend downwards into the disposed DU.

BASIS FOR INTERROGATORY:

For the 3-meter and 10-meter burial cases, SC&A made GoldSim model runs both without and with gullies and compared with the embankment surface peak radon fluxes (PeakRadonFlux) from Section 9.4 of the Unsaturated Zone Modeling report. Since the presence of gullies would provide a "short-circuit" pathway for radon to escape from the embankment, a higher peak radon flux was expected for the cases with gullies than for the cases without gullies. This is especially true since some of the gullies contained within the PA model extend downward through the cap's radon barrier. However, when the GoldSim-calculated peak radon fluxes were compared, the flux with gullies was identical to the flux without gullies.

Also, for some of the 3-meter burial case realizations, the gullies extend downward into the DU itself. However, a review of the GoldSim model did not reveal where it calculates the direct release of radon to the atmosphere due to the decay of uncovered Ra-226. For example, EPA (1986, page 3-15) specifies as a "rule-of-thumb" a Rn-222 release rate from uncovered Ra-226 of 1 pCi (Rn-222)/m^2-s per pCi (Ra-226)/g, or the Rn-222 release rate can be calculated from the diffusion equation. The model inputs should be revised accordingly and the simulations re-run. Alternatively, Energy*Solutions* should explain and justify why its approach as currently modeled is representative of future site conditions.

ES RESPONSE:

In its response, ES confirmed that "*The effects of the gullies on biotic activities, enhanced infiltration, or enhanced radon flux were not examined.*" ES also stated that: "*Further erosion modeling needs is being evaluated….*"

REBUTTAL:

We assume that this "*further…modeling*" will include the impact of erosion on the radon flux, and we look forward to receiving and reviewing these further erosion modeling efforts.

V1.2 CRITIQUE (ROUND 3):

FRV1.2 Section 7.1, page 83, confirms that the "*impact of gullies has not been fully developed in terms of their effect on biotic activity, radon transport, or infiltration*." Therefore, this interrogatory remains open until the impacts of gully formation on radon transport and infiltration have been determined.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2,* NAC-0024_R1, June 5, 2014.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Final Rule for Radon – Emissions from Licensed Uranium Mill Tailings, Background Information Document*, Office of Radiation Programs, EPA 520/1-86-009, August 15, 1986.

INTERROGATORY CR R313-25-19-121/2: GULLIES AND RECEPTOR LOCATION

PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

INTERROGATORY STATEMENT:

When gullies are assumed to be present in the embankment, provide justification for using the radionuclide soil concentration and radon flux averaged over the entire embankment surface (including areas without and with gullies) when calculating exposures to hunters, ranchers, and off-highway vehicle (OHV) enthusiasts. Alternatively, provide the estimated exposures to these receptors when they are assumed to spend all (or most) of their time in the gullies.

BASIS FOR INTERROGATORY:

SC&A's review of the GoldSim model (Exposure_Dose.Dose_Calculations.Environ_Concs_2D) reveals that the average embankment air and soil concentrations are used to calculate OHV enthusiast doses. This implies that the time an OHV enthusiast spends inside the gullies is proportional to the areal size of the gullies relative to the areal size of the embankment. For example, if gullies are formed over 5% of the entire embankment area, then the present GoldSim model assumes that the OHV enthusiast spends 5% of his or her time in the gullies.

However, Section 3.2.2, page 4, of the Erosion Modeling report states that the "*engineered cap at the Clive facility may be subject to gully erosion via a disturbance attributed to…off-highway vehicle (OHV) track.*" Since the gullies may be formed by the OHV enthusiasts, it seems logical that the OHV enthusiasts' exposure calculation would assume that they spent all (or most) of their time in the gully tracks. For the example above, an assumption that the OHV enthusiast spends 100% of his or her time in the gullies (instead of 5%) would result in an exposure that is a factor of 20 larger than what is currently predicted.

Because the GoldSim model also assumes that the hunters and ranchers use OHVs, this interrogatory also includes them.

ES RESPONSE:

In its response, ES stated that it would add the following text to the Erosion Modeling report (Appendix 10 to FRV1):

> *…The steep-walled profile of the eventual deeply-incised and narrow gullies would likely preclude extensive OHV activity in the gullies themselves; i.e., once a gully forms, OHV users (if any) would likely ride elsewhere on the cap.…*

It also stated the following:

> *The deeply incised portions of the gullies are too narrow for OHVing.*
>
> *…, the* [gully/erosion] *model is being updated to address removing the riprap cap and replacing it with an ET cover. An erosion model is being abstracted and adapted to these conditions from previous work performed on the Borrow Pit. Questions about erosion and gullies are being re-addressed.*

REBUTTAL:

First, this interrogatory has more to do with the OHV enthusiast dose model than with the gully/erosion model. Thus, this interrogatory applies equally well to the existing and revised gully/erosion models.

The gist of this interrogatory is that OHV riders would spend proportionally more of their time in gullies than on the top surface of the embankment. ES argued that the steep walls of the gullies would preclude OHV enthusiasts from riding in the gullies. However, the steep gully walls would offer a challenge to the OHV enthusiasts and encourage them to ride there to demonstrate the capabilities of their machine and/or to demonstrate their driving skills. A cursory review of results to a Google search on "dunes gullies ATVs" demonstrates that gullies are some of the favorite places for ATV enthusiasts to ride.

Furthermore, a gully in the side of the embankment would provide a preferential path to the top for the OHV enthusiasts, so that they would not have to go up the steeper sides of the un-eroded embankment.

In brief, DRC does not agree with the ES response and believes that further investigation into this issue is warranted. We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Erosion Modeling for the Clive PA*, June 1, 2011. (Appendix 10 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

INTERROGATORY CR R313-25-8(4)(D)-122/2: SIZE OF PLUVIAL LAKES

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Provide complete references to support assumptions with respect to the size of recurring pluvial lakes. Revise the Deep Time Assessment report to rely on more recent paleolake evidence focused on the Bonneville Basin.

BASIS FOR INTERROGATORY:

Section 3.1, page 5, of the Deep Time Assessment report states the following:

> *However, of the seven most recent 100 ky glacial cycles, it is estimated that only four of them presented very large lakes in the Bonneville Basin. Variation in climatic conditions appears to be sufficient that large differences have occurred in each of the past 100 ky cycles.*

This statement attempts to tie global climate cycles as manifested in high latitude ice cores (Jouzel et al., 2007) to large lakes in the mid-latitude Bonneville basin. While existing journal literature (e.g., Balch et al., 2005; Davis, 1998) documents a number of 100 ky glacial-interglacial lake cycles, the exact number, timing, and recurrence interval over the past 2 million years is not firmly established. Moreover, for cycles of large lakes documented regionally throughout geologic time, the recurrence interval is not uniform, and it is smaller than 100 kya. The Little Valley lake peaked in elevation at about 135 ky BP, the Cutler Dam lake peaked about 65 ky BP, and the Bonneville lake peaked about 18 ky BP (see Machette et al. 1992).

Energy*Solutions* should revise the appendix to also rely on more recent paleolake evidence focused on the Bonneville Basin, such as that in Machette et al. (1992) and Madsen (2000).

ES RESPONSE:

In its response, ES described the approach taken to model the number, timing, and recurrence interval of the lakes. It also provided replacement text for the Deep Time Assessment report (Appendix 13 to FRV1).

REBUTTAL:

The ES response is satisfactory; ES should correct the text accordingly in the revised report. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES changed the text in the revised Deep Time Assessment report (Appendix 13 to FRV1.2) as proposed. Therefore, this interrogatory is closed.

REFERENCES:

Balch D.P., A.S. Cohen, D.W. Schnurrenberger, B.J. Haskell, B.L.V. Garces, J.W. Beck, H. Cheng, and R.L. Edwards, *Ecosystem and paleohydrological response to Quaternary climate change in the Bonneville basin, Utah*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 221, pp. 99–121, 2005.

Davis, O.K., *Palynological evidence for vegetation cycles in a 1.5 million year pollen record from the Great Salt Lake, Utah, U.S.A.*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 138, pp. 175–185, 1998.

Jouzel, J., V. Masson-Delmotte, O. Cattani, and G. Dreyfus, et al., *Orbital and millennial Antarctic climate variability over the past 800,000 years*, Science, Vol. 317, pp. 793–796, 2007.

Machette, M.N., S.F. Personius, and A.R. Nelson, *Paleoseismology of the Wasatch fault zone: A summary of recent investigations, interpretations, and conclusions*, in Gori, P.L., and W.W. Hays, eds., Assessment of regional earthquake hazards and risk along the Wasatch Front, Utah, U.S. Geological Survey Professional Paper 1500-A-J, pp. A1–A71, 1992.

Madsen, D.B., editor, *Late Quaternary Paleoecology in the Bonneville Basin*, Utah Geological Survey Bulletin 130, 2000.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0032_R1, June 5, 2014.

INTERROGATORY CR R313-25-8(4)(D)-123/2: TIMING OF LAKE CYCLES

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Incorporate other existing literature on lake cycles in the Bonneville basin for a complete perspective on lake cycles in the Bonneville basin. Describe why the Burmester core data are applicable to the Clive site, including location and distance from Clive, ground elevation, and geologic setting.

BASIS FOR INTERROGATORY:

Section 3.2, page 6, of the Deep Time Assessment report states the following:

> *To establish the approximate timing of previous lake cycles, Oviatt et al. (1999) examined sediments from the Burmester sediment core and suggested that a total of four deep-lake cycles occurred during the past 780 ky (Table 2). They found that the four lake cycles correlated with marine $\delta^{18}O$ stages 2 (Bonneville lake cycle: ~24–12 ky), 6 (Little Valley lake cycle: ~186–128 ky), 12 (Pokes Point lake cycle: ~478–423 ky), and 16 (Lava Creek lake cycle: ~659–620 ky).*

The report should also describe why the Burmester core data are applicable to the Clive site, including, but not limited to, location and distance from Clive, ground elevation, and geologic setting and similarities (or differences). This discussion should consider that a greater understanding and more data are available concerning the four different stages of Lake Bonneville most likely because it was the most recent paleolake to exist in the Bonneville Basin. In other words, older pluvial lakes may have also had multiple shorelines at varying elevations, but because of the inherent mechanics of erosion and sediment redistribution forces of the more modern Lake Bonneville sequence, modern evidence of these former lake features has likely been lost.

In addition to Oviatt et al. (1999), Balch et al. (2005) and Davis (1998) provide a picture of lake cycles in the Bonneville basin that is considerably more complex than this statement would indicate. Additional information on the Bonneville Basin paleolakes can be found in sources such as Machette et al. (1992) and Madsen (2000).

ES RESPONSE:

In its response, ES stated described the uncertainty associated with the timing of lake cycles and the conceptualization of the glacial lake cycles in the deep time assessment. ES stated that: "*Oviatt has also collected sediment data from Knolls (to the west of Clive) and at Clive itself (described further in Section 3.3). These data are largely consistent with the more recent layers from Burmester, indicating similar sedimentation processes at work at least during these time periods.*"

REBUTTAL:

We continue to believe the descriptions of the Clive exposure are not relatable to the Burmester core, and that the Knoll section documentation of the Deep Time Assessment report (Appendix 13 to FRV1) is inadequate. ES should revise its report to resolve this finding.

REFERENCES:

Balch D.P., A.S. Cohen, D.W. Schnurrenberger, B.J. Haskell, B.L.V. Garces, J.W. Beck, H. Cheng, and R.L. Edwards, *Ecosystem and paleohydrological response to Quaternary climate change in the Bonneville basin, Utah*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 221, pp. 99–121, 2005.

Davis, O.K., *Palynological evidence for vegetation cycles in a 1.5 million year pollen record from the Great Salt Lake, Utah, U.S.A.*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 138, pp. 175–185, 1998.

Machette, M.N., S.F. Personius, and A.R. Nelson, *Paleoseismology of the Wasatch fault zone: A summary of recent investigations, interpretations, and conclusions,* in Gori, P.L., and W.W. Hays, eds., Assessment of regional earthquake hazards and risk along the Wasatch Front, Utah, U.S. Geological Survey Professional Paper 1500-A-J, pp. A1–A71, 1992.

Madsen, D.B., editor, *Late Quaternary Paleoecology in the Bonneville Basin*, Utah Geological Survey Bulletin 130, 2000.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Oviatt, C.G., R.S. Thompson, D.S. Kauffman, J. Bright, and R.M. Forester, *Reinterpretation of the Burmester core, Bonneville Basin, Utah*, Quaternary Research, Vol. 52, pp. 180–184, 1999.

INTERROGATORY CR R313-25-8(4)(D)-124/2: MECHANISMS FOR PLUVIAL LAKE FORMATION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

The discussion of mechanisms for pluvial lake formation is incomplete. Describe other possible forcing mechanisms that have been proposed for the formation of Great Basin pluvial lakes and present the basis for the selected approach.

BASIS FOR INTERROGATORY:

Section 3.2, page 7, of the Deep Time Assessment report states the following:

> *These extensive glaciations are suggested to have been controlled by the mean position of storm tracks throughout the Pleistocene, which were in turn controlled by the size and shape of the ice sheets (Oviatt, 1997; Asmerom et al., 2010).*

However, other mechanisms have been proposed for the formation of the Great Basin pluvial lakes. For example, Lyle et al. (2012) propose that changes in Pacific Ocean circulation were the forcing mechanism for Great Basin pluvial lakes, rather than steering of storm tracks by the continental ice sheets. Ruddiman (2006) is another source of information on the subject. The DU PA should provide an assessment of alternate forcing mechanisms.

ES RESPONSE:

In its response, ES provided text changes pertaining to isotopic evidence for alternating warm and cool periods.

REBUTTAL:

ES should correct the text accordingly in the revised report. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES changed the text in the revised Deep Time Assessment report (Appendix 13 to FRV1.2) as proposed. Therefore, this interrogatory is closed.

REFERENCES:

Asmerom, Y., V.J. Polyak, and S.J. Burns, *Variable winter moisture in the southwestern United States linked to rapid glacial climate shifts*, Nature Geoscience, Vol. 3, pp. 114–117, 2010.

Lyle, M., L. Heusser, C. Rovelo, M. Yamamoto, J. Barron, N.S. Diffenbaugh, T. Herbert, D. Andreasen, *Out of the Tropics: The Pacific, Great Basin Lakes, and Late Pleistocene Water Cycle in the Western United States*, Science, Vol. 337, pp. 1629–1633, 2012.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0032_R1, June 5, 2014.

Oviatt, C.G., *Lake Bonneville fluctuations and global climate change*, Geology, Vol. 25, Issue 2, pp. 155–158, 1997.

Ruddiman, W.F., *Orbital Changes and Climate*, Quaternary Science Reviews, Vol. 25, pp. 3092–3112, 2006.

INTERROGATORY CR R313-25-8(4)(D)-125/2: DEEP LAKE CYCLES

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses* *shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Correct the age ranges for the Lake Bonneville flood events to reflect more recent information.

BASIS FOR INTERROGATORY:

Section 3.2, page 8, of the Deep Time Assessment report states that *"The high-stand (i.e., the highest level reached) of the lake at the Zenda threshold (1,552 m), located north of Red Rock Pass, occurred approximately 18.3–17.4 ky BP."*

However, Miller et al. (2013) give a more up-to-date review of the correct chronology of Lake Bonneville and the Bonneville flood event.

ES RESPONSE:

In its response, ES provided text clarifications in the Deep Time Assessment report (Appendix 13 to FRV1) for the anticipated lake levels.

REBUTTAL:

ES should correct the text accordingly in the revised report. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES added the proposed text to Section 3.2, page 11, of the revised Deep Time Assessment report (Appendix 13 to FRV1.2). Therefore, this interrogatory is closed.

REFERENCES:

Miller, D.M., C.G. Oviatt, and J.P. Mcgeehin, *Stratigraphy and chronology of Provo shoreline deposits and lake-level implications, Late Pleistocene Lake Bonneville, eastern Great Basin, U.S.A.*, Boreas, Vol. 42, pp. 342–361, 2013.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0032_R1, June 5, 2014.

INTERROGATORY CR R313-25-8(4)(D)-126/2: SHALLOW LAKE CYCLES

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent* *soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Examine the presumed shallow lake cycles within the context of other references regarding lake cycles from other areas of the Great Basin.

BASIS FOR INTERROGATORY:

Section 3.3, page 9, of the Deep Time Assessment report states the following:

> *From the Clive pit wall interpretation, it is presumed that at least three shallow lake cycles occurred prior to the Bonneville cycle, although there is some uncertainty associated with that estimate. These shallow cycles could in fact be part of the transgressive phase (i.e., rising lake level) of the Bonneville cycle (C.G. Oviatt, personal communication). By analyzing the Knolls core interpretation, which is more representative of Clive than the Burmester core due to its relative proximity and differences in their regional topography, the Little Valley cycle is present at approximately 16.8 m from the top of the core. Given the pit wall at Clive was 6.1 m deep and does not capture the Little Valley cycle, it can be speculated that other smaller lake cycles occurred in the Clive region in addition to the three shallow lake events noted in Table 3 (labeled as Pre-Bonneville Lacustrine Cycles).*

We note that the sedimentation rates described are speculative without any age dating. While the examination of the Clive exposure in the field and the Knoll core was accomplished by an acknowledged expert in Great Basin geochronology and geomorphology (Oviatt), these conclusions should be examined within the context of other references regarding lake cycles from other areas of the Great Basin (e.g., Balch et al., 2005; Davis, 1998).

ES RESPONSE:

In its response, ES indicated that several typographical errors will be corrected and provided text changes for the shallow and intermediate lake cycles. The new text describes the distinction between shallow and intermediate lakes made for modeling purposes.

REBUTTAL:

ES stated that: "*Intermediate lakes are assumed to be smaller lakes that reach and exceed the altitude of Clive, but are not large enough that carbonate sedimentation can occur.*" We believe that this assumption is incorrect, as explained in the comments on the ES response to Interrogatory CR R313-25-8(5)(a)-44/1: Occurrence of Intermediate Lakes. ES should revise the report accordingly.

REFERENCES:

Balch D.P., A.S. Cohen, D.W. Schnurrenberger, B.J. Haskell, B.L.V. Garces, J.W. Beck, H. Cheng, and R.L. Edwards, *Ecosystem and paleohydrological response to Quaternary climate change in the Bonneville basin, Utah,* Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 221, pp. 99–121, 2005.

Davis, O.K., *Palynological evidence for vegetation cycles in a 1.5 million year pollen record from the Great Salt Lake, Utah, U.S.A.*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 138, pp. 175–185, 1998.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(D)-127/2: CARBONATE SEDIMENTATION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Provide additional rationale for the assumption that carbonate sedimentation will not occur in intermediate lakes, based on the limnology literature.

BASIS FOR INTERROGATORY:

Section 3.3, page 10, of the Deep Time Assessment report states that *"Intermediate lakes are assumed to be smaller lakes that reach and exceed the altitude of Clive, but are not large enough that carbonate sedimentation can occur."*

However, lake size has little relationship to the nature of lacustrine sedimentation, carbonate or otherwise. Standard limnology texts and journal literature illustrate the complexity of sedimentation in lakes of all sizes. For example, the relatively shallow modern Great Salt Lake has well documented carbonate sedimentation (Gwynn, 2002, and references therein; Hutchinson, 1957; Kalff, 2002). Sediments at Clive may be dominantly carbonates. Studies for the licensee conducted at the University of Utah Research Institute (1993) show that clay and silt particles of a sample of Unit 4 silty clay at the Clive site consist predominantly of calcium carbonate (65% of total fines). Of that, most is aragonite (82% of all calcium carbonate). The cited assumption should be revised based on the information in these references.

ES RESPONSE:

In its response, ES described the role of carbonate mineralogy in understanding sedimentation rates. ES also indicated that it is adding detail on lake dynamics/circulation and processes of radionuclide partitioning in lake carbonate and evaporite deposits during lake recession.

REBUTTAL:

The ES response is satisfactory; ES should correct the text accordingly in the revised report. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

The following text was added to Section 3.3, pages 13–14, of the Deep Time Assessment report (Appendix 13 to FRV1.2):

> *A key assumption for the deep time assessment is the observation, based on core sediment studies, that the net depositional rate of deep lakes is lower than the sediment depositional rate for intermediate lakes. The conceptual basis for this assumption is sedimentation rates are dependent on basin location, presence or absence of fluvial deposition, wave dynamics, availability of local sediment sources, slope, water chemistry and biological activity. Carbonate deposition is likely to occur under a wide range of lake conditions but the ratio of carbonate deposition to clastic sedimentation will increase as the lake deepens because of the reduction in sedimentary influx with increased distance from shoreline processes and decreased wave activity.*
>
> *There are recognized trends in carbonate mineralogy that can be correlated with lake volume and indirectly lake depth (for example, Oviatt, 2002; Oviatt et al., 1994; Benson et al., 2011). The transitions from low-magnesium calcite to high-magnesium calcite to aragonite generally reflect increasing lake salinity and increasing magnesium concentration, which occur with decreasing lake volume. Similarly, for a hydrologically closed pluvial lake system, the relative concentration of total inorganic carbon should decrease as lake size increases. The $\delta^{18}O$ of deposited carbonate can be correlated with rising lake levels because of the interplay between the $\delta^{18}O$ value of river discharge entering a lake and the $\delta^{18}O$ value of water vapor exiting the system via evaporation (Benson et al. 2011). The mineralogy and isotopic composition of carbonate composition can be obtained from sediment cores. However, interpretation of the data is complicated by multiple processes, including: local groundwater discharge; introduction of glacial rock flour; and, reworking of lake sediments during transgressive and regressive lake cycles.*
>
> *The model parameters used in the deep time assessment are sensitive to lake duration and sedimentation rates but are not dependent on the dynamics of carbonate deposition. Radionuclides in sediment will partition between the lake water and solid phase dependent on element-specific solubility and assigned sorption properties. Radionuclides remaining in the pore water can diffuse into*

> *the lake water. Some radionuclide species may bind with carbonate ions in the lake water and precipitate as carbonate. However, the deep time assessment conservatively assumes all waste is precipitated with and incorporated into local sediments during lake recession.*

Note that there are two Oviatt et al. 1994 references in the list on page 44 of the Deep Time Assessment report.

Section 3.4, page 16, was revised to state the following:

> *The types of sediment resulting from the formation and long-term presence of lakes in the Bonneville Basin are genetically diverse and can be divided into three components (Schnurrenberger et al. 2003: 1) chemical sediment (inorganic materials formed within the lake); 2) biogenic sediment (fossil remains of former living organisms); and, 3) terrigenous or clastic sediments (grains and clasts that are mechanically and chemically fragmented from existing material, transported and deposited by sedimentary processes). A fourth type of associated sediment, not formed by lakes, includes aeolian deposits consisting of windblown grains of sand, silt or dust (loess). These deposits can locally be interbedded with lake sediments and may be affected by soil-forming processes (pedogenesis) during prolonged periods of subaerial exposure (land surface). All four types of sediments can be intermixed by lake-wave action and deposited as clastic sediments during transgressive and regressive lake cycles.*

> *During all pluvial lake cycles, chemical and biogenic sediment are deposited [in] the form of evaporites and carbonates as tufas, marls, mudstones, and may contain varying components of shells (of mollusks), and ostracodes (Hart et al., 2004). Terrigenous sedimentation however, accounts for the major thickness of sediment observed throughout the sediment core record (C.G. Oviatt, personal communication). The geomorphological evidence in the form of depositional and erosional landforms produced at lake edges (lake shorelines) are carved into the landscape in the Bonneville Basin and provide examples of the erosional capacity of lake systems over long time periods. Given the difficulty in separating chemical, biogenic and terrigenous sediment deposits in cores and natural exposure, estimates reported below are assumed to be representative of cumulative sedimentation from all causes during a lake event.*

Section 6.3, page 32, was revised to state the following:

> *Deposition of material in the area of the Clive facility is a continuous process that occurs during shallow, intermediate and large lake periods. During shallow lake periods, as observed in present-day conditions, aeolian deposition of sand, silt and loess is the primary sedimentary mechanism. However, aeolian deposits are rarely observed in sediment cores, presumably because of reworking of the depositions during lake transgressions and mixing with lake-derived sediments. Note however that the upper part of the Clive pit is now interpreted to be of aeolian origin and soils have been described in the Burmester core indicating prolonged periods of subaerial exposure (Oviatt, personal communication, April*

2014). Intermediate lake sediments include chemical, biogenic, and terrigenous sediments, with their proportions dependent on the size and duration of the lake and the interplay between deep lake deposition and near-shore sedimentary processes. Schofield et al. (2004) note that the large fetch of Lake Bonneville (distance of wave forming winds) produced a variety of wave-dominated erosional and depositional sedimentary and geomorphic features. They identified cross-sections of erosion-dominated and deposition dominated shorelines and the composite sedimentation rates of shoreline profiles will be dependent on local process of wind/wave erosion and deposition and supply of sediments from alluvial fans flanking pluvial lakes (See Schofield et al. 2004; their Figs 3 and 4). Moreover, as noted previously, since aeolian deposition layers are not commonly observed in the sediment cores, the model effectively combines aeolian deposits with lake sediments. The mixing probably occurs during intermediate lake cycles, which are likely to be the first lakes after inter-glacial periods. These assumptions require that there is a mixing depth associated with each lake recurrence. However, the mixing process itself makes it very difficult to assign mixing depths for the different layers in the sediment cores; mixing depths are probably determined by the dynamics of wave activity and resulting erosion/deposition during lake transgressions and regressions.

Large lakes, by contrast, have similar sediment deposition rates to intermediate lakes in their transgressive and regressive phases, but have different, slower, rates when the lake is deep enough that the dominant sedimentation process is precipitation of chemical and biogenic material. Records from the sediments cores are able to distinguish between layers associated with intermediate lakes with predominant sediment mixing and sedimentary layers associated with a large deep lake that are dominated instead by chemical and biogenic deposition.

Note that the Schofield reference on page 45 has an incorrect page number; it should be 1675 instead of 167.

The following text was added to Section 6.5.2, page 40:

Fick's law for this case estimates the activity diffusing from a given area of sediment into the lake with time. The activity per area per time is the flux. Fick's law states that this flux is given by the change in activity with distance multiplied by a free-water diffusion coefficient. The calculation assumes that there is a stagnant interface boundary layer of water between the sediment and the open water that is 0.1 m thick. The assumption is also made that the activity concentration is zero in the open water. The difference in concentration across the stagnant layer is then the concentration in the sediment C_v *minus the concentration in the open water or* C_v *- 0. Fick's law would be written as:…*

Once the two minor editorial concerns noted above are resolved, this interrogatory is closed.

REFERENCES:

Benson, L.V., S.P. Lund, J.P. Smoot, D.E. Rhode, R.J. Spencer, K.L. Verosub, L.A. Louderback, C.A. Johnson, R.O Rye, and R.M. Negrini, *The Rise and Fall of Lake Bonneville Between 45 and 10.5 ka*, Quaternary International, Vol. 235, pp. 57–69, 2011.

Gwynn, J.W., ed. *Great Salt Lake: An overview of change*, Utah Geological Survey Special Publication of the Division of Natural Resources, 2002.

Hutchinson, G.E., *A treatise on limnology: Volume 1*, Geography, physics and chemistry, Part 2 – Chemistry of lakes, Wiley and Sons, New York, 1957.

Kalff, J., *Limnology*, Prentice Hall, 592 pp., 2002.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA, Clive DU PA Model v1.2,* NAC-0032_R1, June 5, 2014. (Appendix 13 to FRV1.2)

Oviatt, C.G., G.D. Habiger and J.E. Hay, *Variation in the Composition of Lake Bonneville Marl: A Potential Key to Lake-Level Fluctuations and Paleoclimate*, Journal of Paleolimnology, Vol. 11, pp. 19–30, 1994.

Oviatt, C.G., W.D. McCoy, and W.P. Nash, *Sequence stratigraphy of lacustrine deposits: a Quaternary example from the Bonneville basin*, Utah. Geological Society of America Bulletin, Vol. 106, pp. 133–144, 1994.

Oviatt, C.G., *Comparing the Shoreline and Offshore Sedimentary Records of Lake Bonneville*, Abstracts with Programs – Geological Society of America, Vol. 34, Issue 6, p. 292, 2002.

Schnurrenber, D.J. Russell, and K. Kelts, *Classification of lacustrine sediments based on sedimentary components,* Journal of Paleolimnology, Vol. 29, pp. 141–154, 2003.

Schofield, I., P. Jewell, M. Chan, D. Currey, and M. Gregory, *Shoreline development, longshore transport, and surface water dynamics, Pleistocene Lake Bonneville, Utah*, Earth Surf. Process. Landforms, Vol. 29, pp. 1675–1690, 2004.

University of Utah Research Institute, *Summary of X-Ray Diffraction Analysis, University of Utah Research Institute, Earth Science Laboratory*, included as an attachment to a letter report on Evaluation of Long Term Permeability of Treated Clay Notice of Deficiency: Radioactive Materials License UT2300249, Envirocare Disposal Facility, Toole County, Utah, Project No. 11293, from Robert E. Edgar of Applied Geotechnical Engineering Consultants, Inc., to Steve Petersen of Envirocare of Utah, Inc., February 17, 1993.

INTERROGATORY CR R313-25-8(4)(D)-128/2: LAKE SEDIMENTATION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure,* *settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Use the information in existing journal literature on sedimentation rates to update statements in the Deep Time Assessment report. Emphasize how the core data and sedimentation rates for those locations are relevant to the Clive site given the paleodepositional facies involved.

BASIS FOR INTERROGATORY:

Section 3.4, page 11, of the Deep Time Assessment report states that "*Given the Little Valley event occurred 150 ky BP, a sedimentation rate can be approximated for the depth between this event and the transgressive phase of the Bonneville cycle of 110 mm/kr.*" This section also includes other similar statements. However, a variety of core types exist in the Bonneville basin, exhibiting a wide variety of sedimentation rates, as indicated in the literature (Balch, et al., 2005; Davis, 1998). The statements in the report should be reviewed in light of this literature. Discussion of this and other available technical literature should emphasize how the core data and sedimentation rates for those locations are relevant to the Clive site given the paleodepositional facies that were involved.

ES RESPONSE:

In its response, ES described the assumptions for the heuristic model for the glacial lake cycles and how sedimentation rates were integrated into the deep time modeling.

REBUTTAL:

We agree with the ES response but recommend that the final report discuss a deep time sensitivity analysis, similar to that provided for doses, which expands on the information provided in the ES response. ES should revise the report accordingly.

REFERENCES:

Balch, D.P., A.S. Cohen, D.W. Schnurrenberger, B.J. Haskell, B.L.V. Garces, J.W. Beck, H. Cheng, and R.L. Edwards, *Ecosystem and paleohydrological response to Quaternary climate change in the Bonneville basin, Utah,* Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 221, pp. 99–121, 2005.

Davis, O.K., *Palynological evidence for vegetation cycles in a 1.5 million year pollen record from the Great Salt Lake, Utah, U.S.A.*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 138, pp. 175–185, 1998.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(D)-129/2: LAKE EROSION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Provide a reference to support the assumption that a lake is large enough to obliterate a relatively soft pile. Explain why such obliteration will not be cause for ongoing active maintenance.

BASIS FOR INTERROGATORY:

Section 4.0, page 13, of the Deep Time Assessment report states that *"In effect, it is assumed that a lake is large enough that obliteration of a relatively soft pile will occur."* However, no references are given to support this assumption. A wide range of engineering and scientific literature exists to substantiate this statement and should be referenced (e.g., Komar, 1998, and references therein) and the appendix revised accordingly. On the other hand, whether or not obliteration occurs depends on meteorological conditions and the extent of the growth of boundaries of a lake and its depth relative to the position of the facility.

Energy*Solutions* should also explain and justify how erosion of the waste embankment during deep time (10,000 years or more) will not be cause for ongoing active maintenance by the future owner or responsible party.

ES RESPONSE:

In its response, ES detailed the assumptions pertaining to the deep time erosion of the embankment and obliteration of the disposal site through wave action.

REBUTTAL:

We agree with the ES response but recommend that the final report discuss a deep time sensitivity analysis, similar to that provided for doses, which expands on the information provided in the ES response. ES should revise the report accordingly.

REFERENCES:

Komar, P.D., *Beach Processes and Sedimentation*, 2nd Ed., Prentice Hall, New Jersey, 1998.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(D)-130/1: LAKE GEOCHEMISTRY

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

Section 4.1, page 20, of the Deep Time Assessment report (Appendix 13 to FRV1.2) has been revised to clarify that the discussion is referring to precipitation of radionuclides with soluble carbonate ions to form carbonate minerals, and that it is not discussing adsorption onto clays or carbonates. Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-8(4)(D)-131/2: POTENTIAL WAVE ENERGY

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Provide support and references for the assumption that shallow lakes have low wave energy.

BASIS FOR INTERROGATORY:

Section 4.0, bottom of page 13, of the Deep Time Assessment report (FRV1, Appendix 13) states the following:

> *It should be noted that a Gilbert-sized lake would just barely reach Clive and the wave energy would very likely not erode the waste embankment (C.G. Oviatt, personal communication). The size of lake in the PA model that is needed to obliterate the waste embankment can be as small as 1 m, which might not have sufficient wave power to obliterate the site.*

This statement seems at odds with other statements in the Deep Time Assessment report , e.g., the last introductory paragraph of Section 4.0, top of page 12 and the first paragraph of page 12.

Waves that develop in small lakes, such as the relatively shallow modern Great Salt Lake, have been shown to be extremely destructive to features such as the railroad causeway that separates the north and south arms of the lake.

Fundamental wave dynamics and theory demonstrate that wave energy is concentrated in the upper few meters of the water column that wave energy is a function of storm duration, wind speed, and fetch of the water body. This means even shallow lakes are capable of producing significant wave power. References such as the Shore Protection Manual, Griggs and Fulton-Bennett (1988), and Komar (1998) should be reviewed and the report revised accordingly.

ES RESPONSE:

In its response to the request to provide support for the assumption that shallow lakes have low wave energy, ES stated that: "*Waves in small lakes could be destructive and potentially erode the waste embankment.*"

REBUTTAL:

This position appears to be the opposite of that taken in the Deep Time Assessment report (Appendix 13 to FRV1), as indicated by the text from Section 4.0 quoted above. ES should clarify its position on the effects of wave action from small lakes, provide appropriate references for this conclusion, and ensure that its position is consistent throughout the report.

REFERENCES:

Griggs, G.B., and K.W. Fulton-Bennett, *Rip rap revetments and seawalls and their effectiveness along the central California coast*, Shore and Beach, Vol. 56, pp. 3–11, 1988.

Komar, P.D., *Beach Processes and Sedimentation*, Prentice Hall, New Jersey, 1998.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Army Corps of Engineers, *Shore Protection Manual*, Waterways Experiment Station, Coastal Engineering Research Center, Volumes I and II, 1984.

INTERROGATORY CR R313-25-8(4)(D)-132/2: SEDIMENTATION MODEL

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Provide more detail on the sedimentation model as it relates to the text.

BASIS FOR INTERROGATORY:

Section 6.3, page 26, of the Deep Time Assessment report states the following:

> *The year-to-year variation can be modeled as a second-order autoregressive process AR(2) (Brockwell and Davis, 1991), a model that accounts for year to year temporal correlations in the variation.*

Figure 10 provides an example of a simulation of an AR(2) process.

However, the text should provide the basis for using a time series technique (Brockwell and Davis, 1999).

ES RESPONSE:

In its response, ES described the use of a time history curve in the sedimentation model, the use of auto regression to achieve variability, climate cycles beyond the inter-glacial period, and sedimentation processes. ES indicated that sedimentation and mixing processes are being described in greater detail in the revised report.

ES stated that: "*The text description is being expanded to include more information on the modeling, in particular the transgressive and then regressive curve that underlies the process.*"

It also stated that: "*More information can be provided about the processes affecting lake sedimentation.*"

Finally, it stated that: "*These interacting processes are being described in greater detail in the revised report. In addition, supplemental research is being performed using analogue features in the Lake Bonneville basin to better constrain processes of sedimentation and embankment erosion, as well as how the disposal mound might be partially covered by the time a lake returns.*"

REBUTTAL:

We look forward to reviewing the revised report, including a description of how wind-blown sediments, sediments moved by lake action, and sediments resulting from oolitic precipitation affect the overall lake sedimentation.

REFERENCES:

Brockwell, P.J. and R.A. Davis, *Time Series: Theory and Methods*, *2nd Ed.*, Springer Verlag, New York, NY, 579 pp., 1991.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(D)-133/2: CALCULATIONS OF RADIOACTIVITY IN WATER AND SEDIMENT

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Provide context for the equations and variables presented for calculating radioactivity in water and sediment.

BASIS FOR INTERROGATORY:

Sections 6.5.1 and 6.5.2, pages 31-32, of the Deep Time Assessment report present a number of equations without providing an interpretation of what the results for R (radioactivity), C (concentration), and $C_{sediment}$ (concentration in the sediment) actually mean, since the text provides no background on specific input variables, such as time, area of sediment that contains the waste, diffusion coefficients, and possible lake depths.

ES RESPONSE:

In its response, ES described how the dispersal of waste is modeled from the destruction of the waste embankment/facility by an intermediate lake and the diffusion of activity from the lake sediments to the lake water. ES also indicated that the text in the Deep Time Assessment report is being revised to provide context for the equations and variables presented.

REBUTTAL:

The ES response is adequate, assuming that ES will add to the revised PA report the information provided in the response. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

ES added the proposed text to Section 6.5.1, page 39, and Section 6.5.2, pages 40–41, of the Deep Time Assessment report (Appendix 13 to FRV1.2). Therefore, this interrogatory is closed.

REFERENCES:

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0032_R1, June 5, 2014. (Appendix 13 to FRV1.2)

INTERROGATORY CR R313-25-8(4)(D)-134/1: FUTURE LAKE LEVEL ELEVATIONS

*Round 1 Interrogatory Response is satisfactory, with the exception of the statement that "*Intermediate lakes are assumed to be smaller lakes that reach and exceed the altitude of Clive, but are not large enough that carbonate sedimentation can occur.*" ES should revise this statement to be consistent with corrections needed in response to Interrogatories CR R313-25-8(5)(a)-44/2: Occurrence of Intermediate Lakes and CR R313-25-8(4)(d)-126/2: Shallow Lake Cycles. We look forward to reviewing the revised report.*

V1.2 CRITIQUE (ROUND 3):

Sections 3.3 and 3.4 of the Deep Time Assessment report (Appendix 13 to FRV1.2) have been revised to clarify the distinction between shallow and intermediate lack cycles. A statement has also been added to page 14 indicating that the deep time assessment conservatively assumes that all waste is precipitated with and incorporated into local sediments during lake recession. Therefore, this interrogatory is closed. Note, however, that there are two 1994 Oviatt references; they should be differentiated as 1994a and 1994b.

INTERROGATORY CR R313-25-19-135/3: EXPOSURE TO GROUNDWATER

PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

INTERROGATORY STATEMENT:

Provide a calculation of the doses to an individual who pumps, processes, and uses the groundwater from a well located near the Clive facility to ensure that exposures are below the levels specified in R313-25-19. Examine how byproducts of future desalination processes that might rely on radio-contaminated groundwater at Clive will need to be managed to protect public health and the environment, incorporating additional dose to a member of the public if needed.

BASIS FOR INTERROGATORY:

DRC is aware that a number of individuals and/or companies in the region near the Clive facility are presently pumping the groundwater to the surface, processing it through a desalination system, and making use of the groundwater. These include the Delle Auto Truck Stop located on Interstate 80 at Exit 70, among other industrial users in the region. Because it is already occurring in the vicinity of the Clive site, it is not unreasonable to expect that at some point in the future an individual or company will use the desalinized groundwater from the Clive site as a water source.

We performed a simple scoping calculation of the doses to an individual who processes and uses the groundwater and found that the doses have the potential to exceed the limits specified in R313-25-19. This calculation recognized that the groundwater would need to be processed before it could be used and took credit for the processing reducing not only the TDS but also any Tc-99 and I-129 that the GoldSim model predicted would be present.

The results of the calculation for Tc-99 are shown in the table below. The calculation also found that I-129 in the groundwater may be of concern, although to a lesser degree. The maximum doses from either Tc-99 or I-129 were calculated to occur at about 1,700–1,800 years, which is slightly longer than the 500-year Neptune model predictions but well within the minimum 10,000-year model prediction interval required by UAC R313-25-8(5)(a).

Tc-99 Pathway Maximum Dose

Groundwater Cleanup Level	Tc-99 Pathway Maximum Dose (mrem/yr)					
	Drinking Water	**Animal Products**	**External Plume and Groundshine**	**Inhalation**	**Terrestrial Crops**	**Total**
DF = 1 – No Processing	716.5	62.7	0.30	0.00	1343.5	2,123.
DF = 10 – NUREG-0017	71.7	6.3	0.03	0.00	134.3	212.3
DF = 21.1 – R309-200-5, 2,000 mg/L	33.9	3.0	0.01	0.00	63.6	100.5
DF = 42.2 – R309-200-5, 1,000 mg/L	17.0	1.5	0.01	0.00	31.8	50.3
DF = 84.5 – 10 CFR 143.3, 500 mg/L	8.5	0.74	0.00	0.00	15.9	25.1

The table shows the calculated Tc-99 doses if the groundwater was (1) used unprocessed (included as a benchmark only, in recognition that the unprocessed groundwater could not be used), (2) processed once through a reverse osmosis system with the NRC's recommended decontamination factor (DF) of 10, (3) processed to meet the Utah Drinking Water Board's "no better water available" TDS limit of 2,000 mg/L, (4) processed to meet the Utah Drinking Water Board's TDS limit of 1,000 mg/L, or (5) processed to meet EPA's Secondary Drinking Water TDS limit of 500 mg/L (10 CFR 143.3).

These results should not be taken as definitive, but rather as an indication that even after processing to make the groundwater drinkable, the doses from this pathway may exceed the limits specified in R313-25-19, and more detailed analysis is needed. Energy*Solutions* should also examine how byproducts of future desalination processes (e.g., reject brines and precipitates) that might rely on radio-contaminated groundwater at Clive will need to be managed to protect public health and the environment. Depending on the type of management required or assumed for these byproducts, additional dose to a member of the public may also need to be incorporated into these calculations.

ES RESPONSE:

In its response, ES referred the reader to its response to Interrogatory CR R313-25-7(2)-91/1: Design Criteria for Infiltration. Under the referenced interrogatory, ES stated the following:

> *Groundwater at the Clive site is not a potential dose pathway. As demonstrated in Table 3-2 of the 2013 Compliance Report, untreated consumption would lead to death for 100 percent of the receptors within a matter of days. Revised calculations in response to interrogatory 181 do not change this basic conclusion. It is not reasonable to assume that groundwater in the shallow unconfined aquifer would be treated for TDS then consumed. While technically possible, the shallow unconfined aquifer is of low yield; better groundwater production and quality is available at other locations in the west desert.*

REBUTTAL:

As discussed elsewhere (see, for example, Interrogatory CR 313-25-8(4)(a)-96/2: Current and Future Potability of Water, and Interrogatory CR R313-25-8(4)(a)-97/2: Need for Potable and/or Industrial Water), SC&A believes that additional information must be provided to demonstrate the groundwater at Clive is not a potential dose pathway.

Under Interrogatory CR 313-25-8(4)(a)-96/2, SC&A indicates that ES needs to examine the possibility that the lower confined aquifer at Clive could become contaminated and thus become a source of exposure. If the water from this deep aquifer were used for domestic and/or industrial uses but did not meet the test of a public water system, regulation would be left to the Tooele County. It is our understanding that the County does not require testing for uranium or other radioactive contaminants. It does, however, require that the TDS for an individual water system be less than 2,000 mg/L. As noted in the table above, for Tc-99 Pathway Maximum Dose, when treating Clive groundwater, exposures exceeding the limits of R313-25-19 are possible, depending on the initial concentration of Tc-99 in the groundwater.

ES needs to explain why there are no viable groundwater pathways such as those discussed in Interrogatory CR 313-25-8(4)(a)-96/2 or include them in the DU PA.

V1.2 CRITIQUE:

Groundwater from deeper portions of the confined aquifer, or other aquifers, has, after treatment, historically been used in the region for drinking. Furthermore, yields from the deeper portions of the confined aquifer may be moderately high. As previously described, ES formerly proposed to drill water wells in the deeper portions of the confined aquifer on site. Shrum (2005) refers to modeling on the site of "*a production well screened from 550 to 600 feet below ground surface (bgs), pumped at 200 gallons per minute, 24 hours per day, 4 months per year*...."

REFERENCES:

Adams, K.D., *Age and paleoclimatic significance of late Holocene lakes in the Carson Sink, NV, USA*, Quaternary Research, Vol. 60, pp. 294–306, 2003.

Balch, D.P., A.S. Cohen, D.W. Schnurrenberger, B.J. Haskell, B.L.V. Garces, J.W. Beck, H. Cheng, and R.L. Edwards, *Ecosystem and paleohydrological response to Quaternary climate change in the Bonneville basin, Utah*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 221, pp. 99–121, 2005.

Benson, L.V., S.P. Lund, J.P. Smoot, D.E. Rhode, R.J. Spencer, K.L. Verosub, L.A. Louderback, C.A. Johnson, R.O Rye, and R.M. Negrini, *The Rise and Fall of Lake Bonneville Between 45 and 10.5 ka*, Quaternary International, Vol. 235, pp. 57–69, 2011.

Briggs, R.W., S.G. Wesnousky, and K.D. Adams, *Late Pleistocene and late Holocene lake highstands in the Pyramid Lake subbasin of Lake Lahontan, Nevada, USA*, Quaternary Research, Vol. 64, pp. 257–263, 2005.

Code of Federal Regulations, Title 40, *Protection of Environment*, Part 143, *National Secondary Drinking Water Regulations*.

Currey, D.R., G. Atwood, and D.R. Mabey, *Major levels of Great Salt Lake and Lake Bonneville*, Utah Geological Survey Map 73, May 1984.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0032_R1, June 5, 2014. (Appendix 13 to FRV1.2)

Oviatt, C.G., G.D. Habiger and J.E. Hay, *Variation in the Composition of Lake Bonneville Marl: A Potential Key to Lake-Level Fluctuations and Paleoclimate*, Journal of Paleolimnology, Vol. 11, pp. 19–30, 1994.

Oviatt, C.G., W.D. McCoy, and W.P. Nash, *Sequence stratigraphy of lacustrine deposits: a Quaternary example from the Bonneville basin*, Utah. Geological Society of America Bulletin, Vol. 106, pp. 133–144, 1994.

Oviatt, C.G., *Comparing the Shoreline and Offshore Sedimentary Records of Lake Bonneville*, Abstracts with Programs – Geological Society of America, Vol. 34, Issue 6, p. 292, 2002.

Oviatt, C.G., and B. P. Nash, *The Pony Express Basaltic Ash: A Stratigraphic Marker in Lake Bonneville Sediments*, Utah, Miscellaneous Publication 14-1, Utah Geological Survey, 2014.

Shrum, D.B., *Request to Install Production Well – Submittal of Revised Modeling*, Letter from Dan Shrum to Dane Finerfrock, April 11, 2005.

U.S. Nuclear Regulatory Commission, *Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors*, NUREG-0017, Revision 1, Office of Nuclear Reactor Regulation, April 1985.

Utah Drinking Water Board, *Primary Drinking Water Standards*, UAC R309-200-5, September 4, 2009.

INTERROGATORY CR R313-25-7(1)-136/2: IRON (HYDRO)OXIDE FORMATION

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

Refer also to R313-25-8(4)(a): *Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.*

INTERROGATORY STATEMENT:

Clarify whether the formation of iron (hydro)oxides derived from the waste containers was considered in predicting sorption.

BASIS FOR INTERROGATORY:

Section 2.0, page 3, of the Geochemical Modeling report states that *"No credit is given for containment by the steel drums or cylinders."* However, it is not clear whether the geochemical model includes any degradation of the steel to form iron (hydr)oxide phases and subsequent sorption of the radionuclides to those phases. Degradation of the engineered barrier materials is known to produce (hydr)oxide phases with high sorption capacities for cationic radionuclides (see, for example, Bargar et al. 2000, McBeth et al. 2011, Powell et al. 2005, and Tochiyama et al. 1995). For steel canister degradation, these phases may include ferrihydrate, magnetite, goethite, and hematite. If no credit is given for sorption to these steel degradation products, this should be explicitly stated. Furthermore, due to the known strong sorption of uranium to these iron phases, specific consideration of these phases when selecting appropriate K_d values must be demonstrated.

ES RESPONSE:

In its response, ES stated that it will revise the Geochemical Modeling report (Appendix 6 to FRV1) to state that no credit was taken for adsorption onto the steel drums in the development of K_d values for the waste materials.

REBUTTAL:

ES provided an approach that seems appropriate, although overly conservative. In addition to revising the Geochemical Modeling report to state that no credit was taken for adsorption onto the steel drums, ES should also state that no credit was taken for iron (oxyhydr)oxide phases formed during canister degradation. Based on the concerns raised in the discussion for Interrogatory CR R313-25-8(4)(a)-64/1: Yucca Mountain Studies, the modeling of the source term will be reevaluated with regard to the estimation of uranium solubilities. We look forward to reviewing the revised report.

REFERENCES:

Bargar, J.R., R. Reitmeyer, J.J. Lenhart, and J.A. Davis, *Characterization of U(VI)-carbonato ternary complexes on hematite: EXAFS and electrophoretic mobility measurements*, Geochimica et Cosmochimica Acta, Vol. 64, pp. 2737–2749, 2000.

McBeth, J.M., J.R. Lloyd, G.T.W. Law, F.R. Livens, I.T. Burke, K. Morris, *Redox interactions of technetium with iron-bearing minerals*, Mineralogical Magazine, Vol. 75, pp. 2419–2430, 2011.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Powell, B.A., R.A. Fjeld, D.I. Kaplan, J.T. Coates, and S.M. Serkiz, *$Pu(V)O_2$+ adsorption and reduction by synthetic hematite and goethite*, Environ. Sci. Technol., Vol. 39, pp. 2107–2114, 2005.

Tochiyama, O., S. Endo, and Y. Inoue, *Sorption of Neptunium(V) on Various Iron-Oxides and Hydrous Iron-Oxides*, Radiochim. Acta, Vol. 68, pp. 105–111, 1995.

INTERROGATORY CR R313-25-7(1)-137/2: TOTAL DISSOLVED CARBONATE CONCENTRATIONS AND OTHER GEOCHEMICAL DATA

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

Refer also to R313-25-8(4)(a): *Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.*

INTERROGATORY STATEMENT:

1. Reassess the total dissolved carbonate concentrations to determine whether they were underestimated, leading to the underestimation of uranium sorption in subsurface earth materials.
2. Explain and justify why the geochemical data from the seven wells listed in Tables 5 and 6 of the Geochemical Modeling report are representative of the shallow aquifer at Clive, especially in light of the presence of 78 compliance monitoring wells now found in Section 32.
3. Describe what hydrostratigraphic units the water table occupies below the Class A South cell, including in terms of groundwater mounding that exists near GW-19A.
4. Explain and justify the range of TDS quoted for the shallow aquifer at Clive.

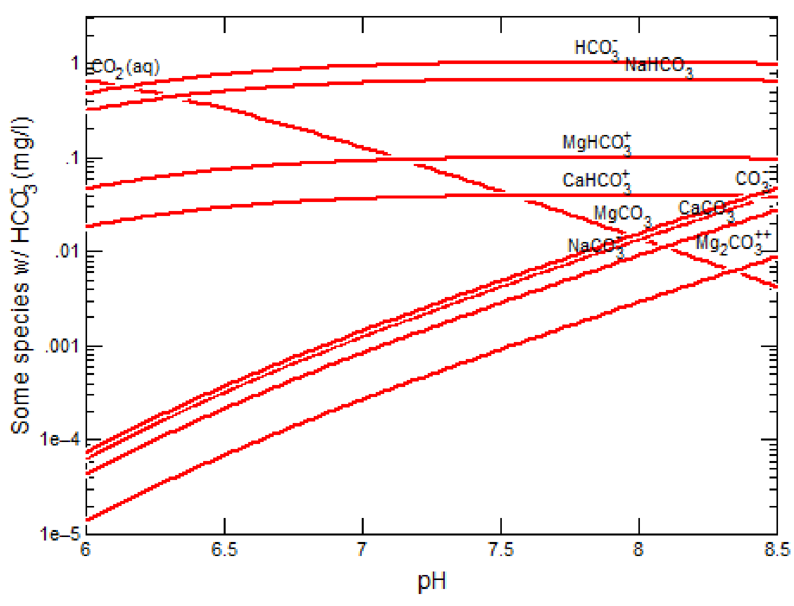
BASIS FOR INTERROGATORY:

1. Section 2.1, page 5, of the Geochemical Modeling report states that *“Dissolved oxygen and carbon dioxide are expected to be largely in equilibrium with atmospheric conditions, at least in the upper profile including the DU waste zone.”*

As noted in other interrogatories, the silt and clay earth materials laid down by the Gilbert Stage of Lake Bonneville are dominated by carbonate minerals. Therefore, specific dissolution of carbonate minerals in the vadose zone and aquifers may yield concentrations of aqueous carbonate higher than those expected assuming equilibration with atmospheric carbonate. The presence of carbonate can hinder uranium sorption through the formation of uranyl-carbonate species as noted in Section 2.0 of the Geochemical Modeling report and by Um et al. (2007), Wan et al. (2005), and Don et al. (2005). It is notable that decreased sorption can be due to binary U(VI)-carbonate species or ternary alkali earth-U(VI)-carbonate species. Therefore, it is important to know both the carbonate and alkali earth element concentrations.

For example, assuming a pH range of 6–8.5 and the average ion concentrations listed in Table 6, the total carbonate concentration in equilibrium with atmospheric carbon dioxide should be around 1 mg/L (see the Geochemist Workbench model output in the figure below). However, the bicarbonate concentrations listed in Table 5 of the report range from 102–350 mg/L. Thus, by assuming only equilibration with atmospheric carbonate, the total dissolved carbonate concentration will be underestimated. This assumption appears to conflict with a statement in Section 2.2, page 5, of the Geochemical Modeling report that previous consultants to Energy*Solutions* have determined the shallow aquifer is super-saturated in calcite and dolomite.

(Modeling was performed with Geochemist Workbench Standard 8.0, using database thermo.com.v8.r6+.dat.)



2. Energy*Solutions* should explain and justify why geochemical data from the seven wells listed in Tables 5 and 6 of the Geochemical Modeling report are representative of the shallow aquifer at Clive; especially in light of the presence of 78 compliance monitoring wells now found in Section 32. Alternatively, if DU disposal is to be done only in the Class A South cell, the text should explain and justify why the seven wells in Tables 5 and 6 adequately represent the 19 shallow monitoring wells that surround the Class A South cell.

3. With respect to hydrostratigraphic units already identified at Clive, Section 2.2, page 5, of the Geochemical Modeling report should describe what units the water table occupies below the Class A South cell, including in terms of groundwater mounding known to exist at the southwestern margin of the Class A South cell (e.g., near GW-19A).
4. Energy*Solutions* should explain and justify the range of TDS quoted for the shallow aquifer at Clive. Energy*Solutions* sampling in 2012 (Energy*Solutions* 2013) found the low end of the range at 10.4 parts per thousand (10,400 mg/L in GW-60, located on the southeast margin of the Class A South cell).

ES RESPONSE:

In its response, ES indicated that the carbonate assumptions and monitoring well data are being clarified, the Geochemical Modeling report (Appendix 6 to FRV1) is being revised, and new TDS values are being incorporated into the Geochemical Modeling report.

REBUTTAL:

We look forward to reviewing the revised report.

REFERENCES:

Dong, W., W.P. Ball, C. Liu, Z. Wang, A.T. Stone, J. Bai, and J.M. Zachara, *Influence of calcite and dissolved calcium on uranium(VI) sorption to a Hanford subsurface sediment*, Environ. Sci. Technol., Vol. 39, pp. 7949–7955, 2005.

Energy*Solutions*, *2012 Annual 11e.(2), LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, March 1, 2013.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Um, W., R.J. Serne, C.F. Brown, and G.V. Last, *U(VI) adsorption on aquifer sediments at the Hanford Site*, J. Contam. Hydrol., Vol. 93, pp. 255–269, 2007.

Wan, J., T.K. Tokunaga, E. Brodie, Z. Wang, Z. Zheng, D. Herman, T.C. Hazen, M.K. Firestone, and S.R. Sutton, *Reoxidation of bioreduced uranium under reducing conditions*, Environ. Sci. Technol., Vol. 39, pp. 6162–6169, 2005.

INTERROGATORY CR R313-25-26(1)-138/3: MONITORING WELL COMPLETION ZONES

PRELIMINARY FINDING:

Refer to R313-25-26(1): *At the time a license application is submitted, the applicant shall have conducted a preoperational monitoring program to provide basic environmental data on the disposal site characteristics. The applicant shall obtain information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the disposal site. For* *those characteristics that are subject to seasonal variation, data shall cover at least a 12-month period.*

Refer also to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Clarify from which completion zones the wells are sampled.

BASIS FOR INTERROGATORY:

Section 2.2, page 6, of the Geochemical Modeling report states that "*The Clive Facility has a large number of monitoring wells with completion zones in this aquifer and monitoring data are currently collected from these wells on at least an annual basis.*" Although this section relates to the shallow aquifer, both the deep confined aquifer and the shallow aquifer are discussed in the preceding paragraph, so clarification is needed as to which is meant by "*this aquifer*."

ES RESPONSE:

In its response, ES indicated that it is changing the text of the Geochemical Modeling report (Appendix 6 to FRV1) describing the well screen depths and completion zones.

REBUTTAL:

The ES response is adequate. ES should complete the clarification to the report as described. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

The text was not changed in Section 2.2, page 8, of the revised Geochemical Modeling report (Appendix 6 to FRV1.2). The original wording (i.e., without the substitution of "*the shallow aquifer*" for "*this aquifer*") remains.

REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Geochemical Modeling for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0025_R1, June 5, 2014. (Appendix 6 to FRV1.2)

INTERROGATORY CR R313-25-7(1)-139/2: ION CHARGE BALANCE

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Clarify the ion charge balance.

BASIS FOR INTERROGATORY:

Section 2.2, page 7, of the Geochemical Modeling report states that "*Excellent charge balance is obtained using these data, indicating all major ions are being accounted for.*" This statement may be misleading, since sodium and chloride are the dominant ions by far and thus a clear picture of the other major ion concentrations is obscured by the balance of sodium and chloride. The charge balance values should be clarified in the report. The text should note what fraction of the charge is due to sodium and chloride and what fraction is due to all other ions. Doing so will demonstrate how the dominance of sodium and chloride is influencing the reported values.

ES RESPONSE:

In its response, ES indicated that it is adding a table of ion concentrations and additional clarifying text to the Geochemical Modeling report (Appendix 6 to FRV1).

REBUTTAL:

The ES response appears adequate, but it may need to be modified depending on the reassessment of total dissolved carbonate concentration and the justification for the representativeness and range of TDS data described in Interrogatory CR R313-25-7(1)-137/2: Total Dissolved Carbonate Concentrations and Other Geochemical Data. We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(1)-140/2: DETERMINATION OF K_d VALUES

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization* *activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

1. Provide a more detailed description of the determination of K_d values used in the recent PA modeling.
2. For those elements/nuclides that are redox sensitive, describe the redox condition assumed in selecting appropriate K_d values and compare this assumption with all aquifer redox data collected from the shallow Clive aquifer to date.
3. Add a summary table to Section 4.1 of the Geochemical Modeling report that provides more detail on inputs to the model.
4. Compare the site-specific K_d values determined by Adrian Brown Consultants (1997) with the PA model's K_d descriptive statistics and explain and justify any similarities or differences in light of the local geologic conditions and geochemistry and the depositional environment that created the pluvial lake deposits occupied by the Clive vadose zone and shallow aquifer.

BASIS FOR INTERROGATORY:

1. Section 4.1.3, pages 11–12, of the Geochemical Modeling report describes the determination of the K_d range for cesium. However, the description of how the K_d values were selected is too vague to determine if representative values were actually selected. Clarification is needed for statements such as, "*For this PA model, cesium* K_d *values were selected largely from the look up tables in EPA (1999c), but were adjusted lower due to the high TDS in the saturated zone*" (page 12). A description of how the values were adjusted and the range of TDS values considered from EPA (1999c) (402-R-99-004B) should be included so readers can determine how far down the values were extrapolated.

In addition, the text should explain why and how the K_d values for protactinium were reduced based on high TDS values. Section 4.1.8, page 14, of the report does not provide evidence that protactinium sorbs via ion exchange, making the rationale in reducing the K_d based on TDS unclear.

Strong cesium sorption to many soils is predominantly due to ion exchange reactions that are profoundly influenced by ionic strength. Since the empirical K_d model selected for this PA cannot account for changes in ionic strength, it is vital that the proper range of K_d values is selected.

2. For those elements/nuclides that are redox sensitive, Energy*Solutions* should also describe the redox condition assumed by Neptune in its selection of appropriate K_d values, then compare this assumption with all aquifer redox data collected from the shallow Clive aquifer to date.
3. A summary table should be added to Section 4.1 of the Geochemical Modeling report to provide the following information:
   - Nuclide simulated in the GoldSim model

- K_d distribution used in the model, whether normal or log-normal
- Mean K_d value (or geomean)
- Standard deviation (or geometric standard deviation)
- Coefficient of variance for each nuclide K_d
- Full range of K_d inputs used for each nuclide, whether minimum and maximum values or the upper and lower confidence intervals
- The corresponding laboratory-determined K_d, using Clive soils and Clive groundwater, reported by Adrian Brown Consultants (1997)

4. Energy*Solutions* should compare the site-specific K_d values determined by Adrian Brown Consultants (1997) with the Neptune model's K_d descriptive statistics, as listed in the new table. Any K_d similarities or differences in the values used by Neptune should be explained and justified. Where the Neptune used K_d values show a significant difference in mean (or geomean) values, or a higher degree of variance, compared to the site-specific data reported by Adrian Brown Consultants (1997), this practice should be explained and justified in light of the local geologic conditions and geochemistry and the depositional environment that created the pluvial lake deposits occupied by the Clive vadose zone and shallow aquifer.

ES RESPONSE:

In its response, ES indicated that it is making numerous changes with respect to the K_d values in the Geochemical Modeling report (Appendix 6 to FRV1).

REBUTTAL:

We look forward to reviewing the associated text changes described in the response.

REFERENCES:

Adrian Brown Consultants, *Response to UDEQ K_d Interrogatories*, Report 3101B.970422, April 22, 1997.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Understanding the Variation in Partition Coefficient, K_d, Values*, 402-R-99-004B, Volume II, 1999.

INTERROGATORY CR R313-25-7(1)-141/2: pH AND K_d VALUES AND SERNE (2007)

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic,* *ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Consider pH values when estimating K_d values and provide more detail on the "*non-groundwater scenario*" used in Serne (2007).

BASIS FOR INTERROGATORY:

Section 4.0, page 10, of the Geochemical Modeling report refers to the work of Serne (2007) and states that "*Of note is that the Hanford soils are slightly acidic, with organic content of 0.5 to 1.5% organic carbon somewhat different from the Clive location.*" However, Section 2.0, page 3, of the report indicates that the pore water pH values at the Clive location are neutral to slightly alkaline. The pH of a system may be the most important variable influencing sorption. If the pH values are different, there will be a very high level of uncertainty when using data from Serne (2007), even if the results are important only "*from a semi-quantitative perspective*."

The text should cite the range of pH values for the Hanford system examined by Serne (2007).

Additionally, the text should cite the range of total organic carbon content in the groundwater, based on analysis of local groundwater samples.

In addition, Section 4.0 refers in several places (e.g., Section 4.1.2, page 11) to the "*non-groundwater scenario*" included in Serne (2007). The text should describe this scenario.

ES RESPONSE:

In its response, ES stated that: "*The text is being modified to clarify the chemical speciation of the element in the reference, along with a discussion of the applicability of the reference for K_d distribution development at the Clive site.*"

It also stated the following:

> *The solid phase composition of sites is being compared if possible and if applicable. The emphasis for the level of detail needed for justification of the applicability of a reference should be on demonstrating that the most appropriate data were used. Carbonate concentrations and pH may be more important factors than solid phase composition, although clay and iron oxide contents are also important.*

REBUTTAL:

The clarification of the chemical speciation of the element will be vitally important text since it provides justifications for the selected K_d ranges. We look forward to reviewing the revised Geochemical Modeling report (Appendix 6 to FRV1).

It is indeed likely that pH and carbonate are more important than the specific sorbing phases. However, since the model is based on empirical K_d values, it is unclear how variable clay and iron content will be used. ES should discuss the manner by which all factors (pH, dissolved ions (competing ion effect), and solid phase composition) are used to determine the appropriate K_d range.

REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Serne, R.J., *K_d Values for Agricultural and Surface Soils for Use in Hanford Site Farm, Residential, and River Shoreline Scenarios*, Technical Report for Ground-Water Protection Project – Characterization of Systems Task, PNNL-16531, August 2007.

INTERROGATORY CR R313-25-7(1)-142/2: REFERENCES FOR K_d DISCUSSION

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Provide additional references to support the discussion of K_d values. Alternatively, either (1) select conservatively low K_d values or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).

BASIS FOR INTERROGATORY:

Section 4.0, pages 11–16, of the Geochemical Modeling report describes the derivation of the partition coefficient for each element used in the transport model. Each subsection begins by stating the expected chemical species of each ion. The model used to determine these species should be provided, including a referenced list of thermodynamic constants or a referenced database.

Furthermore, since this PA used an empirical K_d model, it seems the discussion of the chemical speciation is somewhat irrelevant. However, since it is included, it should be properly documented. A recommended approach would be to show that speciation and the speciation from the sites from which the K_d values are selected. Matching the aqueous species between the two sites would enable much more confidence in the K_d approach.

The solid phase composition between sites should also be compared, if possible. However, this may not be possible when using the EPA look-up tables since exact solid phase compositions are not considered when using the tables. Since direct comparisons cannot be made in all cases, and use of data from the EPA look-up tables is necessary for this modeling framework, the emphasis should be on demonstrating that the most appropriate data were selected from the tables. Alternatively, Energy*Solutions* can either (1) select conservatively low K_d values (i.e., values that equal or are nearly equal to the lowest data in the peer-reviewed literature) or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).

ES RESPONSE:

In its response, ES stated that: "*The text is being modified to clarify the chemical speciation of the element in the reference, along with a discussion of the applicability of the reference for K_d distribution development at the Clive site.*"

ES also stated that: "*The solid phase composition of sites is being compared if possible and if applicable. The emphasis for the level of detail needed for justification of the applicability of a reference should be on demonstrating that the most appropriate data were used. Carbonate concentrations and pH may be more important factors than solid phase composition, although clay and iron oxide contents are also important.*"

REBUTTAL:

The text modification described will be vitally important text since it provides justifications for the selected K_d ranges. We look forward to reviewing the revised report.

Regarding the second statement, it is indeed likely that pH and carbonate are more important than the specific sorbing phases. However, since the model is based on empirical K_d values, it is unclear how variable clay and iron content will be used. ES should discuss the manner by which all factors (pH, dissolved ions (competing ion effect), and solid phase composition) are used to determine the appropriate K_d range. The use of empirical K_d values for Clive soils and groundwater is imperative in the PA analysis process.

REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(1)-143/2: NEPTUNIUM SPECIATION

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

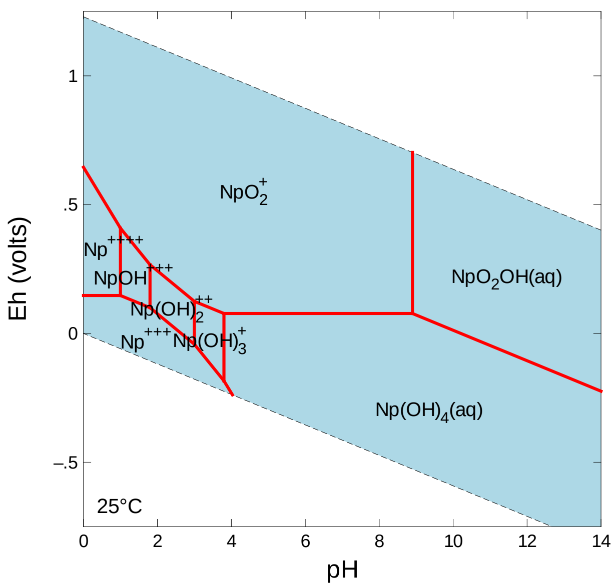
INTERROGATORY STATEMENT:

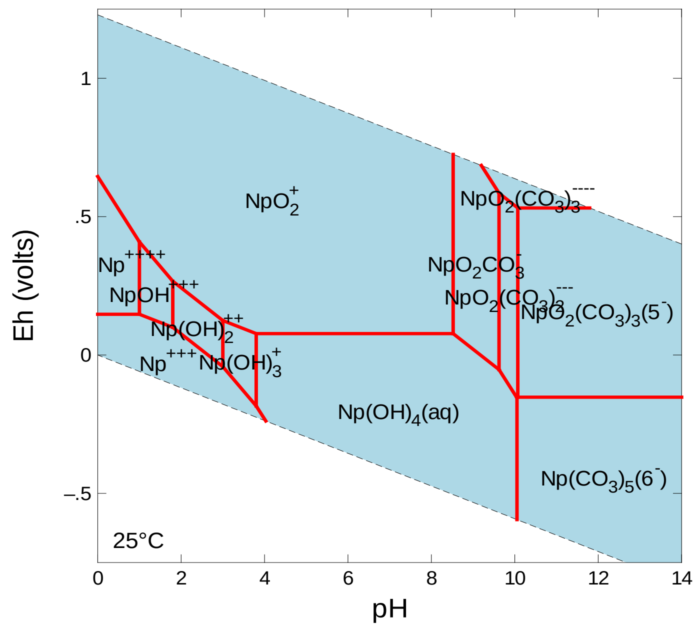
Correct a reference to Np(VI) and provide citations. Alternatively, either (1) select conservatively low K_d values or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).

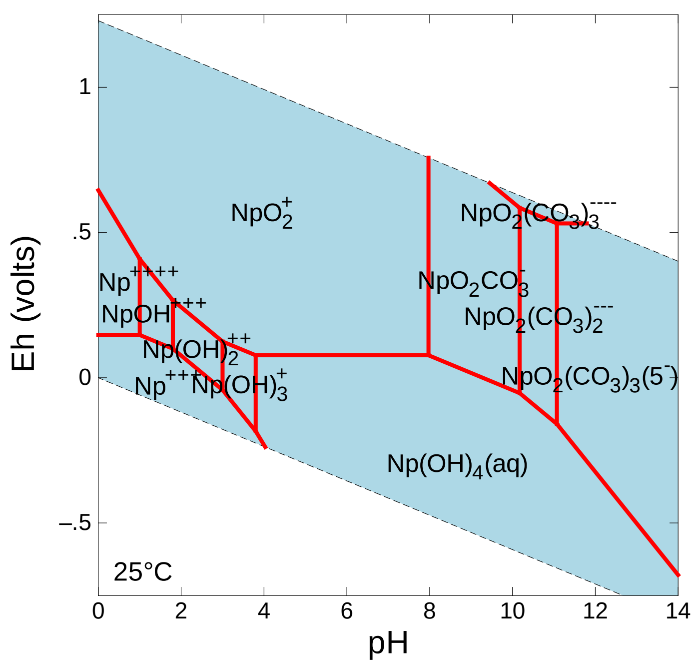
BASIS FOR INTERROGATORY:

Section 4.1.6, page 13, of the Geochemical Modeling report states that "*The transient, mildly reducing conditions that can exist at Clive and the presence of carbonates may lead to the formation of Np(VI) carbonate complexes above pH 7*." However, based on the E_H-pH diagrams below, Np(VI) phases will not form under the reported conditions of the Clive site. Modeling was performed without atmospheric CO_2(g) (top figure),with atmospheric CO_2(g) (middle figure), and with 350 mg/L of total carbonate (bottom figure) with Geochemist Workbench Standard 8.0 using database thermo.com.v8.r6+.dat. The maximum carbonate concentration listed in Table 5 of the Geochemical Modeling report is 350 mg/K. Only a small region of stability for Np(VI) exists in the presence of carbonate around pH 10 and electrode potentials of 0.6 volts. Increasing the carbonate concentration only increases the stability of the Np(V) complexes, not the NP(VI) complexes. If the mention of Np(VI) in the text was a typographical error and the text intended to refer to Np(IV) forming carbonate species, it should include a reference for the thermochemical constants used to determine that speciation.

If for any reason Energy*Solutions* is unable to reconcile these or any other discrepancies with neptunium K_d values used in the GoldSim model with local Clive geologic and geochemical conditions (vadose or shallow aquifer), Energy*Solutions* will need to (1) use conservatively low K_d values found in available peer-reviewed technical literature or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).







ES RESPONSE:

In its response, ES described the graphs presented from the Geochemist's workbench to explain the aqueous speciation of neptunium. ES stated the following:

> *For example, see Figure 5.8 below, taken from EPA (2004). This figure shows that for Np(V), carbonate complexes begin to form at pH 7, where dissolved carbonate concentrations are 57 mg/L. So, while Np carbonate complexes do not*

> *dominate Np speciation, there could be 10 20% (or more, depending on redox and carbonate concentrations) of soluble Np complexed with carbonates for the Clive range of pH values.*

ES also stated: "*That said, there is very little research on Np carbonate complex sorption and a limited number of K_d studies for Np. So, the effects of carbonate solution complexation on K_d are not evaluated for Np.*"

REBUTTAL:

With regard to the first statement, we note that EPA 2004 was not included in the references in Section 3 of the ES response document and so could not be reviewed. ES is correct that both E_H-pH and activity-pH diagrams need to be considered. However, the E_H-pH diagrams provided do show the dominance of the carbonate complexes discussed here. At carbonate concentrations higher than 57 mg/L, mono-, di-, and tri-carbonate species can dominate Np(V) speciation. Therefore, while the point made by ES using the activity-pH diagram is well taken, it should be noted that the speciation is highly sensitive to the total carbonate concentration and should be considered in establishing solubility ranges. The sensitivity of neptunium solubility to high salinities should also be considered, in particular whether the Visual MINTEQ thermodynamic database is as robust as the Pitzer database used for PHREEQC.

With regard to the second statement, we encourage ES to review Bidoglio et al. (1985), Kohler et al. (1999), Turner et al. (1998), and Yu et al. (2007) and incorporate some consideration of the influence of Np-carbonate complexes. ES should revise the report to address these issues and concerns.

REFERENCES:

Bidoglio, G., G. Tanet, and A. Chatt, *Studies On Neptunium (V) Carbonate Complexes Under Geologic Repository Conditions*, Radiochimica Acta, Vol. 38, pp. 21–26, 1985.

Kohler, M., B.D. Honeyman, and J.O. Leckie, *Neptunium(V) sorption on hematite (alpha-Fe_2O_3) in aqueous suspension: The effect of CO_2*, Radiochimica Acta, Vol. 85, Issue 1-2, pp. 33–48, May 1999.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Turner, D.R., R.T. Pabalan, and F.P. Bertetti, *Neptunium(V) sorption on montmorillonite: An experimental and surface complexation modeling study*, Clays and Clay Minerals, Vol. 46, No. 3, pp. 256–269, 1998.

Yu, Z., Y. Lin, A.J. Smieciski, and K.J. Stetzenbach, *Geochemical modeling of solubility and speciation or uranium, neptunium, and plutonium*, Yucca Mountain Publications, University of Nevada Las Vegas Digital Library, 2007.

INTERROGATORY CR R313-25-7(1)-144/2: PLUTONIUM SPECIATION

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Provide additional information to support the assumptions with respect to plutonium speciation.

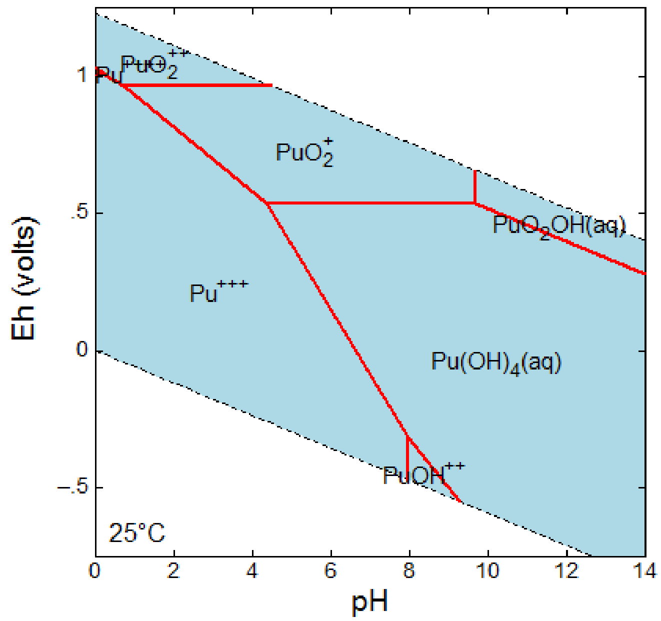
BASIS FOR INTERROGATORY:

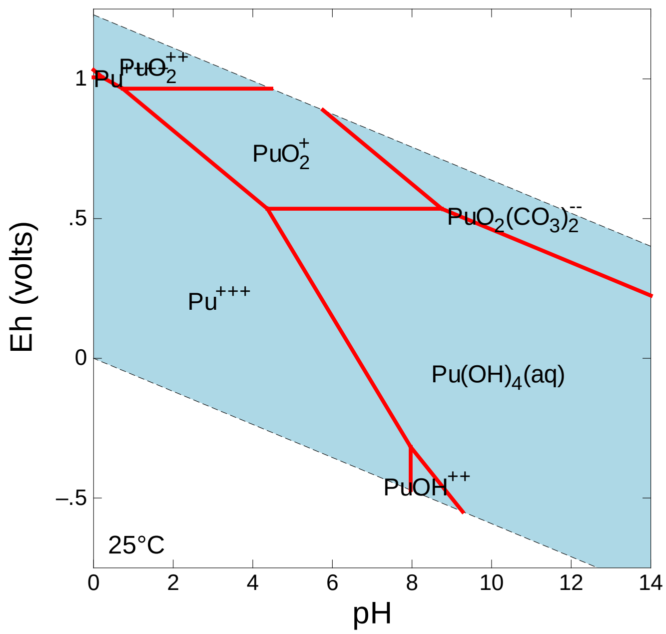
Section 4.1.7, page 13, of the Geochemical Modeling report states that "*Plutonium can be found in a number of valence states under the conditions at Clive. The most likely states are as Pu(V) and Pu(VI) both as cations and complexed with hydroxide and carbonate.*"

The specific data or model used to verify the statement should be provided. The simple Eh-pH figure below, generated from our own modeling, and many similar ones that can be found in the literature indicate that Pu(V) and Pu(VI) species will likely not be the dominant species given the pH and Eh ranges reported in Table 5. The top figure is the model output in the absence of atmospheric carbonate and the bottom figure is the model output with the carbonate concentration set to 350 mg/L total carbonate (which is the maximum carbonate concentration listed in Table 5 of the Geochemical Modeling report). There is no significant change in the redox speciation between the two models. Since the existing thermochemical databases for plutonium may have some conflicting data, it is important to document the model used for the statements quoted from the Geochemical Modeling report. However, even if Pu(V) and Pu(VI) are thermochemically predicted to be stable under the porewater conditions at the Clive site, many studies have demonstrated surface mediated reduction of Pu(V) on metal oxide, soil, and sediments (see Kenney-Kennicutt and Norse, 1985; Powell et al., 2004 and 2005; Romachuk et al., 2011; and Sanchez et al., 1985).

(Modeling was performed with Geochemist Workbench Standard 8.0 using database thermo.com.v8.r6+.dat.)

If for any reason Energy*Solutions* is unable to reconcile these or any other discrepancies with neptunium K_d values used in the GoldSim model with local Clive geologic and geochemical conditions (vadose or shallow aquifer), Energy*Solutions* will need to (1) use conservatively low K_d values found in available peer-reviewed technical literature or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).





ES RESPONSE:

In its response, ES focused on the geochemistry of Pu(IV), redox conditions, and K_d distributions.

In particular, ES stated the following:

EPA (1999) indicates that soil redox conditions are not as important as ligand presence and concentration, as well as carbonate ion concentrations (Section 5.6.6.1). There is some discrepancy between EPA (1999) Figure 5.3, which indicates Pu(OH)2(CO3)2- would be the dominant Pu solution species, and the figures above, generated using Geochemist Workbench.

REBUTTAL:

ES should delete the following sentence of its response, since it would also not be correct for Pu(VI): "*It is assumed that discussion of neptunium in the Interrogatory text is a typo and should have been plutonium.*" The DEQ error with reference to Np(VI) has been corrected and there is no need for further explanation.

Regarding the statement about EPA (1999), there is considerable debate regarding the appropriate Pu(IV) hydroxycarbonate species and the associated stability constants. Therefore, if this speciation information is used for K_d determination, it has a potential for introducing a high degree of uncertainty. ES should review Clark et al. (1995) for a discussion of the Pu(IV) hydroxycarbonate species.

Additional discussion and justification are needed to incorporate findings from this literature reference. We look forward to reviewing the revised report.

REFERENCES:

Clark, D.L., D.E. Hobart, M.P. Neu, *Actinide Carbonate Complexes and Their Importance In Actinide Environmental Chemistry*, Chemical Reviews, Vol. 95, No. 1, pp. 25–48, 1995.

Kenney-Kennicutt, W.L., J.W. Morse, *The redox chemistry of Pu(V)O_2+ interaction with common mineral surfaces in dilute solutions and seawater*, Geochimica et Cosmochimica Acta, Vol. 49, pp. 2577–2588, 1985.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Powell, B.A., R.A. Fjeld, D.I. Kaplan, J.T. Coates, and S.M. Serkiz, *Pu(V)O_2+ adsorption and reduction by synthetic hematite and goethite*, Environ. Sci. Technol., Vol. 39, pp. 2107–2114, 2005.

Powell, B.A., R.A. Fjeld, D.I. Kaplan, J.T. Coates, and S.M. Serkiz, *Pu(V)O_2+ adsorption and reduction by synthetic magnetite (Fe_3O_4)*, Environ. Sci. Technol., Vol. 38, pp. 6016–6024, 2004.

Romanchuk, A.Y., S.N. Kalmykov, and R.A. Aliev, *Plutonium sorption onto hematite colloids at femto- and nanomolar concentrations*, Radiochim. Acta, Vol. 99, pp. 137–144, 2011.

Sanchez, A.L., J.W. Murray, and T.H. Sibley, *The adsorption of plutonium-IV and plutonium-V on goethite*, Geochimica et Cosmochimica Acta, Vol. 49, p. 2297, 1985.

U.S. Environmental Protection Agency, *Understanding Variation in Partition Coefficient, K_d, Values*, Volume II, 1999.

INTERROGATORY CR R313-25-7(1)-145/2: SORPTION REVERSIBILITY AND GLOVER ET AL. (1976) DATASET

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Provide further explanation for the potential impact of reversibility of sorption on the PA and the relevance of the Glover et al. (1976) dataset.

BASIS FOR INTERROGATORY:

Section 4.1.7, page 13, of the Geochemical Modeling report states that "*Some studies indicate the sorption is non-reversible.*" Since a K_d model was selected for this work and a fundamental assumption in it is that of reversibility, this has significant implications for the model of plutonium transport. The significance of the statement about non-reversibility should be explained, particularly in light of the deep time aspects now required in PA modeling and possible changes in local geochemical conditions.

In addition, the text states that "*Data by Glover et al. (1976) found in the EPA (EPA 1999c) series may be of particular relevance to the Clive location.*" The text should clarify what exactly in the dataset from Glover et al. (1976) makes it particularly relevant for the Clive site and explain how and why Energy*Solutions* increased the limit on the K_d values.

ES RESPONSE:

In its response, ES discussed the processes controlling the sorption of plutonium and americium.

REBUTTAL:

ES should explain why the higher K_d values for plutonium used in the Geochemical Modeling report (Appendix 6 to FRV1), rather than those in Glover et al. (1976), are more current or applicable to Clive soil and groundwater conditions. We look forward to reviewing the revised report.

REFERENCES:

Glover, P.A., F.J. Miner, and W.O. Polzer. *Plutonium and americium behavior in the soil/water environment, I: Sorption of plutonium and americium by soils*, in Proceedings of Actinide-Sediment Reactions Working Meeting, Seattle, Washington, pp. 225–254, BNWL-2117, Battelle Pacific Northwest Laboratories, Richland, Washington, 1976.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Understanding the Variation in Partition Coefficient, K_d, Values*, 402-R-99-004B, Volume II, 1999.

INTERROGATORY CR R313-25-7(1)-146/2: DETERMINATION OF K_d VALUES

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Provide further explanation on how the K_d values for each radionuclide were selected. Elaborate on how the soil textures listed in Table 1 of the Geochemical Modeling report, or any other factors, were used to determine the Clive K_d ranges for the respective nuclides. Provide a summary table of actual K_d values used for each element/nuclide.

BASIS FOR INTERROGATORY:

Table 1 of the Geochemical Modeling report provides the distribution parameters for K_d for materials, as explained in Section 4.0. The text should explain exactly how the K_d values in Table 1 were selected, including the quantitative means used to take the K_d values reported in the literature and determine the ranges given in Table 1. For example, Section 4.1.9, page 14, states that "*A range based on all of the above data was chosen for each material class*," but does not explain how. Energy*Solutions* should elaborate how the soil textures listed in Table 1, or any other factors, were used to determine the Clive K_d ranges for the respective nuclides. A summary table should be provided to disclose the actual K_d values used for each element/nuclide.

ES RESPONSE:

In its response, ES stated that: "*The Geochemical Modeling report is being revised to include a table of the ranges of K_d values for the three soil textures (sand, silt, clay) for each element in the model, and relate them to the literature references as described in the subsections of the report.*"

REBUTTAL:

We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(1)-147/2: DETERMINATION OF K_d VALUE FOR URANIUM

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Provide support for assumptions regarding the derivation of the partition coefficient for uranium with regard to the results of an increase in ionic strength and the potential bias of high K_d values for ferrihydrite and kaolinite.

BASIS FOR INTERROGATORY:

Section 4.1.13, page 15, of the Geochemical Modeling report states that "*As the ionic strength increases, other cations will displace the uranyl* $(UO_2)^{2+}$ *ion.*" This statement should be supported with a reference; also note that uranyl should be written as (UO_2^{2+}).

In addition, Section 4.1.13, page 16, of the report states the following:

> *The minimum value was based on values calculated for quartz with the maximum value based on data calculated for ferrihydrite and kaolinite. These very high* K_d *values are considered potentially biased by one order of magnitude.*

The rationale for this assumption should be presented and justified. If for any reason Energy*Solutions* is unable to adequately justify the uranium K_d values used in the model, in terms of local Clive geologic and geochemical conditions (vadose or shallow aquifer), Energy*Solutions* will need to (1) use conservatively low K_d values found in available peer-reviewed technical literature or (2) collect additional Clive soil and groundwater samples and perform new, independent laboratory testing to determine a site-specific range of empirical values.

ES RESPONSE:

In its response, ES stated that: "*The Geochemical Modeling report is being revised to clarify assumptions and derivations of geochemical parameters, as discussed in other interrogatories, such as Interrogatory CR R313-25-7(1)-140/1.*"

REBUTTAL:

We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(1)-148/2: INFLUENCE OF CARBONATE ON URANIUM SPECIATION

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Resolve contradictory statements regarding uranium sorption and focus the discussion on the influence of carbonate on uranium speciation.

BASIS FOR INTERROGATORY:

Section 4.1.13, page 15, of the Geochemical Modeling report states the following:

> *Uranium sorption on iron oxide minerals and smectite clays is extensive except in the presence of carbonate where this is reduced (EPA 1999c).*

However, Section 4.1.13, page 16, states the following:

> *The U(VI) species in the aqueous environment will not have particularly strong sorption tendencies.*

These and other similar statements appear to contradict one another. The text should clarify this discrepancy and focus more on the influence of carbonate on uranium speciation. This is particularly important given that groundwater in the shallow aquifer appears to be super-saturated with carbonate minerals, and its matrix is heavily dominated by carbonate minerals (as noted in another interrogatory).

The wide range of uranium K_d values identified in this section is primarily dependent on the system pH and the concentration of carbonate in the aqueous phase. As the text notes, the presence of carbonate causes a marked decrease in uranium sorption. Therefore, to ensure that proper K_d values were captured within that range, appropriate documentation is needed regarding the carbonate values used in experiments where the selected K_d values were determined. Those carbonate values need to compare favorably to those listed in Table 5 of the report. Some overall discussion should be added regarding how the carbonate concentrations were qualitatively or quantitatively considered when selecting the uranium K_d values. The proposed uranium K_d values should also be compared and justified against the value determined by Adrian Brown Consultants (1997) on Clive soils and groundwater.

If for any reason Energy*Solutions* is unable to adequately justify the uranium K_d values used in the model, in terms of local Clive geologic and geochemical conditions (vadose or shallow aquifer) or the Clive-specific values previously determined by Adrian Brown Consultants (1997), Energy*Solutions* will need to (1) use conservatively low K_d values found in available peer-reviewed technical literature or (2) collect additional Clive soil and groundwater samples and perform new, independent laboratory testing to determine a site-specific range of empirical values.

ES RESPONSE:

In its response, ES indicated that: "*As stated in the Response to Interrogatory CR R313-25-7(1)-140/1, more detailed documentation of how these distributions were developed is being provided in a revised Geochemical Modeling report.*"

REBUTTAL:

We look forward to reviewing the revised report.

REFERENCES:

Adrian Brown Consultants, *Response to UDEQ K_d Interrogatories*, Report 3101B.970422, April 22, 1997.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Understanding Variation in Partition Coefficient, K_d, Values*, Volume II, 402-R-99-004C, 1999.

INTERROGATORY CR R313-25-7(1)-149/2: AMERICIUM SORPTION

PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

INTERROGATORY STATEMENT:

Provide additional justification for the assumptions made regarding americium sorption and for the preferred range of values in light of the elevated TDS content of shallow Clive groundwater and the competing ion effect.

BASIS FOR INTERROGATORY:

Section 5.1.2, page 19, of the Geochemical Modeling report states the following:

> *At Yucca Mountain the americium solubility used in the TSPA model ranged from 10^{-10} M to 10^{-6} M (LANL 1997). A similar range is used in this PA model.*

This wide range of solubility values for Am(III), without redox reactions causing a broad range, should be explained. In LANL (1997) (LA-13262-MS), most of the Am(III) values were within the range of 10^{-9}–10^{-8}. A value of 10^{-6} was reported as potentially suspect. Therefore, the range considered in the PA model as noted in Section 5.1.2 may be unnecessarily broad. Energy*Solutions* should also justify the preferred range of values in light of the elevated TDS content of shallow Clive groundwater and the competing ion effect.

ES RESPONSE:

In its response, ES discussed how sensitivity analysis can inform the model user about the need for a narrower range of americium K_d inputs.

REBUTTAL:

As ES extends its groundwater infiltration and transport modeling from 500 to more than 10,000 years, additional model inputs could be found to be "sensitive." We look forward to reviewing the revised report. Furthermore, several of the exponents are missing negative signs in the paragraph of the response that begins "*Given these assumptions….*"

REFERENCES:

Los Alamos National Laboratory, *Summary and Synthesis Report on Radionuclide Retardation for the Yucca Mountain Site Characterization Project*, LA-13262-MS, 1997.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7(2)-150/3: PLANT GROWTH AND COVER PERFORMANCE

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

INTERROGATORY STATEMENT:

Clarify the nature and degree to which plant growth might impact future system performance. Justify the use of the selected root penetration value and discuss the potential for deep plant rooting.

BASIS FOR INTERROGATORY:

FRV1 Section 4.1.2.1, page 27, and various of its appendices describe the cover profile and indicate that the uppermost layer is rip rap, which would seem to inhibit growth of grasses and forbs, at least initially. On the other hand, Section 3.1, page 11, of the Dose Assessment report suggests that aeolian deposits of fine material may allow vegetation to become established. The text further states that increased vegetation would lead to higher evapotranspiration rates (thereby enhancing performance by lowering recharge). Although this may be the case, the macropores left by root systems of former plants (particularly phreatophytes) could lead to focused recharge and significantly greater infiltration rates and depths. Macropores could also lead to increased radon emissions to the surface from the disposal embankment. The text should more fully discuss the potential impacts on embankment and site performance due to the type and distribution of plant growth on the cap.

After discussing the smaller, shallow-rooted greasewood plants noted on site, Neptune and Company, Inc. (2011a) indicates that more deeply rooting black greasewood plants are also observed on site, especially where precipitation runoff is concentrated, and these plants may extend taproots to exploit deeper water. A maximum root depth of 5.7 meters (Robertson 1983, p. 311) is used in this model. It is noted that the depth of only 5.7 meters used in the Neptune and Company, Inc. (2011a) model is far less than the 10–18 meters reported by a number of scientists for maximum depth of rooting by black greasewood at other sites. Thus, the depth described in the PA model does not appear to be reasonably conservative. Energy*Solutions* should justify the use of the root penetration value.

Other plants reported to live on site include shadscale saltbush (*Atriplex confertifolia*) and four-wing saltbush (*Atriplex canescens*). The latter is known from studies at other sites to root very deeply (e.g., USDA 2013). Shadscale saltbush may naturally hybridize with four-wing saltbush when both are present in the same area, since the two species are similar (Simonin 2001). Numerous sources report that saltbush species serve as forage for cattle and sheep (e.g., USDA 2013). Therefore, the PA, which currently denies the potential for deep plant rooting and for forage and plant uptake on site, needs to discuss forage plants on site, including black greasewood, shadscale saltbush, and four-wing saltbush.

In addition, saltbush can potentially bring radionuclides to the surface. Dreesen and Marple (1979) report that, in a greenhouse experiment, uranium nuclides and radium-226 were taken up from soil-covered uranium-mill alkaline tailings by four-wing saltbush and were found in the plant's above-ground biomass at elevated concentrations. Uranium was found at mean concentrations about 41 times that found in four-wing saltbush grown in uncontaminated soil, and radium-226 was found at mean concentrations about 15.5 times that found in four-wing saltbush grown in uncontaminated soil. It is likely that similar activities can occur in shadscale saltbush.

Howard (2003) states that "*Where soils allow, taproots* [of four-wing saltbush] *often extend more than 20 feet (6 m).*" Since four-wing saltbush is present on site, the potential for its taproots to penetrate the cover system and move down into waste and perhaps beyond must be considered in the PA and its associated model.

ES RESPONSE:

In its response, ES stated the following:

> *It may be possible for the species that occur at the site to create deep taproots at other sites, but there is no evidence that the conditions are right at this site to develop deep taproots. The model did not include deeper roots because it was assumed that the plants would grow out instead of down and based on the survey of the aboveground vegetation and root excavations at the site it does not appear that greasewood form deep taproots.*
>
> *The above explanation will apply to the ET cover that is currently being modeled as a replacement for the riprap cover. Text is being modified as necessary to address the ET cover effects on plant roots.*

REBUTTAL:

The PA indicates that greasewood size and rooting depth on the site is likely limited by the presence of a shallow, compressed, thin clay layer currently located 2 feet below the ground surface that apparently traps water and maintains roots at shallow depth. However, there is no evidence that, subsequent to this shallow, compressed, thin clay layer being locally homogenized with other soil and lost as a distinct layer as a result of mining and processing of portions of the on-site near-surface silty clay layer prior to emplacement in the Federal Cell, and with the shallow perching layer that this thin layer once created therefore being locally destroyed, conditions will exist at the site that will inhibit or prevent deeper rooting by shrubs such as greasewood. Changes will occur. Moreover, the size of greasewood plants at the surface is not a sure indicator of the length of their taproots. One expert, whose views are presented by the U.S. Forest Service in an article on SPECIES: *Sarcobatus vermiculatus*, indicates that greasewood typically sends taproots down to the water table and states that there is an inverse relationship between above-ground greasewood height, canopy coverage and total leaf surface area and the associated depth to groundwater (Anderson, 2004): "*Black greasewood height, canopy coverage, and total leaf surface area are inversely related to depth to water.*" In other words, when groundwater is deep, and taproots must extend down to a great depth to acquire pore water from the capillary fringe, greasewood plant size at the surface tends to be small, just as is seen at the Clive site. Excavations of root systems of only two greasewood plants on the site by one of the licensee's consultants do not make for a comprehensive study that can be fully relied on, when numerous other studies claim that greasewood taproots in arid or semi-arid environments can grow down to depths of 12.7 meters (42 feet) below ground surface or more (Chimner and Cooper, 2004; Harr and Price, 1972; Nichols, 1993; Meinzer, 1927; Waugh and Smith, 1998; White, 1932; WSDNR, 2011).

We understand that the ET cover system is currently being modeled and that a report will soon be presented that deals with deep plant rooting. We look forward to reviewing this response when the ET cover report is available.

V1.2 CRITIQUE (ROUND 3):

Deep rooting is potentially problematic at the Federal Cell. It has not been fully evaluated yet. It can be very important relative to evaluating potential radon-barrier damage, hydraulic conductivity changes, infiltration rates and contaminant transport rates. As stated in Benson (2009), "*Roots seek out water in wet fine-grained soils, e.g., clay radon barriers.*" Waugh and Smith (1988) indicate that at a DOE LLW site at Burrell, Pennsylvania, the hydraulic conductivity increased by two orders of magnitude at locations where roots penetrated the radon barrier.

REFERENCES:

Anderson, M.D., *Sarcobatus vermiculatus*, in Fire Effects Information System, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, 2004, retrieved May 2014 from http://www.fs.fed.us/database/feis/plants/shrub/sarver/all.html.

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Howard, J.L., *Atriplex canescens*, in Fire Effects Information System, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, 2003, retrieved October 2013 from www.fs.fed.us/database/feis/plants/shrub/atrcan/all.html.

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Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Biologically-Induced Transport Modeling for the Clive DU PA*, prepared for Energy*Solutions*, May 28, 2011a.

Nichols, W.D., *Estimating discharge of shallow groundwater by transpiration from greasewood in the Northern Great Basin*, Water Resources Research, Vol. 29, pp. 2771–2778, 1993.

Robertson, J.H., *Greasewood (*Sarcobatus vermiculatus (Hook.) Torr.*)*, Phytologia, Vol. 54, pp. 309–324, 1983.

Simonin, Kevin A, *Atriplex confertifolia*, in Fire Effects Information System, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, 2001, retrieved October 2013 from www.fs.fed.us/database/feis/plants/shrub/atrcon/all.html/.

U.S. Department of Agriculture, *Fourwing saltbush, Atriplex canescens (Pursh) Nutt.*, Plant Guide, Natural Resources Conservation Service. Retrieved February 2013 from http://plants.usda.gov/plantguide/pdf/pg_atca2.pdf.

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Washington State Department of Natural Resources (WSDNR), *Ecological Integrity Assessments: Inter-Mountain Basins Greasewood Flat*, Natural Heritage Program, Version 2.22.201, 2011.

INTERROGATORY CR R313-25-8(4)(A)-151/2: RADON BARRIER ATTENUATION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

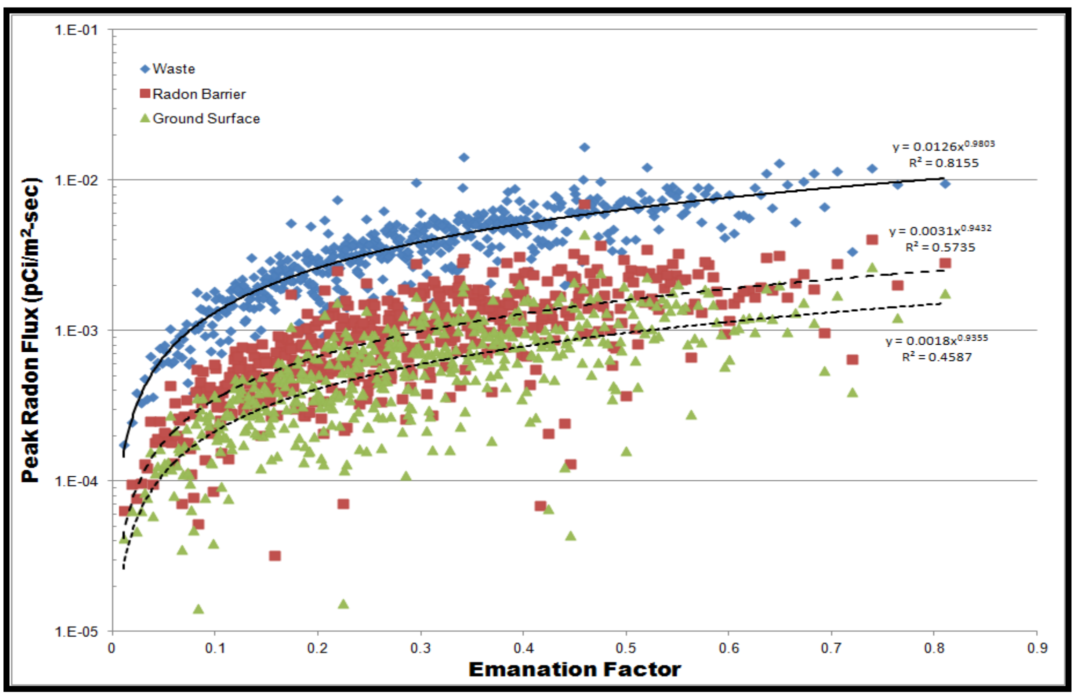
Describe the role performed by the design of the radon barrier in demonstrating that the exposures to humans from the release of radon will not exceed the limits in R313-25-19. Include the value of any diffusion coefficients used (and justification for their selection) and the basis for any radon attenuation calculated. If either of the diffusion coefficients or attenuation is different for the DU PA model from what were used for other facilities at the Clive site (e.g., the LLRW and 11e.(2) disposal facilities), provide justification for those differences.

BASIS FOR INTERROGATORY:

As a part of this review, GoldSim analyses were performed using the DU PA model that was supplied to DRC by Energy*Solutions*. The figure below shows some of the results from running that model for the case of 10-meter burial, without gullies. It depicts the peak radon flux on top of the 27-layer waste pile, on top of the two-layer radon barrier, and on the ground surface, as a function of the radon emanation factor. These fluxes were extracted from the Results Mode of the GoldSim file.

Best fit equations have been formed for each of the three sets of radon fluxes, and the resulting trendlines are also shown on the figure. The R^2 value associated with each set shows that the emanation factor accounts for about 82% of the flux variability on top of the waste, about 57% on top of the radon barrier, and only about 46% on the ground surface. This behavior is expected and shows that as the flux gets further away from the source, there are more parameters with uncertainty to influence the flux.

Peak Radon Flux on Top of the Waste, on Top of the Radon Barrier, and on the Ground Surface



The mean emanation factor used in the DU PA model is 0.29 (Table 25 of the Model Parameters report). If this mean emanation factor is plugged into the best fit equations for on top of the waste and on top of the radon barrier, the resulting radon fluxes are 0.0037 and 0.00096 $pCi/m^{2-}s$, respectively. By dividing the top of the waste flux into the top of the barrier flux, the attenuation of the radon barrier is calculated to be about 0.26 (0.00096 / 0.0037).

IAEA (2013) states that the radon attenuation of a material of thickness “t” centimeters can be estimated by: exp(-t / DL), where DL is the diffusion length, defined as:

$$\sqrt{D_C/\lambda},$$

Where:

λ = the Rn-222 decay constant (s^{-1})
D_c = the radon diffusion coefficient (cm^2/s)

These relationships can be rearranged to calculate the radon diffusion coefficient associated with a 2-foot (61-centimeter) thick radon barrier that provides about 0.26 attenuation. Plugging these values into the rearranged equations results in a diffusion coefficient estimate of about 0.0053 cm^2/s.

Rogers (2002) provides an analysis and argument for using a radon diffusion coefficient for the clay material of the LLRW and 11e.(2) disposal facility’s radon barrier of 0.00064 cm^2/s (Rogers 2002, Scenarios 1, 3, and 5) to replace a coefficient of 0.008 cm^2/s (Rogers 2002, Scenarios 2 and 4).

It is not clear why the radon barrier over the DU disposal area would have a different diffusion coefficient from the barrier over the LLRW and 11e.(2) disposal facilities. Since in the DU PA model the doses to the general population (both individual and population) are dominated by radon flux, it is important that the basis for calculating the attenuation of the radon barrier be thoroughly understood. The radon diffusion coefficients used in the PA model should be fully explained and justified.

ES RESPONSE:

In its response, ES stated that: “*The role of the radon barrier…for the evapotranspiration cover system is currently being modeled by Neptune….*” ES went on to provide a basic description of the radon diffusion process in general, and of GoldSim’s approach to calculating the diffusion process.

REBUTTAL:

We look forward to reviewing the results of the ET cover radon modeling effort, and we anticipate that these results will be consistent with previous results for the Clive site.

REFERENCES:

International Atomic Energy Agency, *Measurement and Calculation of Radon Releases from NORM Residues*, Technical Report Series No. 474, 85 pp., 2013.

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Rogers, T., *A Change in Envirocare’s Disposal Cell Design*, Envirocare of Utah, Waste Management ’02 Conference, February 24–28, Tucson, AZ, 2002.

INTERROGATORY CR R313-25-8(5)(A)-152/2: GOLDSIM INPUT PARAMETERS

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Provide documentation and justification for the radon correction factors (RnDiffusivityCorrection) used in the GoldSim DU PA Model.

BASIS FOR INTERROGATORY:

FRV1 and its appendices describe in detail the DU PA Model developed by Energy*Solutions* and Neptune. This model was converted into one or more GoldSim model files (i.e., .gsm files). The GoldSim model file "Clive DU PA Model v1.0.gsm" was reviewed to determine whether the data from FRV1 and its appendices were correctly implemented.

We primarily reviewed three data types: (1) scalar data, GoldSim icon: , (2) stochastic data or probability distributions, icon: , and (3) lookup tables, icon: . We used the GoldSim icons to identify the data to be reviewed and then searched FRV1, primarily the Model Parameters report, to confirm that the GoldSim value was the same as the documented value. Using this method, we reviewed in total almost 1,200 data points.

In subcontainers to the TopSlope container, the term RnDiffusivityCorrection is used several times. In the LocalAir subcontainer, RnDiffusivityCorrection has the value of 0.96, while in the RnBarrierLayers/LocalAir and Liner/LocalAir subcontainers, it has the value of 0.85, and in the WasteLayers\LocalAir subcontainer it has the value of 0.343. FRV1 and its appendices did not provide documentation for these numerical values. Although Section 9.4.3, pages 55–56, of the Unsaturated Zone Modeling report describes why the radon correction factors are needed and how they should be calculated, it does not document what radon correction factors should be used.

Because no documentation is provided for these values, it is unknown whether the three radon corrections factors are conservative, realistic, or liberal. Since the radon pathway is a major contributor to the dose for most of the cases studied (including burial at 10 meters), additional documentation and justification of these radon correction factors is needed.

ES RESPONSE:

In its response, ES stated: "*The radon correction factors are not model inputs, which is why they do not appear in the Parameters Document.*" It then proceeded to give instruction on how to obtain the radon correction factors from the GoldSim model.

REBUTTAL:

ES described how to run the GoldSim model to gain the answer to the question. However, we do not agree with this approach. A reader of the report should not be forced to run the GoldSim model to "*gain an appreciation of where* [the radon correction factors] *come from.*" It is the report's function to provide this information to its readers, particularly those without access to GoldSim.

In addition, while the radon correction factors are calculated by GoldSim, for the purposes of the PA they are treated like input parameters. As such, they should be described in the documentation, just as any other input parameter. We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-8(4)(D)-153/2: IMPACT OF PEDOGENIC PROCESS ON THE RADON BARRIER

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Demonstrate that the impact of pedogenic processes has been included in embankment cover performance, particularly with respect to effects on hydraulic conductivity.

BASIS FOR INTERROGATORY:

Traditional rock covers require perpetual maintenance of the surface to ensure the radon barrier remains visible. Vegetation gets established in the silt that accumulates in the pores in the rock layer and extends roots into the radon barrier, causing it to desiccate and crack. However, the assessments of the water balance and rock armor cover designs do not acknowledge that pedogenic processes may alter the hydraulic properties of the radon barrier substantially, resulting in an increase in saturated hydraulic conductivity and potentially an increase in percolation rate into the underlying waste (Benson et al. 2011). The radon barrier will be moist compared to other layers in the profile, particularly if compacted near optimum water content to achieve the desired saturated hydraulic conductivity of 5×10^{-8} cm/s. Over time, opportunistic vegetation will extend roots into this layer to remove the moisture for transpiration, resulting in a decrease in pore water pressure, shrinkage of the barrier material, and cracking.

This phenomenon was observed in 2007 when exhuming caisson lysimeters used to evaluate a water balance cover for the Monticello Disposal Facility in Monticello, Utah. Roots had penetrated the radon barrier, resulting in cracks and higher than anticipated hydraulic conductivity. One large-scale undisturbed block sample from the radon barrier had a saturated hydraulic conductivity of 3.2×10^{-4} cm/s (Benson et al. 2008), or nearly four orders of magnitude more permeable than radon barrier proposed in the water balance and rock armor covers for the Federal Cell.

In addition, Section 3.1.5, page 3-4, of the 2013 Compliance Report, Revision 1, states that "*Vegetation had two primary effects on the cover system: increasing the hydraulic conductivity of the cover material and root clogging of the lateral drainage layers.*" Energy*Solutions* should provide additional information on how the model input parameters account for the deleterious effects of vegetation on the cover system and the subsequent impacts on the modeling results.

ES RESPONSE:

In its response, ES stated the following:

> *The sensitivity of cover infiltration to changes in radon barrier integrity has been evaluated (Energy*Solutions*, 2014) for the ET cover design.…*
>
> …
>
> *A revised model of the engineered cover is being developed, based on an ET cover design.*

With regard to the influence of biointrusion on model parameters, ES referred to its response to Interrogatory CR R313-25-8(4)(a)-108/1: Biointrusion. It also reproduced part of its response to Interrogatory CR R313-25-7(2)-05/1: Radon Barrier for additional information.

REBUTTAL:

ES' response focused on infiltration; it should also address radon diffusion:

1. The ES response began by referring to Energy*Solutions* 2014, which obviously was not included in FRV1. ES needs to integrate the information from this document into the revised

report. Then DRC can review and comment on how that information is being used in the DU PA.

2. The ES response indicates that the ET cover would reduce infiltration by two orders of magnitude compared with the rock armor mulch cover. The revised GoldSim DU PA model (v1.199) provided by ES on May 5, 2014 (Rogers 2014) does not support this statement. The original mean infiltration rate (VerticalFlow_BelowCap) was about 0.12 cm/yr, whereas with the ET cover the rate is about 0.04 cm/yr—reduced by only a factor of three.
3. The ES response indicates that the ET cover design will limit infiltration down to the radon barrier. However, the response does not address what impact pedogenesis, burrowing animals (if any), plant roots, gullies, and similar mechanisms would have on the radon diffusion upwards to the surface.
4. Finally, in its response ES described the cover performance modeling that is required. DRC looks forward to receiving and reviewing this refined modeling effort.

REFERENCES:

Benson, C., W. Albright, D. Fratta, J. Tinjum, E. Kucukkirca, S. Lee, J. Scalia, P. Schlicht, X. Wang, *Engineered Covers for Waste Containment: Changes in Engineering Properties & Implications for Long-Term Performance Assessment*, NUREG/CR-7028, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, 2011.

Benson, C., S. Lee, X. Wang, W. Albright, and W. Waugh, *Hydraulic Properties and Geomorphology of the Earthen Component of the Final Cover at the Monticello Uranium Mill Tailings Repository*, Geological Engineering Report No. 08-04, University of Wisconsin, Madison, Wisconsin, 2008.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Energy*Solutions*, *Evapotranspirative Infiltration Sensitivity to Changes in Radon Barrier Hydraulic Conductivity*, Energy*Solutions* Technical Memorandum to the Utah Division of Radiation Control, March 31, 2014.

Rogers, Vern C., *DU PA – ET Cover GoldSim Files*, email to H. Gabert, Utah Division of Radiation Control and W.C. Thurber, S. Cohen & Associates, May 2, 2014.

INTERROGATORY CR R313-25-8(4)(D)-154/2: USE OF FIELD DATA TO VALIDATE DISPOSAL CELL COVER PERFORMANCE

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Document the extent to which field data were used to validate the performance of the proposed Federal Cell cover design; include consideration of information from DOE disposal sites.

BASIS FOR INTERROGATORY:

Hydrologic assessment of cover performance has become increasingly reliant on confirmation of performance using field data from site-specific studies or from analog studies with similar properties. This type of comparison is used to confirm or build confidence in predictions made with variably saturated flow models in performance assessments.

There are two field studies of particular relevance to the Federal Cell: (1) the long-term monitoring study being conducted by the DOE Office of Legacy Management on the water balance cover at the Monticello Disposal Facility and (2) the Enhanced Cover Assessment Project study being conducted by the same DOE office on rock armor covers at the Cheney Disposal Facility near Grand Junction, Colorado (DOE 2012, DOE 2013). Monticello is wetter than the location of the Federal Cell (average annual precipitation = 353 mm/yr), whereas the Cheney site has comparable precipitation (average annual precipitation = 196 mm/yr).

Figure 1 (Benson et al. 2008) and Figure 2 (Bareither and Benson 2013) show the cover profiles at these sites. Both sites employ large-scale volumetric lysimeters based on the design developed in the Alternative Cover Assessment Program, as described in Benson et al. (2001) and Albright et al. (2010). The Cheney site has two replicate lysimeters, labeled C and R. Percolation rates measured at these sites are summarized in Table 1 (Monticello) and Table 2 (Cheney) (DOE 2012, DOE 2013). The lysimeters at Monticello and Cheney are at 2% grade, similar to the top deck of the Federal Cell.

The average percolation rate for the water balance cover at Monticello is 0.5 mm/yr, which is about 25 times higher than the percolation rate predicted for the water balance cover for the Federal Cell. Monticello is in a wetter climate, which can increase the percolation rate, but Monticello also uses a much thicker storage layer (Figure 1) than the cover proposed for the Federal Cell, which will reduce the percolation rate. Thus, the very low percolation rate predicted for the Federal Cell needs additional justification.

Similarly, for the rock armor cover at the Cheney Disposal Facility, the average percolation rate is 1.0 mm/yr (Cheney-C) or 2.8 mm/yr (Cheney-R), or 1.9 mm/yr on average. This percolation rate is more than two times the average percolation rate predicted for the rock armor cover for the Federal Cell as reported in Energy*Solutions* (2012) (pp. 3-7 and 3-8), even though the average precipitation at Cheney has been lower than the average precipitation cited for the Federal Cell. The significance of this difference in percolation rates needs clarification.

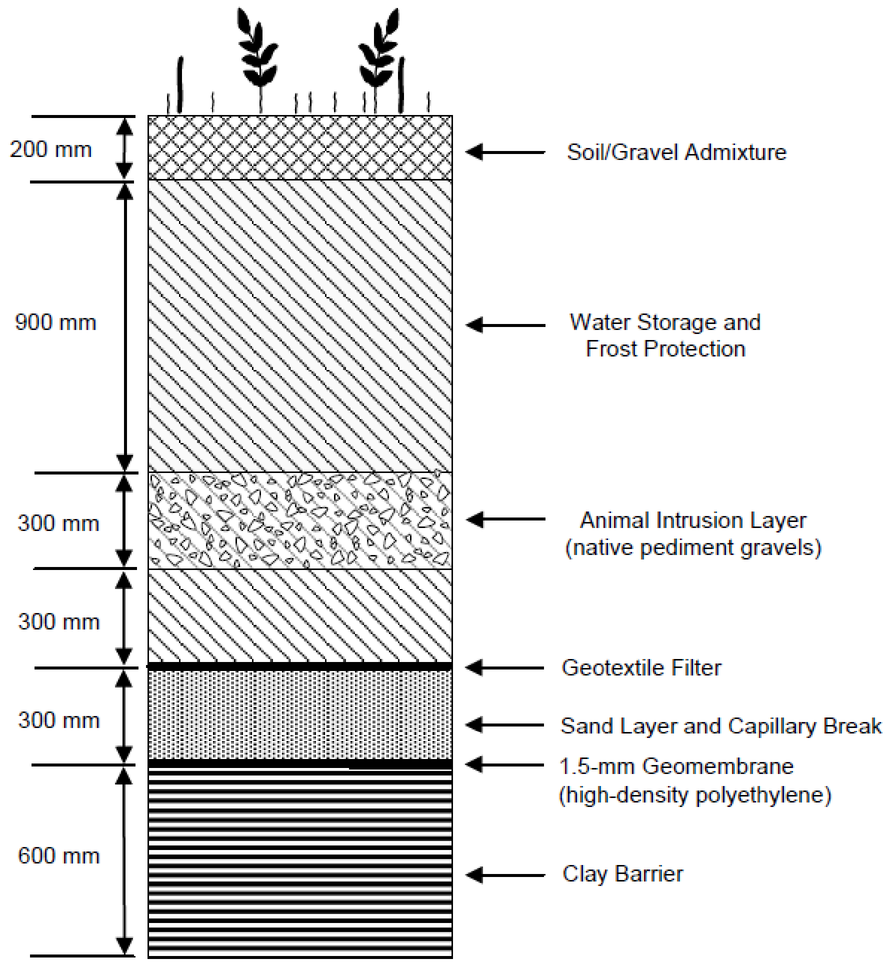


Fig. 1. Profile of cover used at Monticello Disposal Facility. The cover prolife above the geomembrane constitutes the water balance cover

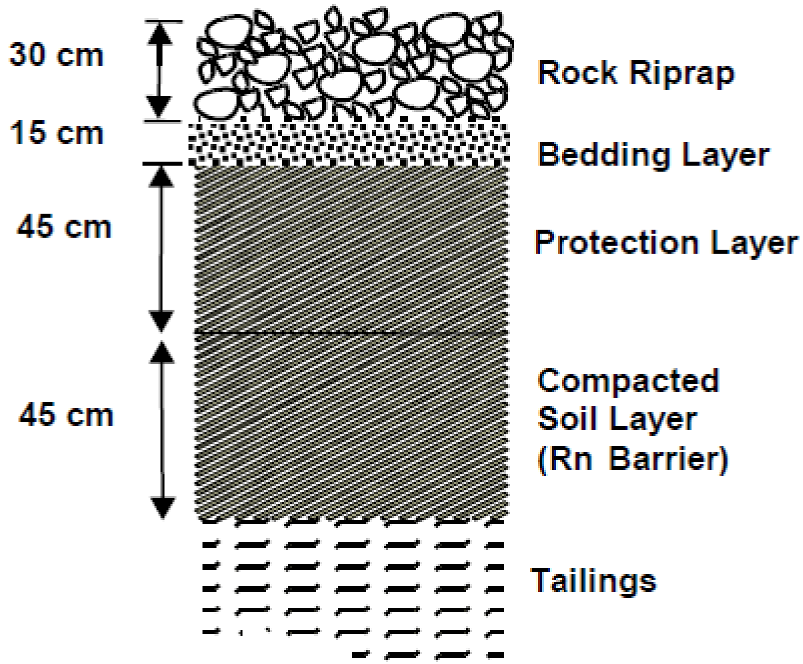


Fig. 2. Profile of rock armor cover used at Cheney Disposal Facility.

Table 1. Summary of water balance data from Monticello Lysimeter.

Year	Precipitation (mm)	Runoff (mm)	Evapotranspiration (mm)	Percolation (mm)
2001	377.7	4.2	400.4	0.0
02	231.9	3.3	221.2	0.0
03	364	0	360.5	0.0
04	442	12.3	352.4	0.2
05	481.6	28.1	515.7	3.8
06	447.3	0	389.1	0.2
07	304.5	1.2	317.5	0.0
08	293.6	3.6	329.4	0.7
09	241.0	4	246.9	0.0
10	512.6	15	446.3	1.9
11	354.9	0.1	395.3	0.1
12	275.0	2.3	287.3	0.0
13	273.6	1.4	269.1	0.0
Avg	**353.8**	**5.8**	**348.5**	**0.5**

Table 2. Summary of water balance data from Cheney Lysimeters.

Cover	Period	Precipitation (mm)	Runoff (mm)	ET (mm)	Percolation (mm)
C	11/15/07-06/30/08	122.4	0.0	110.6	1.4
	07/01/08-06/30/09	195.1	0.0	175.7	0.5
	07/01/09-06/30/10	209.0	0.0	203.2	0.6
	07/01/10-06/30/11	234.7	0.1	241.3	1.3
	07/01/11-06/30/12	177.0	0.0	188.0	0.6
	07/01/12-06/30/13	93.8	0.0	112.4	1.0
	07/01/13-12/26/13	267.0	0.0	265.9	1.3
	Average	**185.6**	**0.0**	**185.3**	**1.0**
R	11/15/07-06/30/08	122.4	0.0	100.3	2.8
	07/01/08-06/30/09	195.1	0.0	163.0	0.1
	07/01/09-06/30/10	209.0	0.0	224.3	6.4
	07/01/10-06/30/11	234.7	0.1	232.8	3.6
	07/01/11-06/30/12	177.0	0.0	187.5	3.9
	07/01/13-09/29/13	93.8	0.0	108.0	0.0
	07/01/13-12/26/13	267	0.1	263.5	3.0
	Average	**185.6**	**0.0**	**182.8**	**2.8**

ES RESPONSE:

In its response, ES noted in part the following:

> *Enhanced investigations of these components of uncertainty require both different approaches in the structure of the modeling studies and application of methods of global sensitivity and uncertainty using probabilistic modeling. There are significant limitations in assessing the effects of parameter and conceptual*

> *uncertainty using deterministic modeling with specified (discrete) cover designs and bounding transport parameters and assumptions. To provide a more comprehensive sensitivity analysis for infiltration modeling, it should not be based on selective and non-systematic changes in physical properties of cover materials. Instead what is required would be refined modeling of closure cover performance using probabilistic cover parameters and multiple model simulations designed so that the output from the multiple simulations can be abstracted into the probabilistic performance assessment model.*

ES also stated the following:

> *However, site-specific data help build confidence in model predictions. Data have been collected from scaled structures located at the disposal sites such as the lysimeters described in this Interrogatory and the Test Cell at Clive. This approach avoids the problems of differences in climate, vegetation, and material characteristics and can provide valuable information for model calibration and verification but can be vulnerable to issues resulting from differences in scale.*

REBUTTAL:

ES did not address the fact that the Monticello Disposal Facility in Utah uses an ET cover, but the measured percolation rate is substantially higher than that proposed for the Federal Cell. ES should address the possible causes of this discrepancy.

With regard to ES' responses related to Cover Test Cell (CTC) data collected to date, DEQ has determined that only cover soil temperature data are reliable from that facility. Hence, ES reference to other water balance-related data collected at the CTC facility may be suspect. Further, the CTC facility was constructed to simulate the riprap cover design of the Low-Activity Radioactive Waste Cell, and not any ET cover now proposed for the DU disposal cell.

Also see Interrogatory CR R313-25-7(3)-60/2: Modeled Radon Barriers.

We look forward to completing our review of this response when the revised ET cover report is available.

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U.S. Department of Energy, *Long-Term Surveillance Operations and Maintenance Fiscal Year 2013 Year-End Summary Report*, LMS/ESL/S10692, ESL-RPT-2013-03, prepared by Environmental Sciences Laboratory for the DOE Office of Legacy Management, Washington, DC, September 2013.

INTERROGATORY CR R313-25-8(4)(D)-155/3: COVER PERFORMANCE FOR 10,000 YEARS

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Document how expected climate changes and other FEPs that may degrade cell performance over 10,000 years have been factored into the cover cell design. Also discuss historical analogs of similar structures and how they have functioned over long periods of time.

BASIS FOR INTERROGATORY:

To provide confidence in the performance of the disposal cell embankment for a minimum of 10,000 years, the PA should examine historical analogs of similar structures that have remained reasonably intact for long time periods. The analog evidence should be buttressed by simulations of FEPs that may degrade over that time period. For example, climate change can result in episodic precipitation events that are greater in both magnitude and frequency than those based on the historical record. Climate change can affect animal and vegetation species. These effects need to be considered in the PA.

Thus, an evaluation of processes that alter the behavior of the cover should be conducted, including long-term changes in climatic conditions, evolution of the vegetation community in response to changes in climate or other externalities, and the impacts of the environment on the engineering properties of the cover materials (e.g., wet-dry cycling, freeze-thaw cycling, root intrusion). The latter includes changes in the properties of the earthen materials that comprise the cover, which are known to change substantially and quickly in some cases (Benson et al. 2011). None of these issues appear to have been taken into account when evaluating the hydrology of the cover for 10,000 years. Section 3.2, page 14, of the Unsaturated Zone Modeling report contends that "*bioturbation and homogenization of radon barriers will probably occur very slowly relative to the 10,000-yr time frame*," an inference that is inconsistent with current thinking regarding the engineering properties of cover materials, particularly radon barriers compacted with high water saturation and low saturated hydraulic conductivity (Benson et al. 2011).

ES RESPONSE:

In its response, ES stated that: "*A compromised radon barrier is being modeled under the PA Maintenance program. It is not considered necessary at this time because the ET Cover design will limit infiltration down to the radon barrier. With no infiltration down to that level, the naturalization of the radon barrier has no effect on performance.*"

ES also stated the following:

> *We are considering studying well dated volcanic landforms in the Black Rock Desert volcanic field located in the southern Utah within the former footprint of Lake Bonneville (39.0 degrees N, 112.5 degrees W). A series of basaltic volcanic centers with associated lava flows in the volcanic field (Pavant Butte, Ice Springs and the Tabernacle volcanoes) range in age from 16,000 to 800 years BP (before present). The lava and scoria cone/tuff rings provide unique landforms that can be examined to establish benchmarks for the operation of erosional and depositional process that would likely effect a waste embankment at the Clive site. Data can be gathered to assess whether aeolian depositional rates are sufficient to blanket and/or protect a closure cover. The properties of the aeolian cover/soils can be examined to evaluate erosional and biological processes affecting materials comparable to closure covers providing information on the long-term stability of the disposal site.*

REBUTTAL:

It is not clear that a naturalized radon barrier has no effect on radon releases. Affirmative evidence is needed to support this claim. ES should also indicate when the compromised radon-barrier report mentioned in its response will be available. It is not clear why this modeling should not be part of the DU PA. The claim that "*the ET Cover design will limit infiltration down to the radon barrier*" is not substantiated when considering that the PA model to date has not accounted for or implemented NRC guidance indicating that, based on a vast amount of experimental and field data, shallow soil layers (<10 feet deep) in a cover system undergo dramatic degradation over time; that is, with increases of hydraulic conductivity values generally ranging from one to three orders of magnitude (see Benson et al., 2011, in NUREG/CR-7028). Moreover, the same study shows that the use of small-diameter soil samples in laboratory testing of soil hydraulic conductivity values generally underestimates these values compared to actual field-scale hydraulic conductivities by one or more orders of magnitude. The PA uses small-diameter soil sample values instead of field-scale values. Both of these factors suggest that the current, unmodified PA modeling does not properly account for increased rates of infiltration down to the radon barrier. ES should modify the PA model to account for these factors.

The ES response also mentioned possibility of a new study of "*volcanic landforms in the Black Rock Desert*." If that study has been completed, ES should provide the results/data for DEQ review. If not, ES should provide a schedule for completion of the new study, or the reason it is not being undertaken.

In addition, the interrogatory requested a discussion of historical analogs of similar structures and how they have functioned over long periods of time. ES did not provide such a discussion.

The ES response also stated that: "*It is not considered necessary at this time because the ET Cover design will limit infiltration down to the radon barrier. With no infiltration down to that level….*" The revised GoldSim DU PA model (v1.199) provided by ES on May 5, 2014 (Rogers 2014), does not support this statement. The original mean infiltration rate at the waste level (VerticalFlow_BelowCap) was about 0.12 cm/yr, whereas the rate with the ET cover is about 0.04 cm/yr—reduced by only a factor of three, instead of being eliminated as claimed in the ES response. ES should clarify. Moreover, that calculated infiltration rate reflects modeling without ES having made adjustments in hydraulic conductivity values as requested above, which would likely increase modeled rates of infiltration down to the waste.

We look forward to evaluating other issues (such as erosion) when the ET cover report is available.

Also see Interrogatory CR R313-25-7(3)-60/2: Modeled Radon Barriers.

V1.2 CRITIQUE (ROUND 3):

As demonstrated in Interrogatory CR R313-25-7(2)-189/3: Modeling Impacts of Changes in Federal Cell Cover-System Soil Hydraulic Conductivity and Alpha Values, the PA does not yet include modeling to show the impacts of degradation over time of the entire cover system within 10 feet of the surface. Degradation will occur within several years for all shallow cover-system soils (see Benson et al., 2011). Therefore, modeling done to date is inadequate because it does not show important changes expected to occur nearly simultaneously (relative to the overall modeling period) in hydraulic conductivity and van Genuchten alpha values for all shallow soils (i.e., those less than 10 feet deep) within the cover system. As such, as of this time the PA does not contain adequate modeling of infiltration at the Federal Cell. Therefore, claims that infiltration will not extend (at appreciable rates) down to the depth of the radon barrier appear to be groundless. If infiltration does extend down to the radon barriers, then compromise of the radon barrier will have an impact on performance. ES should either demonstrate that these important cover-system changes will not occur (contrary to what is indicated in Benson et al., 2011), or change the model to account for these changes, with an expected consequent increase in predicted infiltration rates.

Another important factor related to cell cover system performance over the long term is freezing. Freezing can cause substantial damage to radon barriers and the soils above them, should sufficiently cold temperatures be reached in the radon barriers. The current PA does not sufficiently account for freezing. As described below, a number of reports and data show actual freezing conditions in Utah occurring, or having occurred, at greater depths than the depth currently proposed in the PA for the top of the Federal Cell upper radon barrier. The PA model needs to account for damage to the radon barriers from frost. Alternatively, the cover system should be re-designed so as to provide for thicker soil layers above the upper radon barrier.

During testing in January 2002 and January 2004, ES measured freezing or close to freezing temperatures using thermocouple temperature probes at the midpoint of the sacrificial soil in the Cover Test Cell, at a depth of about 30 inches (Edwards, 2011; Envirocare, 2005). Currently, the PA proposes the top of the radon barrier to be located at a depth of 30 inches. However, these incidents of freezing noted in the past took place during portions of winter that were not especially cold. Mean monthly low air temperatures at Dugway for January 2002 and January 2004 were, respectively, 15.45° F and 11.35° F (Western Regional Climate Center, 2014). However, in the 56 years between 1951 and 2006, inclusive, there were 13 years (i.e., 23% of the time) in which mean monthly low air temperatures for January dropped to values that were lower, and sometimes much lower, than 11.35° F, the colder of the temperatures for the two referenced reported incidents (Western Regional Climate Center, 2014).

By contrast, the coldest January on record during these 56 years of record is that of 1989, when the mean January low air temperature at Dugway was only 0.39° F. That is nearly 11 degrees colder than in January 2004, so freezing temperatures in the soil in the Cover Test Cell, had it been created and instrumented back then, would likely have gone considerably deeper than the 30 inches in the Cover Test Cell that were measured in January 2004. If so, with the cover system proposed in the PA, freezing temperatures would extend considerably deeper than the top of the upper radon barrier.

Furthermore, there are accounts of frosts of more extreme depth having occurred in Utah. For example, "*JANUARY 1–9, 1979 – 'Bitterly cold arctic air dominated all of Utah. Due to a lack of snow cover, ground frost permeated the ground to a depth of six feet* [72 inches] *in many areas*'" (Adler, et al., 1996). Although this information comes from an almanac rather than a more scientific source, it is posted by the Utah Center for Climate and weather, which appears to be a reasonably reliable source, and it prompts some additional consideration of this issue.

In addition, significant information comes from the Federal Highway Administration (FHWA) (2008), which conducted frost penetration analysis at 41 sites nationwide for its E-FROST research analysis. FHWA used data from two Utah sites in its analysis. For one of these sites, FHWA reported a maximum (worst-case-scenario estimate) frost depth estimate of 2.019 meters (6.54 feet, or 78.5 inches). This is 350% of the value predicted by ES above.

Moreover, the frost penetration equation used for Utah by the Utah Department of Transportation (UDOT) (2012) is:

$$\textit{Frost Penetration} = 1.482(\textit{Freezing Index})^{0.4911}$$

This equation results in a value of 44.9 inches for 100-year frost penetration depth for Dugway, based on the National Oceanic and Atmospheric Administration (NOAA) air freezing index of 1,037 for a 100-year frost at Dugway, Utah (NOAA, 2012). This value of 44.9 inches is 200% of the value predicted by ES above. It is evident that freezing temperatures may extend deeper than 30 inches in the West Desert.

Contrary to ES calculations, a "correction factor" of 0.7 should not be used with this equation for soils. The UDOT (2012) manual itself does not appear to mention this correction factor but simply states the following:

> *Frost Penetration is approximately equal to 1.482 (freezing index)$^{0.4911}$*
>
> *This frost depth information should be used in the formulation of initial DARWin-ME pavement sections and selection of base and subbase materials. DARWin-ME computes the frost depth over the years of climate data available and this information may be useful in formulating a design.*

However, another publication (Department of the Army, 1954) may provide insight into the use in this one example of a correction factor of 0.7. This publication states, "*the surface freezing index for bituminous surfaces (kept cleared of snow) may be computed by multiplying the freezing index based on air temperatures by a correction factor of 0.7.*" It is noted that this air-temp/surface-temp correction factor applies only to bituminous surfaces, such as would be found on roads. Dark, bituminous road surfaces soak up heat from sunlight, if the surfaces are not isolated and insulated from sunlight, such as by snow. The average albedo for new asphalt is only 0.05 to 0.10, and that of aged asphalt is only 0.10 to 0.20 (American Concrete Pavement Association, 2002). Bituminous road surfaces absorb more energy from sunlight per unit area per unit time than does typical soil, which generally has an albedo in the range of 0.2 to 0.3.

By contrast, rather than tending to absorb light and heat at a higher flux than usual, a high-albedo surface, such as light-colored, mostly carbonate silty clay in the West Desert, would tend to reflect the light and heat more than usual. The average albedo of the West Desert is estimated to be in the range of 0.30 to 0.40, which is three to eight times that of bitumen asphalt, and much greater than typical soil. An air-temp/surface-temp correction factor less than unity is therefore not likely to apply to an embankment at Clive. The UDOT (2012) manual does not call for such a correction factor for soil. Therefore, the 100-year frost penetration depth for Dugway is calculated as 44.9 inches, which would bring freezing temperatures down into the currently proposed upper and lower radon barriers at Clive. It is anticipated that frost penetration depths for 500-, 1,000-, and 10,000-year return intervals would be significantly greater than the 44.9 inches estimated for a 100-year return interval. (See Budikova, 2013; Coakley, 2003; Dobos, 2003; Grace, 1998; Knorr et al., 2001; and Zhang et al., 2014.)

Given the potential for deeper frost depths as noted above, and with documented freezing-temperature depths at Clive measured as low as 30 inches during a January interval when the air temperature was not especially low, ES should plan for far more than 30 inches of frost protection on the top slope of the cover. ES should develop a more robust approach to estimating frost depth and planning for defense against the radon barrier freezing. This would involve, among other things, increasing the thickness of the cover system above the radon barriers.

With the current proposed cell design, ES' modeling should account for substantial disruption of near-surface layers above and within the radon barriers, with accompanying increases for initially low-permeability soil in both hydraulic conductivity and correlated alpha values, which should greatly affect modeled infiltration rates (see Interrogatory CR R313-25-7(2)-189/3: Modeling Impacts of Changes in Federal Cell Cover-System Soil Hydraulic Conductivity and Alpha Values). ES is required by rule to minimize infiltration (see UAC R313-25-24(3) and (4)), and it is important for ES to model infiltration under realistic assumed site conditions in order to achieve this.

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Envirocare of Utah, *Cover Test Cell Data Report Addendum: Justification to Change EZD from 18-inches to 24-inches*, October 5, 2005,

Federal Highway Administration, *Long-Term Pavement Performance Computed Parameter: Frost Penetration*, Publication FHWA-HRT-08-057, November 2008.

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Rogers, Vern C., "*DU PA – ET Cover GoldSim Files*," email to H. Gabert, Utah Division of Radiation Control and W.C. Thurber, S. Cohen & Associates, May 2, 2014.

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INTERROGATORY CR R313-25-26(2–3)-156/3: SEPARATION OF WASTES IN FEDERAL CELL

PRELIMINARY FINDING:

Refer to R313-25-26(2–3): *(2) During the land disposal facility site construction and operation, the licensee shall maintain an environmental monitoring program. Measurements and observations shall be made and recorded to provide data to evaluate the potential health and environmental impacts during both the construction and the operation of the facility and to enable the evaluation of long-term effects and need for mitigative measures. The monitoring system shall be capable of providing early warning of releases of waste from the disposal site before they leave the site boundary.*

(3) After the disposal site is closed, the licensee responsible for post-operational surveillance of the disposal site shall maintain a monitoring system based on the operating history and the closure and stabilization of the disposal site. The monitoring system shall be capable of providing early warning of releases of waste from the disposal site before they leave the site boundary.

INTERROGATORY STATEMENT:

Since the Federal Cell will have no isolation barrier or groundwater monitoring system, explain how the DU waste and 11e.(2) waste will be isolated from each other and how groundwater passing beneath the DU will be monitored before site closure and for 100 years after site closure so as to meet Utah rules and protect the public from undue radiation exposure during the time before DOE takes stewardship of the Federal Cell.

BASIS FOR INTERROGATORY:

Page ES-1 of the Executive Summary of the 2013 Compliance Report, Revision 1, states the following:

> *Once approved, it is Energy*Solutions’ *intention to begin disposal of significant quantities of depleted uranium in a Federal Cell using the currently-approved Class A West Embankment cover design. The Federal Cell was initially submitted*

> *for DRC approval as the "Class A South" cell, with a revised application and completeness review response package dated June 9, 2009. Energy*Solutions*' records show that DRC indicated interrogatories on this design were under preparation but not received at the time the application was withdrawn on May 2, 2011.*

In addition, Section 1, page 1-1, of the 2013 Compliance Report, Revision 1, states the following:

> *As is illustrated in Figure 1-1, Energy*Solutions *has evaluated a new Federal Cell, using the Division-approved and licensed Class A West Embankment cover design, as the ultimate destination for the large volumes of depleted uranium. The Federal Cell was initially submitted for DRC approval as the "Class A South" cell, with a revised application and completeness review response package dated June 9, 2009. Energy*Solutions*' records show that DRC indicated interrogatories on this design were under preparation but not received at the time the application was withdrawn on May 2, 2011. Reviewers should note that the former Class A South cell included an isolation barrier between Class A and 11e.(2) wastes as well as a proposed system for monitoring groundwater beneath this barrier; in order to differentiate the source of any potential groundwater contamination as being from Class A or 11e.(2) wastes. Depending on the terms of DOE agreement to take stewardship of a Federal Cell, these features may not be required.*

Section 2.2, page 2-6, of the 2013 Compliance Report, Revision 1, states the following:

> *Note that the former Class A South design included an isolation barrier and groundwater monitoring system beneath this barrier, intended to provide separation between Class A LLRW and 11e.(2) waste materials. This separation was considered necessary due to the differing long term stewardship regimes applicable to each waste type (Class A waste staying with the state of Utah and 11e.(2) going to the Department of Energy). It is anticipated that these distinctions will not be required for a Federal Cell, and accordingly the isolation barrier and groundwater monitoring system will not be necessary.*

The basis for stating that waste separation is not needed within the Federal Cell requires additional justification, since DOE ownership of the disposed DU may not occur for some period of time after waste disposal has been completed.

ES RESPONSE:

In its response, ES stated that: "*The Federal Cell will be entirely within DOE stewardship and there will be no requirement to segregate Class A LLRW from 11e.(2) wastes; therefore, the additional requirements will not apply.*"

REBUTTAL:

The ES response is satisfactory assuming that the appropriate written agreements as to long-term stewardship are obtained from DOE on a timely basis.

V1.2 CRITIQUE (ROUND 3):

ES has not provided documentation of the necessary agreement between it and DOE. Although it is not expected that it would have any effect on the Clive DU PA, the agreement between ES and DOE must be received by DEQ before any authorization to dispose of DU could be granted.

REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

INTERROGATORY CR R313-25-8(5)(A)-157/2: INCLUSION OF DU AND OTHER WASTES IN PA

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Provide documentation that the PA includes the total quantities of DU and other wastes.

BASIS FOR INTERROGATORY:

Section 1, page 1-1, of the 2013 Compliance Report, Revision 1, states that "*Under this License authorization, approximately 18,400 Ci of depleted uranium were safely disposed in the* [sic] *at Clive between 1990 and 2010.*" This is equivalent to about 46,000 MTU assuming that the specific activity of depleted uranium is 4.02E+02 pCi/mg (Battelle 2011).

UAC R313-25-8(5)(a) requires a PA that does the following:

> …*demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the* ***total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of*** *and the quantities of concentrated depleted uranium the facility now proposes to dispose.* [emphasis added]

Therefore, it follows that Energy*Solutions*' PA must include a demonstration that the performance standards will be met for the total quantities of concentrated DU and other wastes, including wastes already disposed of. However, the PA does not appear to include this demonstration.

ES RESPONSE:

In its response, ES stated that: "*Performance assessment for these nuclides is addressed via the ET cover performance assessment currently undergoing DRC review (Energy*Solutions*, 2013d)* [2013b]*.… As such, the condition of the disposal of other Class A low-level radioactive bulk wastes within the Federal Cell is a modeled condition. Therefore, it is unnecessary to repeat this analysis in this Depleted Uranium Performance Assessment.*"

REBUTTAL:

It is not clear how the ES response satisfies the UAC R313-25-8(5)(a) requirement that the PA include "*total quantities of concentrated depleted uranium and other wastes.*" Among other open questions is how the source term for total quantities of DU and other wastes will be developed. ES should coordinate resolution of this interrogatory with Interrogatory CR R313-25-7(9)-89/2: Contamination Levels in DUF_6. We look forward to reviewing the revised report.

REFERENCES:

Battelle, *Site Profiles for Atomic Weapons Employees that Worked Uranium Metals*. Battelle-TBD-6000, Rev. 1, 2011.

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

INTERROGATORY CR R313-15-1009(2)(B)(I)-158/2: WASTE PACKAGING

PRELIMINARY FINDING:

Refer to R313-15-1009(2)(b)(i): *Waste shall have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.*

INTERROGATORY STATEMENT:

Address in the PA the use of soft-sided containers for the disposal of DU oxides, including how well these containers would survive long-distance transportation to and handling at the Clive low-level waste facility, how full of DU oxides each container would be and how much headspace would remain, the weight of the contents of each container, and the nature of the materials constituting the container.

BASIS FOR INTERROGATORY:

According to B&W Conversion Services (2013), use of newer, soft-sided containers is being considered for shipping and disposal of DU:

> *Babcock & Wilcox Conversion Services, LLC (BWCS), the prime Contractor to the United States Department of Energy (DOE) for the Depleted Uranium Hexafluoride (DUF6) Conversion Plants, is submitting a request for information (RFI) from prospective parties that have the capability to provide a system design for packaging containers of depleted uranium oxide ("oxide") into soft-sided oxide containers to meet facility production requirements.*
>
> *The current process at the BWCS DUF_6 conversion facilities involves filling modified DUF_6 cylinders with oxide after processing the original content. This existing system is proving inadequate for keeping pace with plant production capabilities….*
>
> *STATEMENT OF REQUIREMENTS*
>
> *1. The DUF6 conversion facilities operate 24 hours per day, seven days a week. The Portsmouth DUF6 Conversion Facility currently has a projected life cycle of 18 years, and 25 years at the Paducah DUF6 Conversion Facility.*
>
> *2. Containers and fill/packaging systems must meet the requirements for Department of Transportation (DOT) Industrial Package Type 1 (IP-1) rated soft side packages in accordance with 49CFR 173.410 and 49CFR 173.411.*
>
> *3. The waste product is compacted U3O8 powder with a density of approximately three grams per cubic centimeter (approximately190 pounds per cubic foot). The most common cylinder processed is the 48G, with an internal volume of approximately 140 cubic feet.*

However, the 2013 Compliance Report, Revision 1, does not contain any assessment related to the use of soft-sided oxide containers for DU oxides. It does not describe how well these containers would survive long-distance transportation to and handling at the Clive low-level waste disposal facility. The weight of the contents of each container and the nature of the materials constituting the container are also unknown.

The PA does not indicate whether all DU oxide materials or only a fraction of them will go into the new containers. It is not known how well these newer containers will be packed and how much headspace (on a percentage basis) will be left. The PA should clearly discuss the fraction of headspace in each container and evaluate it with respect to the future stability of the embankment cover.

ES RESPONSE:

In its response, ES stated the following:

> *In fact, similar soft-sided containers to those referenced in the Basis for this interrogatory from the DOE Fernald site have been disposed using CLSM in the 11e.(2) waste portion of the Federal Cell. Therefore, continued disposal of*

> *depleted uranium does not create an unanalyzed condition regarding the type of container or procedures required to safely manage and dispose of them.*

REBUTTAL:

It is our understanding that that ES has experienced some problems in the past with shipments from Terranear (DOE subcontractor) in soft sided packaging. ES should provide a discussion of these problems and indicate the relevance of the Terranear experience to handling of DU_3O_8 in soft-sided packaging.

REFERENCES:

B&W Conversion Services, LLC, *Request for Information on Soft-Sided Containers for Depleted Uranium Oxide*, August 2, 2013. Available at www.bwconversionservices.com/index.php?cID=295

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

INTERROGATORY CR R313-25-8(4)(D)-159/2: EMBANKMENT DAMAGE BY LAKE FORMATION

PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

INTERROGATORY STATEMENT:

Explain how radon releases will be controlled when the embankment is destroyed by wave action and the intruding waters subsequently recede to levels below the current ground surface.

BASIS FOR INTERROGATORY:

Section 1, page 1-3, of the 2013 Compliance Report, Revision 1, identifies one of the policy issues as follows:

> *3. Although the Performance Assessment evaluates disposal both above- and below-grade, depleted uranium will be disposed below grade to enhance assurance of continued isolation under geologic-time events such as the return of a large lake inundating Clive. Figure 1-2 below demonstrates that the entire depleted uranium inventory evaluated can be disposed in such a manner.*

Although we agree that destruction of an above-ground embankment by wave action associated with development of one or more large-scale lakes sometime in the next 2 million years is likely, it is not sufficient for Energy*Solutions* to address this simply by disposing of waste below ground, as shown in Figure 1-2 of the 2013 Compliance Report, Revision 1. Not only must waste remain below ground when lakes develop, but adequate soil barriers to radon emanation above the waste must be available. Otherwise, potential exposure from the waste to humans becomes a problem. Energy*Solutions* should plan for such barriers in the PA or explain why they are not necessary.

ES RESPONSE:

In its response, ES stated that: "*Accumulation rates can be highly variable but are likely to be > 0.1 mm/yr (1 meter per thousand years) during interpluvial conditions. The expected case for these conditions is progressive burial of the waste embankment by aeolian deposition until the return of the first lake.*"

REBUTTAL:

We believe that this assumption regarding aeolian deposition is incorrect, as explained in the comments on the ES response to Interrogatory CR R313-25-8(5)(a)-18/1: Sediment Accumulation. In addition, with regard to the period beyond 10,000 years, see comments on Interrogatory CR R313-25-8(5)(a)-86/2: Consequences of Sedimentation on Disposal Cell.

REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

INTERROGATORY CR R313-25-7(2)-160/2: COMPARISON OF CLASS A WEST AND FEDERAL CELL DESIGNS

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

INTERROGATORY STATEMENT:

Address the significant differences between the Class A West embankment and Federal Cell designs in order to justify why the existing Class A West design would suffice for the Federal Cell.

BASIS FOR INTERROGATORY:

Energy*Solutions* speaks of a new Federal Cell that uses the Division-approved and -licensed Class A West embankment cover design. However, Energy*Solutions* should make it clear that no design has yet been submitted for the Federal Cell, and that, although the proposed Federal Cell may use a design for a cover similar to that which has been approved for the Class A West embankment cell, no design for Federal Cell embankment has yet been submitted nor approved by DRC. The Federal Cell will have a different location, different dimensions, different geometry, different waste, and different waste containers within it as compared to the Class A West embankment cell. Moreover, the performance of the Federal Cell must be demonstrated for 10,000 years.

Section 2.2, page 2-6, of the 2013 Compliance Report, Revision 1, states the following:

> *Analyses in support of the Class A West Embankment cover design are applicable to the Federal Cell on the following bases:*
>
> *1. The Class A West Embankment has a larger surface area and thicker overall waste column than the Federal Cell. This indicates that bounding conditions have been evaluated for infiltration, runoff, and static and seismic stability.*
>
> *2. Waste characteristics and placement procedures will be identical, as captured in the LLRW and 11e.(2) Construction Quality Assurance/Quality Control (CQA/QC) Manual.*
>
> *3. Embankment liner and construction procedures will be identical, as captured in the LLRW and 11e.(2) Construction Quality Assurance/Quality Control (CQA/QC) Manual.*

Section 2.5 of the 2013 Compliance Report, Revision 1, makes a similar argument about the Class A West analysis being bounding for the Federal Cell. However, Energy*Solutions* has not demonstrated that, regardless of the larger surface area and thicker overall waste column of the Class A West cell compared to the Federal Cell, and other similar characteristics, the design would not need to take into account the following facts:

- The geometry, slopes, and boundary shapes and sizes would differ between the two different cells.
- The distance to a monitoring well from the central portion of the cell would differ between the two cells.
- The current PA proposes that the DU waste disposal cell be conjoined with the 11e.(2) cell, with no isolation barrier between them.
- DU waste components in the Federal Cell would ingrow, thereby becoming more hazardous instead of less hazardous with time, contrary to what would be the case for the bulk of waste in the Class A West cell.
- Over a sufficiently long time, Ra-226, which would be present at relatively high concentrations in the Federal Cell, would increase in activity until it exceeds Class C limits, unlike the bulk of the waste disposed of in the Class A West cell.
- Some of the containers from the Paducah and Portsmouth GDPs that would be disposed of in the Federal Cell would contain heels having relatively high concentrations of highly mobile Tc-99, unlike the bulk of the waste disposed of in the Class A West cell.

- The heels in these cylinders would also contain transuranics, unlike the bulk of the waste deposited in the Class A West cell.
- The Federal Cell must meet design requirements for a minimum of 10,000 years.

Moreover, the Construction Quality Assurance/Quality Control Manual would need to reflect any and all changes in design that could in any way affect the transport of radionuclides vertically, horizontally, or both. Energy*Solutions* should make these revisions or justify why they are not required.

ES RESPONSE:

In its response, ES stated that: "*The depleted uranium Performance Assessment is being revised to reflect the construction of an evapotranspirative cover over the proposed Federal Cell. As such, this Interrogatory is no longer applicable.*"

REBUTTAL:

It is our understanding that an ET cover is now being considered for the Class A West cell as well as for the Federal Cell. Comparisons of the structural design and expected performance of the two cells are needed. The following issues still need to be addressed in the PA:

- The geometry, slopes, and boundary shapes and sizes would differ between the two different cells.
- The distance to a monitoring well from the central portion of the cell would differ between the two cells.
- The current PA proposes that the DU waste disposal cell be conjoined with the 11e.(2) cell, with no isolation barrier between them, whereas the Class A West cell would not be conjoined with an 11e.(2) cell.
- DU waste components in the Federal Cell would ingrow, thereby becoming more hazardous instead of less hazardous with time, contrary to what would be the case for most of the waste in the Class A West cell.
- Over a sufficiently long time, Ra-226, which would be present at relatively high concentrations in the Federal Cell, would increase in activity until it exceeds Class C limits, unlike the bulk of the waste disposed of in the Class A West cell.
- Some of the containers from the Paducah and Portsmouth GDPs that would be disposed of in the Federal Cell would contain heels having relatively high concentrations of highly mobile Tc-99, unlike the bulk of the waste disposed of in the Class A West cell.
- The heels in these cylinders would also contain transuranics, unlike the bulk of the waste deposited in the Class A West cell.
- The Federal Cell design must meet performance standards for a minimum of 10,000 years.

As previously discussed, any proposed Federal Cell that contains DU waste must have an approved design such that its cover system is fully integrated with, or completely isolated from, the existing 11e.(2) cover system, as required by applicable federal and state laws, regulations, and rules. Pertinent DOE and NRC guidance should be followed as well. A more complete description of structural design and performance of the proposed Federal Cell, one that incorporates and accounts for all of the factors mentioned above, is requested.

REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

INTERROGATORY CR R313-25-7(2–3)-161/3: INCONSISTENT INFORMATION ON WASTE EMPLACEMENT

PRELIMINARY FINDING:

Refer to R313-25-7(2–3): *(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

(3) Descriptions of the principal design criteria and their relationship to the performance objectives.

INTERROGATORY STATEMENT:

Resolve the conflicting statements about available thickness in the embankment for waste emplacement and emplacement depths. Explain and justify the plans given in the text of the PA given the information in Figure 1.2 and revise as necessary.

BASIS FOR INTERROGATORY:

Section 2.5, page 2-12, of the 2013 Compliance Report, Revision 1, claims that, in the 10-meter (completely below grade) model, GDP contaminated waste, SRS waste, and GDP uncontaminated waste may all be contained within a zone that is 11.58 feet thick, at depths between 33.07 and 44.65 feet below the base of the top slope engineered cover, which presumably would all be below grade. However, Figure 1.2 of the 2013 Compliance Report, Revision 1, shows the embankment extending only 10.0 to 10.5 feet below grade, with 3 feet of that being clay liner or liner protective cover, leaving only 7.0 to 7.5 feet for below-grade disposal of DU waste. This limitation appears to conflict with the description in Section 2.5, which as noted assumes that DU waste is disposed of in a zone 11.58 feet thick. This is 4.08 to 4.58 feet greater than the space that appears to be available, based on Figure 1.2.

Section 2.5 allocates a layer with a thickness of only 1.65 feet (= 34.72–33.07 feet) for contaminated waste from the GDPs. However, most DU waste that would be transported to Clive would be in 12-foot-long, 4-foot-diameter sturdy steel cylinders, which would not fit in the 1.65-foot-thick layer. The PA should explain how the waste would be emplaced in the allocated layer (e.g., would it be removed from the cylinders, and then what would be done with the cylinders).

Similarly, Section 2.5 allocates a layer with a thickness of only 1.66 feet (= 36.38–34.72 feet) for SRS waste. However, this waste is contained in 55-gallon drums that have diameters of approximately 2 feet. Such drums, if intact and uncrushed, would not fit in the 1.66-foot-thick layer. The PA should explain how the SRS waste would be emplaced in the allocated layer (e.g., would it be removed from the drums, and then what would be done with the drums).

ES RESPONSE:

In its response, ES committed to sequester only the volume of DU that can be disposed of below grade in the Federal Cell.

REBUTTAL:

We look forward to confirming the disposition plan by reviewing the revised Figure 1.2 and note that, regardless of the depth of disposal, the revised report should not contain discrepancies, including but not limited to inconsistencies regarding available below-grade DU disposal volume and DU container dimensions. ES should include in its response information on the number of containers (cylinders and drums) of DU waste that can be placed in the designed disposal space, including the volume of backfill materials and any protective earthen blanket layers required. ES should also indicate how this number of DU containers and waste volume compares with the total DOE inventory needing disposal.

V1.2 CRITIQUE (ROUND 3):

The revised Embankment Modeling report (Appendix 3 to FRV1.2) indicates that the original grade level is 4272 ft amsl and the bottom of the waste is an average of 4264.17 ft amsl. This leaves 8 feet for waste burial if the DU waste is to be at or below grade level. The revised PA does not include any of the requested information noted in the Rebuttal. We also note that Figure 9 in the revised Embankment Modeling report does not reflect the current plan to bury all of the DU waste below grade.

REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model*, NAC-0019_R1, June 5, 2014. (Appendix 3 to FRV1.2)

INTERROGATORY CR R313-25-22-162/2: DISPOSAL CELL STABILITY

PRELIMINARY FINDING:

Refer to R313-25-22: *The disposal facility shall be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate, to the extent practicable, the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.*

INTERROGATORY STATEMENT:

Address factors affecting stability, including wave-cutting erosion, gully erosion, catastrophic storms, differential settling driven by canister disintegration and cover rock degradation in greater detail to demonstrate long-term disposal system stability.

BASIS FOR INTERROGATORY:

The PA needs to provide a complete analysis of ways in which the embankment can be constructed to minimize or eliminate damage from the following:

1. erosion by wave-cutting of embankment materials by lacustrine waves, including how this will affect exposures and doses prior to complete washing away of the embankment
2. gully erosion on a large scale after long periods of time, including how this would affect mammalian and plant biointrusion into bulk waste, and possibly into DU waste, as well as how it would affects doses to inadvertent intruders
3. destruction of embankments by catastrophic storms such as tornadoes
4. damage via differential settlement of the cover system as a result of collapse of DU canisters as they deteriorate, such as may occur if the canisters are not filled completely
5. cover-system rock degradation

Most of these are also not addressed in previous discussions of stability of the Class A West embankment (AMEC 2011), which is supposed to be an analog for the Federal Cell. Energy*Solutions* should fully address all aspects of embankment stability, including the five items listed above. The discussion below expands on these deficiencies.

<u>Erosion by wave-cutting of embankment materials</u>. As waves from future Lake-Bonneville-type lakes start to cut into the embankment, bulk waste in the embankment will be exposed. The process of wave cutting may take place over decades or hundreds of years. During this time, potential radioactive exposures may be high. After complete inundation by lake water, there may still be high levels of radioactive exposure to people or animals above the site. Unless radon barrier clays are placed where they will not be eroded by wave action, there will be little or no protection against radioactive exposures from disposed of DU and its daughter products, including radium and radon. The dose from the initial wave cutting may be peak at this time, and it needs to be determined in the PA, as UAC R313-25-8(5)(a) mandates simulations out to peak dose.

<u>Gully erosion</u>. Gully erosion is expected on the embankment and may provide inadvertent intruders with exposure to radioactive bulk waste. Previous simulations in the PA have experimented with various degrees of gully erosion, but quantification as a function of time has not been provided. As noted in Section 4.0, pages 4–5, of the Erosion Modeling report, "*The purpose of the initial gully model in the Clive PA model is to determine whether gullies and fans are significant contributors to dose and whether a more sophisticated erosion model is needed*. [To that end,] *a simple screening-type gully model was developed…*." Since gullies can have a significant impact on long-term performance, such as by increasing radon release and increasing infiltration, it appears that a more sophisticated erosion model is needed.

Destruction of embankments by catastrophic storms. Previous versions of the PA have not properly accounted for damage to the embankment by tornados in Utah. However, the Tornado History Project (2014) indicates that Utah has experienced about 100 recorded tornados over the last century. Destruction or damaging of the embankment by tornados or other storms needs to be modeled.

Damage to the cover system from differential settlement. The amount of headspace in cylinders partially filled with deconverted triuranium octaoxide (U_3O_8) is not known, nor is the ability to fill the void space in these cylinders with controlled low-strength material (CLSM). Section 3.4, page 3-14, of the 2013 Compliance Report, Revision 1, states the following:

> *Disposal of containers of depleted uranium in CLSM in the Federal Cell (mirroring the Division-approved Class A West Embankment design) is consistent with the waste disposal methods considered in that licensing action; i.e., a solid waste is disposed in a CLSM matrix that fills voids and prevents subsidence. Therefore, post-closure stability of the embankment is met.*

However, the information provided is not sufficient to address differential settling issues. The PA model specifically needs to account for differential settlement and cover-system damage due to degradation of the cylinders, perhaps over several hundred years, with subsequent collapse.

Cover-system rock degradation. Some of the rocks at Vitro have been noted in field inspections to have undergone moderate to severe degradation over a period of 10 to 20 years (Bishop 2014). The PA needs to account for any rip rap used at the Federal Cell undergoing similar degradation over similar and extended periods of time.

In order for the disposal facility to be designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate, to the extent practicable, the need for ongoing active maintenance of the disposal site following closure, the PA needs to consider each of the above factors.

ES RESPONSE:

In its response, ES addressed questions related to the effects of wave-cutting action, gully erosion, catastrophic storms, and differential settlement.

REBUTTAL:

We look forward to judging the adequacy of parts of the response once we have the results of the SIBERIA modeling.

REFERENCES:

AMEC Earth & Environmental, Inc., *Geotechnical Update Report, Energy Solutions Clive Facility, Class A West Embankment Study, Clive, Tooele County, Utah*, AMEC Job No. 10-817-05290, February 15, 2011.

Bishop, Charles, Memorandum to Files: *Energy*Solutions *Petrographic Studies of Rock Fragments*, Utah Division of Radiation Control, January 29, 2014.

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

Neptune and Company, Inc., *Erosion Modeling for the Clive PA,* June 1, 2011. (Appendix 10 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

TornadoHistoryProject.com, Tornadoes in Utah, *accessed January 3, 2014. (www.tornadohistoryproject.com/tornado/Utah/table; data within this database has been pulled from the Storm Prediction Center's (SPC) historical tornado data file at www.spc.noaa.gov/wcm/#data)*

INTERROGATORY CR R313-25-8(5)(A)-163/3: GROUNDWATER COMPLIANCE FOR 10,000 YEARS

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Include results describing groundwater concentrations for a minimum of 10,000 years and indicate whether a dose standard of 4 mrem/yr TEDE is met for the compliance period.

BASIS FOR INTERROGATORY:

FRV1 Section 1.3, page 16, states that "*Part 1.D.1 of the Permit specifies that the performance standard for radionuclides is 500 years.*" However, Part 1.D.1 of the permit actually states, "*However, under no circumstances shall the facility cause ground water at the compliance monitoring wells (Part I.F.I) to exceed the ground water protection levels in Part I.C for the following minimum periods of time.*" After this statement, the table gives 500 years for mobile and non-mobile radionuclides. Thus, the 500-year time frame is a minimum, not a maximum, time period. The time frame can be longer, based on an assessment of need by the DRC Director.

Furthermore, based on UAC R313-25-8(5)(a), a compliance period of 500 years would only apply to facilities that have not proposed to dispose of significant quantities of concentrated DU. For those facilities in Utah that have proposed to dispose of significant quantities of concentrated DU, UAC R313-25-8(5)(a) gives 10,000 years as the minimum period of compliance during which performance standards must be met for DU and other wastes. The groundwater performance standard of 4 mrem/yr must be met throughout the compliance period of 10,000 years or more. Thus, the PA should include results that model groundwater concentrations over a period of at least 10,000 years.

ES RESPONSE:

In its response, ES referred the reader to its response to Interrogatory CR R313-25-7(2)-91/1: Design Criteria for Infiltration, which states in part the following:

> *Groundwater at the Clive site is not a potential dose pathway. As demonstrated in Table 3-2 of the 2013 Compliance Report, untreated consumption would lead to death for 100 percent of the receptors within a matter of days. Revised calculations in response to interrogatory 181 do not change this basic conclusion. It is not reasonable to assume that groundwater in the shallow unconfined aquifer would be treated for TDS then consumed. While technically possible, the shallow unconfined aquifer is of low yield; better groundwater production and quality is available at other locations in the west desert.*

REBUTTAL:

As discussed elsewhere **(**see, for example, Interrogatory CR R313-25-8(4)(a)-96/2: Current and Future Potability of Water, and Interrogatory CR R313-25-8(4)(a)-97/2: Need for Potable and/or Industrial Water), SC&A believes that additional information must be provided to demonstrate the groundwater at Clive is not a potential dose pathway. Under Interrogatory CR R313-25-8(4)(a)-96/2, SC&A indicates that ES needs to examine the possibility of that the lower confined aquifer at Clive could become contaminated and thus become a source of exposure. If the water from this aquifer were used for domestic uses but did not meet the test of a public water system**,** regulation would be left to Tooele County. It is our understanding that the County does not require testing for uranium or other radioactive contaminants.

V1.2 CRITIQUE (ROUND 3):

Groundwater from deeper portions of the confined aquifer, or from other aquifers, has historically been used in the region for drinking and other human uses, such as washing and showering, following treatment. Therefore, the PA needs to consider a groundwater dose pathway.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

State of Utah, Division of Water Quality, Utah Water Quality Board, Ground Water Quality Discharge Permit No. UGW450005, issued to Energy*Solutions*, LLC, 2013. Available from www.radiationcontrol.utah.gov/EnSolutions/docs/2013/10Oct/SignedfinalPermit.pdf.

INTERROGATORY CR R313-15-1009-164/1: INCORRECT RULE CITATION

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES made the proposed changes to Section 4.2.2, page 23, and the caption of Figure 5, page 18, of the revised Conceptual Site Model report (Appendix 2 to FRV1.2). Therefore, this interrogatory is closed.

INTERROGATORY CR R313-15-1009(1)(C)(I)-165/1: INCORRECT CITATION OF Ra-226 LIMIT

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised text.

V1.2 CRITIQUE (ROUND 3):

ES made the proposed changes to Section 4.2.2, page 23, and the caption of Figure 5, page 18, of the revised Conceptual Site Model report (Appendix 2 to FRV1.2). Therefore, this interrogatory is closed.

INTERROGATORY CR R313-25-22-166/2: STABILITY OF WASTE

PRELIMINARY FINDING:

Refer to R313-25-22: *The disposal facility shall be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate, to the extent practicable, the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.*

INTERROGATORY STATEMENT:

Analyze stability conditions as compaction of disintegrating drums and cylinders occurs. Consider the presence of any headspace in the waste containers and include a statement that the waste is **not** uncontainerized but rather is emplaced in drums and cylinders.

BASIS FOR INTERROGATORY:

Section 8.3, page 46, of the Conceptual Site Model report states the following:

> *Subsidence is not expected to be an important process at the Clive facility, since the waste is aggressively compacted in order to prevent this occurrence (Energy*Solutions, *2009c).*

However, this subsidence does not include compaction of DU in its drums or canisters, which may behave very differently in the embankment from, for example, bulk waste that may be compacted. Drums or canisters of DU-related low-level waste from SRS or the GDPs, respectively, may have headspace within the associated containers that may not respond to compaction efforts at Clive. This headspace may become important as the containers deteriorate over long periods of time and as the headspace is filled in by overlying waste, resulting in differential subsidence.

Section 9.2, page 51, of the Conceptual Site Model report states that "*The disposed DU waste is assumed to be uncontainerized, since standard operations at the site include significant compaction of disposed waste.*" However, this appears to be an incorrect assumption. Planned disposal practices at the site include disposal of SRS drums and GDP canisters as well as the DU waste that each type of container holds. This discrepancy needs to be resolved in the model and the text. Any headspace in the containers or air gaps under the containers will eventually allow for partial collapse of the waste and cover above it, affecting the physical stability of the design.

ES RESPONSE:

In its response, ES described how similar waste forms have been handled in the past and explained the requirement that waste emplacement will be in accordance with the Construction Quality Assurance/Quality Control procedures.

REBUTTAL:

ES should indicate what revisions to the quality assurance/quality control procedures will be needed to handle the DU oxide shipments in canisters from the GDPs or explain how canisters are covered under current quality assurance/quality control procedures. Examples of some of the topics that need to be addressed include, but are not limited to, the following:

- Details on how headspace will be eliminated from the DUF_6 containers after arrival at Clive, including methods and equipment necessary for detecting headspace, access of the container to insert CLSM fill material, and re-sealing or closure of the DUF_6 container
- Discussion of potential interactions between CLSM material and DU waste materials, including any possible effects on the ability of the CLSM material to harden sufficiently to sustain needed stresses without deformation of the cover system
- DUF_6 container spacing and geometry on a waste lift and details about any co-location of DUF_6 cylinders with DU waste drums
- Placement of fill material between individual containers on a waste lift.

REFERENCES:

Energy*Solutions*, *LLRW and 11e.(2) Construction Quality Assurance/Quality Control Manual*, *rev 24e*, Salt Lake City, Utah, September 16, 2009.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-15-1009(2)(A)(VII)-167/1: PYROPHORICITY OF DUO_2

Round 1 Interrogatory Response is generally satisfactory, but a license condition may be needed to set an upper limit on particle sizes and quantities of DUO_2 in any given container. Such conditions will be coordinated with the resolution of Interrogatories CR R313-15-1009(2)(b)(i)-

158/2: Waste Packaging, CR R313-25-22-162/2: Disposal Cell Stability, and CR R313-25-22-166/2: Stability of Waste.

INTERROGATORY CR R313-25-7(2)-168/1: RIP RAP SIZING

ES notes that this interrogatory is no longer relevant since the Federal Cell will use an ET cover and rip rap is not used in the ET cover. However, ES should describe any use of rip rap on the lower parts of side slopes and on adjacent ditches and discuss the issues associated with this interrogatory that are pertinent to this use.

INTERROGATORY CR R313-25-7(9)-169/3: CLARIFICATION OF STATISTICAL TREATMENT OF CHEMICAL AND ISOTOPIC ASSAYS

Round 1 Interrogatory Response is satisfactory. We look forward to reviewing the revised report.

V1.2 CRITIQUE (ROUND 3):

1. In its response, ES indicated that the data used came from a Waste Profile Record file that is labeled Waste Profile Record SRS DU 9021-33_r0.pdf, as referenced in the Waste Inventory report. It is an EnergySolutions radioactive waste profile record that is signed by a DOE representative (Glenn Siry). The DOE signature is dated November, 2009. It is clear in this Waste Profile Record that the original 33 samples were used to characterize most radionuclides, and that the same (six) samples were used for the atom% data. However, it is not clear why Sample #8 is missing from the atom% table (listed as Attachment 2 in the Waste Profile Record), or why there are duplicate results presented for each of the six samples that are included.

   This explanation was added as a footnote to Table 4, page 9, of the Waste Inventory report (Appendix 4 to FRV1.2).

2. In its response, ES stated that the U-233 atomic% values were treated as non-detects. Since they were reported as 0.000000at%, an assumption was made that the actual value is less than 0.0000005at%. Further explanation is being added to the report.

   However, no further explanation was added to Section 3.2.2, pages 14–15, of the Waste Inventory report.

3. In its response, ES stated that the requested documents will be included with the next submittal.

   However, these documents still do not appear to be available on the DRC website for the DU PA.

4. In its response, ES stated that the references will be included with the next submittal.

   However, no changes appear to have been made in response to this comment. Since the SRS-2002 dataset is Beals et al. (2002), it is not clear which citations, if any, refer to SRS 2002, *SRS Interoffice Memorandum 071802 Sampling Plan for DU*, dated July 18, 2002, included on the reference list.

5. In its response, ES stated that the appropriate reference is:

Fussell, G.M, and D. L. McWhorter, 2002. Project Plan for the Disposition of the SRS Depleted, Natural, and Low-Enriched Uranium Materials. *WSRCRP-2002-00459, Washington Savannah River Site, November 21, 2002.*

This citation was added to Section 2.2, page 5, of the Waste Inventory report.

6. In its response, ES stated that clarification is being included in the report, and the units are pCi/G of DU waste.

   In the captions for Tables 2 (page 2), 5 (page 11), 6 (page 11), and 9 (page 18), “pCi/g” was changed to “pCi/g of DU waste.” Footnote 1 stating that “Concentration units for the data are expressed in terms of activity per gram of DU waste” was added to Table 4 on page 9. However, no such changes were made to the tables in the appendix to the Waste Inventory report.

INTERROGATORY CR R313-25-7-170/2: DU WASTE FORM RELEASE MECHANISMS AND RATES

PRELIMINARY FINDING:

Refer to R313-25-7: *The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:*

(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.

(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.

Refer also to R313-25-23: *(1) The primary emphasis in disposal site suitability is given to isolation of wastes and to disposal site features that ensure that the long-term performance objectives are met.*

(2) The disposal site shall be capable of being characterized, modeled, analyzed and monitored.

INTERROGATORY STATEMENT:

Provide a detailed description of the conceptual mechanisms, equations, and assumptions used in the model to determine the rate of release of contaminants from the DU waste material (solid phase) to infiltrating waters (liquid phase).

BASIS FOR INTERROGATORY:

DRC review of both the Embankment Modeling report and the Unsaturated Zone Modeling report shows that Energy*Solutions* did not describe how a contaminant release rate or leach rate for embankment contaminants was determined for the model. Consequently, it is unknown what conceptual mechanisms, equations, bounding conditions, and assumptions were used to estimate the rate of contaminant release from the solid matrix of the DU waste form to infiltrating waters. Without this information, DRC is unable to confirm the fraction of the total contaminant source term (or inventory) that will remain in the embankment in solid form for any given year of the model, nor the fraction (and rates) that will exit the disposal cell via leachates. Likewise, the current report does not allow DRC to confirm the model-predicted time intervals when a given nuclide, as a solute, may reach a point of compliance, nor when said nuclide may exceed its respective state GWPL in the future (i.e., in deep time).

Energy*Solutions* should modify the report to fully describe whether the nuclide-specific DU contaminant release rates were fixed and unchanging in the GoldSim model, or whether they were allowed to vary under Monte Carlo analysis. If they were allowed to vary, Energy*Solutions* should provide the descriptive statistics the model used to generate the waste form values used in its calculations, including, but not limited to, mean rate and standard deviation, total release rate variance, and type of statistical distribution used (normal or log normal).

Energy*Solutions* should also explain and justify why the conceptual mechanisms, equations, bounding conditions, and assumptions used to arrive at the model's waste release rates (or leach rates) are representative of the physio-chemical environment that will exist in the embankment waste after disposal. As an alternative, Energy*Solutions* may use conservatively high release rates.

If a contaminant solubility approach was used to determine release rates, Energy*Solutions* should explain how element speciation was accounted for in determining an appropriate release rate. For example, two statements in FRV1 require clarification. The FRV1 Executive Summary, page 5, explains how the SRS DU, as UO_3, will be "*washed out of the embankment in roughly 50,000* [years]." FRV1 Section 4.1.2.13, page 41, states that "*The deep-time model assumes that the form of DU available for deep-time transport is* U_3O_8*, which is far less soluble than* UO_3." After Energy*Solutions* discloses how the contaminant release rates were simulated in the PA model, it should explain and justify why the deep time simulations would rely only on the less soluble U_3O_8 species. Alternatively, it should explain how the PA model already accounted for these solubility differences, in an adequate or conservative manner; or modify the PA model accordingly.

ES RESPONSE:

In its response, ES stated that clarification can be added to FRV1 on the release of waste from the waste cell and to the Deep Time Assessment report (Appendix 13 to FRV1) to address how and why the soluble uranium (UO_3) leaves the system within 50,000 years.

ES also stated that: "*Thermodynamically,* U_3O_8 *is much less soluble (and more stable) than* UO_3*. Over time, it is apparent that* U_3O_8 *is immobile, whereas the* UO_3 *would be more mobile and thus more likely to leave the system.*"

REBUTTAL:

However, UO_3 is a mineral and will not be "*mobile*," although the ions dissolving from UO_3 may be mobile. The major distinction between U_3O_8 and UO_3 is the uranium oxidation state. U_3O_8 is less soluble because the U(IV) present in the mineral is less soluble. Therefore, the discussion of the potential release rates and the likely solid phases present in the facility need to be tied to the redox conditions of the site. In addition, the clarifications noted in the ES response regarding release of waste should be added to the PA documentation. We look forward to reviewing the revised report.

REFERENCES:

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model,* May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0,* June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA,* May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

INTERROGATORY CR R313-25-7-171/2: ADEQUACY OF DU CELL BUFFER ZONE

PRELIMINARY FINDING:

Refer to R313-25-7: *The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25: …*

(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures. …

(12) A description of the environmental monitoring program to provide data and to evaluate potential health and environmental impacts and the plan for taking corrective measures if migration is indicated.

INTERROGATORY STATEMENT:

Describe the location, dimensions, and attributes of the buffer zone at the proposed DU disposal cell, and explain and justify how it will be adequate for environmental monitoring and future mitigative actions, if needed.

BASIS FOR INTERROGATORY:

After Energy*Solutions* determines the specific engineering design for the DU disposal cell and submits engineering plans and specifications, it must provide a description and analysis of the buffer zone surrounding the cell. This analysis and justification will assist the DRC Director in determining that the proposed buffer zone location, dimensions, and attributes are adequate to allow representative environmental monitoring to be performed and future corrective action or mitigation to be taken, if needed. Some of the issues that need to be included in this analysis, but not all, are described in the DRC letter and completeness review (Morton 2008).

ES RESPONSE:

In its response, ES stated that the Federal Cell buffer zone is described in Section 1.2.2.2 of the License Amendment Request for the Class A West Cell (Energy*Solutions* 2012). It considers approval of the License Amendment Request on November 26, 2012, to also constitute approval of the Federal Cell buffer zone, which was described therein. Since all of the Federal Cell is presumed to fall under the ownership of DOE for long-term stewardship, the additional requirements in Morton 2008 do not apply to the consolidated Class A South and 11e.(2) units comprising the Federal Cell.

REBUTTAL:

The ES position is contingent upon DOE accepting stewardship of the combined cell and DEQ receipt of a written/executed agreement between ES and DOE. On page 1-3 of the Compliance Report, Revision 1, ES indicated that this policy issue must be resolved before disposing of concentrated DU in the Federal Cell. We note that ES did not include a reference for the approval of the License Amendment Request on November 26, 2012. This should be provided to ensure completeness of the review record.

REFERENCES:

Energy*Solutions*, *Radioactive Material License #UT 2300249 and Ground Water Quality Discharge Permit No. UGW450005. Amendment and Modification Request – Class A West Embankment: Response to Remaining Round 3 Interrogatory*, February 23, 2012.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Morton, L.B., Utah Division of Radiation Control, letter to Tye Rogers, *January 4, 2008 Request to Convert 11 e.(2) Disposal Cell to Class A South Cell for Low-Level Radioactive Waste (LLRW) Disposal: Completeness Review*, November 26, 2008; includes *Completeness Review; Energy*Solutions, *LLC 'Amendment Request; Class A South/11e.(2) Embankment' dated January 4, 2008*, November 25, 2008.

INTERROGATORY CR R313-25-20-172/3: INADVERTENT INTRUDER PROTECTION

PRELIMINARY FINDING:

Refer to R313-25-20: *Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed.*

INTERROGATORY STATEMENT:

Provide a comprehensive analysis of possible inadvertent human intrusion scenarios.

BASIS FOR INTERROGATORY:

At a minimum, the following inadvertent intruder scenarios should be considered:

1. Sand, gravel, clay mining near Section 32. Tooele County has already zoned both the sections to the north (Section 29) and to the south (Section 5) of the Clive site for sand and gravel operations. Energy*Solutions* needs to explain whether or not leaving these excavations could undermine a disposal embankment or lead to long-term erosion on the adjoining sections.
2. Failure to demolish and reclaim existing Energy*Solutions* buildings in Section 29 (currently not accounted for in the Energy*Solutions* low-level radioactive waste or 11e.(2) sureties). These structures could attract people in the future to occupy this adjoining land and encourage human activities of many kinds on the margin of the buffer zone, thus increasing the chance of intrusion into buffer zone or embankment at a later date.

ES RESPONSE:

In its response, ES stated that any erosion of nearby sand and gravel borrow pits is not an inadvertent intruder scenario. However, as discussed with regard to Interrogatory CR R313-25-8(4)(b)-07/1, erosion impacts are being addressed.

REBUTTAL:

ES did not address one of the concerns stated in the interrogatory, namely that the failure to demolish and reclaim existing ES buildings in Section 29 (currently not accounted for in the ES LLRW or 11e.(2) sureties) could attract people in the future to occupy this adjoining land. The presence of these buildings could encourage human activities of many kinds on the margin of the buffer zone, thus increasing the chance of intrusion into the buffer zone or embankment at a later date. This concern needs to be addressed.

V1.2 CRITIQUE (ROUND 3):

The DRC staff does not agree that mining of clay, silt, and sand could not be conducted by an inadvertent intruder, with consequent greater exposure to radioactive materials by that inadvertent intruder. Any breach of the cover system would likely result in greater exposures. Drilling of wells and use of groundwater on site, either as part of the mining and soil-treatment process or for drinking during work, could also result in greater exposures. These need to be assessed as part of the inadvertent intruder analysis.

ES also needs to explain why water ponding in open or partially open excavations will not lead to groundwater mounding that will change the course of groundwater flow under the site. This is currently happening on and near the site wherever ponding is occurring.

INTERROGATORY CR R313-25-7(2)-173/2: STABILITY OF EMBANKMENT

PRELIMINARY FINDING:

Refer to UAC R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

INTERROGATORY STATEMENT:

Demonstrate that the loading created by the high-density DU waste form will not result in subsidence in the disposal embankment that will compromise the performance of the cover/radon barrier system.

BASIS FOR INTERROGATORY:

Unlike other disposal embankments at the Clive facility, the DU waste proposed for disposal will have a significantly higher density than typical low-level radioactive waste. The DU PA models U_3O_8 as having the same properties as Unit 3 silty sand, with a particle density of 2.65 g/cc and a bulk density somewhat lower as determined by the porosity (see Table 9 of the Model Parameters report).

However, the particle density of U_3O_8 is 8.3 g/cm^3 (Wikipedia 2014), and the tapped bulk density can be about 4 g/cm^3 (Mosley 1982). The increased loading on the unsaturated zone could result in increased subsidence within the embankment.

ES RESPONSE:

In its response, ES provided a loading calculation in Section 5 of the response document demonstrating that the DU waste form meets existing criteria for waste liner loading. The calculation showed that the surface loading of two horizontally arrayed cylinders of DU oxide was 2,677 psf as compared to a design limit of 3,000 psf.

REBUTTAL:

ES should provide additional information in response to the following comments on this calculation:

- The calculation appears to have included the weight of only one cylindrical shell rather than two. The currently proposed design involves stacking an additional cylindrical shell over each cylindrical shell at the base of the embankment for at least a portion of the embankment.
- The shell weight was assumed to be 2,500 lb, whereas the B&W Conversion Services website (http://www.bwconversionservices.com/our-process/) indicates that some shells weigh 4,500 lb.
- The density of the U_3O_8 is assumed to be 8.3 g/cc. Presumably, this is the particle density. The bulk density, as noted in the ES response to Interrogatory CR R313-25-22-162/1: Disposal Cell Stability, is 2.4 to 2.7 g/cc. Using the value of 2.7 g/cc and assuming that the shell is completely filled with U_3O_8, the mass of the contents would be about 25,000 lb. This mass is similar to the range of DUF_6 masses of 20,000 lb to 28,000 lb, depending on container wall thickness, quoted by B&W Conversion Services (see above link).
- ES engineering drawing 14004-L1 provided in the response to Round 1 Interrogatories, dated March 31, 2014, shows the DU disposal zone to be between 7.0 to 7.8 feet thick. Since UF_6 cylinders have a nominal diameter of 4 feet, it is apparent that ES may place drummed waste immediately above or below a cylinder. If this is the case, the calculations also need to account for this added weight.

In addition, the loading calculation does not include the contribution of materials in the embankment above the DU layers. We look forward to reviewing the revised report.

REFERENCES:

B&W Conversion Services, *The DUF_6 Process*, accessed at http://www.bwconversionservices.com/our-process/ on May 14, 2014.

Energy*Solutions*, *Responses to 28 February 2014 – Round 1 Interrogatories Utah LLRW Disposal license RML UT 2300249 Condition 35 Compliance Report*, March 1, 2014.

Mosley, W.C., *Use of Cation Exchange Resins for Production of U_3O Suitable for the Al-U_3O^8 Powder Metallurgy Process*, Savannah River Laboratory, March 12, 1982. Available at http://sti.srs.gov/fulltext/dpst82388/dpst82388.pdf.

Neptune and Company, Inc., *GoldSim Parameters*, June 1, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Wikipedia, *Triuranium octoxide*, last modified January 14, 2014, accessed at http://en.wikipedia.org/wiki/Triuranium_octoxide.

INTERROGATORY CR R313-25-7(6)-174/1: WASTE EMPLACEMENT IN CLASS A SOUTH DISPOSAL CELL

Round 1 Interrogatory Response is satisfactory.

INTERROGATORY CR R313-25-7(2)-175/1: INFILTRATION RATES FOR THE FEDERAL CELL VERSUS THE CLASS A WEST CELL

ES notes that this interrogatory is no longer relevant since the Federal Cell will use an ET cover. We agree with this position. However, a thorough discussion of the modeling of infiltration rates, with soil hydraulic conductivity values as provided in NUREG/CR-7028 (Benson et al., 2011), is expected in the report on the ET cover system.

INTERROGATORY CR R313-25-8(5)(A)-176/1: REPRESENTATIVE HYDRAULIC CONDUCTIVITY RATES

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Model the migration of DU and other associated wastes, including bulk Class A waste components, assuming corrected hydraulic conductivity values provided in NRC guidance (NUREG/CR-7028).

BASIS FOR INTERROGATORY:

Utah rule UAC R313-25-8(5)(a) expressly requires that "*Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC.*" Therefore, Energy*Solutions* needs to revise its PA as needed to reflect NRC guidance, specifically NUREG/CR-7028.

ES RESPONSE:

In its response, ES indicated that a recent sensitivity analysis indicates that the infiltration results are insensitive to changes in radon barrier integrity.

REBUTTAL:

Claims made regarding PA modeling for the Class A West Cell ET cover design require review and verification by DEQ. Until such time, this interrogatory will remain open. We recognize that this interrogatory spans two topics: (1) alternative assignments of initial cover properties and (2) alternative approaches to degradation models for changes in cover properties over time.

REFERENCES:

Benson, C.H., Albright, W.H., Fratta, D.O., Tinjum, J.M., Kucukkirca, E., Lee, S.H., Scalia, J., Schlicht, P.D., and Wang, X., *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, Volume 1, NUREG/CR-7028, NRC Office of Nuclear Regulatory Research, December 2011.

INTERROGATORY CR R313-25-8(5)(A)-177/2: DOSE FROM PLANT UPTAKE

PRELIMINARY FINDING:

Refer to R313-25-8(5)(a): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Include a quantitative analysis of dose resulting from plant uptake through “other wastes” in addition to DU.

BASIS FOR INTERROGATORY:

Section 3.1.5, page 3-4, of the 2013 Compliance Report, Revision 1, states the following:

> *Exposure by the plant uptake pathway could occur by (1) the production of food crops in contaminated soil at the site, and (2) root intrusion into the waste by native plants that are subsequently consumed by humans or animals. The natural site’s characteristics help prevent exposures via the plant uptake pathway because...there are few deep-rooted native plants in the site vicinity. Even those deep-rooted native plants present in the site vicinity do not have root depths sufficient to penetrate the Division-approved cover systems, overlying wastes, and into the depth at which depleted uranium is modeled for disposal (i.e., greater than 5 meters below the base of the cover).*

However, this statement fails to acknowledge the need for a quantitative analysis of dose resulting from plant uptake through “other wastes” in addition to DU itself for a minimum of 10,000 years, as is required by UAC R313-25-8(5)(a).

In addition, black greasewood can be used as forage by cattle and sheep. According to the U.S. Department of Agriculture (2009), “*Black greasewood is poisonous year round, but plants can be consumed safely in light to very moderate amounts in the spring while the leaves are* *growing, as long as there is a substantial amount of other preferable forage available.*" It is said in that reference that cattle can generally eat up to two or three pounds of the plant per animal at a time and not be poisoned. Sheep can generally eat up to about two pounds per animal at a time. If cattle or sheep were to eat leaves of black greasewood, shadscale saltbush, or four-wing saltbush containing radionuclides from root uptake, then people eating the cattle or sheep could potentially receive doses of radionuclides. The plant pathway needs to receive full consideration within the PA model and text.

ES RESPONSE:

In its response, ES described the relationship between the plant root depths and the wastes. It also indicated that deep-rooted native plants would not have root depths sufficient to penetrate the Division-approved cover systems.

REBUTTAL:

This statement is correct in that the currently approved cover at Clive has a capillary break in it above the radon barrier, which would discourage deep rooting. However, ES has proposed an ET cover for the DU waste. This ET cover has no effective capillary break layer in it. The grain size distribution has not been engineered thus far to provide for one. Therefore, ES needs to address potential doses from plant uptake assuming that the ET cover system is used. Furthermore, ES needs to consider the potential for plant uptake and potential doses beyond 500 years.

REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

U.S. Department of Agriculture (2009) Black Greasewood: *Sarcobatus vermiculatus* (Hook.) Torr., Plant Guide, U.S. Department of Agriculture, Natural Resources Conservation Service, Retrieved December 2012 from http://plants.usda.gov/plantguide/pdf/pg_save4.pdf

INTERROGATORY CR R313-25-8(5)(A)-178/2: SURFACE WATER PATHWAY

PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.

INTERROGATORY STATEMENT:

Analyze potential doses to humans through the surface water exposure pathway.

BASIS FOR INTERROGATORY:

Section 3.1.4, page 3-4, of the 2013 Compliance Report, Revision 1, states the following:

> *Due mainly to the natural site characteristics, there are no radioactive releases expected through the surface water pathway from non-intruder scenarios. The annual precipitation is low and the evaporation is high. No permanent surface water bodies exist in the site vicinity. In addition, the site is far from populated areas. Since they mirror the Division-approved Class A West Embankment, the Federal Cell design features also minimize the potential for releases by the surface water pathway. Federal Cell design includes drainage ditches around the waste disposal areas. After precipitation events, these ditches divert runoff from the closed disposal cell cover to areas away from the disposal cells.*

At the Class A West Embankment, surface drainage systems currently route water from precipitation to ponds after large storm events. The high levels of precipitation in May 2011 (4.28 inches at Clive; see EnergySolutions, 2012) are reported by both ES and DRC personnel to have caused the southeast pond to overflow. Furthermore, the cover system may be compromised due to mammalian burrowing, gully erosion, bank slumping, and other causes, which would potentially allow storm water to mix with waste below the cover system and then overflow or otherwise enter through drainage systems to ponds. EnergySolutions should analyze potential doses to humans due to this exposure pathway.

ES RESPONSE:

In its response, ES described the lack of near-term surface water features and limited potential exposure pathways.

REBUTTAL:

Although limited potential exposure pathways could be the case for the next 500 years, the site has to be modeled at least 10,000 years quantitatively and 1,000,000 years qualitatively. Furthermore, ES needs to address potential surface water pathways associated with the ET cover as opposed to the rip rap.

REFERENCES:

Energy*Solutions*, January 2011 through December 2011 and January 1993 through December 2011 Summary Report of Meteorological Data Collected at Energy*Solutions*' Clive, Utah Facility, Meteorological Solutions, Inc., Project No. 011110111, February 2012.

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

INTERROGATORY CR R313-25-7(2)-179/1: RIP RAP

ES notes that this interrogatory is no longer relevant for the top slope of the Federal Cell since the Federal Cell will largely use an ET cover. However, this interrogatory should be addressed in regard to any rip rap that will be used on portions of the side slope and on ditches.

INTERROGATORY CR UGW450005 PART I.D.1-180/2: COMPLIANCE PERIOD

PRELIMINARY FINDING:

Refer to Ground Water Quality Discharge Permit UGW450005, Part I.D.1: *Best available technology for the facility will incorporate discharge technology based on the use of earthen materials both in the bottom liner and final cover. However, under no circumstances shall the facility cause ground water at the compliance monitoring wells (Part I.F.1) to exceed the ground protection levels in Part I.C for the following minimum periods of time:*[mobile and non-mobile radionuclides – 500 years].

Refer also to UAC R313-25-8(5)(c): *Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*

INTERROGATORY STATEMENT:

Indicate how pertinent performance standards will be met for groundwater for a compliance period of at least 10,000 years, or justify why those standards do not need to be met. Correct the discussion of the type of analysis needed to comply with UAC R313-25-8(5)(a).

BASIS FOR INTERROGATORY:

Section 1.1, page 1-5, of the 2013 Compliance Report, Revision 1, referring to facility-wide Ground Water Quality Discharge Permit UGW450005, states that "*This permit specifies that groundwater quality protection levels for radioactive constituents must be met for no fewer than 500 years following facility closure.*" Although the permit does specify this **minimal** requirement, the criteria for a facility that proposes to dispose of concentrated DU are higher. As stated in UAC R313-25-8(5)(c), these higher criteria are for "*any facility that proposes to land dispose of significant quantities of concentrated depleted uranium*." For such a facility, the rule says that, relative to performance standards for total quantities of concentrated DU and other wastes, a PA must be conducted, and "*the compliance period shall be a minimum of 10,000 years*." Energy*Solutions* needs to indicate how it will ensure that pertinent performance standards will be met for groundwater for a compliance period of at least 10,000 years, or justify why those standards do not need to be met.

In addition, Section 1.5, page 1-20, of the 2013 Compliance Report, Revision 1, states the following:

> *This Report documents the depleted uranium Performance Assessment, conducted in compliance with UAC R313-25-8(5)(a). Analysis includes evaluation of potential groundwater migration of contaminants to a Point of Compliance well for a period of 500 years following embankment closure, projected peak groundwater well concentrations and general public doses for a period up to 10,000 years following Federal Cell closure, doses to hypothetical individuals who have inadvertently intruded into the waste within 10,000 years following Federal Cell closure, and additional simulations out to deep geologic time frames to qualitatively inform the Performance Assessment.*

Contrary to what is implied in the first two sentences, compliance with UAC R313-25-8(5)(a) does not call for an evaluation of potential groundwater migration of contaminants to a Point of Compliance well for a period of 500 years following embankment closure. Instead, UAC R313-25-8(5)(a) simply calls for modeling of compliance with dose limits for all exposure pathways involving environmental media, including groundwater, as well as biota. Energy*Solutions* should revise this statement accordingly.

ES RESPONSE:

In its response, ES simply referred to its response to Interrogatory CR R313-25-7(2)-91/1: Design Criteria for Infiltration.

REBUTTAL:

However, it is still necessary for ES to demonstrate that exposures to groundwater will remain below the R313-25-19 dose limit (4 mrem/yr) during the entire R313-25-8(5)(a) defined compliance period (10,000 years or more). No additional response to this interrogatory is required from ES.

REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

State of Utah, Division of Water Quality, Utah Water Quality Board, Ground Water Quality Discharge Permit No. UGW450005, issued to Energy*Solutions*, LLC, 2013.

INTERROGATORY CR R313-25-19-181/2: GROUNDWATER MORTALITY

PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv*

(0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

INTERROGATORY STATEMENT:

Provide more detailed justification, including more specific references, for the risk factors and the calculated mortalities presented in Table 3-2 of the 2013 Compliance Report, Revision 1.

BASIS FOR INTERROGATORY:

During our review of the 2013 Compliance Report, Revision 1, DRC was unable to verify many of the data presented in Table 3-2. For example, the EPA Integrated Risk Information System (IRIS) (2014) is given as the source for the non-radionuclide drinking water unit risk (DWUR) factors, but when IRIS was checked many of the DWUR factors could not be confirmed, such as those listed below:

- Antimony: "*This substance/agent has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential*."
- Arsenic: IRIS says of this metalloid substance and its compounds, "*Drinking Water Unit Risk — 5E-5 per (ug/L)*."
- Barium: *II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure. Not applicable. The results of the oral carcinogenicity study suggest that barium is not likely to be carcinogenic to humans*.
- Beryllium: No data for oral exposure carcinogenic risk; one study with rats showed no evidence of excess cancer when exposed to 5 ppm beryllium sulfate over a lifetime.
- Cadmium: Under II.B, IRIS says, "*Not available. There are no positive studies of orally ingested cadmium suitable for quantitation*."
- Chromium: Under II.B, IRIS says, "*No data were located in the available literature that suggested that Cr(VI) is carcinogenic by the oral route of exposure*."
- Mercury: Under II.B, IRIS says, "*None*."
- Molybdenum: "*This substance/agent has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential*."
- Selenium: Under II.B, IRIS says "*No data*" for Quantitative Estimate of Carcinogenic Risk from Oral Exposure.
- Silver: Under II.B, IRIS says "*Not available*" for Quantitative Estimate of Carcinogenic Risk from Oral Exposure.
- Zinc: IRIS says "*Not applicable*" for Quantitative Estimate of Carcinogenic Risk from Oral Exposure.

Table 3-2 gives Patterson (2005) as the source for the DWUR factors for TDS and sulfate. However, review of Patterson (2005) did not identify the TDS or sulfate DWUR factors listed in Table 3-2 anywhere in the document, and we question the applicability to humans of risk factors that were developed in a study of steer.

Table 3-2 lists cyanide and TDS, although they are not. While it is conceivable that a listed concentration for cyanide in some instances might be regarded as a surrogate for total or summed concentrations of all dissolved cyanide compounds containing metals, cyanide itself is a non-metallic anion. TDS is a parameter that includes non-metals (e.g., anions) and metalloids as well as metals, so it should not be listed as a metal. Table 3-2 omits thallium, which is a metal and is tested and analyzed for on a regular basis at the Clive facility.

Concentrations for volatiles and semi-volatiles are listed with units of mg/L, which do not appear to be correct. Table 3-2 references Energy*Solutions* (2012c) as the source of the concentrations. However, the units found in this reference differ by three orders of magnitude and are listed as µg/L, not mg/L. Therefore, while Table 3.2 gives numerical values or numbers that match the numerical values listed in Energy*Solutions* (2012c), the units are off by three orders of magnitude. Table 3.2 should list the units for volatiles and semi-volatiles as µg/L, and the PA calculations should be checked to ensure that they are based on these units.

Some of the values assumed for data used in Table 3-2 are not statistically valid, such as those under the heading of the second column, labeled "*Clive's Average Natural Groundwater Concentration*[a]." The note below the table for the superscript "a" states, "*Long-term average concentrations from up-gradient well GW-19A, (Energy*Solutions*, 2012c). Reported concentration for non-naturals is an average of the detection limit.*" Semi-volatile and volatile concentration data for groundwater sampled from upgradient well GW-19A in Table 3-2 are fictitious, and their selection is based on a method that has been shown to be invalid; it is discredited in the literature, as described below. Footnote "a" for these data indicate that the assumed values are equal to "*the average of the detection limit*." Appendix A of Energy*Solutions* (2012c) shows that actually no detections of semi-volatiles (µg/L) were made (29 samples, 29 non-detects), and very few detections of volatiles (µg/L) were made (4% of carbon disulfide, 2% of methylene chloride, and 0% of six other volatiles). However, Table 3-2 lists positive average values for all of the semi-volatiles and volatiles. The use of detection limits, or some fraction of the detection limits, as a substitute for non-detections is not a valid, approved approach. Researchers (Helsel 2005, 2006; Singh et al. 2006) have demonstrated that substitution of the detection limit or half of a detection limit as a value for a non-detect when analyzing statistics for a set of sampled chemical concentration data is a faulty practice; it results in biased mean values. Singh et al. (2006) show that substituting half the detection limit does not work well even when the fraction of non-detects is as low as 10%. Analogous problems would exist when substituting the full detection limit. Therefore, the values assigned to non-detects as found in Energy*Solutions* (2012c) and in the PA are not statistically valid.

In addition, Energy*Solutions* should clarify the meaning of the note in Table 3-2 that the "*Reported concentration for non-naturals is an average of the detection limit*." "*Non-naturals*" appears to be an incorrect choice of term.

Additionally, the Table 3-2 groundwater concentrations were from Energy*Solutions* (2012c). DRC is concerned that the method used to remove “outliers” did not follow EPA recommendations (EPA 2009). Since it directly affects the results in Table 3-2, Energy*Solutions* needs to confirm that EPA (2009) recommendations were correctly followed when the Energy*Solutions* (2012c) groundwater concentrations were developed.

Table 3-2 is titled “*Mortality Rates From The Consumption Of Native Groundwater*” and it lists the Federal Guidance Report 13 mortality risk factor (Eckerman et al. 1999) for the radionuclides given. However, EPA defines the DWUR factors associated with chemicals in the IRIS tables as a cancer morbidity risk and not as a mortality risk. It appears that what is being calculated is a combination of cancer morbidity and mortality risks, which should not be combined.

Finally, to calculate the total probability of cancer, it appears that Energy*Solutions* simply added the individual contaminant’s cancer probabilities. While this approach often produces acceptable results when the probabilities are sufficiently small, it is incorrect to use it for Table 3-2, where the total probability approaches 100%. The correct approach is to first calculate the probability that no cancer would occur using the following formula:

$$Q = \prod_{j=1}^{N} (1 - p_j)$$

Where:
Q = Total probability that no cancer will occur
p_j = Probability of cancer from contaminant j
N = Number of contaminants

In this case, the probability that at least one cancer occurs is simply $(1 - Q)$.

ES RESPONSE:

In its response, ES primarily reiterated the information that was already presented in the Compliance Report, Revision 1, and did not address the interrogatory.

REBUTTAL:

The issue with the untraceability of the data ES used remains, and the response also did not address the use of incorrect statistical analysis performed by ES. Both of these facts severely weaken the arguments presented in the response and limit our ability to agree with ES’ conclusions.

REFERENCES:

Eckerman, K.F., R.W. Leggett, C.B. Nelson, J.S. Pushkin, and A.C.B. Richardson. *Federal Guidance Report No. 13: Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, EPA 402-R-99-001, EPA Office of Radiation and Indoor Air, September 1999.

Energy*Solutions*, *Comprehensive Groundwater Quality Evaluation Report – Waste Disposal Facility, Clive Utah*, Report to the Utah Division of Radiation Control, December 10, 2012.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Helsel, D.R., *Nondetects and data analysis: statistics for censored environmental data*, Wiley-Interscience, Hoboken, NJ, 2005.

Patterson, H.H., P.S. Johnson, W.B. Epperson, and R. Haigh, *Effect of Total Dissolved Solids and Sulfates in Drinking Water for Growing Steers*, Departments of Animal and Range Sciences and Veterinary Science, South Dakota State University, 2005.

Singh, A., R. Maichle, and S.E. Lee, *On the Computation of a 95% Upper Confidence Limit of the Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations*, EPA/600/R-06/022, March 2006.

U.S. Environmental Protection Agency, *Integrated Risk Information System*, Office of Research and Development and National Center for Environmental Assessment, Electronic Database, available online at www.epa.gov/iris/, accessed February 2014.

U.S. Environmental Protection Agency, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance*, EPA 530-R-09-007, Office of Resource Conservation and Recovery, March 2009.

INTERROGATORY CR R313-25-19-182/2: GROUNDWATER EXPOSURE PATHWAYS

PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem)committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable*.

INTERROGATORY STATEMENT:

Expand the discussion in Section 1.3.1, page 1-9, of the 2013 Compliance Report, Revision 1, to include other pathways in addition to ingestion and explain whether or not these additional pathways can significantly contribute to doses.

BASIS FOR INTERROGATORY:

The groundwater radioactive dose standard for compliance within the 10,000-year compliance period is given by UAC R313-25-19. However, contrary to implied claims in Section 1.3.1, page 1-9, of the 2013 Compliance Report, Revision 1, exposure through groundwater is not solely "*based on the associated health effects from ingestion*." Instead, the Utah rule refers to "*concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals*" and states that they "*shall not result in* *an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater.*" Groundwater can contribute to total dose from exposure pathways other than ingestion.

For example, groundwater can contribute to exposure to radiation when groundwater containing radionuclides is used for purposes such as construction or industrial activities. Specific activities that may potentially be associated with exposure via groundwater include dust control, washing, cleaning, thermal cooling, climate control activities, and mixing with clays or other materials. Groundwater may also affect radioactive uptake through plants when plant roots invade the groundwater table or the capillary fringe directly above it. Groundwater that rises over long periods of time to the ground surface as soil moisture may evaporate, leaving behind non-volatile radioactive salts and other compounds. Groundwater can also distribute volatile radioactive compounds such as radon and tritium to indoor air spaces (and thus contribute to exposure via inhalation) through, for example, showering. Personnel at the Clean Harbors Aragonite plant (Edwards 2014) indicated that that company uses groundwater for staff showering. Energy*Solutions* needs to acknowledge the potential for impacted groundwater to lead to potential exposure routes other than direct ingestion.

ES RESPONSE:

In its response, ES referred to its responses to Interrogatory CR R313-25-8(4)(a)-96/1: Current and Future Potability of Water and Interrogatory CR R313-25-7(2)-91/1: Design Criteria for Infiltration.

REBUTTAL:

As discussed elsewhere **(**see, for example, Interrogatory CR R313-25-8(4)(a)-96/2 and Interrogatory CR R313-25-8(4)(a)-97/2: Need for Potable and/or Industrial Water), SC&A believes that additional information must be provided to demonstrate the groundwater at Clive is not a potential dose pathway. Under Interrogatory CR R313-25-8(4)(a)-96/2, SC&A indicates that ES needs to examine the possibility that the lower confined aquifer at Clive could become contaminated and thus become a source of exposure, either to an inadvertent intruder or to a member of the public. If the water from this aquifer were used for domestic uses but did not meet the test of a public water system**,** regulation would be left to Tooele County. It is our understanding that the County does not require testing for uranium or other radioactive contaminants.

REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Edwards, D. 2014. Personal communication with Mr. Lonnie Brown, Clean Harbors Aragonite Plant, (435) 884-8170, January 2014.

INTERROGATORY CR R313-25-19-183/2: MEAT INGESTION

PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem)committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable*.

INTERROGATORY STATEMENT:

Provide justification for the beef and game ingestion parameters (i.e., Gamma distribution means and standard deviations) used in Table 1 of the Dose Assessment report (Appendix 11 to FRV1).

BASIS FOR INTERROGATORY:

A review of the beef and game ingestion DU PA parameters provided in Table 1 of the Dose Assessment report (Appendix 11 to FRV1) revealed that they did not accurately model the cumulative meat ingestion distributions presented in Tables 13-33 (beef) and 13-41 (game) of the EPA Exposure Factors Handbook (EPA 2009).

The information in this interrogatory was transmitted to ES previously, and on May 9, 2014, ES provided updated beef and game ingestion gamma distribution means and standard deviations (Energy*Solutions* 2014), which are to be incorporated into the DU PA model. The information provided on May 9, 2014, by ES satisfactory addresses this interrogatory, and no additional response is required. This interrogatory is included in order to complete the record of DU PA inquiries.

REFERENCES:

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Energy*Solutions*, *More on doses from beef*, email from Sean McCandless to Helge Gabert, Utah Division of Radiation Control, May 9, 2014.

U.S. Environmental Protection Agency, *Exposure Factors Handbook: 2009 Update*, Office of Research and Development, EPA/600/R-09/052A, July 2009.

INTERROGATORY CR R313-25-19-184/2: GOLDSIM SKIPS STABILITY CALCULATIONS

PRELIMINARY FINDING:

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

INTERROGATORY STATEMENT:

Depending on whether GoldSim Player 10.5 SP1 or SP4 is used, the same GoldSim DU PA model file can produce significantly different results. ES needs to determine, demonstrate, and document which GoldSim version produced the “correct” results.

Additionally, steps need to be taken to ensure that only the “right” GoldSim version is used in conjunction with the DU PA model file. For example, if ES demonstrates that SP1 is giving “correct” results, then the DU PA model file should be “crippled” so as not to run under SP4, or anything other than SP1.

BASIS FOR INTERROGATORY:

ES provided the DRC with an updated version of the GoldSim DU PA model file (Energy*Solutions* 2014). While testing this updated version with GoldSim Player, it was noticed that messages were written to the Run Log indicating that GoldSim skipped the solubility calculations in some of the cells because of the high turnover rate in those cells. Checking the GoldSim Containment Transport Module User’s Guide (GoldSim 2013), it was determined that this is a feature of GoldSim to keep the calculation from slowing down:

> ***Warning**: The “turnover rate” for a species in a Cell is defined as the ratio of the discharge rate for the species to the current amount of species in the Cell. The product of the turnover rate and the timestep indicates how many times the Cell is “flushed” within one timestep. If this product is very high, due to roundoff error the species could oscillate between a saturated and unsaturated condition, which can cause the solution to slow down considerably. To prevent this, if the turnover rate multiplied by the timestep exceeds 1000 (implying that in one timestep, the Cell flushes its mass on the order of 1000 times), solubility limits are no longer applied (for all species). The fact that this occurs is written to the Run Log (but it is not treated as a Warning or Error, so that you will not be notified). Note that if the turnover rate varies dramatically, application of solubility limits may be activated and deactivated multiple times during a simulation. However, only the first instance is written to the Run Log.* [GoldSim 2013, page 150]

Additional testing was performed using both Player 10.5 SP1 and SP4. It was found that when Player 10.5 SP4 was used, the “skip solubility calculation” messages were generated, but the older Player 10.5 SP1 was used they were not.

The updated DU PA model was run under both Player 10.5 SP1 and SP4 to compare differences in the results. Of the results from 10 realizations and 131 parameters compared, it was found that two-thirds of the results matched exactly, while one-third differed. In some cases, the differences were significant. For example, the thorium and uranium groundwater concentrations differed by up to a factor of 3,000. The Peak Mean Uranium Hazard also showed significant differences. The SP4 results are consistently higher than the SP1 results, which could be the result of skipping the solubility calculation, especially for uranium.

The information in this interrogatory has been transmitted to ES previously (DRC 2014). This interrogatory is a duplicate of what was previously transmitted to ES; it is included here in order to complete the record of DU PA inquiries.

REFERENCES:

Energy*Solutions*, *DU PA - ET Cover GoldSim Files*, email from Vern C. Rogers to Helge Gabert Utah Division of Radiation Control, May 2, 2014.

GoldSim Technology Group, *GoldSim Containment Transport Module User's Guide*, Version 6.3, July 2013.

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Utah Division of Radiation Control, *Solubility Calcs*, email from Helge Gabert to Sean McCandless, Energy*Solutions*, May 6, 2014.

INTERROGATORY CR R313-25-7(10)-185/3: ADD APPENDIX 18 TO LIST OF APPENDICES

PRELIMINARY FINDING:

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

INTERROGATORY STATEMENT:

Update the List of Appendices on page 91 of FRV1.2 to include the Radon Diffusion Modeling report (Appendix 18 to FRV1.2).

BASIS FOR INTERROGATORY:

ES has added a new Radon Diffusion Modeling report (Appendix 18 to FRV1.2), but it was not included in the List of Appendices on page 91 of FRV1.2.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2*, NAC-0024_R1, June 5, 2014.

Neptune and Company, Inc., *Radon Diffusion Modeling for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0033_R0, May 31, 2014. (Appendix 18 to FRV1.2)

INTERROGATORY CR R313-25-7(10)-186/3: SENSITIVITY ANALYSIS APPENDIX MIS-REFERENCED

PRELIMINARY FINDING:

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

INTERROGATORY STATEMENT:

Change references to the Sensitivity Analysis report from Appendix 19 to Appendices 15(I) and (II).

BASIS FOR INTERROGATORY:

FRV1.2 lists the Sensitivity Analysis report as Appendix 19 in the abstract (page ii) and in Section 6.1.2, page 63. However, in FRV1.2, the sensitivity analysis is contained within Appendices 15(I) and 15(II).

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2*, NAC-0024_R1, June 5, 2014.

Neptune and Company, Inc., *Machine Learning for Sensitivity Analysis of Probabilistic Environmental Models*, NAC-0029_R1, June 5, 2014. (Appendix 15(I) to FRV1.2)

Neptune and Company, Inc., *Sensitivity Analysis Results for the Clive DU PA, Clive DU PA Model v1.2*, NAC-0030_R0, June 5, 2014. (Appendix 15(II) to FRV1.2)

INTERROGATORY CR R313-25-19-187/3: INDUSTRIAL WORKER EXPOSURES

PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

INTERROGATORY STATEMENT:

Include in FRV1.2 a scenario description for the exposure of an industrial worker, as well as the calculated doses.

BASIS FOR INTERROGATORY:

Section 2.6.3, page 2-14, of the 2013 Compliance Report, Revision 1 (Energy*Solutions* 2013), identified an industrial worker as a "*credible exposure scenario*." Consistent with the scenario described in that report, the industrial worker would be exposed to contamination via the same pathways outlined for the rancher but with longer exposure times.

REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

INTERROGATORY CR R313-25-7(2)-188/3: MODELING GULLIES WITH SIBERIA

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

INTERROGATORY STATEMENT:

Provide the input and output files used to make the SIBERIA runs, as well as documentation for the input parameters selected.

BASIS FOR INTERROGATORY:

The results of all models have an inherent uncertainty attached to them. For a model like SIBERIA, as referenced in FRV1.2, there are several uncertainties: (1) there is uncertainty in the prediction of a parameter by a model or equation, which is called estimation uncertainty; (2) there is uncertainty in the prediction of a parameter by a model or equation over relatively long time scales, which is called temporal estimation uncertainty; and (3) there is uncertainty in the underlying theory of the model itself, which is called theoretical uncertainty. The simulated results of the SIBERIA model would be subject to these uncertainties. For example, there are numerous empirical equations and coefficients within the SIBERIA model that could be verified or validated for the Clive facility. However, ES has not provided documentation in support of this activity. As such, the estimation uncertainty of the model predictions is likely to be very large. No documentation has been provided regarding the rainfall intensities used herein, and how these intensities might change over time periods of 100, 500, 1,000, and 10,000 years, especially given potential changes in global climate. As such, the temporal uncertainty of the model predictions also is likely to be very large. (There is obviously the potential that the uncertainties noted here could interfere either constructively or destructively. It will be assumed that the errors would, at the very least, be additive.) In summary, while the SIBERIA model has several distinct advantages over the "Screening Gully Model," uncertainties of the model results have not been rigorously determined, and these uncertainty bounds likely would be very large.

REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model, Clive DU PA Model v1.2,* NAC-0024_R1, June 5, 2014.

INTERROGATORY CR R313-25-7(2)-189/3: MODELING IMPACTS OF CHANGES IN FEDERAL CELL COVER-SYSTEM SOIL HYDRAULIC CONDUCTIVITY AND ALPHA VALUES

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

Refer also to R313-25-7(4): *Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

INTERROGATORY STATEMENT:

Explain why the model does not consider the effects of a compromised radon barrier.

BASIS FOR INTERROGATORY:

An important component of assessing infiltration rates and contaminant concentrations as a function of time entails modeling of realistic changes in saturated hydraulic conductivity (K_s) values and van Genuchten alpha (α) values simultaneously for all cover-system soils near the ground surface. So far, ES has not done this in its PA modeling.

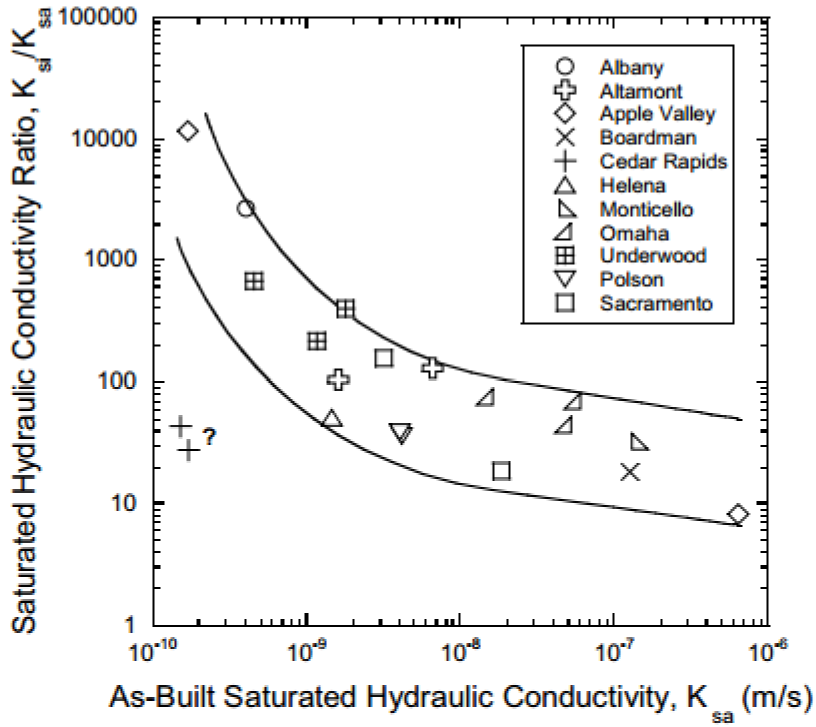
Based on extensive studies of some of field-scale testing involving a large number of embankment cover systems, the guidance in NUREG/CR-7028 (Benson et al., 2011) demonstrates that, to properly account for infiltration, the design and modeling of new cover systems must account for expected degradation of the shallow portions of these cover systems over time. A variety of physical and biological processes combine to cause this degradation. These processes may include frost heave, other freeze-thaw activity, wet-dry cycling, distortion, animal burrowing, plant root intrusion, and/or additional disruptive processes.

Changes in field-scale K_s and α values for cover-system soils occur soon after cover-system construction. These changes tend to be dramatic. For low- to moderate-permeability soils, the changes usually are at least one order of magnitude, and often two or three orders of magnitude, in value, depending on the initial, or as-built, K_s and α values. The changes tend to happen within several years of cover-system construction. These changes occur regardless of cover-system design or climate (Benson et al., 2011). In terms of modeling for 1,000, or 10,000 years, or longer, the changes tend to occur so rapidly following embankment construction, on a relative basis, that modeled K_s and α values, if they are limited in the model to single values for all time for a given soil layer, should reflect long-term in-service conditions rather than short-term as-built conditions.

In-service cover-system K_s values for soils should be modeled within the ranges described in NUREG/CR-7028. The guidance in this document is based on extensive studies. The guidance should be applied to all soils within 10 feet of the surface. As stated in NUREG/CR-7028:

> *For covers of typical thickness (< 3 m), the saturated hydraulic conductivity of earthen barrier and storage layers will increase over time in response to processes such as wet-dry and freeze-thaw cycling, with larger increases occurring in layers having lower as-built saturated hydraulic conductivity.* [page 10-2]

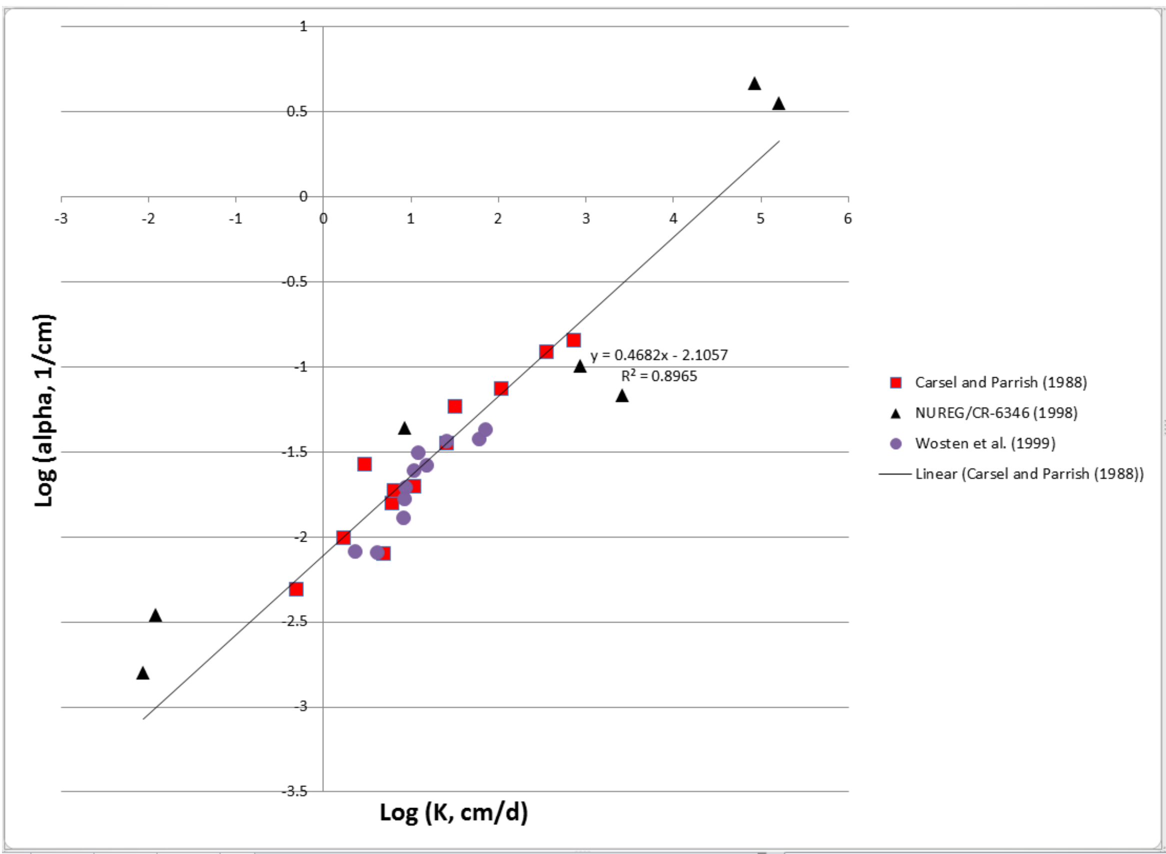
DRC asks ES to conduct sensitivity and uncertainty analyses for hydraulic conductivity values for soils in the cover system, as recommended in NUREG/CR-1573 (NRC, 2000). The values used for in-service saturated hydraulic conductivity for a particular soil should be considerably larger than the design or as-built saturated hydraulic conductivity values. The in-service saturated hydraulic conductivity values used in modeling should cover the entire range of values presented in NUREG/CR-7028, based on a particular as-built saturated hydraulic conductivity value. The relationship between the in-service and the as-built values is shown here in Figure 6.8 from NUREG/CR-7028:



It is noted that values are expressed in this chart with units of m/s, rather than cm/s. As can be seen, for a radon barrier with an as-built hydraulic conductivity of $5x10^{-8}$ cm/s ($5x10^{-10}$ m/s), the increase in saturated hydraulic conductivity over time (usually after several years) is expected to vary between about two and three orders of magnitude. But even the surface layer and evaporative zone hydraulic conductivity values are expected to increase by one to two orders of magnitude. Sensitivity and uncertainty analyses should account for simultaneous increases in the in-service hydraulic conductivity of all shallow soil layers, since similar physical and biological processes affect all shallow soil layers. It is not reasonable to increase K_s values for some soil layers but not for others in any given model run. Although ES has done some preliminary modeling involving changes in K_s values of certain soil layers, it has not done modeling involving simultaneous changes in K_s values in all shallow cover-system soil layers.

ES should consider that actual field-scale hydraulic conductivity values are typically much larger than those obtained as a result of laboratory testing using conventional small-scale samples or specimens. As stated in NUREG/CR-7028, page 28: "*the saturated hydraulic conductivity of in-service storage and barrier layers that were evaluated is sensitive to scale. Saturated hydraulic conductivities determined from testing conventional small-scale specimens (< 76-mm diameter) in the laboratory are appreciably lower (more than 1000x in some cases) than the actual field hydraulic conductivity.*" This is significant, because the hydraulic conductivities assumed in the PA model are based on testing of conventional small-scale soil specimens, which may be orders of magnitude smaller than actual field-scale hydraulic conductivities at Clive.

The van Genuchten alpha (α) values assumed for modeling moisture in a particular soil layer within the cover system must be correlated with the hydraulic conductivity assigned during modeling to that soil layer whenever measured values are not available. Benson et al. (2007) provide field data showing that, for cover-system soils, α values increase, just as K values are known to increase, within several years after ET cover system construction. Moreover, there are correlations between K and α. Therefore, α values cannot be modeled as being random, or uncorrelated with hydraulic conductivity. Several sets of commonly used soil properties data exhibit good correlations, as is illustrated in the graph below:



The data in Carsel and Parrish (1988) include information about 15,737 samples from 12 USDA soil textural classifications. The Carsel and Parrish (1988) publication is shown in Google to have been cited by 1,198 other articles that are peer reviewed. Statistical data based on Carsel and Parrish (1988) are included in NUREG/CR-6565, -6656 and -6695. The regression equation in the chart above [log(alpha) = 0.4682*log(K_s) - 2.1057] is developed based solely on the data in Carsel and Parrish (1988).

The data in NUREG/CR-6346 (NRC, 1996) are for one site described in this NRC guidance document. It is interesting to note that an equation for a linear regression for the NUREG/CR-

6346 data is very similar, almost identical, to that developed for the data in Carsel and Parish (1988).

The Wösten et al. (1999) database comprises HYPRES (Hydraulic Properties of European Soils) data collected from 20 institutions of higher learning in 12 European countries. Although the data exhibit some variability, they generally fall in a range expected based on correlations for the other two sets of data.

ES can alternatively use a theoretical expression developed by Guarracino (2007) for the alpha/K_s relationship: $K_s = 4.65x10^4{}_{(\phi)}\,alpha^2$. This theoretical expression is based on fractal scaling laws, a pore-size probability density function, the Hagan-Poisseuille equation, the Brooks and Corey equation, and other physical approaches. When applied to the Carsel and Parrish (1988) data, and using an mean value for volumetric water content at saturation (0.412), the expression for log(alpha) based on the theoretical expression is as follows: $\log(alpha) = 0.5\log(K_s) – 2.14$. This is very similar, almost identical, to the linear regression equation developed independently for the Carsel and Parrish (1988) data, as shown above. When compared with the Carsel and Parrish (1988) soil-class data, the root mean square (RMS) values for log(alpha) predictions using the linear regression equation is 0.144, whereas the RMS values for log(alpha) predictions using the modified Guarracino (2007) equation shown above is 0.147. This latter value differs from the RMS value using the linear regression equation by only 2%.

The results of deep infiltration modeling when accounting for changes in cover-system soil hydraulic conductivity and alpha values are extremely important. Rates of deep infiltration govern contaminant migration rates and whether or not standards appear to be complied with during a given modeling period. This type of analysis is essential to PA at Clive. Currently, the PA model assumes no simultaneous significant changes in all cover-system soil hydraulic parameters. Since the soil layer with lowest hydraulic conductivity predominantly governs the rate of infiltration, leaving any soil layer unchanged in its hydraulic conductivity may give a falsely small and overly optimistic result in terms of infiltration rates. Similar problems exist with leaving the alpha value of any layer unchanged. If modeled rates of downward water movement are inappropriately limited by use of unrealistic values of field-scale K_s and α values in the model, then evaporation rates can trump rates of downward flow in the model and give the appearance of relatively little deep infiltration per unit time, in other words, the appearance of a cover system performing much more effectively than it actually would do subsequent to site closure.

A sensitivity analysis should be performed in which the K_s for all of the model layers are raised simultaneously to fall in the ranges shown in Figure 6.8 of NUREG/CR-7028, and the correlation between K_s and α values is represented properly, as discussed above. NRC guidance calls for sensitivity analyses of significant variables affecting compliance, as this would be. For example, NUREG/CR-1573 states that: "*Sensitivity and uncertainty analyses are integral parts of the LLW performance assessment process, and are often used to assist in interpreting results and to optimize strategies for building confidence in compliance demonstrations.*" UAC R313-25-9(5)(a) affirms that this NRC guidance should be followed in the PA, since, in general, "*Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC.*"

REFERENCES:

Benson, C.H., W.H. Albright, D.O. Fratta, J.M. Tinjum, E. Kucukkirca, S.H. Lee, J. Scalia, P.D. Schlicht, and X. Wang, *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, Volume 1, NUREG/CR-7028, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, December 2011.

Benson, C.H., A. Sawangsuriya, B. Trzebiatowksi, and W.H. Albright, *Postconstruction Changes in the Hydraulic Properties of Water Balance Cover Soils*, Journal of Geotechnical and Geoenvironmental Engineering, American Society of Civil Engieners, Vol. 133, pp. 349–359, 2007.

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Meyer, P.D., M.L. Rockhold, and G.W. Gee, *Uncertainty Analysis of Infiltration and Subsurface Flow and Transport for SDMP Sites*, NUREG/CR-6565, U.S. Nuclear Regulatory Commission, 1997.

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Meyer, P.D., and R.W. Taira, *Hydrologic Uncertainty Assessment for Decommissioning Sites: Hypothetical Test Case Applications*, NUREG/CR-6695, U.S. Nuclear Regulatory Commission, 2001.

U.S. Nuclear Regulatory Commission, *A Performance Assessment Methodology for Low-level Radioactive Waste Disposal Facilities; Recommendations of NRC's Performance Assessment Working Group*, NUREG-1573, Office of Nuclear Material Safety and Safeguards, October 2000.

U.S. Nuclear Regulatory Commission, *Hydrologic Evaluation Methodology for Estimating Water Movement Through the Unsaturated Zone at Commercial Low-Level Radioactive Waste Disposal Sites*, NUREG/CR-6346, Office of Nuclear Regulatory Research, January 1996.

Wösten, J.H.M., A. Lilly, A. Nemes, and C. Le Bas, *Development and use of a database of hydraulic properties of European soils*, accepted by GEODERMA, 1999.

INTERROGATORY CR R313-25-7(2)-190/3: LIKELIHOOD OF SEISMIC ACTIVITY

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure* *and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

Refer also to R313-25-7(4): *Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

INTERROGATORY STATEMENT:

Correct the statement on Section 6.0, page 9, of the revised FEP Analysis report (Appendix 1 to FRV1.2) that "*…seismic activity is unlikely to impact the Clive facility*."

BASIS FOR INTERROGATORY:

The design peak ground acceleration (PGA) during nearby seismic events (for all but the worst 16% of events), assuming an earthquake that occurs at a return interval of 1% every 50 years, is considered to be 0.24 g, or about a quarter of earth's natural gravitational acceleration. AMEX (2012) says of the site, "*The maximum of the 84th percentile PGA values calculated for the M max events on the fault sources is equal to 0.24 g, as obtained for the Stansbury and the Skull Valley faults (Table B-1.1).*" This indicates that the site may potentially be affected by nearby seismic events.

The following table, adapted from Table 3-53 in U.S. Geological Survey (USGS) (2008), displays correlation between PGA values and potential damage:

Instrumental Intensity	Acceleration (g)	Velocity (cm/s)	Perceived Shaking	Potential Damage
I	< 0.0017	< 0.1	Not felt	None
II-III	0.0017 - 0.014	0.1 - 1.1	Weak	None
IV	0.014 - 0.039	1.1 - 3.4	Light	None
V	0.039 - 0.092	3.4 - 8.1	Moderate	Very light
VI	0.092 - 0.18	8.1 - 16	Strong	Light
VII	0.18 - 0.34	16 - 31	Very strong	Moderate
VIII	0.34 - 0.65	31 - 60	Severe	Moderate to heavy
IX	0.65 - 1.24	60 - 116	Violent	Heavy
X+	> 1.24	> 116	Extreme	Very heavy

As seen in the table, a PGA of 0.24g (i.e., 24% of 1 g) is typically associated worldwide with perceived shaking that is very strong, and with moderate potential damage. While an embankment behaves differently than buildings, it is not correct for ESo state that "*seismic activity is unlikely to impact the Clive facility*"; instead, the PA should reflect actual study conclusions regarding the site.

REFERENCES:

AMEX, *Response to Interrogatory CAW R313-25-8(4)-16/3, Energy*Solutions *Clive Facility, Class A West Embankment*, April 6, 2012.

Neptune and Company, Inc., *FEP Analysis for Disposal of Depleted Uranium at the Clive Facility*, NAC-0020_R1, June 5, 2014. (Appendix 1 to FRV1.2)

U.S. Geological Survey, *New York State Hazard Mitigation Plan*, Section 3.12, 2008. Available at http://www.dhses.ny.gov/oem/mitigation/archive/documents/2011/3.12-Earthquake-2011.pdf.

INTERROGATORY CR R313-25-7(2)-191/3: EFFECT OF GULLY EROSION

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

Refer also to R313-25-7(4): *Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

INTERROGATORY STATEMENT:

Provide additional information about the ability of steep side slopes to resist gully erosion.

BASIS FOR INTERROGATORY:

Section 3.6.2, page 17, of the revised Conceptual Site Model report (Appendix 2 to FRV1.2) states that:

> *Sheet erosion by wind and water is expected to be minor, and is likely to be counteracted by aeolian deposition of loess (wind-blown sediment) filling the interstices of the gravel. It is possible, however, that the surface layer may be degraded by processes such as unusual weather events (e.g., tornadoes), animal and plant activity, or human activities after the loss of institutional control. These events may result in damage to the cover, though the damage is likely to be localized. This could result in gully erosion, and possibly the exposure of deeper parts of the cover or the waste itself. Details are provided in the* Erosion Modeling *white paper.*

Gully erosion is expected at the site. It currently exists each year, and slopes have to be smoothed down using mechanical equipment. The DRC staff has serious concerns about the ability of steep side slopes to resist gully erosion. Since Utah rules require designs to reduce or eliminate maintenance, the PA must be revised to account for gully erosion.

Elsewhere, ES describes attempts to stabilize the soil against erosion by planting of various types of vegetation. We fully expect soils that soils would develop some vegetation if left long enough. However, the vegetation may not be very dense, considering the following:

- The current paucity of native plant growth (outside of biological soil crust) at the site
- The differences in slope that would be present on embankment
- The destruction before and during construction of the native thin, highly compressed clay layer located 2 feet underground in the undisturbed soil in at least some parts of the site
- The impact of soil mining, disturbance, mixing and embankment creation on surface- and near-surface micronutrients
- The effects of burial on many microorganisms found in biological soil crust
- The effects of rill and gully erosion, which will start before plants are established, and as plants are being established, on slopes

The photo below shows some of the gully erosion at the Clive site.

Photo credit: Dave Esser, DRC

In response to interrogatories for another PA, ES has claimed that the photo is of bare soil. However, this is not the case in all parts of the photo, which shows abundant plant growth on the lower slopes and down in the topographic depression, but not on the mid to upper parts of the slopes where rills are present and erosion dominates. This photo has brightness and contrast increased 35% to show the vegetation more clearly, although this adjustment also washes out a view of the rills.

Erosional rills may make it hard for vegetation to be established on 20-degree slopes within the first year. During the first year of reclamation, it appears that, based on the evidence at Clive to date, rills would tend to develop. Once rills develop, it would be hard for vegetation to grow in the rills. The rills, by their nature, are erosional features that are unstable, with moving particles. If vegetation does not become well established locally, then unmanaged rills will likely grow larger over time, eventually leading to some gully formation. ES should explain how it would encourage vegetation to grow in active rills, while erosion is still occurring, or how it would prevent rills from forming in the several years before vegetation is well established.

As to short-term impacts, the photo above definitely shows short-term impacts of erosional rill formation. We do not dispute the possibility that, depending on the way it is done, seeding embankment soils may allow for a different type of short-term outcome – that is, one with more vegetation. However, there are numerous instances in which re-vegetation and reclamation projects using plants have not succeeded very well, particularly during their early years. There are many things that can go wrong. Even at the Monticello LLW waste disposal site, where abundant federal resources were made available for reclamation, and where the project was ultimately relatively successful, there were serious difficulties getting the selected variety of plants to become re-established, and it was necessary to undertake seeding or re-seeding more than once before most of the desired outcomes were achieved (DOE, 2007; Waugh et al., 2008). The Monticello site receives much more rainfall than the Clive site. Nevertheless, reviews by DOE (2007) and Waugh et al. (2008) indicate that development of plant cover on the site was fraught with problems throughout much of the first 7 years after reclamation started. There were major challenges and failures along the way that required remedial action.

REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, NAC-0028_R1, June 5, 2014. (Appendix 2 to FRV1.2)

U.S. Department of Energy, *Long-Term Surveillance and Maintenance Plan for the Monticello NPL Sites*, DOE-LM/1465-2007, Office of Legacy Management, Grand Junction, Colorado 2007.

Waugh, W., C. Benson, W.H. Albright, and P.S. Mushovic, *Monitoring the Performance of an Alternative Landfill Cover at the Monticello, Utah, Uranium Mill Tailings Disposal Site*, Waste Management Conference Proceedings, 2008.

INTERROGATORY CR R313-25-7(2)-192/3: IMPLICATIONS OF GREAT SALT LAKE FREEZING ON FEDERAL CELL PERFORMANCE

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance;*

inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.

Refer also to R313-25-7(4): *Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

INTERROGATORY STATEMENT:

Revisit the potential for infiltrating water in and/or above the radon barrier to freeze, given the periodic freezing of this part of the lake water in this region.

BASIS FOR INTERROGATORY:

Section 3.2.1, page 7, of the revised Conceptual Site Model (Appendix 2 to FRV1.2) states that:

> *The most influential feature affecting regional climate is the presence of the Great Salt Lake, which can moderate downwind temperatures since it never freezes....*

Although the entire Great Salt Lake does not freeze very often, portions of the Great Salt Lake periodically do freeze, including portions of the lake in the south where the water has somewhat lower salinity. Average salinity of the Great Salt Lake south of the causeway has ranged over time from two to seven times that of seawater (USGS, 2007). The periodic freezing of this part of the lake water in this region emphasizes concerns about the potential for infiltrating water in and/or above the Federal Cell radon barrier to freeze, since freezing temperatures are expected to exist at depths much greater than the currently proposed depth of the radon barrier (see Interrogatory CR R313-25-8(4)(d)-155/3: Cover Performance for 10,000 Years). For pictures and other information dealing with portions of the Great Salt Lake freezing, see Davis Area Convention and Visitors Bureau (2011), *Does the Great Salt Lake Freeze?* (blog post), University of Utah (2014), and Aeon (2008).

REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, NAC-0028_R1, June 5, 2014. (Appendix 2 to FRV1.2)

U.S. Geological Survey, *Great Salt Lake, Utah*, Water-Resources Investigations Report 1999–4189, April 2007, retrieved June 2014 from http://pubs.usgs.gov/wri/wri994189/PDF/WRI99-4189.pdf.

Davis Area Convention and Visitors Bureau, *Does the Great Salt Lake Freeze?*, Thoughts from the Great Salt Lake (blog), February 15, 2011, retrieved June 2014 from http://dacvb.blogspot.com/2011/02/does-great-salt-lake-freeze.html.

Does the Great Salt Lake Freeze? (blog post), December 25, 2011, retrieved June 2014 from http://daypackandthecross.blogspot.com/2011/12/does-great-salt-lake-freeze.html.

University of Utah, *Great Sale Lake Throughout the Year*, Generic Science Learning Center, 2014, retrieved June 2014 at http://learn.genetics.utah.edu/content/gsl/year/.

Aeon, N., *When the Great Salt Lake Freezes*, uploaded January 10, 2008, retrieved June 2014 at www.youtube.com/watch?v=ER0LfL7JOLc.

INTERROGATORY CR R313-25-7(2)-193/3: PREDOMINANCE OF UPWARD OR DOWNWARD VERTICAL FLOW DIRECTION

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

Refer also to R313-25-7(4): *Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

INTERROGATORY STATEMENT:

Correct the assumption that ambient groundwater flow will always be vertically upward from the deep aquifer to the shallow aquifer.

BASIS FOR INTERROGATORY:

Section 3.3.1, page 9, of the revised Conceptual Site Model (Appendix 2 to FRV1.2) states that:

> *Deeper saturated zones in Unit 1 below approximately 14 m (45 ft) bgs are reported to show higher potentiometric levels than the shallow unconfined aquifer. Differences in potentiometric levels are attributed to the presence of the Unit 2 clays. These observations are interpreted as indicating that the shallow unconfined aquifer below the site does not extend into Unit 1 but is contained within Units 2 and 3 (Bingham Environmental, 1994).*

However, not all deeper wells at or near the Clive site have hydraulic heads or potentiometric values that are greater than those of groundwater in wells screened in the so-called shallow aquifer. For example, when the borehole associated with Water Right 16-816 was drilled just north of the site in Section 29 to a depth of 620 feet, the static water level in the wellbore was reported to be 84 feet below the surface (http://waterrights.utah.gov/docSys/v907/d907/d9070ckv.htm). This would place the water level for the deeper aquifer far below the base of the shallow aquifer. The overall hydraulic gradient (at least in the deeper aquifer) would thus be the reverse of that currently described in the PA.

Likewise, when a well was drilled under Water Right 16-190 to a depth of 276 feet below the surface several miles east of the site, the water level was reported to be at 264 feet below the surface, which is 12 feet above the base of the well (http://waterrights.utah.gov/cgi-bin/docview.exe?Folder=WL361S11WSL&Title=Scanned+Well+Logs+for+section+36+township+1S+range+11W+SL+b%26m). The water level for the deeper aquifer was thus far below the base of the shallow aquifer. The overall hydraulic gradient (at least in the deeper aquifer) would thus be the reverse of that currently described in the PA.

Figure 3, page 17, of the revised Unsaturated Zone Modeling report (Appendix 5 to FRV1.2) shows the water level for the deeper aquifer to be lower than the base of the so-called shallow aquifer. This, however, may have been an unintentional mistake.

Section 4.0, page 18, of the revised Unsaturated Zone Modeling report states that: "*Differences in potentiometric levels are attributed to the presence of the Unit 2 clays….*". It also states that: "*These observations are interpreted as indicating that the shallow unconfined aquifer below the site does not extend into Unit 1 but is contained within Units 2 and 3 (Bingham Environmental, 1994).*"

However, attributions are only interpretations, not observations, measurements, or facts, and these interpretations are not consistent with all of the other interpretations made by ES or its consultants, as noted below. It therefore is not appropriate to treat these attributions as observations and state that "*These observations are interpreted as indicating that the shallow unconfined aquifer below the site does not extend into Unit 1 but is contained within Units 2 and 3.*"

In fact, elsewhere, Bingham Environmental (1991) indicates a hydraulic connection between Unit 3 and Unit 1 (which must of necessity be through and also involve Unit 2), stating the following:

> *Unit 1, which consists of a relatively thick silty sand layer, was encountered below the silty clay unit and extends below depths ranging from 60 to 85 feet below the ground surface. Piezometric levels for wells screened in Unit 3 and the upper part of Unit 1 were similar indicating hydraulic connection between them.*

First, it is noted that there is a discrepancy between the statement above and other statements in the PA that indicate that Unit 1 starts at about 40 to 45 feet bgs and extends downward. The statement quoted gives a value of 60 to 85 feet bgs.

Second, this statement clearly indicates an interpretation of the presence of a hydraulic connection between Units 1 and 3. This suggests that the long-standing assumption of two separate and distinct hydraulic systems (i.e., the shallow aquifer and the deeper aquifer, not hydraulically connected), with an upward hydraulic gradient, may be an artificial construct that does not appear to be well documented, if at all, in the PA or other reports. The construct is not consistent with a number of field data showing water levels that are equivalent at the two depths, or even lower in the deeper aquifer, at some locations. As Bingham Environmental (1991) points out, the potentiometric values for groundwater in the shallow and deeper aquifers often do not vary much with depth, if at all.

This is consistent with much of the other field data. For example, Whetstone Associates (2005) says the following of the purported upward hydraulic gradients existing at the site:

> *Early hydrogeological reports for the Envirocare site identified very slight upward vertical gradients based on freshwater elevations and downward or mixed, vertical gradients based on saltwater heads. However, the most recent hydrogeologic report (Envirocare, 2004) identified no significant vertical gradients. Envirocare (2004) identified slight downward vertical gradients near well pair GW-19/GW-19B, located in the southwest corner of the facility, and*

> *slight upward gradients near wells I-3-30/I-3-100, north of the Mixed Waste Landfill. Because the vertical gradient elsewhere beneath the facility were of very low magnitude, the report concluded that* "vertical flow is not significant either upward or downward." *The steady-state model produced almost negligible vertical gradients (0.00000132 downward), which is considered consistent with overall site conditions.*

As mentioned, Bingham Environmental (1991) indicates that the two systems appear to be in hydraulic connection. Since the soils in the two systems are heterogeneous, with fine-grained layers tending to provide more resistance to flow, some head differences as a function of depth are expected. Furthermore, reports do not appear to provide good evidence for a particular layer of the subsurface below the shallow aquifer (e.g., in Unit 2 or otherwise) functioning effectively as an aquiclude, or even as an aquitard. The fact that ES and its various consultants have inconsistently described the contact between the shallow aquifer and the deep aquifer in different reports over time as being at different depths (varying over between 40 and 85 feet bgs) illustrates the general difficulty ES has in pinpointing the depth of the assumed aquiclude or aquitard.

This lack of clear understanding of the hydraulic connection between the shallow and deeper aquifers needs to be investigated as part of the PA. Based in part on newer information obtained during the more than two decades since the Bingham Environmental (1991) report, the concept that the so-called shallow aquifer and the so-called deep aquifer are two independent hydraulic systems should be reconsidered. ES should conduct integrated studies of the hydraulic heads, hydraulic gradients, hydraulic conductivities, and water quality in the shallow aquifer (e.g., at 35 feet bgs), in the zone interpreted as being an aquiclude or aquitard (e.g., somewhere between 40–85 feet), in the traditional "deep" aquifer (e.g., at 100 feet bgs), and in the deeper part of the deep aquifer (e.g., at 500–700 feet). The latter reflects the depth range at which gravel layers were found just north of the Clive site and the depth range over which much groundwater from the Clean Harbors – Aragonite facility is locally pumped.

The various examples provided above give cases in which the hydraulic gradient in areas appears to be opposite of what is currently claimed in the PA, or neutral. They illustrate the concern that the DRC staff has with regard to potential migration of radionuclides from a contaminated shallow aquifer to a deeper aquifer, when the latter is pumped.

REFERENCES:

Bingham Environmental, *Hydrogeologic Report Envirocare Waste Disposal Facility South Clive, Utah*, prepared for Envirocare of Utah, Inc., Salt Lake City, Utah, October 9, 1991.

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Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, NAC-0028_R1, June 5, 2014. (Appendix 2 to FRV1.2)

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Utah Division of Water Rights, *Document Listing for Folder: Scanned Well Logs for section 36 township 1S range 11W SL b&m*, accessed June 2014 at http://waterrights.utah.gov/cgi-bin/docview.exe?Folder=WL361S11WSL&Title=Scanned+Well+Logs+for+section+36+township+1S+range+11W+SL+b%26m.

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Whetstone Associates, *Evaluation of Potential Drawdown and Gradient Changes Resulting from Pumping Two Deep Wells at the Envirocare Facility*, prepared for Envirocare of Utah, Inc., April 7, 2005.

INTERROGATORY CR R313-25-7(2)-194/3: POTENTIAL FOR DEVELOPMENT IN THE VICINITY AND AT THE SITE

PRELIMINARY FINDING:

Refer to R313-25-7(2): *Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.*

Refer also to R313-25-7(4): *Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

INTERROGATORY STATEMENT:

Provide support for the assumption that the lack of potable water will limit any residential, commercial, or industrial developments.

BASIS FOR INTERROGATORY:

Section 3.1, page 6, of the revised Conceptual Site Model (Appendix 2 to FRV1.2) states the following:

> *While the site is zoned for hazardous waste disposal by Tooele County, the lack of potable water at this site makes the surrounding area an unlikely location for any residential, commercial, or industrial developments (Baird et al., 1990).*

This statement is not supported by the available evidence involving current, regional practices. It is evident that the surrounding area is suitable for industrial development, since ES itself is involved in waste disposal for the nuclear industry, and current waste disposal industry activity is occurring in the area (Clean Harbors – Aragonite, and Clean Harbors – Grassy Mountain). Historically, local groundwater from the deeper portions of the confined aquifer, which is readily available at significant rates, has been used for a wide variety of purposes, including drinking, after treatment by reverse osmosis. This is documented in comments to Interrogatories CR R313-25-8(4)(a)-96/3: Current and Future Potability of Water, CR R313-25-8(4)(a)-97/3: Need for Potable and/or Industrial Water, and CR R313-25-8(4)(a)-106/2: Desalination Potential.

Two wells at the nearby Clean Harbors – Aragonite incinerator facility (the Test Well and the Aptus Well) produce groundwater from deeper gravel zones at relatively high rates. These wells were drilled a long time ago. The State of Utah Public Water System Inventory Report (UTAH23067) indicates that the safe yields for groundwater from the Test Well and the Aptus Well at the site are 138 gpm and 25 gpm, respectively. If the wells continuously produced at these rates, for a total of 163 gpm, the daily rate would be 234,720 gallons per day. There are two large groundwater storage tanks at the facility; one can hold 572,000 gallons of the groundwater. A report by Earthfax Engineering, Inc. (1999) stated that, at least for the time of the report, two Clean Harbors – Aragonite wells "*provide industrial water for the incinerator facility and potable water for approximately 200 people at the facility*." DRC staff member David Edwards reports that, in a telephone conversation with Lonnie Brown, the Environmental Manager for the Clean Harbors – Aragonite facility, Mr. Brown confirmed that, for some time, reverse osmosis-treated groundwater at the site was provided to employees as potable water for drinking. Today, however, employees apparently no longer drink the treated groundwater but instead use bottled water for consumption. However, according to Mr. Brown, the employees still use reverse osmosis-treated groundwater for industrial and sanitary purposes such as scrubbing, electricity generation, cleaning, washing, and showering.

Nearby, the Delle Auto Truck Stop treats pumped groundwater using reverse osmosis and uses the potable water obtained for drinking, as well as other purposes. Some of the treated groundwater is routed to a soft-drink machine.

Thus, with local groundwater wells currently producing groundwater at rates of up to potentially more than 100,000 gallons per day, and with local industries having used this groundwater for a wide variety of industrial purposes, including drinking after reverse-osmisis treatment, the PA should not claim that a "*lack of potable water at this site*" exists or that this supposed lack of potable water "*makes the surrounding area an unlikely location for any residential, commercial, or industrial developments*." Groundwater in the area can readily be pumped, treated, if necessary (via reverse osmosis), and then used for industrial, commercial, or even residential developments.

REFERENCES:

Baird, R.D., M.K. Bollenbacher, E.S. Murphy, R. Shuman, and R.B. Klein, *Evaluation of the Potential Public Health Impacts Associated with Radioactive Waste Disposal at a Site Near Clive, Utah*, Rogers and Associates Engineering Corporation, Salt Lake City, Utah, 1990.

Earthfax Engineering, Inc., *Drinking Water Source Protection Plan for Safety Kleen (Aragonite), Inc. Test and Production Wells*, September 1999.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, NAC-0028_R1, June 5, 2014. (Appendix 2 to FRV1.2)

Utah Department of Environmental Quality, *Public Water System Inventory Report, Clean Harbors-Aragonite (UTAH23067)*, Division of Drinking Water, 2013.