Utah Department of Environmental Quality
Division of Radiation Control

Technical Assessment

EnergySolutions
Proposed Disposal of
Low-Level Radioactive Waste
Generated by SempraSafe [1] Treatment Process

December, 2011

Introduction

The purpose of this document is to present factors considered by the Division of Radiation Control (DRC) during review of a proposal to dispose of processed resins as Low-Level Radioactive Waste (LLRW) under its current License, UT 2300249 at its disposal facility near Clive, Utah.

In a February 14, 2011 submittal EnergySolutions (ES) proposed to land dispose treated ion-exchange (IX) resins from the Studsvik low-level radioactive waste (LLRW) treatment facility in Irwin, Tennessee. The Studsvik facility is licensed by Tennessee as a radioactive waste processor. These spent ion exchange (IX) resins may potentially come from as many as 90 of the 104 nuclear power plants in the United States, and after treatment, would be disposed in the Containerized Waste Facility (CWF) at the ES Class A North Disposal Cell. Prior to treatment, the spent IX resins would contain varying radionuclide concentrations, but because they have not been packaged for disposal, they are unclassified under NRC rules at 10 CFR 61.55 (and corresponding Utah rules at R313-15-1009). As proposed by ES, after processing and treatment, the resins would be packaged and those containers meeting the Class A concentration limits will then be shipped for disposal to Clive. Operators of the Studsvik treatment process would determine if the packaged material meets the Class A requirements of 10 CFR 61.55 (oversight of this facility is conducted by radiation control program staff with the State of Tennessee).

Background

The disposal of low-level radioactive waste (LLRW) is governed by regulations initially established by the U.S. Nuclear Regulatory Commission (NRC) in the early 1980's, under the authority of the Low-Level Radioactive Waste Policy Act of 1980 (LLRWPA). As an Agreement State with the NRC, Utah has also developed and adopted compatible requirements for LLRW disposal. In supplement to the federal regulations, the NRC develops technical guidance documents that serve to provide technical support, clarification, and direction to both Agreement States and facilities licensed to manage low-level radioactive materials and waste.

In recent years, the availability of disposal services for low-level radioactive wastes significantly changed when one of the waste disposal facilities limited access to LLRW waste generated in the three states that comprise the Atlantic Interstate Low-Level Radioactive Waste Management Compact, as authorized by LLRWPA.

1 SempraSafe is the joint venture between EnergySolutions and Studsvik processing facility.

In February, 2011, EnergySolutions submitted to the Division of Radiation Control (DRC) a proposal to receive and dispose of treated ion-exchange resins that are produced by the commercial nuclear power industry. The treatment process takes place at a facility located in and licensed by the State of Tennessee, as an Agreement State with the NRC. Following treatment, the resins will be packaged for disposal and shipped to the EnergySolutions Clive facility in Tooele County.

March, 2011 NRC Interim Guidance on Waste Blending

On March 17, 2011, the NRC issued guidance to Agreement States addressing large-scale blending of low-level radioactive waste [2]. The following are points taken from this guidance (except as otherwise noted) and have significant relevance to EnergySolutions' proposal regarding SempraSafe waste:

- The guidance serves as interim regulatory direction until NRC completes formal rulemaking [changes to 10 CFR Part 61] and issues guidance for the final rule.
- The guidance was issued to assist in making informed decisions regarding large-scale, low-level radioactive waste blending until formal rulemaking and guidance is completed.
- It is NRC's intent to make its regulation on blending more risk-informed and performance-based.
- Large-scale blending operations are those that could result in disposal of significant quantities of wastes at or near the Class A concentration limit, which was not considered in the analysis supporting the development of the federal LLW disposal regulations ("Large-scale" encompasses the intentional blending of multiple generators' waste at an offsite processing facility, not the type of blending of LLW that has been ongoing for several years).
- "Large-scale blending" means mixing of waste from multiple generators at a separate location (such as a waste-processing facility) prior to disposal. (NRC Fact Sheet, Blending of Low-Level Radioactive Waste, December 2010).
- Under NRC rules, waste is not required to be classified until it is [packaged and] shipped for disposal, since classification is related to the safety of disposed waste only. Thus, waste may have Class B or C concentrations [prior to or] while it is being processed, but it is not classified as B or C waste.
- NRC staff expects that processors engaged in large-scale blending will mix waste with Class B or C concentrations of radionuclides or both, with waste with Class A concentrations to create waste near the Class A concentration limit.
- The performance objectives in 10 CFR Part 61 Subpart C ensure the safe land disposal of LLW, including large-scale blended waste.
- 10 CFR Part 20 Appendix G Section I.C.12 requires waste generators to provide the waste classification on the uniform shipment manifest for waste consigned to a disposal facility.

2 See NRC Memorandum to all Agreement States, Michigan, Summary of Existing Guidance for Reviewing Large-Scale Low-Level Radioactive Waste Blending Proposals, FSME-l l-024, March l7, 2011.

- Because the resin waste that has been proposed as a candidate for large-scale blending is typically dominated by short-lived radionuclides, the performance assessment methods currently used for other LLW streams are expected to apply to performance assessments for large-scale blended waste.

Regulatory Analysis

During the review of the proposal, DRC determined that the new requirements added by the Utah Radiation Control Board (Board) to the Utah Radiation Control Rules in early 2011 [UAC R313-25-8(1)], are critical, in that they require the Executive Secretary determine whether a new performance assessment (PA) is required, in order for a licensee to receive certain low-level radioactive waste for land disposal. This new rule formally took effect on April 4, 2011, after EnergySolutions' February 14, 2011 proposal.

Although both the Executive Secretary and EnergySolutions have treated the rule as in effect, this is a source of uncertainty in this regulatory analysis. A second source of uncertainty is the applicability of the rule to a limited quantity of the SempraSafe waste that EnergySolutions would receive given that EnergySolutions has been approved to receive and has received similar wastes for about 10 years.

Notwithstanding these uncertainties, EnergySolutions has provided notice that a previously-approved PA is applicable to its proposal to accept blended wastes. It did so through the February 14, 2011 initial submittal and a follow-up letter dated July 28, 2011.

The Executive Secretary has analyzed the applicability of the separate provisions of the rule below.

UAC R313-25-8(1)(a):

(1) The licensee or applicant shall conduct a site-specific performance assessment and receive Executive Secretary approval prior to accepting any radioactive waste if:

> *(a) the waste was not considered in the development of the limits on Class A waste and not included in the analyses of the Draft Environmental Impact Statement on 10 CFR Part 61 "Licensing Requirements for Land Disposal of Radioactive Waste," NUREG-0782. U.S. Nuclear Regulatory Commission. September 1981, or*

DRC Findings

This review is to determine if the proposed SempraSafe waste is equivalent to wastes considered in the 1981 NRC Draft Environmental Impact Statement (DEIS). Based on the DRC's review, the SempraSafe material is equivalent to wastes considered in the DEIS, based on the following facts:

1. Ion Exchange (IX) Resins – land disposal of waste IX resins from nuclear power plants was considered in the 1981 NRC DEIS [3].

2. Waste Treatment – the 1981 NRC DEIS evaluated several types of LLRW treatment, before land disposal, including waste incineration [4]. The DRC considers the SempraSafe pyrolysis treatment process (applied heat with limited oxygen) to be equivalent to incineration.

3. Waste Isotopes Considered – the 1981 NRC DEIS considered 24 isotopes in LLRW, as summarized in Table 1, below. All of these 24 nuclides, and 66 others (90 in total) [5] were included in the vertical domain in the July, 19, 2000 ES Performance Assessment (PA) model prepared by Whetstone and Associates (hereafter July 19, 2000 ES PA). For details on the relative locations of vertical and horizontal domains of the ES PA model, see Figure 1 on page 20.

   The horizontal domain of the July 19, 2000 ES PA model also simulated 24 isotopes [6], but many are different from those found in the NRC DEIS. Comparison shows that 17 nuclides from the NRC DEIS were omitted from the horizontal domain of the ES PA model, as indicated in italics in Table 1, below. Most of the 17 omitted nuclides are not mobile in groundwater, and therefore are of little consequence to Clive embankment PA predictions. However, the same may not be said for 2 others not previously analyzed: carbon-14 (C-14), and neptunium-237 (Np-237) [7]. Two others, uranium-235 (U-235) and uranium-238 (U-238) , may also need to be considered, in that they are somewhat mobile in oxidizing groundwater environments.

   In summary, the vertical domain of the July 19, 2000 ES PA model did consider all of the 24 isotopes NRC deemed important in its 1981 DEIS. However, additional work should be undertaken to re-examine the Clive horizontal domain predictions for at least 4 isotopes known to be mobile or somewhat mobile in groundwater (C-14, Np-237 and U-235 and U-238).

3 See 1981 NRC DEIS, Volume 2, Tables 3.1 and 3.3, and waste sources: P-IXRESIN, B-IXRESIN, and L-DECONRS.

4 Ibid., p. 1-8, 3.13, and Table 3.5 (see Waste Spectrums 3 and 4).

5 See July 19, 2000 ES PA model, p. 18 and Tables 19 and 29.

6 For the 24 isotopes in the horizontal domain, see July 19, 2000 ES PA model, Table 33.

7 Mobile isotopes are easily leachable from the waste form, and readily transported in groundwater. A list of 15 mobile isotopes is defined in Utah Ground Water Discharge Permit, UGW450005 (Permit), Part I.D.7.

Table 1. Nuclides Considered in 1981 NRC DEIS [8]

Element	Isotope	Element	Isotope	Element	Isotope
Hydrogen	**H-3** [9]	Technetium	**Tc-99**	Plutonium	*Pu-239*
Carbon	***C-14*** [10]	Iodine	**I-129**		*Pu-240*
Iron	*Fe-55* [11]	Cesium	*Cs-135*		*Pu-241*
Nickel	*Ni-59*		*Cs-137*		*Pu-242*
	Ni-63	Uranium	*U-235*	Americium	Am-241
Cobalt	*Co-60*		*U-238*		Am-243
Niobium	*Nb-94*	Neptunium	***Np-237***	Curium	*Cm-243* [12]
Strontium	Sr-90	Plutonium	Pu-238		*Cm-244*

4. Waste Isotope Concentrations – the NRC DEIS considered 36 different types of LLRW waste streams in its 1981 DEIS [13]. For 30 of these 36 waste streams, the NRC projected a nation-wide inventory for a 20 year period (1980 – 2000) for each of the 24 nuclides considered. DRC then compared the NRC projected national inventory (Ci/m^3) for each of the 24 NRC isotopes to the initial waste source term (Ci/m^3) used in the July 19, 2000 ES PA model's vertical domain, see Table 2, below.

   From review of Table 2, the DRC has concluded that the ES PA model used an initial waste source term concentration that was greater than the 20-year NRC predicted national inventory for 12 isotopes, with excess model amounts ranging from about 2-times to a little over 4 million-times. During an earlier review of the July 19, 2000 ES PA model, the DRC determined that the State's performance standard for the ES PA model would be defined as the protection of groundwater resources near the disposal cell at concentrations at or below the Utah Ground Water Quality Standards for at least 500 years (hereafter Utah PA Standard) [14]. In the DRC's April 11, 2005 review of the Class A North Cell design [15], the Division determined that the Utah PA Standard would be met [16]. However, this performance standard is now in need of re-evaluation, in light of the new rule UAC R313-25-8(1)(b), as discussed below.

   The DRC also compared the initial waste source term concentrations used in the July 19, 2000 ES PA model against the Class A limits. From Table 2, above, at least 9 isotopes were modeled by ES at concentrations slightly above the Class A limits (~ 13% above) and is therefore a conservative approach.

8 See 1981 NRC DEIS, Volume 2, Table 3.3 (waste groups 1 – 4). Isotopes in *italics* are those omitted from the horizontal domain in the July 19, 2000 ES PA model, Table 33.

9 Bold text in Table 1 denotes mobile isotopes, see Permit, Part I.D.7.

10 Gray shading indicates 4 nuclides not included in the horizontal domain of the July, 2000 ES PA model.

11 Underlined nuclides indicate those with a half-life of less than ~ 30 years.

12 Note that the 1981 NRC DEIS considered 2 curium isotopes (Cm-243 and Cm-244), and yet later set Class A, B, and C waste concentration limits for curium-242 which was not considered.

13 See 1981 NRC DEIS, Volume 2, Table 3-1.

14 As determined at a point of compliance well about 90 feet from the outer margin of waste at each disposal cell.

15 The July 19, 2000 ES PA model for the Class A Cell design was relied on to justify performance of the Class A North (CAN) disposal cell, under the premise that the engineering design was equivalent. For details, see April 11, 2005 DRC Statement of Basis.

16 See August 28, 2000 DRC Statement of Basis (SOB) for proposed Permit modification to approve the Class A Cell design. Permit later finalized on October 20, 2000.

Table 2. NRC 20 Year Projected Nationwide Inventory vs. 7/19/00 ES PA Model

1981 NRC DEIS Isotopes [18]	Half-life (yr)	1981 NRC DEIS Total Activity (Ci/m3)	7/19/00 ES PA Model Source Term (Ci/m3)	Ratio of ES Value / NRC DEIS Value	Is ES PA Value Greater than NRC's?	Class A Limit (Ci/m3) [17]		Is ES PA Value Greater than Class A?
						Table I Long-lived	Table II Short-lived	
H-3	12.35	3,274.0	45.0	0.01	No		**40.0**	**YES**
C-14	5,760	576.3	9.0	0.02	No	**0.8 / 8.0** [19]		maybe
FE-55	2.73	2,390.0	792.0	0.33	No	n/a	n/a	n/a
NI-59	76,000.0	1.5	25.2	**16.63**	**YES**	22.0 [20]		**YES**
CO-60	5.27	3,495.4	792.0	0.23	No		700.0	**YES**
NI-63	100.1	453.7	4.0	0.01	No		3.5	**YES**
NB-94	20,300	1.02E-02	2.34E-02	**2.29**	**YES**	0.02 [21]		**YES**
SR-90	28.79	1,156.3	4.50E-02	3.89E-05	No		0.04	**YES**
TC-99	213,000	5.17E-04	3.38E-01	***653.89***	**YES**	0.30		**YES**
I-129	15,700,000	5.11E-04	9.00E-03	***17.61***	**YES**	0.008		**YES**
CS-135	2,300,000	5.17E-04	2.07E+03	**4,004,749.98**	**YES**	n/a	n/a	n/a
CS-137	30.07	1,158.8	1.1	9.75E-04	No		1.0	**YES**
U-235	704,000,000	1.70E-04	3.42E-03	**20.11**	**YES**	n/a	n/a	n/a
U-238	4,470,000,000	1.21E-03	6.05E-01	**500.36**	**YES**	n/a	n/a	n/a
NP-237	2,140,000	1.35E-08	0.018	**1,335,831.04**	**YES**	0.018 [22]		no
PU-238	87.7	1.3	0.018	0.01	No	0.018		no
PU-239 / 240	24,110 / 6,563	1.8	0.036	0.02	No	0.018		no
PU-241	14.4	35.6	0.6	0.02	No	350.0		no
PU-242	373,300	3.87E-03	1.80E-02	**4.65**	**YES**	0.018		no
AM-241	432.2	576.0	0.018	3.12E-05	No	0.018		no
AM-243	7,370	4.29E-04	1.80E-02	**41.91**	**YES**	0.018		no
CM-243	29.1	5.12E-04	1.80E-02	**35.12**	**YES**	0.018		no
CM-244	18.1	4.34E-03	1.80E-02	**4.14**	**YES**	0.018		no

It is also interesting to note in Table 2, above, that of the 24 nuclides considered in the NRC DEIS, the July 19, 2000 ES PA model used excess waste source term concentrations for 3 isotopes that have no corresponding Class A limit (Cs-135, U-235, and U-238). In these 3 cases, the excess waste concentrations ES modeled ranged from about 20-times to a little over 4 million-times over the levels considered by the NRC.

17 Class A waste concentration limits found in 10 CFR 61.55(a)(3), Tables I and II.

18 The 5 isotopes in bold text and underline are part of the 15 mobile isotopes defined in Permit, Part I.D.7.

19 Class A limit for C-14 in 10 CFR 61.55, Table 1 is defined in 2 ways; C-14 in activated metal (8.0 Ci/m^3) and all other C-14 forms (0.8 Ci/m^3).

20 Class A limit for Ni-59 and Nb-94 is based on activity of activated metal.

21 ibid.

22 Class A limit for transuranic (TRU) nuclides with half-life > 5 years (Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, Am-243, Cm-243, and Cm-244) based on 100 nCi/gm limit in 10 CFR 61.55, Table 1. The 7/19/00 ES PA model assumed waste bulk density was 1.8 gm/cc. Therefore, Class A limit for these 10 TRU nuclides = 0.018 Ci/m^3.

The effect of the new peak dose requirement in UAC R313-25-8(1)(b) on the Utah PA Standard that DRC previously applied to the Class A and Class A North Cells, is currently unknown, but can be examined during new PA analysis. New PA analysis is warranted in that after approval of the July, 2000 ES PA model, the NRC published new scientific guidance for PA modeling that has yet to be applied to the Clive facility [23]. New PA modeling with this guidance will provide an opportunity to examine the effects of waste with elevated isotope source term concentrations with respect to disposal facility and site performance.

In conclusion, the DRC has determined that the proposed SempraSafe waste complies with the requirements of UAC R313-25-8(1)(a), although other improvements are needed to the currently approved ES PA model.

UAC R313-25-8(1)(b):

(1) The licensee or applicant shall conduct a site-specific performance assessment and receive Executive Secretary approval prior to accepting any radioactive waste if: …

> *"(b) the waste is likely to result in greater than 10 percent of the dose limits in R313-25-19 during the time period at which peak dose would occur, or"*

DRC Finding

To determine if the proposed SempraSafe waste meets this new requirement, at least 3 questions are relevant:

Question 1: Which exposure pathway is critical to design and performance of the Clive disposal cells and control of the proposed SempraSafe waste?

Answer: groundwater was the critical pathway in the July, 2000 ES PA model. All other potential exposure pathways were previously eliminated due to high saline content of local soil and groundwater, and the expected limited land uses and little beneficial use of nearby water resources.

Question 2: What are the applicable dose limits pursuant to R313-25-19?

Answer: the dose limit for the groundwater pathway defined in R313-25-19 is 4 mR/yr or less. This is the same dose limit for beta-gamma emitters in the Utah Ground Water Quality Protection (GWQP) Rules [24], and is significantly lower than the NRC requirement (25 mR/yr) [25]. Dose limits are directly proportional to the nuclide groundwater concentrations (pCi/l) predicted by the ES PA model at the point of compliance (POC) well, and are calculated by use of dose conversion factors (DCFs). Historically, the DRC has relied on dose conversion factors from published government sources.

23 See NUREG-1573, published in October, 2000.
24 See UAC R317-6-2, Table 1.
25 NRC dose limit, 25 mR/yr, defined in 10 CFR 61.41.

However, when issuing the first Permit (1991), the Executive Secretary of the Water Quality Board followed the requirements of the GWQP Rules, and used DCF from the National Bureau of Standards (NBS) Handbook 69 [26], published in 1963 and is now obsolete in terms of modern human dosimetry models. These same DCFs are currently used in the EPA drinking water regulations [27]. When the 1991 Permit was issued, more current dose conversion factors were available from another branch of the U.S. EPA (1988) [28], but were not used by the State. These 1988 EPA DCFs were based on research found in Publication 30 (circa 1979 – 1981) of the International Commission on Radiation Protection (ICRP) [29].

In May, 1998 [30], and at the request of ES, the DRC modified the GWQS for radionuclides at the Clive site, based on tentative drinking water Maximum Concentration Limits (MCLs) in a July, 1991 draft EPA drinking water rule [31]. Later, in September, 1999, EPA published newer DCFs [32] that were based on research found in ICRP Publication 72 (1996) [33].

Current DRC rules [34] incorporate by reference effluent limits found in the NRC rules at 10 CFR 20, Appendix B, promulgated in 1994, with the intent of protecting individual members of the public. The NRC rules are based on research found in Publications 56 (1989) and 67 (1993) of the International Atomic Energy Agency [35].

A review of the vertical domain of the July 19, 2000 ES PA shows that the nuclide concentration limits (or GWQS, and hence the dose limit) for about 84 of the 90 isotopes [36] were based on proposed 1991 EPA drinking water MCLs that were never promulgated by the EPA. Further, there appears to be more current human dosimetry research (and DCFs) that should be considered in determining GWQS for the Clive facility.

Question 3: Did the July 19, 2000 ES PA model predict peak nuclide groundwater concentrations (pCi/l) at the POC wells? If so, will the proposed SempraSafe waste have concentrations that are more than 10% of said ES PA source term?

Answer: peak concentrations were available for many nuclides in the vertical domain of the ES PA. However the POC well is found in the horizontal domain, and is currently considered the potential point of exposure to the public. DRC review of the ES PA horizontal model predictions shows peak concentration (and hence peak dose) for only 1 of the 90 nuclides simulated, rhenium-187 (Re-187) [37].

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26 For H-3 and Sr-90, the GWQP Rules already promulgated GWQS, so no dose conversion was needed
27 See 40 CFR 141.66(d)(2).
28 September, 1988 EPA Federal Guidance Report No. 11, published by the Office of Radiation Programs.
29 Ibid., see p. 4
30 See May 15, 1998 DRC SOB, p. 6.
31 U.S. EPA draft rule, Federal Register, Vol. 56, No. 138, pp. 33050 - 33127.
32 September, 1991, EPA Federal Guidance Report (FGR) No. 13, published by the Office of Radiation and Indoor Air.
33 Ibid., p. 3.
34 UAC R313-15-302(2)(b)(i)
35 Personal communication, Ms. Gwyn Galloway, DRC.
36 See July 19, 2000 ES PA Model, Table 18.
37 See July 19, 2000 ES PA Model, Table 33. Peak concentration for Re-187 (1.1E+7 pCi/l) found at ~ 1,090 years. The ES report states the corresponding GWQS should be 5.82E+5 pCi/l (see Table 18), and that the GWQS was exceeded in 745 years (see Table 32).

As a result, the DRC can only determine an acceptable initial waste source term (and a 10% corresponding waste limit) for Re-187 only.

The Executive Secretary has also determined that after approval of the July, 2000 ES PA model, the NRC published new scientific guidance for PA analysis (October, 2000). Application of this more recent guidance is timely, and will allow the DRC to consider all appropriate exposure pathways, and peak activity and dose predictions at appropriate points of future potential exposure. As a result, a new PA model is not only in order, but also recognizes the fact that pyrolysis treated Class A resin waste, similar to SempraSafe, has been disposed of at Clive for the last 10 years (approximately).

UAC R313-25-8(1)(c):

(1) The licensee or applicant shall conduct a site-specific performance assessment and receive Executive Secretary approval prior to accepting any radioactive waste if: …

> *"(c) the waste will result in greater than 10 percent of the total site source term over the operational life of the facility, or"*

DRC Findings

At least 3 options are apparent to perform this test:

1. Total Inventory Prediction – including an estimate of the total activity of an isotope or suite of isotopes at closure. This value could be discrete for each disposal cell, or collective for the entire facility. The total could then be multiplied by 10% in order to perform the test. ES has informally stated that it is impossible today to predict what the final inventory will be at closure. The Executive Secretary agrees with the difficulty in determining or predicting the final waste inventory at the time of closure.

2. Approved PA Waste Source Term Concentration – use of the initial waste source term concentration (Ci/m^3) in the vertical domain of the July 19, 2000 ES PA model can allow the total activity or "… site source term over the operational life of the facility, …" to be determined. This is simply done by multiplying initial waste activity in the ES PA model (Ci/m^3) by the total volume authorized (m^3). This approach assumes that: 1) the imaginary cubic meter of waste (ES PA vertical model) is fully representative of all wastes above and beside it, 2) that waste placement has ceased, the cell closed with a cover system, and steady-state infiltration conditions have been reached [38], and 3) that the ES PA was successful in its demonstration that the 500-year Utah Performance Standard was met at the POC well [39]. This approach has already been implied in an ES submittal, but with emphasis on isotopes that meet the Class A limits [40].

   Using this approach, the total activity in each ES disposal cell at the end of its "operational life" can be calculated. In Table 3, below, the total activity authorized for mobile isotope disposal in the Class A Cell is over 155 Million curies, as based on the

38 These are fundamental assumptions in the July 19, 2000 ES PA model, see p. 2.

39 Another possibility is to use the ES PA model's waste concentration from predictions that yield a peak nuclide concentration (or dose), as required by UAC R313-25-8(1)(b). However, this information is currently available for only 1 nuclide, Re-187, see discussion above.

40 See July 11, 2011 ES letter, p. 3.

currently approved ES PA model [41]. Ten percent is 15.5 Million curies. For the Class A North Cell the total mobile isotope activity authorized for disposal would be 70.8 Million curies, and 10% would be 7.08 Million curies. Taken in the aggregate, both cells are currently authorized to receive more than 226 Million curies of mobile nuclides.

It is also important to note that many LLRW isotopes do not have Class A maximum waste limits, in that they are not found in 10 CFR 61.55, Tables I and II (or UAC R313-15-1009, Tables I and II). Six examples of mobile isotopes in this situation are found in Table 3, below (Al-26, Ca-41, Cl-36, K-40, Re-187, and Tb-158). This finding reinforces the need to consider PA model inputs and results to establish maximum isotope activity inventory limits for each disposal cell (and for the site), in order to determine compliance with UAC R313-25-8(1)(c).

In conclusion, the amount of activity already authorized for disposal at Clive is very large, beyond 226 million curies. Hence, the Executive Secretary does not anticipate that limited volumes of SempraSafe material will cause the facility to fail the requirements at R313-25-8(1)(c).

3. Limited Waste Volume Approach – although ES, under their current License and Permit, has historically received and disposed of both untreated and treated [42] spent ion exchange resins as Class A waste, the DRC, under R313-14-15(5), can set a limit on the maximum activity or volume of SempraSafe material that can be received in a given year. One approach to a volume limit would be to restrain receipt of future SempraSafe waste to be equal to or less than 1% of the annual volumes of waste ES has received in recent years. This limit would equate to 40,000 ft^3/yr. This value is conservative for the following reasons:

   a. Conservative Volume – the nationwide annual average volume of spent ion exchange resins generated by nuclear power plants in the United States is about 90,621 ft^3, as estimated by the Electric Power Research Institute (EPRI) [43] As a result, a 40,000 ft^3 limit at Clive would amount to only 44.1% of all resins generated each year nationwide by the U.S. nuclear power industry.

   b. Conservative Activity at Receipt – as determined by the same EPRI report, the nationwide annual average activity was 43,800 Ci/yr for 28 isotopes reported in spent ion exchange resins from the entire U.S. nuclear power industry [44]. The possible fraction of this nationwide annual activity that could arrive at Clive would be only 44.1% of this amount, or 19,333 Ci, which is small compared to the 226,675,444 Ci

41 The 15 mobile isotopes represent only 17% of the 90 isotopes analyzed in the vertical domain of the 7/00 ES PA model. Total activity for all mobile and non-mobile isotopes would be much higher.

42 Historic treatment of spent ion exchange resins includes thermal or pyrolysis treatment.

43 See EPRI Report 1016120, Table 6-8 which provide a 4-year average volume (90,621 ft^3) of spent ion exchange resins generated by the U.S. nuclear power plant industry for both boiling water reactors (37,021 ft^3) and pressurized water reactors (53,0600 ft3) between 2003 and 2006. Report authors state that waste shipment manifests were examined from 41 different power plants (ibid., pp. vi-vii).

44 See EPRI Report 1016120, Table 6-12, where the 4-year average national activity of spent ion exchange resins from U.S. nuclear power plants, for both boiling water reactors and pressurized water reactors was stated to be 43,800 Ci/yr.

for the 15 mobile isotopes already authorized by the DRC in its approval of the July, 2000 ES PA model, see Table 3 below .

Table 3. Authorized Inventory from 7/19/00 ES PA model: **Mobile Isotopes Only**

		7/19/00 ES PA Model		Calculated Total Cell Inventory Based on 7/19/00 ES PA Model Waste Source Term [45]				
				Class A Cell [46]		Class A North Cell [47]		**Both**
Mobile Isotope [50]	Half Life (yrs)	Source Term [48] (Ci/m3)	Class A Limit (Ci/m3)	Total Calculated [49] (Ci)	10% of Total (Ci)	Total Calculated (Ci)	10% of Total (Ci)	**Cell Total (Ci)**
Al-26	717,000	1.21E-07	n/a	0.35	0.04	0.16	0.02	0.51
Bk-247	1,380	1.78E-10	0.018	5.2E-4	5.2E-5	2.3E-4	2.3E-5	7.5E-4
C-14	5,760	9.0	0.8 / 8.0 [51]	2,317,455	231,746	1,053,562	105,356	3,371,017
Ca-41	103,000	2.90E-06	n/a	8.4	0.84	3.8	0.38	12.22
Cf-249	351	2.7E-10	0.018	7.8E-4	7.8E-5	3.6E-4	3.6E-5	1.14E-3
Cf-250	13.08	1.53E-04	0.018	443.2	44.3	201.5	20.15	644.7
Cl-36	301,000	5.09E-07	n/a	1.47	0.15	0.67	0.067	2.14
H-3	12.35	45.0	40.0	115,872,754	11,587,275	52,678,105	5,267,810	168,550,859
I-129	15,700,000	0.009	0.008	23,175	2,317	10,536	1,054	33,710
K-40	1.42E+09	12.6	n/a	36,499,917	3,649,992	16,593,603	1,659,360	53,093,520
Na-22	2.6	792		202,777	20,278	92,187	9,219	294,964
Np-237	2,140,000	0.018	0.018	52,143	5,214	23,705	2,371	75,848
Re-187	4.35E+10	0.0158	n/a	45,770	4,577	20,808	2,081	66,578
Tb-158	180	1.06E-06	n/a	3.07	0.31	1.4	0.14	4.5
Tc-99	213,000	0.338	0.30	869,046	86,905	395,086	39,509	1,264,131
			Total:	155,883,493	15,588,349	70,867,799	7,086,780	**226,675,444**

Further, the 19,333 Ci/yr that might arrive at Clive is likely over-estimated in that:

1) *Reactors in the Atlantic Compact* – power plants found in Connecticut, New Jersey, and South Carolina already have disposal access to the Barnwell, South Carolina facility [52]. Hence not all 104 U.S. nuclear power plants will utilize the SempraSafe treatment process and dispose resins at Clive, and

45 These values represent the end of the operational life of each cell, in that the ES PA model was based on a closed cell, steady state scenario.

46 Total Class A Cell waste capacity = 3,788,896 yd^3 (2,896,819 m^3), as defined by the approved engineering design in Permit.

47 Total Class A North Cell waste capacity = 1,722,509 yd^3 (1,316,953 m^3), as defined by the approved engineering design in Permit.

48 Initial waste source term concentration in the vertical domain of the 7/19/00 ES PA model, see Table 29 (topslope simulation).

49 For each disposal cell, the total calculated cell inventory is based on either the ES PA waste source term value (vertical domain), or the Class A limit, whichever is least (in Ci/m^3), multiplied by the total authorized cell disposal volume (m^3).

50 These 15 mobile isotopes represent only 17% of the 90 isotopes analyzed in the 7/00 ES PA model's vertical domain. Total activity for all mobile and non-mobile isotopes would be much higher.

51 Class A limit for C-14 in activated metal = 8.0 Ci/m^3, for all other forms it is 0.8 Ci/m3, see 10 CFR 61.55, Table I. Cell inventory values here based on the lower limit (0.8 Ci/m^3).

52 States in the Atlantic Compact can be found at the following NRC website: http://www.nrc.gov/waste/llw-disposal/licensing/compacts.html.

2) *Limited Fraction of Mobile Isotopes* - of the 28 isotopes EPRI considered, only 3 were mobile, i.e., H-3 (74.8 Ci/yr), C-14 (63 Ci/yr), and Tc-99 (4.52 Ci/yr) [53]. Under the EPRI report, these 3 mobile isotopes would contribute an average of about 142 Ci/yr to the SempraSafe wastes that could arrive at Clive. In comparison, the combined H-3, C-14, and Tc-99 activity already authorized for Clive disposal is 173,186,007 Ci [54], which equates to 76.4% of the total mobile isotope activity authorized at Clive (226,675,444 Ci).

After due consideration of the 3 options available, the Executive Secretary has decided to set a maximum annual volume of SempraSafe waste that can be received based on 1% of the waste volumes received by ES in recent years, or 40,000 ft^3/yr, as a means to perform the test required by UAC R313-25-8(1)(c). This limit will apply until a new PA is submitted, analyzed and approved.

UAC R313-25-8(1)(d):

(1) The licensee or applicant shall conduct a site-specific performance assessment and receive Executive Secretary approval prior to accepting any radioactive waste if: …

> *"(d) the disposal of the waste would result in an unanalyzed condition not considered in R313-25."*

DRC Findings:

The Executive Secretary has determined it most appropriate to conduct this evaluation by considering 3 issues, including:

1. Considerations in the 1981 NRC DEIS - this was appropriate since it formed the basis for 10 CFR 61, and later UAC R313-25. As discussed above, the Division has determined the SempraSafe waste appears consistent with the ion exchange resins and waste treatment processes historically considered by the NRC in 1981.

   However, new characterization information on isotopes measured in spent ion exchange resins at multiple U.S. nuclear power plants has been recently published by EPRI [55]. Review of this report shows that 11 isotopes known to exist in resin wastes NOT considered in the 1981 NRC DEIS, see Table 4, below [56]. However, on close review all of these 11 are short-lived nuclides with a half-life of less than 3 years. Hence, they are not significant for deep time considerations needed in PA analysis for the Clive site.

53 Ibid., see annual average activity reported by EPRI for H-3, C-14, and Tc-99. The remaining 25 EPRI isotopes are non-mobile. For more information, see EnergySolutions' Ground Water Discharge Permit [UGW450005], Part I.D.7, for the 15 mobile isotopes defined there.

54 See Table 3, below, for authorized activity of H-3 (168,550,859 Ci), C-14 (3,371,017 Ci), and Tc-99 (1,264,131 Ci) in the Class A and Class A North Cells at Clive.

55 See EPRI Report 1016120, Table 6-12 Purpose of report is in part to update characterization of wastes generated in U.S. nuclear power plants (ibid., p. .

56 These same 11 isotopes were also omitted from the 7/00 ES PA model.

Table 4. 2007 EPRI Survey of U.S. Power Plant Spent Ion Exchange Resins [57]

Radionuclide	Half-life [yr], unless indicated [58]	U.S. Nuclear Power Plant Resin Waste Activity (Ci)			Nuclide found in: 59		
					1981 NRC DEIS?	7/00 ES PA Model Domain?	
		BWR	PWR	Total		Vertical	Horizontal
H-3	12.32	19.8	55.0	74.8	y	y	y
C-14 [60]	5,700 [61]	26.0	37.0	63.0	y	y	**N**
Cr-51 [62]	27.7 d	133.0	2.93	136.0	**N**	**N**	**N**
Mn-54	312.12 d	1,230.0	233.0	1,460.0	**N**	**N**	**N**
Fe-55	2.74	10,800.0	1,500.0	12,300.0	y	y	**N**
Fe-59	44.495 d	19.8	1.18	21.0	**N**	**N**	**N**
Co-57	271.74 d	0.29	25.5	25.8	**N**	**N**	**N**
Co-58	70.86 d	101.0	1,240.0	1,340.0	**N**	**N**	**N**
Co-60	1,925.28 d	4,220.0	846.0	5,070.0	y	y	**N**
Ni-59	76,000	8.04	11.6	19.6	y	y	**N**
Ni-63	101.2	163.0	2,980.0	3,140.0	y	y	**N**
Zn-65	243.93 d	543.0	1.09	544.0	**N**	**N**	**N**
Sr-90	28.9	6.2	6.4	12.6	y	y	y
Zr-95	64.032 d	3.76	2.76	6.52	**N**	**N**	**N**
Nb-94	20,300	0.000645	0.0131	0.0138	y	y	**N**
Tc-99	211,100	2.19	2.34	4.52	y	y	y
Ag-110m	249.76 d	*0.00000*	*0.00000*	*0.00000*	**n/a**	**n/a**	**n/a**
Sb-125	2.7582	11.4	2.69	14.1	**N**	**N**	**N**
Cs-134	2.0648	6.83	65.1	71.90	**N**	**N**	**N**
Cs-137	30.07	42.3	851.0	894.0	y	y	**N**
Ce-144	284.893 d	389.0	1,370.0	1,760.0	**N**	**N**	**N**
Pu-238	87.70	30.9	20.0	50.9	y	y	**N**
Pu-239/240	24,110 y / 6,563 y	*0.000000*	0.000125	0.000125	y	y	y
Pu-241	14.35	0.069	0.052	0.121	y	y	**N**
Am-241	432.2	0.11	0.02	0.13	y	y	y
Cm-242	162.8 d	3.05	2.39	5.44	**N**	**N**	**N**
Cm-243	29.1	0.0987	0.0309	0.13	y	y	**N**
Cm-244	18.1	0.0469	0.0267	0.0736	y	y	**N**
	Total:	30,600	13,100	43,800			
Count of Nuclides Missing in DEIS or ES PA Model:					11	11	22

57 See EPRI Report 1016120, Table 6-12. Nuclide half-life values have been added here.
58 Half-life values followed by a "d" indicate days instead of years.
59 Key to indicators: "y" = yes, "N" = no, "n/a" = not applicable, in that no activity reported by EPRI.
60 Isotopes in bold red text = those omitted from the 7/00 ES PA Model's horizontal domain.
61 Blue shading indicates nuclides with a half-life > 30 years and omitted from7/00 ES PA model's horizontal domain.
62 Nuclides in tan shading = those not included in the 1981 NRC DEIS, Vol. 2, Table 3.3.

2. Analyzed Condition in July 19, 2000 ES PA model –this evaluation is appropriate in that a satisfactory PA analysis is required by R313-25. DRC review of the February and July, 2011 ES submittals, showed little information was provided on why the SempraSafe waste would contain the same isotopes and activity concentrations found in the currently approved July, 2000 ES PA model. As shown in Table 4, above, recent EPRI research has determined there to be 11 isotopes now known to exist in U.S. nuclear power plant wastes (spent ion exchange resins), that were not included in the vertical domain of the July, 2000 ES PA model. Consequently, all 11 are short-lived and are insignificant in terms of the deep time element required.

   However, Table 4 also shows 11 other isotopes identified in the recent EPRI report were omitted from analysis in the horizontal domain of the July, 2000 ES PA model [63]. Of these 11, six have half-lives that range from 30 to 76,000 years, and should be considered for analysis in a new PA model, including: C-14, Ni-59, Ni-63, Nb-94, Cs-137, and Pu-238. Here again, the opportunity to improve the ES PA model is important in order to assess the long term performance of these and other nuclides at the Clive disposal site.

3. Comparison of Nuclides Already Disposed at Clive - another way to examine unanalyzed conditions, is to compare the inventory of isotopes already disposed at Clive with 90 nuclides examined in the vertical domain of July, 2000 ES PA model. Disposal site inventory information was provided by ES in an October, 2011 waste inventory report for material disposed in the Class A and CAN Cells. DRC staff compared this ES information and found about 25 longer-lived isotopes have been disposed at Clive, and were not analyzed in the approved PA report. These same 24 unanalyzed isotopes were also not considered in the 1981 NRC DEIS [64]. For details, see Table 5, below.

   While it is currently unclear if all or any of these 24 unanalyzed isotopes will actually be disposed as part of the SempraSafe waste, the Executive Secretary has decided to err on the side of conservatism until ES is able to successfully demonstrate otherwise. In summary, these 24 un-analyzed isotopes deserve consideration in a new PA model in order to determine if any pose a concern for long-term facility performance.

   Such remodeling is also appropriate, as mentioned above, due to the new NRC PA model guidance published in October, 2000. This new modeling may resolve the unanalyzed condition represented by the 24 nuclides in Table 5.

63 These 11 omitted isotopes include: C-14, Fe-55, Co-60, Ni-59, Ni-63, Nb-94, Cs-137, Pu-238, Pu-241, Cm-243, and Cm-244.

64 Compare isotopes in Table 5 here with those found in 1981 NRC DEIS, Vol. 2, Table 3.3.

Table 5. Isotopes Disposed at Clive, but Apparently Not Analyzed

	Class A Cell			Class A North Cell	
Element	**Isotope**	**Half-life (yr)**		**Isotope**	**Half-life (yr)**
Argon	Ar-39	269			
Bismuth	Bi-208	3.68E+5			
Cerium	Ce-142	> 5E+16			
Curium	Cm-250	9,000		Cm-250	9,000
Europium	Eu-150	36.9			
Gadolinium	Gd-152	1.08E+14			
Hafnium	Hf-182	9.0E+6			
Indium	In-115	4.41E+14			
Lutetium	Lu-176	3.78E+10			
Lead	Pb-205	1.53E+7			
Molybdenum	Mo-93	4,000			
Neptunium	Np-236	154,000			
Rubidium	Rb-87	4.75E+10			
Samarium	Sm-146	1.03E+8			
	Sm-147	1.06E+11		Sm-147	1.06E+11
	Sm-148	7.0E+15			
	Sm-149	> 2E+15			
Technetium	Tc-98	4.2E+6			
Tellurium	Te-123	1E+13		Te-123	1E+13
Zirconium	Zr-93	1.53E+6		Zr-93	1.53E+6
Count:	20			4	

Conclusions

After reviewing the February 14, 2011 and other ES submittals, the DRC has determined the following:

1. Class A Waste - the SempraSafe waste is Class A waste and it may be disposed of at the Clive facility in accordance with existing conditions in the License and Permit.
2. New Rule at R313-25-8(1) – comparison of the July 19, 2000 ES PA, already approved by DRC, with the new requirements in UAC R313-25-8(1), show several items that warrant resolution, these include, but are not limited to:

   A. Paragraph (a): 1981 NRC DEIS – additional work is needed to model the horizontal transport of 4 isotopes considered in the DEIS and omitted from the July, 2000 ES PA model, including: C-14, Np-237, U-235, and .U-238.

   B. Paragraph (b): 10% Dose Limit Change and Peak Dose –additional PA analysis includes:

      1) Re-evaluation of critical exposure pathways,
      2) Determination of appropriate groundwater quality standards,
      3) PA model simulation for timeframes beyond 500 years, and
      4) Determination of peak activity (and dose) at appropriate points of compliance for all critical nuclides.

   C. Paragraph (c): 10% of Source Term – no further examination is required for this test. However, the revised PA model will allow evaluation of the long term containment of six mobile isotopes that are without Class A waste limits in 10 CFR 61.55 and the corresponding DRC rule (Al-26, Ca-41, Cl-36, K-40, Re-187, and Tb-158).

   D. Paragraph (d): Unanalyzed Conditions – in general terms the SempraSafe material is similar to waste considered in the 1981 NRC DEIS (ion exchange resins and treated waste). However, six nuclides recently identified EPRI in nuclear power plant spent ion exchange resins were omitted from the horizontal ES PA model analysis. Also, comparison of nuclides already disposed at Clive may suggest that there could be 24 nuclides in the SempraSafe waste that have not yet been modeled and need PA analysis (see Table 5, above).

   The need to re-examine the July, 2000 ES PA model is further reinforced by discovery that NRC published new scientific guidance for PA analysis (October, 2000) shortly after DRC approved the ES PA report. Therefore, it is important to apply this new guidance as ES resolves the above listed PA model concerns.

3. Uncertainty in Application of Rule – as discussed above, there are some uncertainties about the applicability and application of R313-25-8(1). Given those uncertainties, the best course is to request ES to complete a new PA, and to limit the amount of SempraSafe waste that can be received at EnergySolutions until that PA is approved. EnergySolutions will be directed to complete and submit an appropriately updated PA model and report on or before December *30, 2012*.

References

Electric Power Research Institute, November, 2007, "An Evaluation of Alternative Classification Methods for Routine Low Level Waste From the Nuclear Power Industry", prepared by D. James (DW James & Associates) and J. Vance (Vance & Associates), 128 pp. Document can be found on internet at: http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=ObjMgr&parentid=2&control=SetCommunity&CommunityID=404&RaiseDocID=000000000001016120&RaiseDocType=Abstract_id.

EnergySolutions, February 14, 2011, "Radioactive Material License #UT2300249: Justification for the Disposal of Blended Low Level Radioactive Waste at the Clive Containerized Waste Facility", company letter from Dan Shrum to Rusty Lundberg (1 p.), includes 1 enclosure (9 pp.) with 1 attachment (1 p.).

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U.S. Nuclear Regulatory Commission, October, 2000, "A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities - Recommendations of NRC's Performance Assessment Working Group" NUREG 1573, 313 pp.

Utah Division of Radiation Control, May 15, 1998, Draft Permit Modification and Statement of Basis, about 37 pp.

Utah Division of Radiation Control, August 28, 2000, Draft Permit Modification and Statement of Basis, 37 pp.

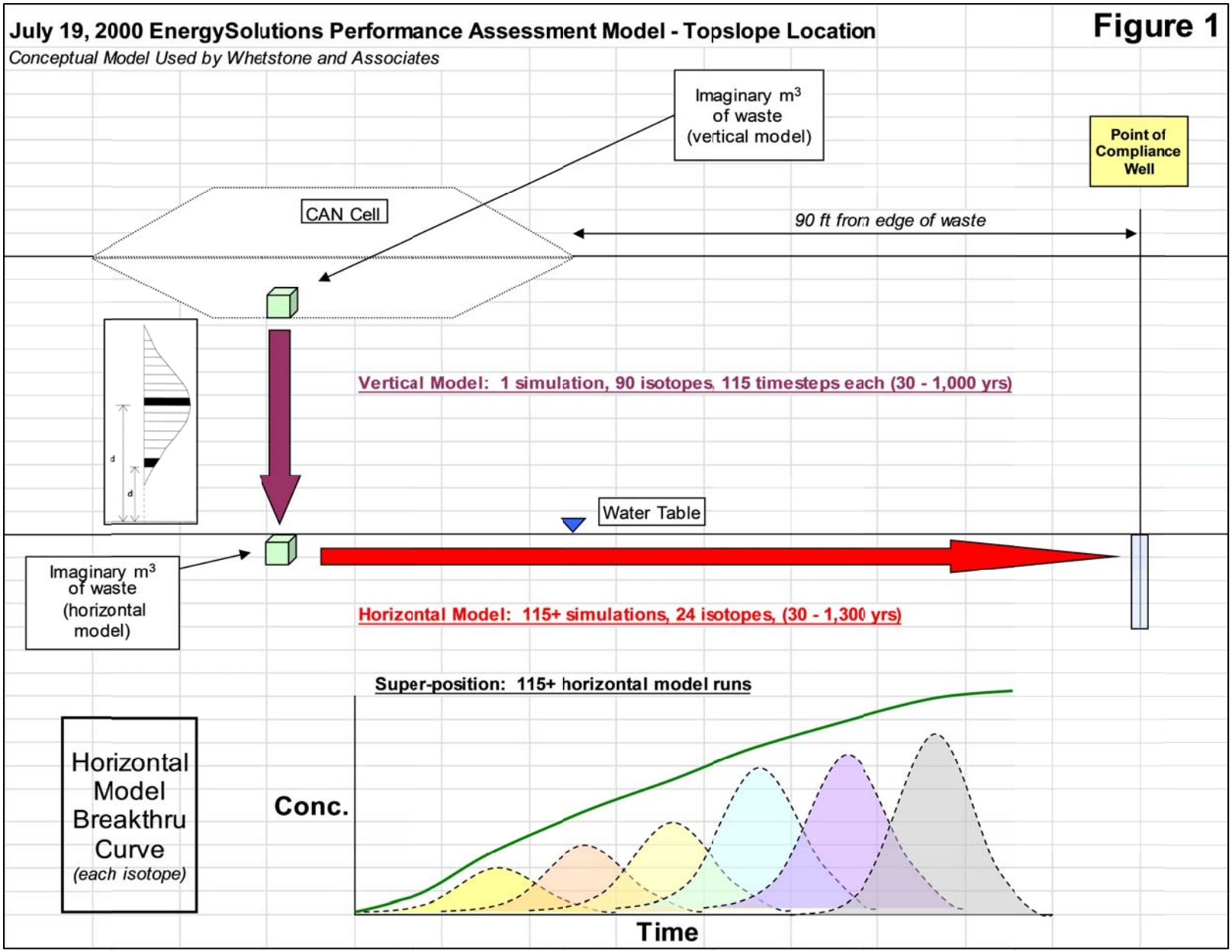
Utah Division of Radiation Control, April 11, 2005, Draft Permit Modification and Statement of Basis, 9 pp.

Whetstone and Associates, July 19, 2000, “Revised Envirocare of Utah Western LARW Cell Infiltration and Transport Modeling” Report, 34 pp., 37 tables, 14 figures, and 7 attachments.

Figure 1

DRC Conceptual Cross-Section
To Illustrate the
Vertical and Horizontal Model Domains
Used in the
July, 2000 ES PA Model

DRC Spreadsheet
Fig. 1_Conceptual Model Diagram.xls


July 19, 2000 EnergySolutions Performance Assessment Model - Topslope Location
Figure 1
Conceptual Model Used by Whetstone and Associates
Imaginary m3 of waste (vertical model)
Point of Compliance Well
CAN Cell
90 ft from edge of waste
Vertical Model: 1 simulation, 90 isotopes, 115 timesteps each (30 - 1,000 yrs)
Water Table
Imaginary m3 of waste (horizontal model)
Horizontal Model: 115+ simulations, 24 isotopes, (30 - 1,300 yrs)
Super-position: 115+ horizontal model runs
Horizontal Model Breakthru Curve (each isotope)
Conc.
Time