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Embankment Modeling for the Clive DU PA

Clive DU PA Model v1.4

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Prepared by

NEPTUNE AND COMPANY, INC.

1505 15th St, Suite B, Los Alamos, NM 87544

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4. Originator	Dan Levitt	May 23, 2014
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6. Remarks 23 May 2014: DL. Revision to R1 of this white paper is not yet complete. Some references to “Class A South” remain in this document and cannot be updated until model parameters are also updated). 2 Jul 2014: R2; Modified Figure 9 in response to Interrogatory 161. – J Tauxe 15 Jul 2015: Amir Mohktari. Updated “Class A South” terminology to “Federal DU.” 15 October 2015: Paul Black, Katie Catlett, final review and finalization of v1.3. 19 October 2015: Final review and finalization of v1.3. – J Tauxe 20 October 2015: Revisions to figures and terminology for v1.4. – J Tauxe 21 October 2015: Additional revisions related to new figures for v1.4. – G. Occhiogrosso; reviewed v1.4. – K. Catlett		

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CONTENTS

FIGURES

TABLES

1.0 Summary of Parameter Values

The parameters that define the characteristics of the Federal Cell at the Clive facility are summarized in Table 1. Of principal interest to the model are the interior dimensions of the volume occupied by waste, and the thicknesses of the various layers in the engineered cover.

Table 1. Summary of embankment engineering parameters

Parameter	Value	Units	Reference / Comment
average original grade elevation	4272	ft amsl*	USGS (1973) see §4.1
height of top of the waste at the ridgeline	47.5	ft amsl	Energy*Solutions* (2014c) see §3.1.1
height of top of the waste at the break in slope	35.0	ft amsl	Energy*Solutions* (2014c) see §3.1.1
average elevation of the bottom of the waste	4264	ft amsl	Energy*Solutions* (2014d) see §3.1.1
height of the clay liner	2	ft	Energy*Solutions* (2014a) see §3.1.2
length overall	1317.8	ft	Energy*Solutions* (2014c) see §3.1.1
width overall	1775.0	ft	Energy*Solutions* (2014c) see §3.1.1
length to break	175.0	ft	Energy*Solutions* (2014c) see §3.1.1
width to break	175.0	ft	Energy*Solutions* (2014c) see §3.1.1
break to ridge length (west)	521	ft	Energy*Solutions* (2014c) see §3.1.1
break to ridge length (east)	447	ft	Energy*Solutions* (2014c) see §3.1.1
break to ridge width	521	ft	Energy*Solutions* (2014c) see §3.1.1
ET Cover Layer Thicknesses			
surface	0.5	ft	Energy*Solutions* (2014a) Federal Cell Drawing 14004 V7
evaporative zone	1.0	ft	*ibid*.
frost protection	1.5	ft	*ibid*.
upper radon barrier	1.0	ft	*ibid*.
lower radon barrier	1.0	ft	*ibid*.

*above mean sea level

2.0 Introduction

The safe storage and disposal of depleted uranium (DU) waste is essential for mitigating releases of radioactive materials and reducing exposures to humans and the environment. Currently, a radioactive waste facility located in Clive, Utah (the "Clive facility") operated by the company Energy*Solutions,* Inc., is being considered to receive and dispose DU waste that has been declared surplus from radiological facilities across the nation. The Clive facility has been tasked with disposing of the DU waste in a manner that protects humans and the environment from future radiological releases.

To assess whether the proposed Clive facility location and containment technologies are suitable for protection of human health, specific performance objectives for land disposal of radioactive waste set forth in Utah Administrative Code (UAC) Rule R313-25 *License Requirements for Land Disposal of Radioactive Waste— General Provisions* (Utah 2015) must be met—specifically R313-25-9 *Technical Analyses*. In order to support the required radiological performance assessment (PA), a probabilistic computer model has been developed to evaluate the doses to human receptors and the concentrations in groundwater that would result from the disposal of radioactive waste, and conversely to determine how much waste can be safely disposed at the Clive facility. The GoldSim systems analysis software (GTG, 2015) was used to construct the probabilistic PA model.

The site conditions, chemical and radiological characteristics of the wastes, contaminant transport pathways, and potential human receptors and exposure routes at the Clive facility that are used to structure the quantitative PA model are described in the conceptual site model documented in the white paper titled *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*.

The purpose of this white paper, *Embankment Modeling for the Clive DU PA,* is to address specific details relating to the dimensional components of the Federal Cell, located at the Clive facility. This paper is organized to give a brief overview of where the Federal Cell section is located at the Clive facility followed by a description of the parameters and calculations used to estimate the various dimensional components of the Federal Cell.

This probabilistic PA takes into account uncertainty in many input parameters, but the dimensions of the Federal Cell are not considered to be uncertain. Given that the disposal cell is carefully designed and constructed, any uncertainty in its dimensions is considered insignificant. Stochastic representation of parameters is reserved for those values about which there is uncertainty.

3.0 Physical Dimensions

The Clive DU PA Model considers only a single embankment. For the purposes of this PA, only the Federal Cell is considered for disposal (Figure 1).

3.1 Federal Cell Dimensions

The Federal Cell, or embankment, location at the Clive facility is identified in Figure 1. A stylized drawing of the Federal Cell is shown in Figure 2.

The general aspect of the Federal Cell is that of a hipped cap, with relatively steeper sloping sides nearer the edges. The upper part, known as the top slope, has a moderate slope, while the side slope is markedly steeper (20% as opposed to 2.4%). These two distinct areas, shown in different colors in the Plan View diagram of Figure 2, are modeled separately in the Clive DU PA Model. Each area is modeled as a separate one-dimensional column, with an area equivalent to the corresponding embankment footprint. The embankment is also constructed such that a portion of it lies below-grade (Figure 2).

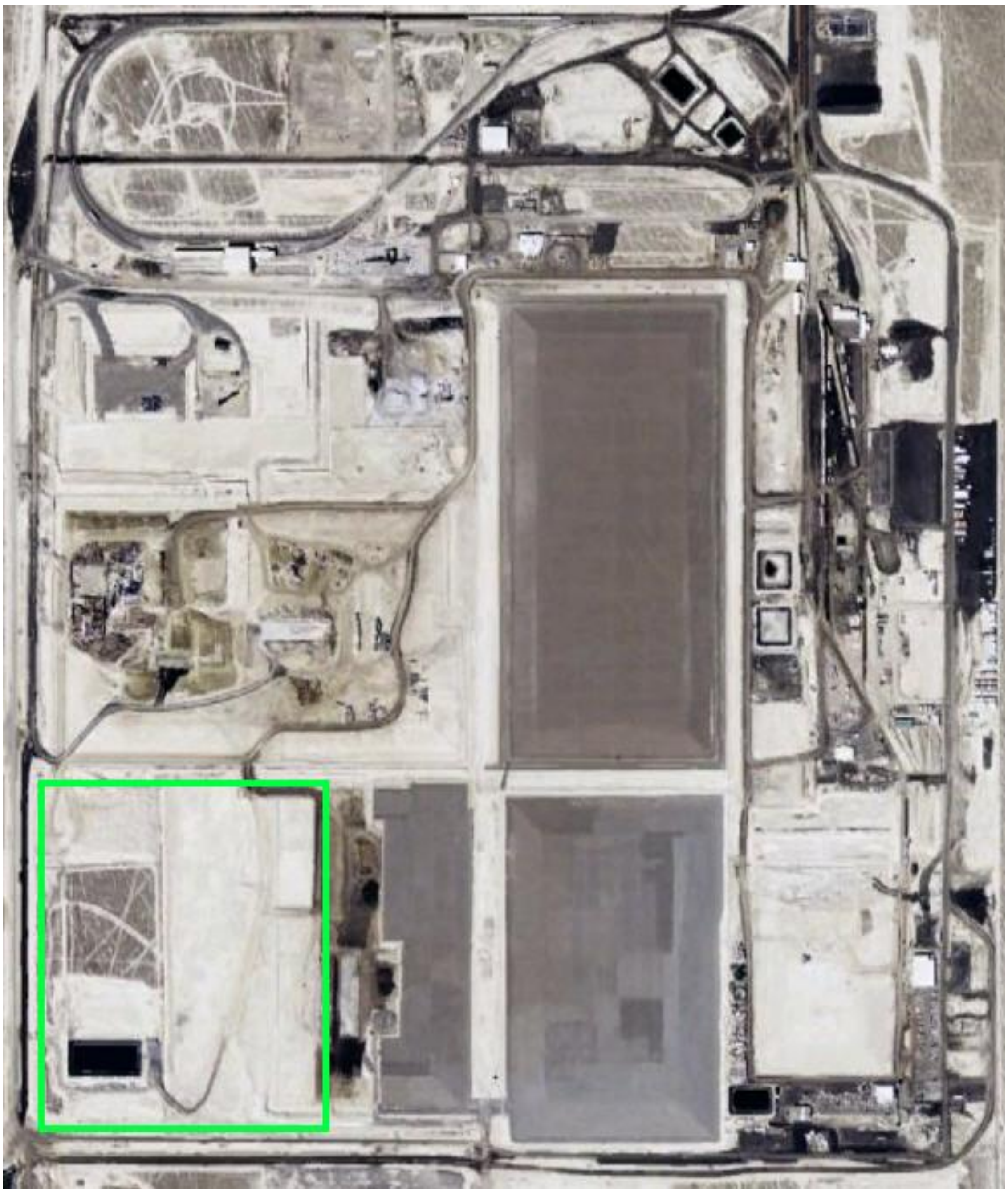

Figure 1. The Clive Facility, with the location of the Federal Cell outlined in green. This orthophotograph is roughly 1 mile across, and north is up.

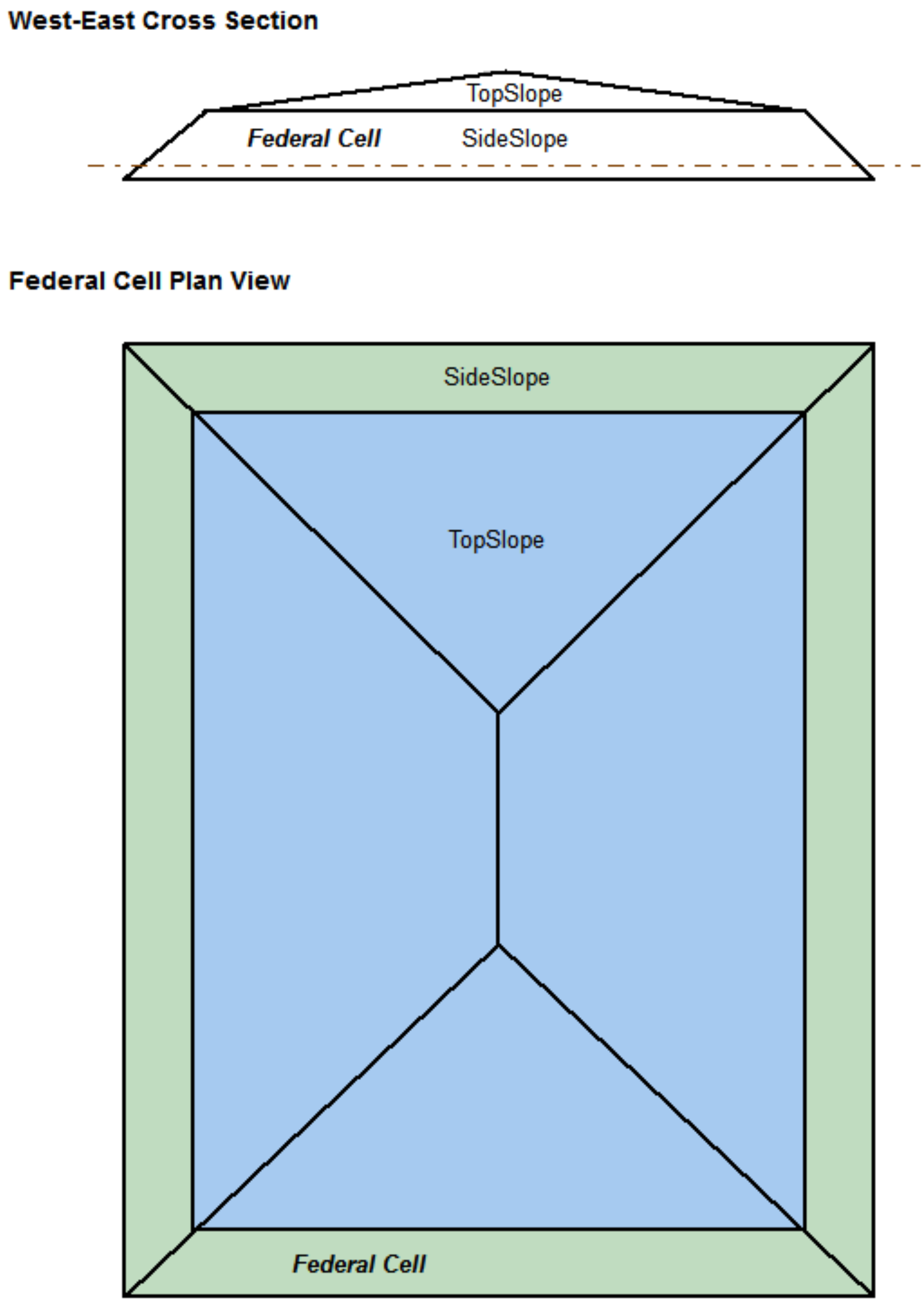

Figure 2. Section and Plan views of the Federal Cell, with top slope shown in blue and side slope in green. The brown dotted line in the West-East Cross section represents below-grade (below the line) and above-grade (above the line) regions of the embankment.

3.1.1 Federal Cell Interior Waste

The Clive DU PA Model requires information about embankment dimensions to be able to determine the footprint areas and the volumes of waste within each area. From this, an average thickness of the waste is determined, since the 1-D column represents a single thickness over its entire area. All dimensions provided in this white paper are with respect to the waste itself, and do not include the liner or cover materials, with a few exceptions as noted. The dimensions of interest that are used in the Clive DU PA Model are shown in Figure 3.

The values of the dimensions shown in Figure 3 are derived from various engineering drawings as noted below.

As shown in the engineering drawings, the exact dimensions of the Federal Cell are somewhat irregular, with a gently sloping bottom and ridge line. The shape of the cell has been somewhat idealized to facilitate calculations, and it is assumed to have a horizontal floor and ridge line.

Height of the top of the waste at the ridge line: Elevations for the top of the waste are shown in drawing 14004 V1A (Figure 4), which has the note "*1. All elevations shown are for top of waste...*" At the ridge, the top of the waste is at height of about 47.5 ft.

Height of the top of the waste at the slope break: Also shown in 14004 V1A (Figure 4), the height of the top of the wastes at the slope break (shoulder) is given as about 35 ft.

Elevation of the bottom of the waste: This is estimated from the values provided in the drawing 14004 V3A (Figure 5). The top of the liner protective cover is at an elevation of 4263 ft at the west end and 4266 ft at the east end, which includes the area under the neighboring 11e.(2) Cell. The elevation of the bottom of the waste at the midpoint of the Federal Cell is estimated by linear interpolation to be at 4264 ft.

Length overall: Defined in Figure 3, the overall length (east to west) of the waste footprint in the Federal Cell is shown in drawing 14004 V1A (Figure 4) to be 1317.8 ft.

Width overall: Defined in Figure 3, the overall width (north to south) of the waste footprint in the Federal Cell is shown in drawing 14004 V1A (Figure 4) to be 1775.0 ft.

Length to break: Defined in Figure 3, the length from edge of the unit to the break in slope is shown in drawing 14004 V1A (Figure 4) to be 175.0 ft. This value is the same on the east and west sides of the disposal unit.

Width to break: Defined in Figure 3, the width from the edge of the unit to the break in slope is shown in drawing 14004 V1A (Figure 4) to be 175.0 ft. This value is the same on the north and south sides of the disposal unit.

Break to ridge length (west): Defined in Figure 3, on the west side of the disposal unit, the length from the break in slope to the ridge is shown in drawing 14004 V1A (Figure 4) to be 521 ft.

Break to ridge length (east): Defined in Figure 3, on the east side of the disposal unit, the length from the break in slope to the ridge is shown in drawing 14004 V1A (Figure 4) to be 447 ft.

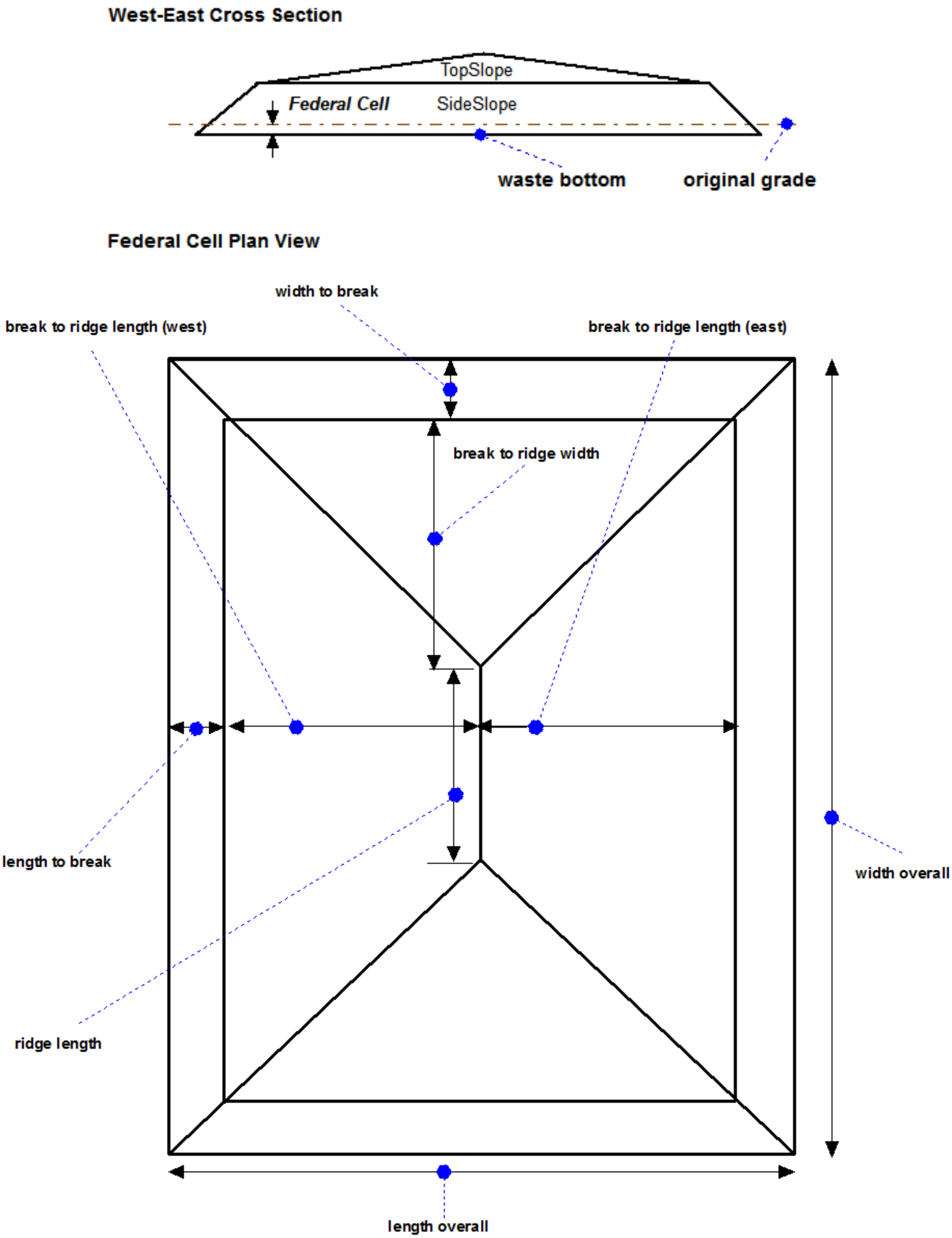

Figure 3. Dimensions of the Federal Cell that are used in the Clive DU PA Model. Not to scale.

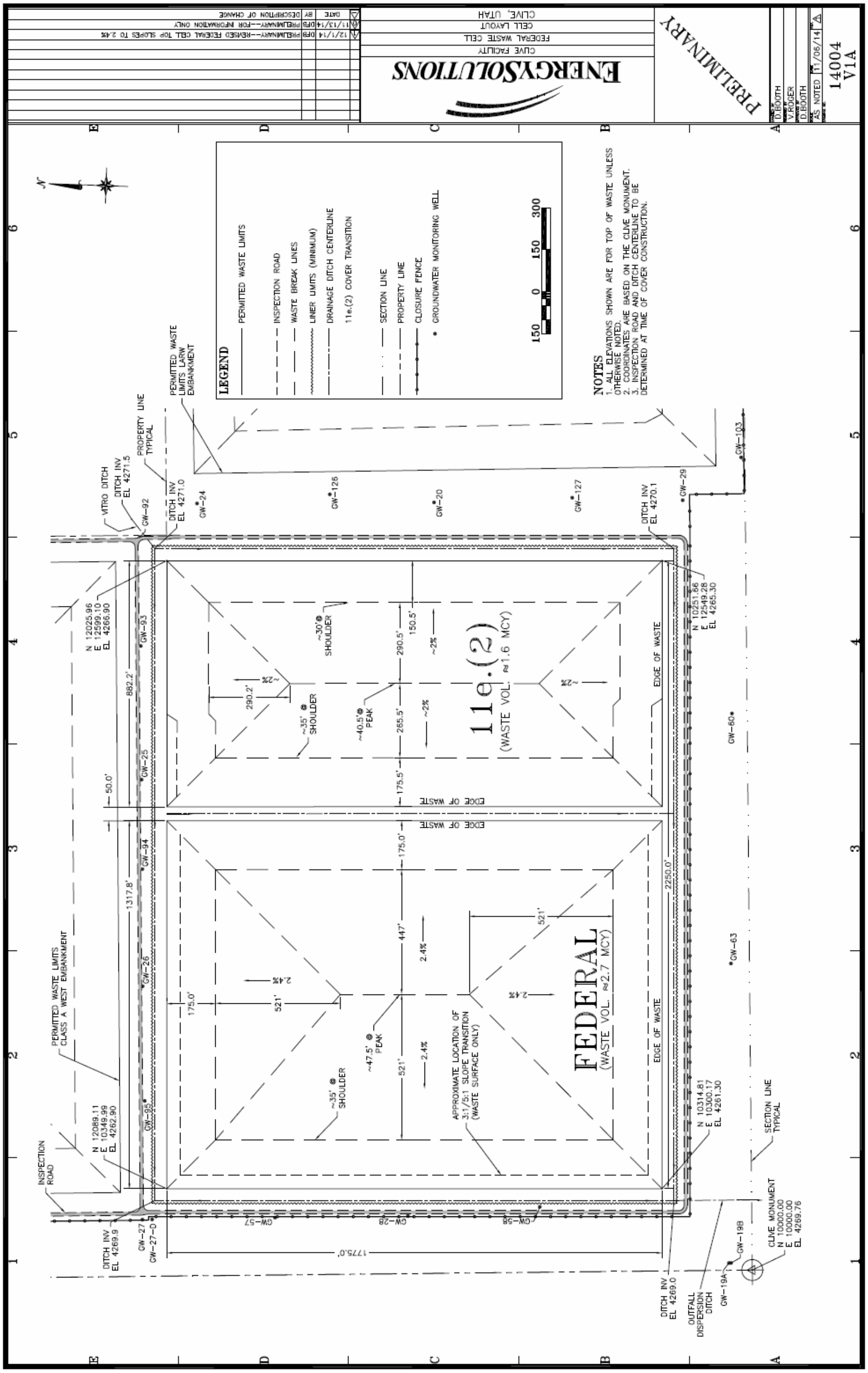

Figure 4. Federal Cell and 11e.(2) Cell engineering drawing 14004 V1A. (EnergySolutions 2014c)

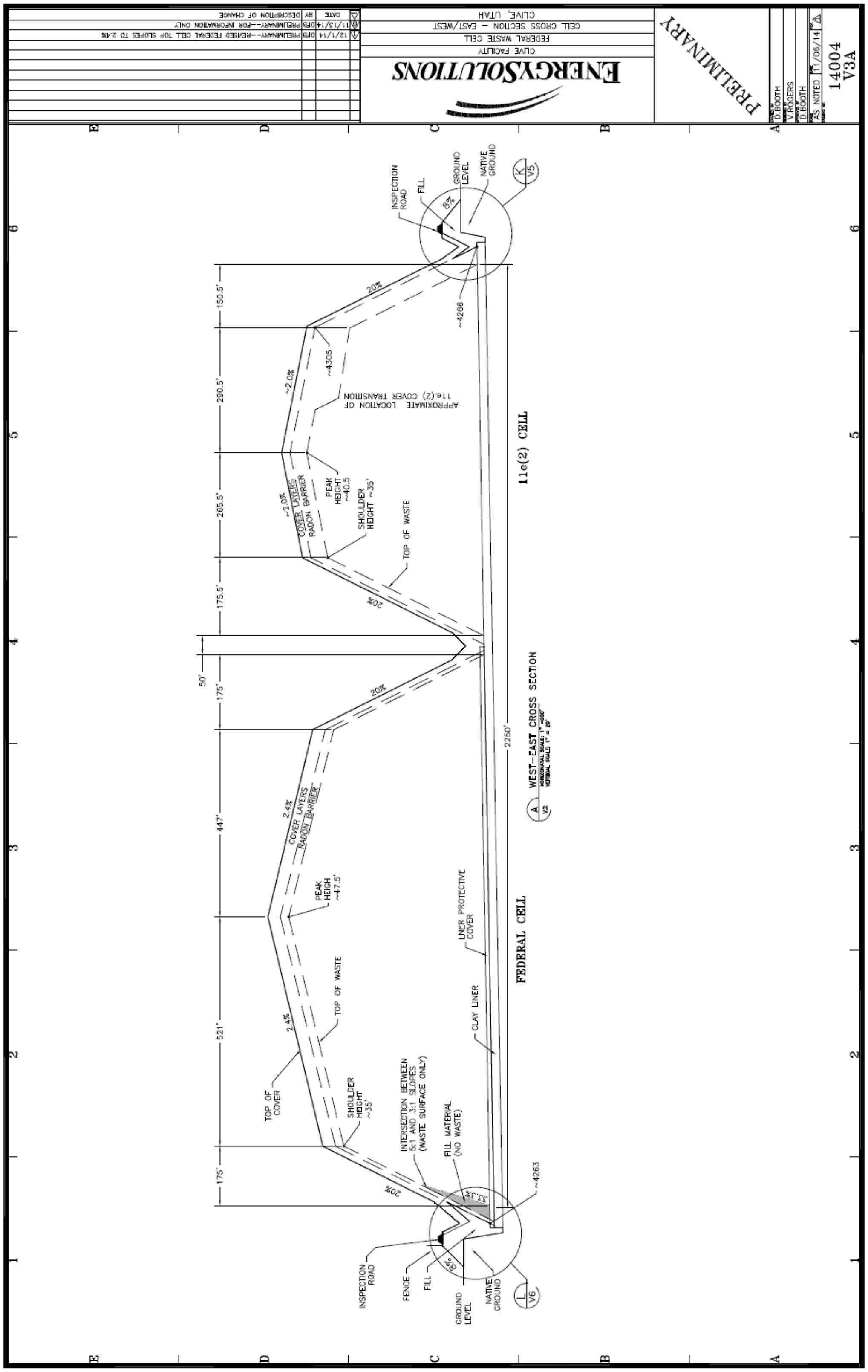

Figure 5. Federal Cell and 11e.(2) Cell engineering drawing 14004 V3A (west-east cross section) (EnergySolutions 2014d).

Break to ridge width: Defined in Figure 3, the width from the break in slope to the ridge is shown in drawing 14004 V1A (Figure 4) to be 521 ft. This value is the same on north and south sides of the disposal unit.

Ridge length: Defined in Figure 3, the length along the ridge (north-south) is derived from drawing 14004 V1A (Figure 4). It is equal to the "overall width" less twice the distance from the edge of the unit to the ridge in the north-south direction. Based on the quantities above, the ridge length is calculated in the GoldSim model as: 1775.0 ft – (2 × (521 ft + 175 ft)) = 383 ft.

3.1.2 Federal Cell Cover and Liner Dimensions

The engineered cover designs for the top slope and side slope sections of the Federal Cell are shown in drawing 14004 V7 (Figure 6). The values chosen from the sections labeled "*ET Cover Top Slopes*" and "*ET Cover Side Slopes*" are summarized in Table 2. The properties of the various layers within the engineered cover and liner are discussed in detail in the *Unsaturated Zone Modeling* white paper.

Table 2. Cover layer thicknesses for the Federal Cell

layer	thickness (ft)	
	top slope	side slope
surface	0.5	0.5
evaporative zone	1.0	1.0
frost protection	1.5	1.5
upper radon barrier	1.0	1.0
lower radon barrier	1.0	1.0

The waste layers of the embankment are underlain by a clay liner, as shown in Figure 7. The thickness of the clay liner is defined in the engineering drawing 14004 L1A (Energy*Solutions*, 2014b) as 2 ft.

Elevation of the bottom of the clay liner: This is calculated simply as the average elevation of the bottom of the waste minus the thickness of the liner. The elevation of the bottom of the clay liner is then 4264 ft – 2 ft = 4262 ft and is calculated as such in the GoldSim model. Note that for model simplification, the liner protective cover is assumed to be a part of the unsaturated zone, in essence below the clay liner instead of above it.

Note that this is also the elevation of the top of the unsaturated zone.

4.0 Original Grade Elevation

The original grade is of interest for determining the vertical location of wastes inside the embankment. Above-ground waste or other material can be considered erodible, and, conversely, below-ground waste to be inherently not erodible. It is therefore of interest to determine the disposal volume that lies below grade since placing waste below grade greatly reduces the potential for erosion during lake cycles. Again, only the Federal Cell is considered at this time.

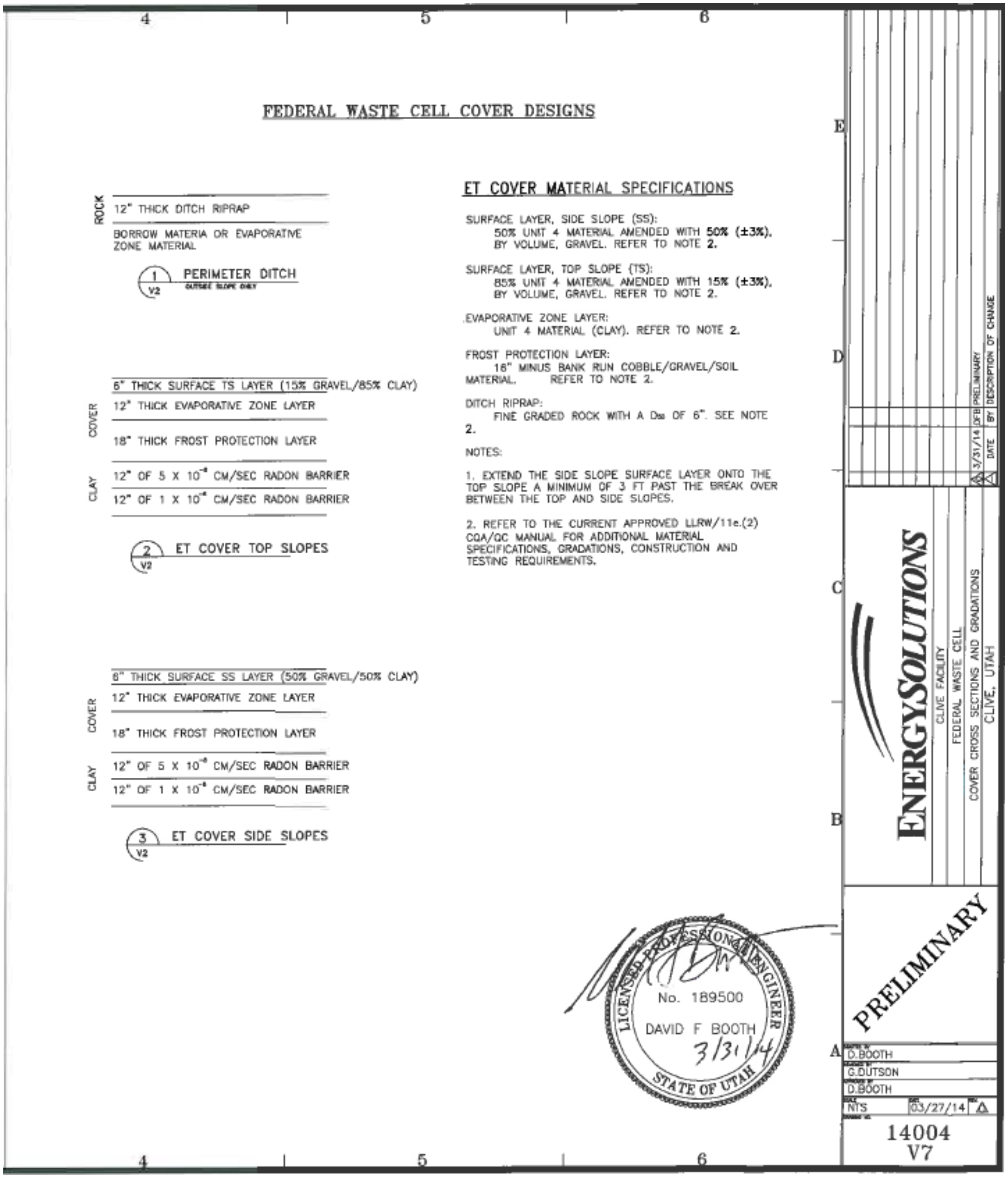

Figure 6. Federal Cell engineering drawing 14004 V7: cap dimensions. (EnergySolutions 2014a)

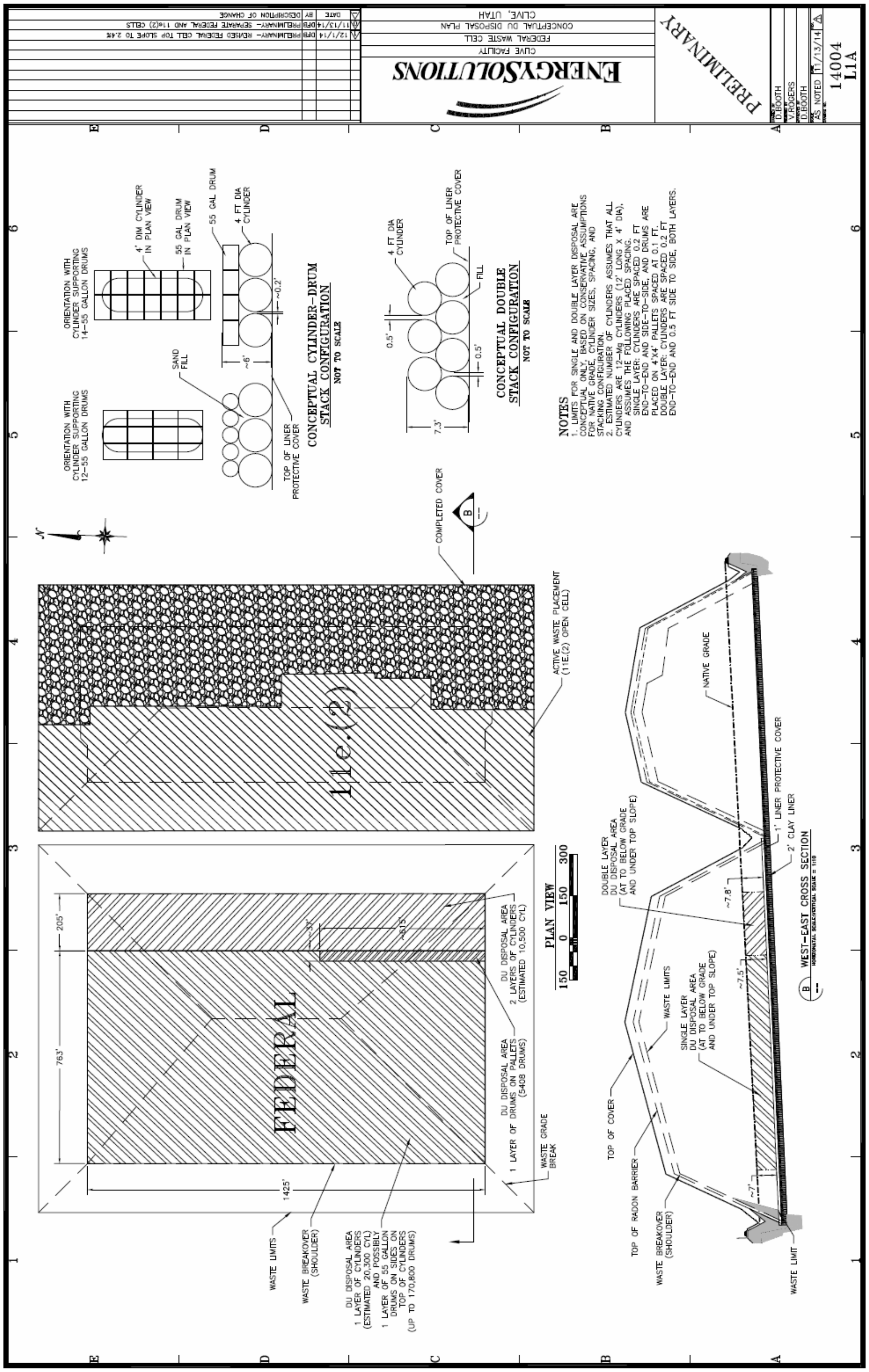

Figure 7. Federal Cell and 11e.(2) Cell engineering drawing 14004 L1A (west-east cross section) (EnergySolutions 2014b).

4.1 Federal Cell Original Grade

The elevation of the original grade is interpreted from the elevations indicated on a 1:24,000 scale quadrangle map for Aragonite, UT (USGS, 1973). The relevant section of this map as it applies to the Federal Cell is shown in Figure 8. This 1-square mile section, Section 32, is the site of the Clive Facility (Figure 8). The southwest corner of Section 32 is at elevation 4270 ft amsl (above mean sea level) while the ground surface (original grade) slopes gently and fairly uniformly up to the northeastern corner, crossing the 4280-ft amsl contour.

The Federal Cell occupies the southwestern corner of Section 32 (refer to Figure 1), and its center is approximately at an elevation of 4272 ft amsl. This is the value used for original grade of the Federal Cell.

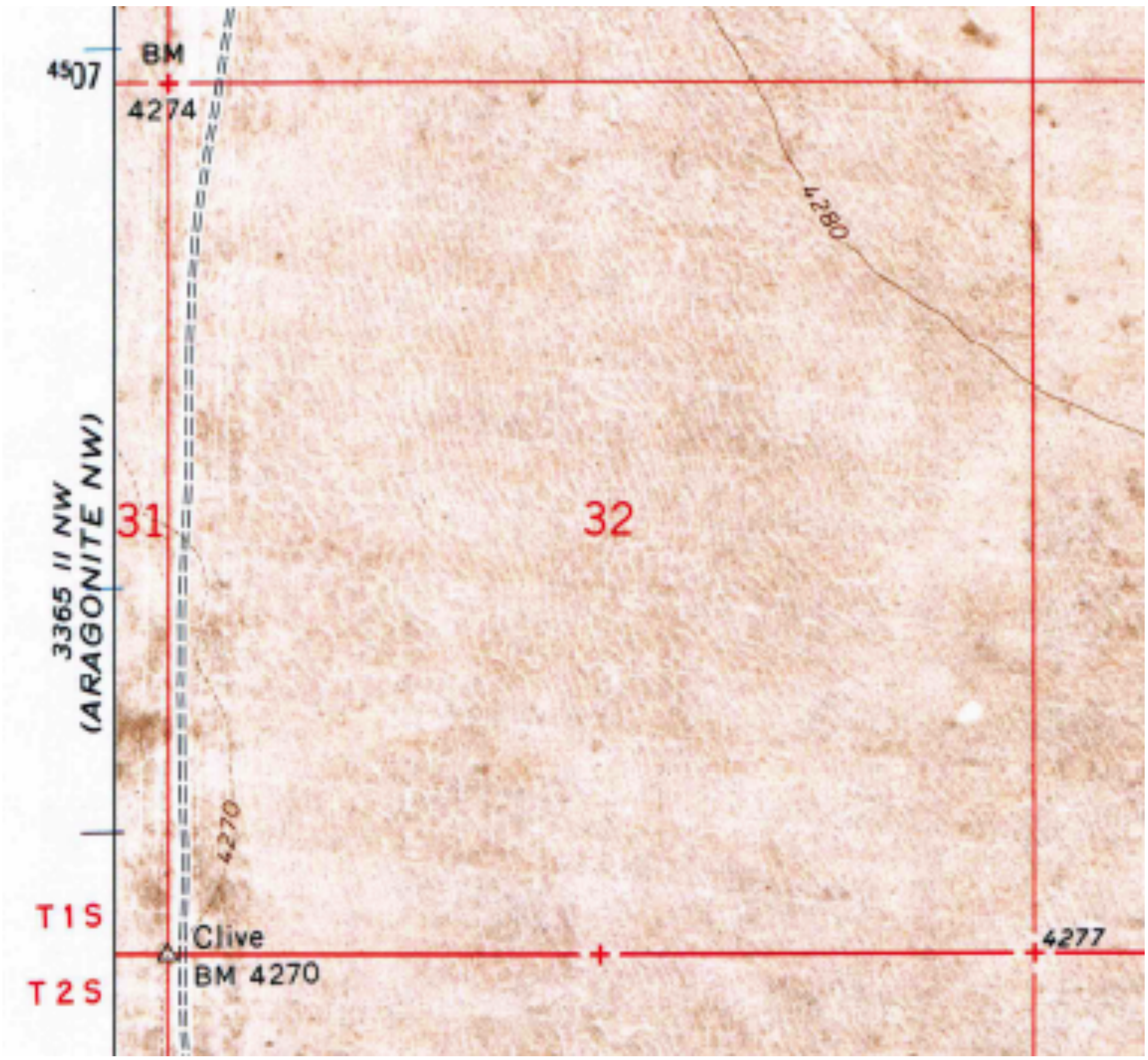

Figure 8. Section 32 within the Aragonite quadrangle, as it appeared in 1973, before construction of the Clive Facility. Note elevation contours at 4270 and 4280 ft amsl. *ARAGONITE NW* is the next quadrangle to the west.

5.0 Model Implementation using GoldSim

5.1 Representation of the Federal Cell

The representation of the Federal Cell in the Clive DU PA Model is essentially one-dimensional (1-D), and is therefore necessarily simplified. The top slope and side slope sections of the embankment are modeled as independent 1-D columns, as discussed below. The volumes of waste and the layers of engineered cap and liner are preserved. Since the cap and liner are laterally continuous and do not vary in dimension within a column, the thicknesses in the model correspond directly to thicknesses in the real world. The waste layers, however, are of a shape that changes in the horizontal, and must be rearranged to produce a shape that is a rectangular prism of equal volume to the actual waste volume.

5.1.1 Federal Cell Dimensions

The dimensions developed in Section 3.1 are documented in the Clive DU PA GoldSim model (GoldSim model) in the container \Disposal\FederalCell\Federal_Cell_Dimensions. The calculation of the waste volumes within the side slope and within the top slope, as identified in Figure 2, is performed within the Model by assembling pieces that have volumes that are easily calculated using basic geometry, as shown in Figure 9. Once the waste volumes for top and side slope are known, the average waste thicknesses are calculated. These are used as the waste thicknesses in the columns within the Model, as described in the following section.

5.1.2 Federal Cell Columns

The top slope and side slope columns are modeled in parallel, since they have different waste and cap layer thicknesses. That is, each column has only vertical flow of water. The vertical flow feeds into the unsaturated zone and thence to groundwater at the bottom. The top slope column has a much thicker waste layer than the side slope, and this is reflected in the overall thickness of the two columns. In order to capture the flexibility available in locating waste during disposal operations, the user can select which waste types go where in the top slope column, using the Waste Layering Definition dashboard. No DU wastes are to be disposed in the side slope column in this model. An example of this selection in the GoldSim model is shown in Figure 10. The waste configuration in Figure 10 is consistent with the most recent engineering drawings, locating the waste in the bottom 7 - 7.8 ft of the embankment (EnergySolutions 2014b).

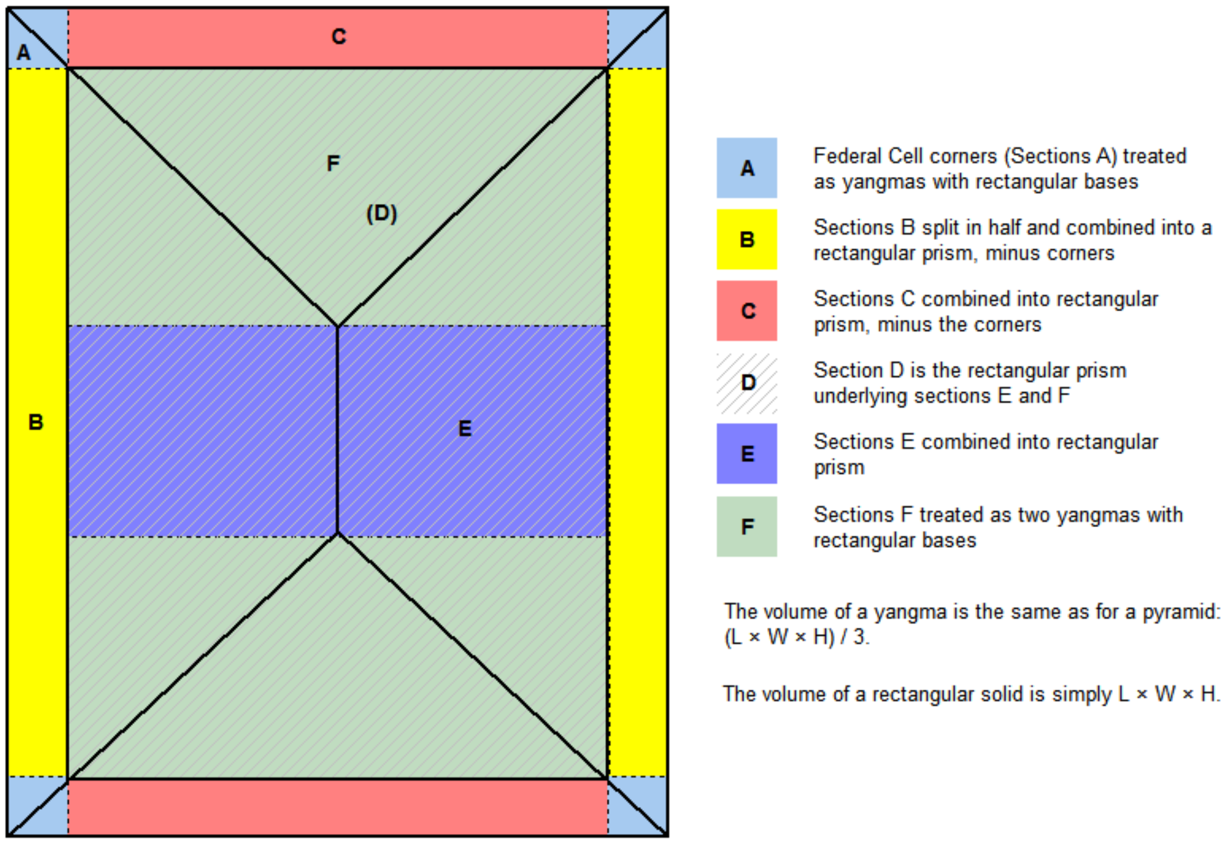

Figure 9. Geometrical deconstruction of the Federal Cell waste volumes.

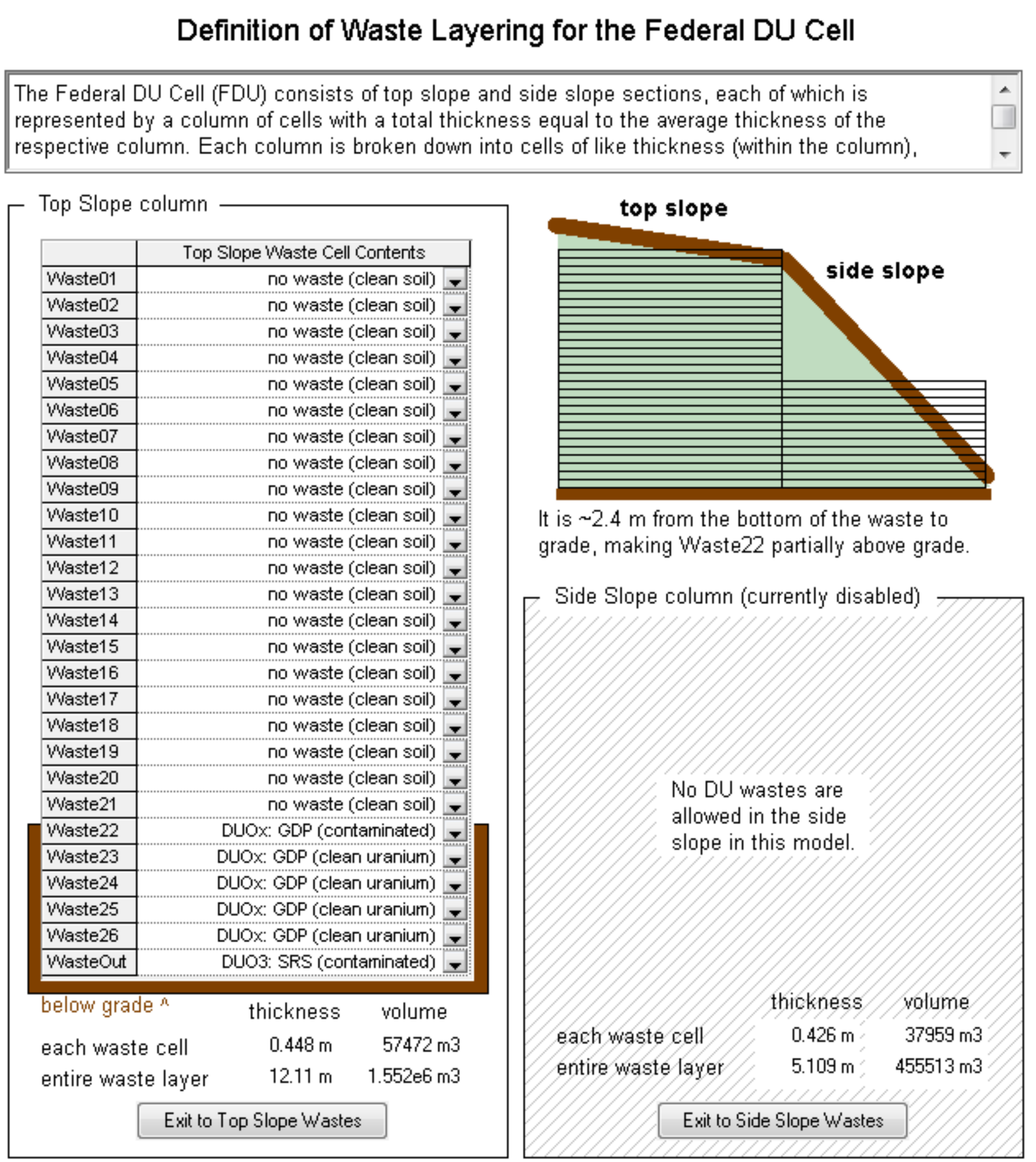

Figure 10. Waste layering definitions within the two columns of the Federal Cell.

6.0 References

Energy*Solutions*, 2009. *EnergySolutions License Amendment Request: Class A South/11e.(2) Embankment, Revision 1*, 9 June 2009 (file: Class A South-11e.(2) Eng Drawings.pdf).

Energy*Solutions*, 2014a. Engineering Drawings (file: Federal Cell drawing 14004.pdf). [Note: Three drawings in this drawing set (14004 V1, 14004 V2, and 14004 L1), are superseded for v1.4; see the three references below.]

Energy*Solutions*, 2014b. Engineering Drawing 14004 L1A, "Conceptual DU Disposal Plan", dated 11/13/2014 with revision on 12/1/2014. (file: FederalCell DUplan 14004 L1A.pdf).

Energy*Solutions*, 2014c. Engineering Drawing 14004 V1A, "Cell Layout", dated 11/06/2014 with revision on 12/1/2014. (file: FederalCell plan 14004 V1A.pdf).

Energy*Solutions*, 2014d. Engineering Drawing 14004 V3A, "Cell Cross Section – East/West", dated 11/06/2014 with revision on 12/1/2014. (file: FederalCell section 14004 V3A.pdf).

GTG (GoldSim Technology Group), 2015. *GoldSim: Monte Carlo Simulation Software for Decision and Risk Analysis*, `http://www.goldsim.com`

USGS (United States Geological Survey), 1973. 1:24,000 topographic quadrangle map for Aragonite, UT, revised 1973 (file: UT_Aragonite_1973_geo.pdf).

Utah, State of, 2015, Utah Administrative Code Rule R313-25. License Requirements for Land Disposal of Radioactive Waste - General Provisions. As in effect on September 1, 2015. (http://www.rules.utah.gov/publicat/code/r313/r313-025.htm, accessed 5 Nov 2015).