Enclosure 3

Draft Response to RAI NP-2.6-x with SAR Markups

RAI NP-2.6-1:

Clarify the origin of the circular features as identified in the red circles on Figure 2-3 below. Specifically, provide the dimensions of the features and determine whether they might represent surface deformation at the site due to subsurface dissolution resulting from past or ongoing natural processes or human activities in the site area, as mentioned in WCS CISF SAR Section 2.6.1. Also, discuss the potential for similar features to develop at the site in the future.

WCS CISF SAR Section 2.6.1 states, "near-surface regional structural controls may be locally modified by differential subsidence related to groundwater dissolution of Permian salt deposits." However, the SAR does not specify where these locally modified areas of differential subsidence are located relative to the proposed site. The NRC staff noted the history of oil and gas exploration and extraction activities in the site area and the presence of some features in SAR Figure 2-3 that are circular in shape (i.e., similar to sinkholes or swales), some of which are shallow depressions 2 to 7 feet in depth.

This information is needed to determine compliance with 10 CFR 72.103(f)(1) and 10 CFR 72.103(f)(2)(ii).

WCS Consolidated Interim Storage Facility Safety Analysis Report Revision 2

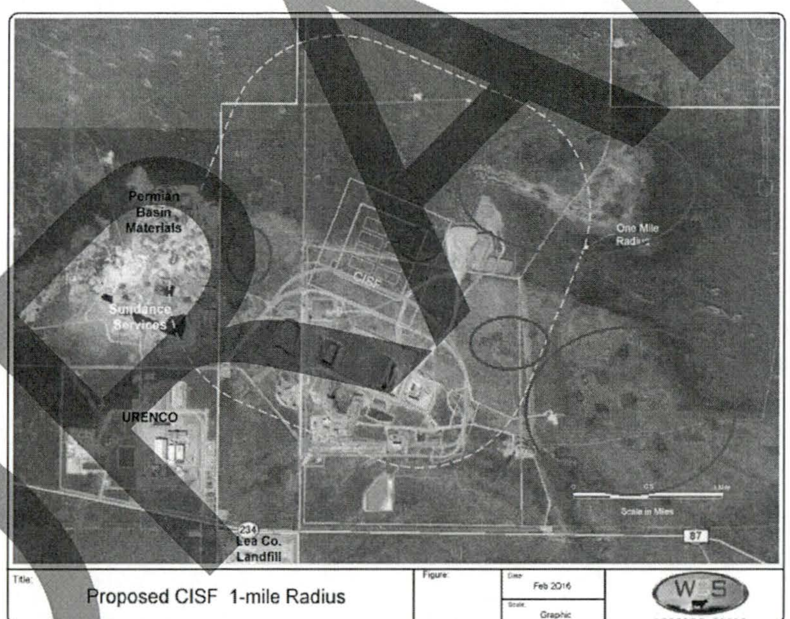

Figure 2-3
Proposed WCS CISF 1-mile Radius

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Response to RAI NP-2.6-1:

Small circular features in SAR Figure 2-3 began as small erosional depressions on the land surface. These depressions accumulated water, which variably dissolved surficial or near-surface pedogenic calcrete and carbonate. This process enlarged the depressions and accumulated sediment as the calcrete was dissolved. They are surficial and show no signs of collapse and subsidence that would indicate dissolution of the much deeper evaporite-bearing formations. Analysis of cores and geophysical logs reveal no evidence of post-depositional dissolution of evaporites that would lead to such collapse. There is no e idence that human activities initiated these depressions. These features are unrelated to oil and gas exploration and extraction activities in the site area, as discussed below. The main part of these depressions ranges from a few hundred feet to more than 1000 ft in length, and none of the localized features appear to reach a depth of 10 ft. Studies of playa fill indicate these features are thousands to tens of thousands of years old and older. There is no indication that these features will form naturally at the site of the WCS CISF in the near geological future.

Relationship of Features. The features enclosed by the red outlines in SAR Figure 2-3 all belong to the set of "oriented drainage and depressions of the Ogallala Formation" (not to be confused with the "Ogallala Aquifer," the saturated portion of the formation) as examined by Bachman (1973b [2]). Bachman (1973a [1], 1976 [3]) also refers to the features as "linear features," "aligned swales and dolines," and "aligned drainage." Nicholson and Clebsch (1961, p. 9 and p. 47 [16]) also use the term "buffalo wallows" because of an early thought that the depressions originated due to the action of buffalo.

Large areas display these features in southeastern New Mexico and locally in Texas near the boundary with New Mexico, including the Waste Control Specialists LLC site (Figure NP-2.6-2-1). The linear features and associated small depressions are most prominent along the eastern side of the Mescalero Ridge (Figure NP-2.6-2-1), smaller areas of pedogenic calcrete outcrops in New Mexico and Texas south of the Mescalero Ridge, and locally as well at Waste Control Specialists *site* LLC. Part of the aerial photo from the NAPP 1996 series (Figure NP-2.6-2-2) represents the broader extent of the features that have been outlined in red in Figure 2.3.

The alignment of the features at the Waste Control Specialists site and WCS CISF is more readily discerned in the NAPP aerial photo (Figure NP-2.6-2-2), although swales or aligned drainages are less prominent at the Waste Control Specialists site and WCS CISF than in some of the areas of southeastern New Mexico. The smaller depressions are apparently more common where pedogenic calcretes ("Mescalero caliche" or Ogallala "caprock") are at or close to the surface.

Previous Regional Investigations. Havens (1966 [7]) reviewed prior discussion of the features and directly investigated the fill of some of the depressions in northern Lea County, New Mexico (Figure NP-2.6-2-1, white circle). Havens (op. cit.) found *that* the pedogenic calcrete (Ogallala "caprock" or caliche) was variably affected. Havens discounted deep dissolution, noting (p. F7) that "Several breached depressions along Mescalero Ridge, however, have no features that would be present if irregular bedding or solution and collapse were the cause of the alinement (sic) of the depressions. Bedding appears to be horizontally continuous, and no rubble zone or recemented rubble is evident beneath the depressions."

Bachman (1973a [1], *1973*b [2]; 1976 [3]) also reviews earlier work related to these features, mainly for New Mexico. Bachman generally favors the hypothesis that the depressions and aligned swales formed between longitudinal dunes that are no longer present.

Osterkamp and Wood (1987 [18]) and Wood and Osterkamp (1987 [24]) concluded that shallow depressions or playas on the southern High Plains developed where water could collect in shallow depressions. They proposed (simplified version) that small depressions were initiated by erosion (Wood, 2002 [25]). Water, dissolved/colloidal and fine-grained/organic materials, and clays accumulated in the depression. Recharging ground water transported organics and clay into the unsaturated zone. Carbon dioxide, from oxidation of organics, dissolved in water to form carbonic acid that dissolved the pedogenic calcrete. Voids and pipes developed in the calcrete that promote further influx. Drainage areas locally were integrated. When most of the calcrete was dissolved, the sediment load began to fill the base of the depression. The playas formed by this process provide approximately 90% of the recharge to the underlying High Plains Aquifer (Wood, 2002 [25]).

In another extensive review and investigation of small playas on the southern High Plains, Holliday et al. (1996 [8]) examined the fill in several playas and also found that the predominant origin of the depressions is a combination of eolian, fluvial, and lacustrine processes unrelated to dissolution of much deeper evaporites. At known areas of evaporite dissolution in the Texas panhandle well north of the WCS CISF and Waste Control Specialists site, some playas do show gently warped fill, effects from dissolution of deeper Paleozoic evaporites and subsidence of overlying rocks. The Waste Control Specialists LLC site and the WCS CISF, however, do not show evidence of deep dissolution of evaporites, and this process is not involved in the formation of these depressions and swales (see further discussion below).

<u>Waste Control Specialists LLC Site Investigations.</u> In 2007, Texas Commission on Environmental Quality (TCEQ) requested that Waste Control Specialists LLC characterize aligned surface features at the Waste Control Specialists LLC site by excavating a trench across a feature that is north of the Compact and Federal disposal sites (*see* Figure NP-2.6-2-3 and Figure NP-2.6-2-4 below). TCEQ specified that the trench was to be examined for evidence of "v-shaped fractures" in the pedogenic calcretes as these were considered at other locations to be evidence of dissolution of underlying evaporites (see Holt and Powers, 2007a [9], p. 3). The trench location (Figure NP-2.6-2-3 and Figure NP-2.6-2-4) across the upslope end of a depression was agreed to by TCEQ and Waste Control Specialists LLC.

A large trench was dug to "refusal" by backhoe and mapped in detail by Holt and Powers (2007a [9]). Features of the upper pedogenic calcrete exposed in the trench are similar to those of the Mescalero "caliche" in southeastern New Mexico and pedogenic calcretes within the Blackwater Draw Formation. The harder rock at the base of the trench was likely the more indurated "caprock" of the Ogallala Formation.

No v-shaped fractures were observed in the trench (Holt and Powers, 2007a [9]), and this was agreed to by TCEQ during a trench visit at the conclusion of mapping. There is no evidence that the depressions and aligned drainage at the site were caused by dissolution of underlying evaporites. "Calcrete units exposed within the trench show varying degrees of dissolution, erosion, and redistribution of carbonate. Three generations of sediment-filled solution pipes and macropores formed during and following the development of the calcic soils exposed in the trench. Relationships between calcic soils, sediment-filled pipes and macropores, and surficial soils indicate that the lineament has been a topographic low since these calcic soils began to accumulate" (Holt and Powers, 2007a [9], p. 15). These observations are consistent with other work showing retrograde or altered pedogenic calcretes (e.g., Havens, 1966 [7]; Powers, 1993 [19]; Holliday et al., 1996 [8]; Osterkamp and Wood, 1987 [18]), and they are consistent with the origins and processes described in these studies.

Two other studies, not specific to these depressions and lineations, were investigated at the Waste Control Specialists site and area for evidence of dissolution of underlying evaporites. These are reviewed in greater detail in the responses below to the second paragraph comment in RAI 2.6-1.

Holt and Powers (2007b [10]) evaluated the evidence for dissolution across the site and for selected areas along Monument Draw (New Mexico) and Mescalero Ridge (New Mexico). Stratigraphic units of the Rustler and Salado continue across the site without evidence of collapse or depressions related to dissolution. Some general thinning does occur as a part of deposition, but it is not oriented with respect to structure of overlying beds. In a peer-reviewed journal article, Holt and Powers (2010 [11]) published much of the information and conclusions included in Holt and Powers (2007b [10]).

A specific location near the southwest corner of the Waste Control Specialists property was chosen to look for evidence of dissolution of the Rustler or upper Salado by taking continuous core from lower Dockum Group (Santa Rosa Formation) across the Rustler and into the upper Salado (Blainey et al., 2009 [4]; see discussion in next section for additional details). The interval thicknesses in the borehole (CP-975) are consistent with the regional evaluation (Holt and Powers, 2007b [10], 2010 [11]), and beds overlying beds with salt and without salt do not show fracturing consistent with dissolution and subsidence.

The topography on the erosional surface at the top of the red beds (top of Dockum Group rocks) at Waste Control Specialists LLC (Blainey et al., 2009 [4]) does not show deviations that indicate subsidence due to dissolution of the underlying evaporites and collapse of the overlying beds.

The general expression of the erosional Dockum surface and mapping in different excavations at the site are also consistent with the observations that these depressions and aligned features do not reflect deep-seated processes such as dissolution of evaporites.

Mapping and photography of excavations at the Federal and Compact facilities do not reveal any lowering of the top of Dockum surface that is related to dissolution of evaporites at depth. TCEQ required in the license that "fractures and other structural features" would be mapped in both excavations (Holt et al., 2011 [12]). Near-vertical faces at approximately right angles were mapped at deeper intervals as excavations of these two landfill sites proceeded. TCEQ observed most activities.

The mapping in both excavations showed laterally extensive lithologic beds that could also be grouped vertically as depostional units. Various sedimentary features were observed that included bedding, bioturbation, and desiccation cracks. Pedogenic features were common. Arcuate to hummocky slicken-sided surfaces were large and well developed. These were interpreted as gilgai (Holt et al., 2011 [12], p. 5). Analysis of mapping data (e.g., stereonets of discontinuity orientations) indicated no preferred orientation. The discontinuities formed in response to local stress fields and not due to larger or regional structural processes. Similar features had been observed while mapping the by-product landfill (Kuszmaul et al., 2010 [13]). No features indicating collapse, which could be related to dissolution of underlying evaporites, were observed.

Dimensions of Depressions. Most of the small depressions shown before and after construction at the Waste Control Specialists site are generally somewhat circular in shape, with a longer dimension of a few hundred feet. The depression where the trench was mapped (Holt and Powers, 2007a [9]) appears ≈1470 ft in longest dimension between closed contours at 2-ft intervals (Figure NP-2.6-2-4). The depth is between 6 and 8 ft, although this depression is part of a larger area of closed contours. Vegetative changes in a recent Google Earth image (Figure NP-2.6-2-4) show a long dimension of ≈630 ft, while Olig et al. (2007 [17]) expressed the longest dimension as 1,050 ft.

Three additional depressions east of the compact facility were examined based on contours and vegetative changes (Figure NP-2.6-2-5). These depressions are within the large red oval in the lower right part of SAR Figure 2-3. The smallest shows long dimension of 372 ft and 312 ft (between closed 2-ft contours and based on vegetative changes, respectively), and the longer depression is estimated to have long dimensions of 1430 ft and 610 ft by these two methods. Based on closed contours, the depths of these three depressions range from ≈2 ft to ≈6-8 ft.

The larger circled area in the northeastern part of Waste Control Specialists property (SAR Figure 2-3) has a series of interconnected depressions and the southeastern depression in this circled area has longer dimensions of 600-800 ft based on vegetative changes in Google Earth images. The 2-ft contour map does not cover this area.

These dimensions are generally consistent with the lower end of size ranges estimated by Havens (1966 [7]). The playas in the southern High Plains examined by Holliday et al. (1996 [8]) range from about this size to much larger. Depths are variable. For the smaller depressions, depths may be a few feet.

Potential to Form New Depressions (and Linear Swales). The evidence compiled by Holliday et al (1996 [8]) indicates that most of the small playas have existed for thousands of years or longer. Olig et al. (2007 [17]) examined the age of sand in mainly eolian sediments at Waste Control Specialists property and found that sand in drainage systems had similar ages to those found by Holliday, with a period of wind erosion between 30,000 and 50,000 years ago. The depressions and aligned drainage may have existed for tens of thousands of years or longer. Overall, there has been general stability to the surfaces at the Waste Control Specialists site and WCS CISF for long periods of time.

The evidence is that these depressions and aligned drainages were formed by surficial processes. There is no evidence consistent with an origin due to dissolution of the underlying salt, a process that might mask the development of a sinkhole until the near-surface materials collapse. There is, therefore, no expectation that these depressions will develop at the site selected for interim storage.

The small depressions at the Waste Control Specialists site are surficial in origin. Geophysical log analysis and continuous core in CP-975 through the Dewey Lake Formation and into the upper Salado Formation show no evidence of thinning of salt beds or fracturing consistent with post-depositional dissolution of the evaporites at the site. Trench and excavation mapping at the Waste Control Specialists site reveal no collapse or subsided sections that would be consistent with dissolution of the underlying evaporites. Major regional subsidence features (San Simon Sink and Monument Draw trough) are clearly related to dissolution of the underlying evaporites. San Simon Sink is ≈23 miles west-southwest of the Waste Control Specialists site, and Monument Draw trough trends south-southeast from near the south rn end of San Simon Sink.

Three of four drillholes within a 1-mile radius of the WCS CISF that penetrate through the evaporites have documents showing plug and abandon actions. The fourth is classified as a dry hole, but public records are not available regarding its status. It is >3000 ft from the outer boundary of the WCS CISF. A fifth drillhole (an active oil well) is within the Waste Control Specialists property but outside the 1-mile radius of the WCS CISF. Th closest wells have been plugged and abandoned.

Three sinkholes in the region developed around drillholes used for brine mining. There are no brine wells within the 1-mile radius of the WCS CISF. Three recent sinkholes in the region are associated with drillholes overlying the Capitan *R*eef, a major aquifer; the drillholes are all believed to have permitted circulation of Capitan water that dissolved salt and led to collapse. Maximum surface diameter of any of these sinkholes is ≈900 ft (Wink #2). The Capitan is not present at the Waste Control Specialists site and the WCS CISF. Oil and gas wells within the 1 mile radius of the WCS CISF have recorded plugging actions and should present no threat to the WCS CISF.

Regional Structure and Dissolution. Holt and Powers (2007b [10]*)* investigated the Waste Control Specialists site and surrounding region for evidence of dissolution of the evaporite section. Cross-sections of the site area, using geophysical logs from oil and gas wells, showed continuity of the evaporites, no thinning related to dissolution, and a modest anticline on the Rustler Formation and deeper units. The structure displayed by these formations is not mirrored by the trends in thickness. There is no evidence of deep dissolution within the halite section in the vicinity of the Waste Control Specialists site and WCS CISF. The small depressions noted in SAR Figure 2-3 are unrelated to dissolution of underlying evaporites (see discussion above).

In addition, Holt and Powers (2007b *[10]*) noted that deeply buried halite has internal fluid pressure that approaches lithostatic, meaning that the hydraulic gradient is generally outward from the salt beds rather than inward. The plastic nature of salt also tends to absorb strain and heal local fracturing. Thus, dissolution within the bedded halite is difficult under natural conditions.

The main results of the study by Holt and Powers (2007b [10]*)* were published in a peer-reviewed journal as Holt and Powers (2010 [11]*)*.

The Texas Commission on Environmental Quality (TCEQ) required Waste Control Specialists to ". . . verify that salt dissolution will not impact the land disposal facility by placing one (1) boring and collecting core samples near the proposed land disposal facility from the lower part of Dockum formation group and into the salt-bearing section of the Salado Formation" (see Powers, 2008 [21]). TCEQ reviewers found that geophysical logs from the Lockhart Federal No. 1 well (API# 30-025-12112; 660 fnl, 660 fel, section 5, T22S, R38E; well is in New Mexico) were not sufficiently reliable to determine whether dissolution affected this area southwest of the Waste Control Specialists site. The borehole was plugged and abandoned.

It was agreed that a borehole near the southwest corner of the Waste Control Specialists site (in New Mexico, near southwest corner of section 33, T21S, R38E) would provide a test of dissolution in the area of the Waste Control Specialists site (Powers, 2008 [21]), supplementing the regional study. CP-975 was drilled and cored to determine if beds of the Rustler or overlying Dewey Lake Formation showed evidence of dissolution and subsidence. Neither Dewey Lake nor Rustler beds exhibited fracturing or other evidence of post-depositional dissolution (Powers, 2008 [21]). Cores of the upper Rustler member (Forty-niner) were of particular interest as anhydrite overlying the uppermost halite was unfractured.

Holt and Powers (2007b [10], 2010 [11]) described some of the known large features where dissolution has affected structure. San Simon Sink is about 23 miles west-southwest of WCS CISF (Figure NP-2.6-2-6). Nicholson and Clebsch (1961 [16]) describe it in some detail. San Simon Sink is a more localized feature within the larger San Simon Swale. A corehole near the center of San Simon Sink (WIPP 15) found about 547 ft of "fill" before encountering red beds of the Dockum (Sandia National Laboratories and University of New Mexico, 1981 [23]). Solution along the front of the Capitan Reef has removed salt, causing subsidence and collapse. Alluvial fill displays annular rings due to continuing subsidence, including an event in the early 20th century (Nicholson and Clebsch, 1961 [16], p. 14).

Nicholson and Clebsch (1961 [16]) and Bachman (1973b [2]) also reported thick alluvial fill (Figure NP-2.6-2-6) to the south of San Simon Sink in a narrow zone that is adjacent to the Capitan Reef. This large feature is often referred to as the Monument Draw trough; south of the southern border of New Mexico with Texas, Monument Draw swings west and then follows the trend of the trough as far as the Pecos River. Ewing et al. (2012 [6]) provided a map of elevation of the top of the Rustler (Figure NP-2.6-2-7) revealing that this is a major buried feature that continues well into Texas. San Simon Sink and Swale lie near the northern end of this mapped feature. The nearest approach to the WCS CISF is approximately the same distance as San Simon Sink.

As noted in the earlier review, regional to local studies do not indicate structural modifications of the Waste Control Specialists site geology related to dissolution of evaporites underlying the site, and there is no indication these processes will affect the proposed WCS CISF location. Major regional dissolution features along the front of the Capitan Reef in New Mexico are at distances of more than 20 miles.

Oil and Gas Related Activity (Wells). Six such wells exist within the 1-mile radius of the WCS CISF (Figure NP-2.6-2-8). A producing oil well (42-003-01811) on the Waste Control Specialists site is outside this radius. The two wells in New Mexico have been plugged and abandoned according to on-line records of the Oil Conservation Division (OCD) of the New Mexico Energy, Minerals, and Natural Resources Department. Texas Railroad Commission (RRC) online records for 42-003-37908 indicate this was a dry hole, and it was plugged and abandoned 05/06/2006. Well 43-003-11054 was plugged and abandoned 03/22/1995. Well 42-003-01812 was plugged and abandoned by Waste Control Specialists (Powers, 2010 [22]) under agreement with TCEQ and witnessed by a representative of the RRC. Online RRC records for 42-003-05031 only list this well as a dry hole. Archived records were obtained by ISP from the RRC for Well 42-003-05031. These records show that the well (aka Charls D. Sands Humble-Sims #1) was plugged on January 29, 1960.

Since 1980, there have been six collapses and surface sinkholes associated with wells in the region (see review by Land, 2013 [15]). Three of these (Denver City sink, Yoakum County, TX; JWS, Eddy County, NM; and Loco Hills sinkhole, Eddy County, NM) are associated with brine mining operations. There are no brine-mining wells at or within the 1-mile radius of the WCS CISF.

Three sinkholes (Jal sinkhole, Lea County, NM; Wink sinks #1 and #2, Winkler County, TX) are associated with industrial wells overlying the Capitan Reef aquifer. The casing and cement in these wells are believed to have allowed Capitan water to circulate, dissolve Permian salt, and create a cavity that collapsed to the surface (Powers, 2003 [20]; Johnson et al., 2003 [14]; Baumgardner et al., 1982 [5]). The maximum width of the largest of these sinks (Wink #2) is ≈900 ft.

The nearest sinkhole associated with a drillhole is Jal sinkhole, ≈20 miles southwest of the WCS CISF. The adjacent water supply well (unused) into the Capitan aquifer was not cemented behind the casing through much of the evaporite section (Powers, 2003 [20]). The casing was damaged, apparently allowing water to circulate into the annulus, dissolving salt and creating a cavity which collapsed. The surface diameter of this sinkhole is approximately 150 ft.

Potential of Oil *and* Gas Wells to Form New Depressions of Sinkholes at CISF. Existing surficial depressions noted in the NRC comment are naturally occurring features unrelated to natural dissolution of deeper evaporites or creation of sinkholes around drillholes.

The Capitan Reef, a common feature to the local collapses not due to brine mining, does not exist at the Waste Control Specialists LLC facilities or WCS CISF site. All oil and gas wells *and* drillholes within a 1-mile radius of the WCS CISF have been plugged according to RRC records and should not be subject to collapse.

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Impact:

SAR Sections 2.6.1 and 2.8 have been revised as described in the response.

Changed SAR pages included after RAI NP-2.6-2 response.

Figure NP-2.6-2-1

Google Earth composite photo of part of southeastern New Mexico and adjoining Texas displaying linear features trending *approximately* NW-SE as well as depressions (especially northwestern portion of photo). The location of the WCS CISF is indicated (lower right) by a white arrow. Three narrow red arrows indicate the escarpment call*ed* the Mescalero Ridge. The white circle near Lovington identifies the general area where Havens (1966 [7]*)* investigated fill of shallow depressions.

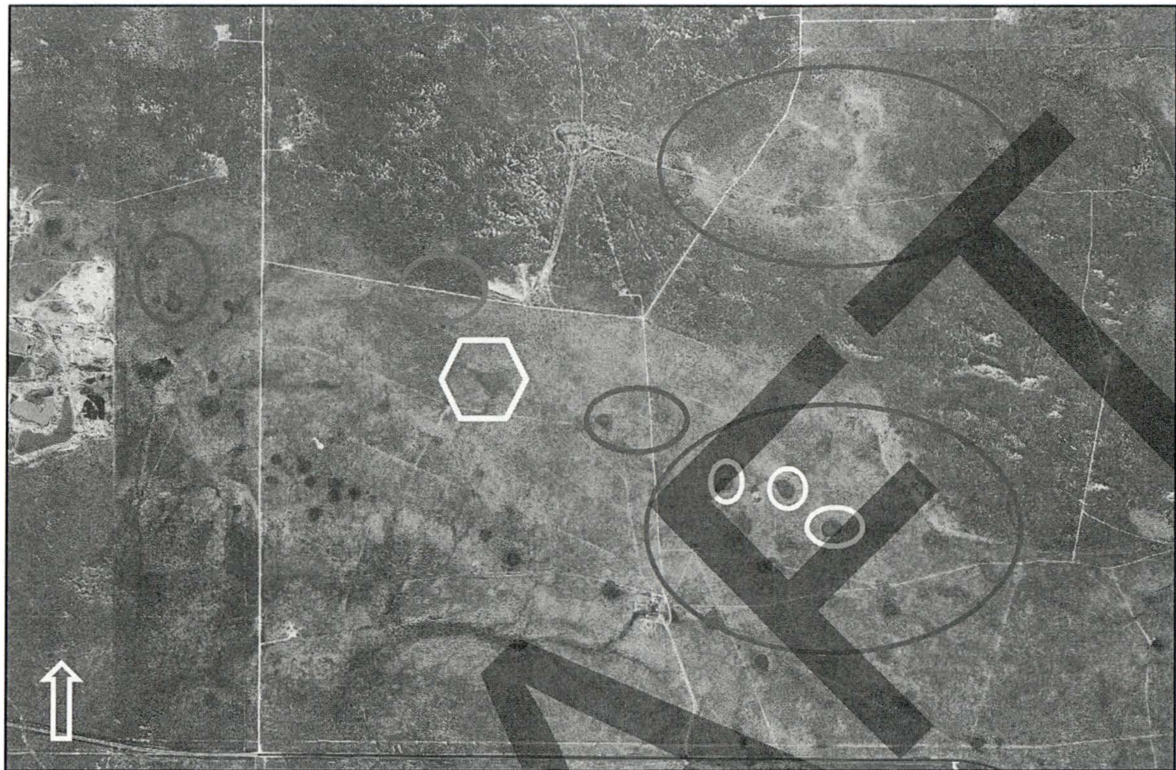

Figure NP-2.6-2-2

Portion of NAPP 1996 aerial photo of Waste Control Specialists site prior to construction, Rotated 4 degrees clockwise. Colored outlines approximate those shown in the figure accompanying the RAI text. The white hexagon outlines a small depression and lineament investigated by a trench (see Figure NP-2.6-2-3 below). The three smaller white ovals identify three depressions in Figure NP-2.6-2-5 where dimensions were determined. White outline arrow in lower left indicates north.

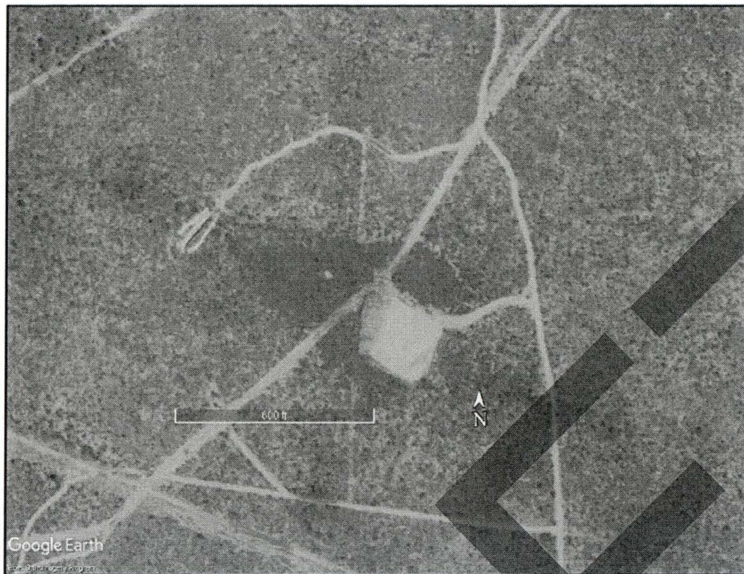

Figure NP-2.6-2-3

Location of trench study (white arrow) by Holt and Powers (2007a [9]) showing that the lineament and edge of depression is not formed in response to dissolution of underlying evaporites. See Figure NP-2.6-2-2 for white hexagon showing location of this study.

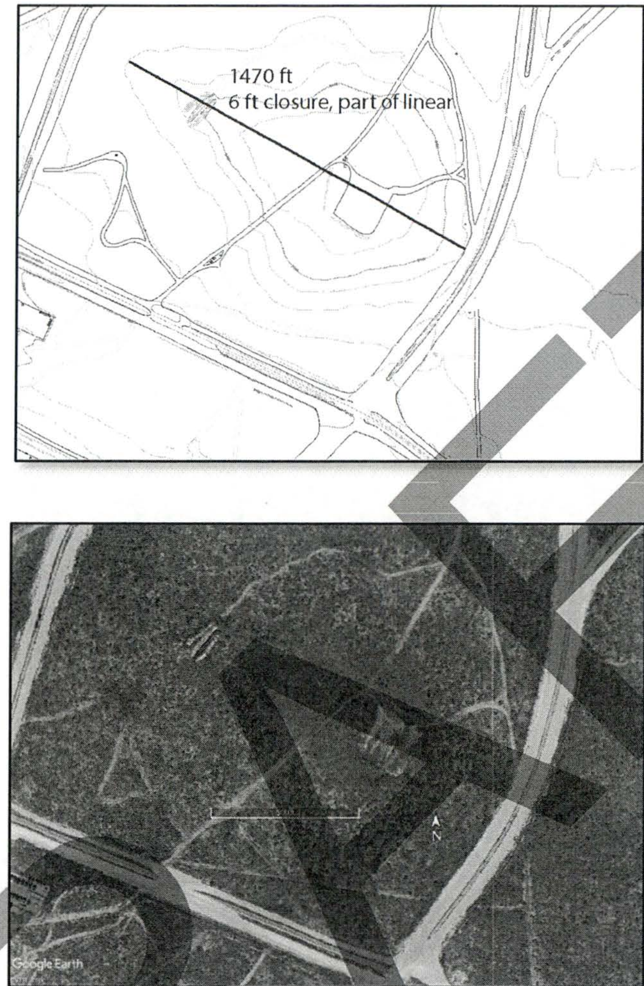

Figure NP-2.6-2-4

Top is topographic map with 2 ft contours with closure of 6+ ft. Additional closed contours to lower right and upper left show that the main depression is within a larger, more linear depression. The long length between contours is ≈1470 ft long. The lower Google Earth image from November 2017 shows a more intensely vegetated area with long dimension ≈630 ft (red line). Aerial photos mainly reflect vegetation changes, with the more intense vegetation (commonly mesquite) concentrated in the deeper part of the depression. This depression is also noted in Figure NP-2.6-2-2 and Figure NP-2.6-2-3, and the trench to investigate origins of the linear feature and depression (Holt and Powers, 2007a [9]) is clearly displayed in the contours and photos.

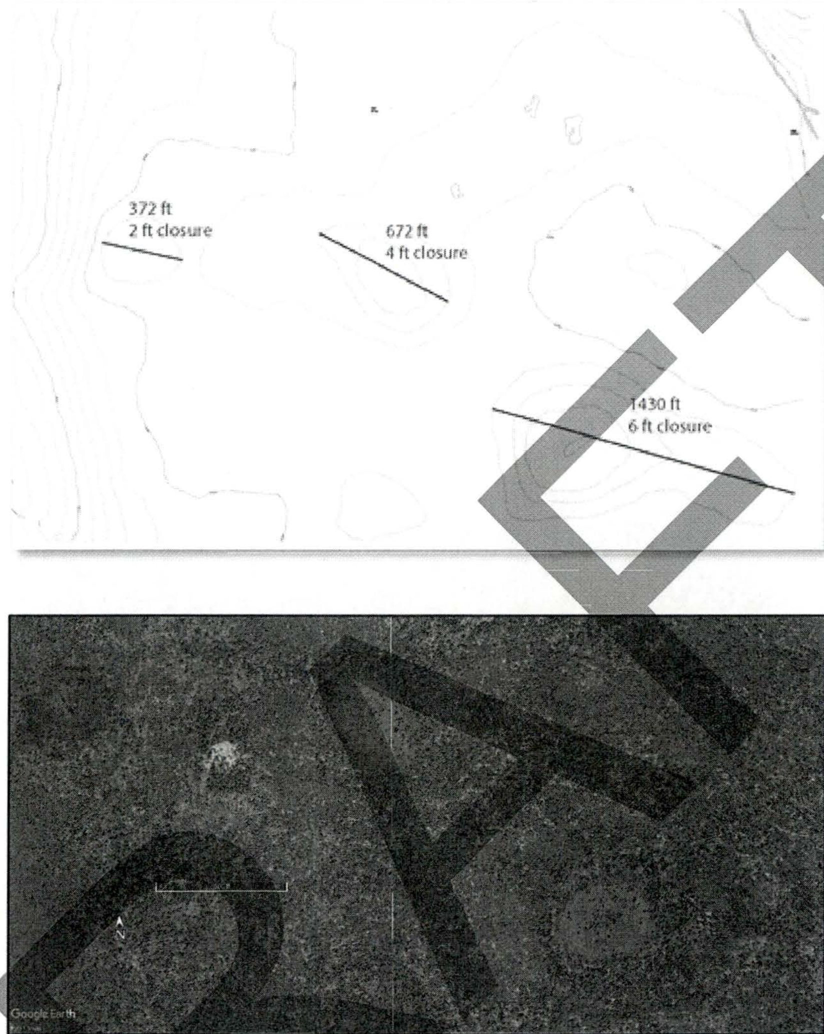

Figure NP-2.6-2-5

Top is topographic map with 2 ft contours with closure of 2+ to 6+ ft on *three* smaller depressions. Additional closed contours to lower right and upper left show that the main depression is within a larger, more linear depression. The long lengths estimated between contours in the upper illustration range from 372 to 1430 ft. The lower Google Earth image from November 2017 of these depressions shows a more intensely vegetated area with long dimensions (red lines) ≈312, 452, and 610 ft, left to right. Aerial photos mainly reflect vegetation changes, with the more intense vegetation (commonly mesquite) concentrated in the deeper part of the depression.

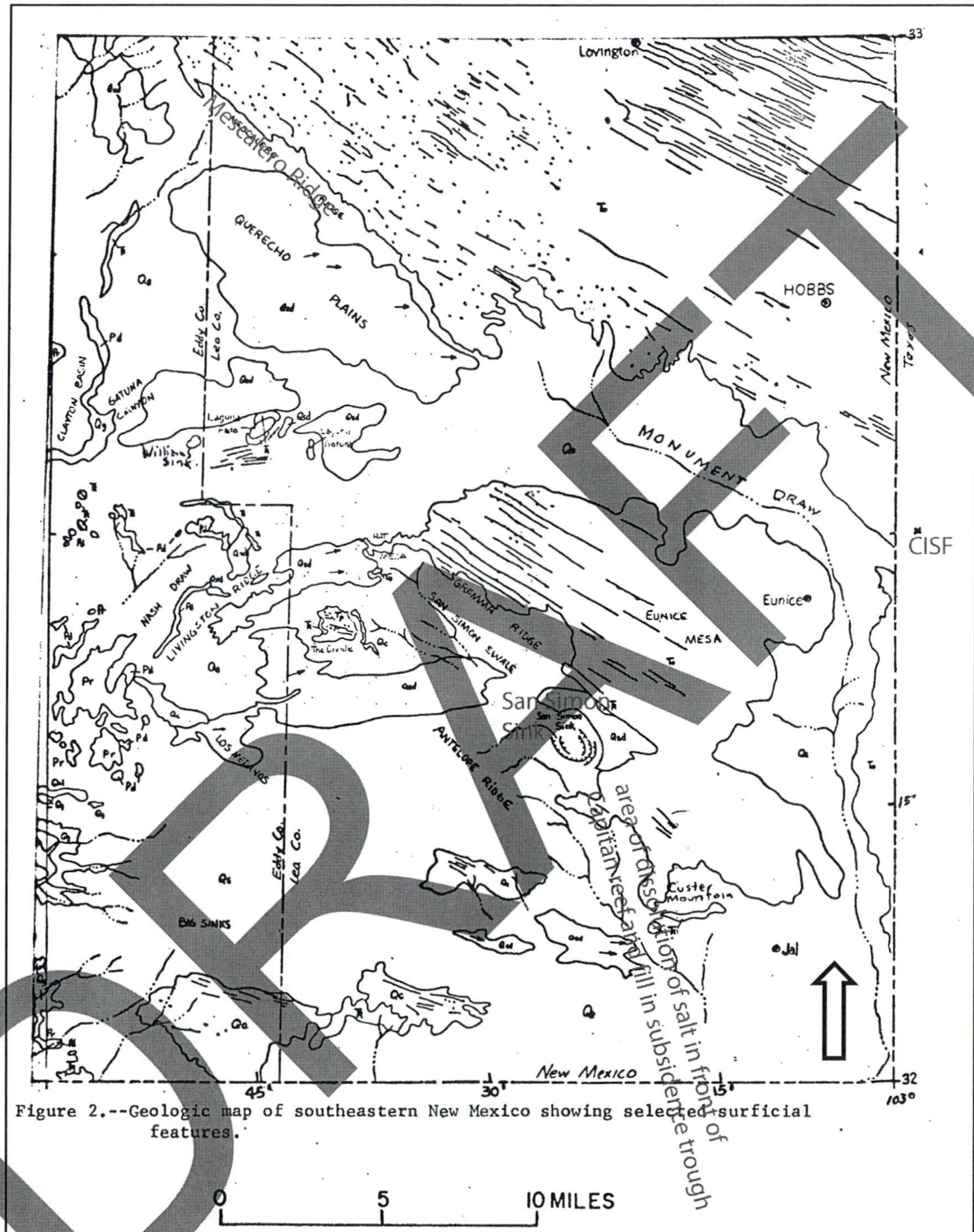

Figure 2.--Geologic map of southeastern New Mexico showing selected surficial features.

Figure NP-2.6-2-6

Figure 2 from Bachman (1973b [2]) emphasizes the relationship of major salt dissolution features nearest the WCS CISF. See Figure NP-2.6-2-7 for structure (elevation) of the top of Rustler along the front of the Capitan *Reef*. Outline arrow in lower right indicates north.

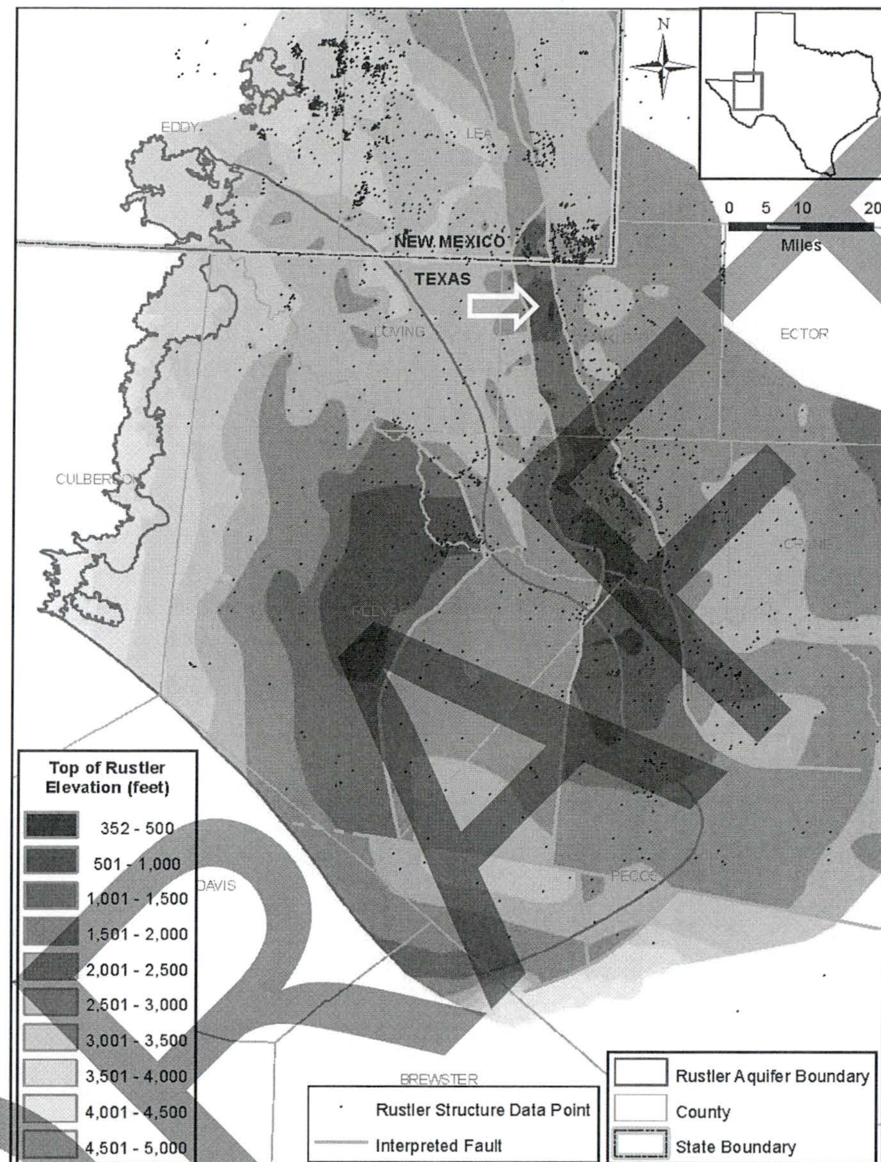

Figure 4.2.3 Interpolated elevation (in feet above mean sea level) of the top of the Rustler Formation.

Figure NP-2.6-2-7

Color-coded map of the elevation of *the* top of Rustler (Ewing et al., 2012 [6]) showing the elongate NNW-SSE depression (arrow) of the Rustler along the front of the Capitan *R*eef. This feature has also been called the Monument Draw (NM) trough. Solution of halite from the late Permian evaporite formations is the cause of this modification of the regional structure.

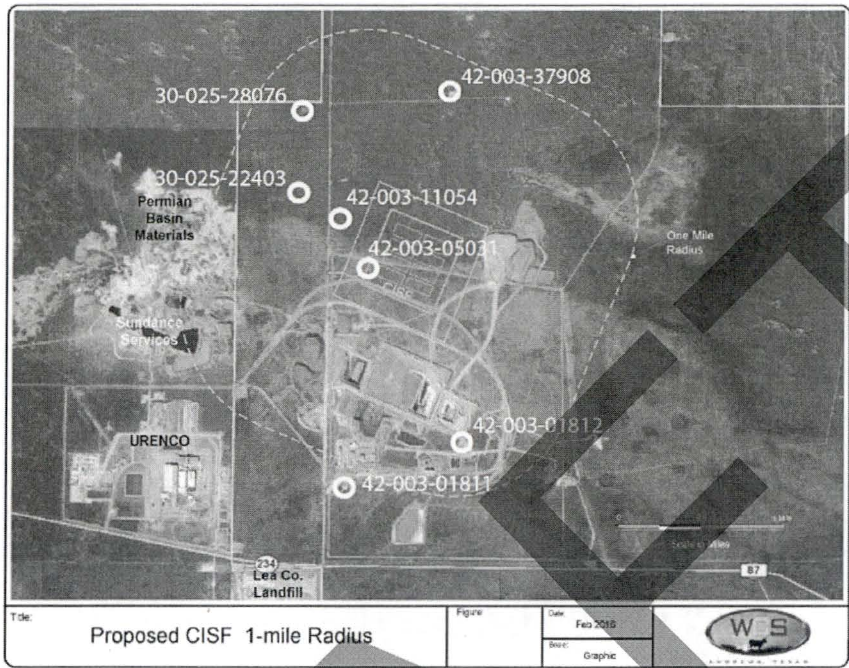

Figure 2-3
Proposed WCS CISF 1-mile Radius

Figure NP-2.6-2-8

Figure NP-2.6-2-2-3 from the SAR with approximate positions of six oil and gas wells within the 1-mile radius of the WCS CISF and an active well (42-003-01811) outside the 1-mile radius. The two wells in NM and 42-003-01812 have been plugged and abandoned (Powers, 2010 [22]). There are no on-line records at Texas Railroad Commission for 42-003-05031. The PI/Dwights scout ticket for this well listed the status in 2004 as "D&A-O" (Attachment 6-1 to Appendix 2.6.1 of Section 2.0 of the Low-Level Radioactive Waste Application). The records on-line at Texas Railroad Commission show 42-003-37908 and 42-003-11054 as plugged. 11054 appears to be mislocated by lat*itude and* long*itude* by the RRC. Descriptions of this well place it at the red circle.

RAI NP-2.6-2:

Describe the origin and extent of the red-bed ridge mentioned in Attachment F, including: the relationship of the ridge to structures such as the inferred anticline and Mescalero Ridge escarpment described in Attachment F, or other local and regional geologic structures, including folds, faults of lineaments. Provide a figure showing the location of the red bed ridge relative to the WCS site. Provide an estimate of the depth to the crest and flanks of the red bed ridge and the estimated slope gradient from the crest to the flanks of the red-bed ridge at the WCS site, including a geotechnical stability analysis, if appropriate.

WCS CISF SAR Section 2.6.1 does not discuss the red-bed ridge, its origin or extent at the site, or its potential association with local and regional geologic structures or features. Attachment F to SAR Chapter 2 also notes that the red-bed ridge is parallel to regional escarpments, including the Mescalero Ridge in New Mexico. Attachment F concludes that the red-bed ridge is not the result of halite dissolution, but a "structural high exists in the southwestern part of the site area and is likely the eastern limb of a north-northwest trending anticline;" the anticline "appears to coincide with the red-bed ridge." Previous site investigation reports from April 2000 (ML041910475) and February 2004 (ML041910489) describe the red-bed ridge as a paleotopographic divide between the Ogallala Aquifer and the Cenozoic basin fill aquifer or as a subsurface structure associated with a regional lineament that developed along the preferred jointing direction (300-310°). The NRC staff noted that based on boring logs from the monitoring wells, the slope gradient of the top of red-beds beneath the site may be as high as 5 percent, while the February 2004 report notes that the slope gradient may vary between 0.6 and 6.2 percent.

This information is needed to determine compliance with 10 CFR 72.103(f)(1).

Response to RAI NP-2.6-2:

The red bed ridge is an expression of the top of the Triassic Dockum Group. The ridge is buried beneath the late Tertiary caprock caliche, which developed on all pre-Quaternary formations on the southern High Plains. Beneath the caprock caliche is the remnant Cretaceous Antlers Formation, which is not observed in bore holes at the WCS CISF, and the Quaternary alluvial and windblown sands of the Ogallala, Gatuña, and Blackwater Draw Formations, which are in turn covered by 10 to 20 feet of recent windblown sand. Waste Control Specialists site and WCS CISF site investigations have followed the convention suggested by Hawley (1993 [7]) to refer to the late Tertiary to Quaternary formations south of the red bed ridge as Gatuña and those north of the ridge as Ogallala. As a consequence, Gatuña is not present at the WCS CISF site. The depth to the top of red beds at the WCS CISF is approximately 50 to 80 feet, based on the logs of borings shown on Figures 2-15, 2-16, and 2-17 of the SAR. The northward slope gradient of the top of the red beds across the WCS CISF ranges from approximately 0.98% (based on red bed elevations between TP-64 (3435 ft msl) and PZ-46 (3414 ft msl)) and 0.84% (based on red bed elevations between TP-65 (3437 ft msl) and PZ-47 (3414 ft msl)). At the CISF the maximum apparent slope on the late Pliocene erosional surface of the red beds is 1.77%, between TP-84 (3432 ft msl) and PZ-36 (3419 ft msl).

In the immediate vicinity of the Waste Control Specialists facilities, the axis of the red bed ridge occurs from approximately the northwest corner of the *b*yproduct landfill to the southeast corner of the Compact Facility, continuing southeastward beyond the Waste Control Specialists landfills (Figure 1). The axis is not located under the WCS CISF area. The nearest location of the crest of the buried ridge to the WCS CISF is approximately 1200 ft south along State Line Road. At this location the depth to the crest of the red beds is about 34 ft, based on the log of boring B-1 in Figure 5-4 from WCS (2007 [11]*)*. In this response*,* the elevations of the top of red beds are estimated from Figures 2-16 and 2-17 in the SAR, with locations estimated from *SAR* Figures 2-15 and 2-35.

The red bed ridge is the position of a drainage divide that has separated two major fluvial systems throughout late Cenozoic time (Hawley, 1993 [7]; Fallin, 1988 [3]). This area was uplifted at the start of the Laramide Orogeny when the Cretaceous seas retreated. From the late Paleocene to near the end of the Pliocene*,* the area was subject to erosion, removing most of the Cretaceous deposits. The relatively resistant limestones over the partially silicified Cretaceous Antlers Formation on the crest of the ridge may have effectively capped the red bed ridge, maintaining the ridge as a mesa or inter-drainage high. The axis of the red bed ridge remains coincident today with a local topographic high, between Monument Draw Texas, which drains to the Colorado River, and Monument Draw New Mexico*,* which drains to the Pecos River. In Andrews County*,* the buried red bed ridge plunges to the south-southeast at about 8 to 10 feet per mile, similar to the surface topography, and the crest of the surface water drainage divide is virtually coincident with the crest of the underlying red bed ridge.

The low-relief ridge is structurally stable, not subject to mass wasting, and buried beneath the erosion-resistant caprock caliche, which is in turn covered by windblown sands in dune fields partially stabilized by Chihuahua desert vegetative cover of shinnery oak, creosote, mesquite*,* and native grasses. As the ridge is buried, stable*,* and not subject to slope erosion or mass wasting, a geotechnical stability analysis is not warranted. The ridge extends for approximately 100 miles, from northern Lea County to Winkler and Ector counties, demonstrating that it is not a local phenomenon.

The origin of the ridge is considered erosional, with possible coincidental structural elements. Holt and Powers (2007 [8], submitted as Attachment F to the WCS CISF SAR) demonstrates that deep-seated structural deformation has folded the late Permian sediments beneath the Waste Control Specialists site and WCS CISF area, with fold axes trending northwest, subparallel to the regional structural grain and preferred jointing direction noted in ML041910475 (Lehmann and Rainwater, 2000 [9]) and ML041910489 (WCS, 2007 [11]). The preferred northwest jointing direction is also reflected in the alignment of lineaments and playas observed in aerial photographs and on the Hobbs, Big Spring*,* and Pecos maps of the Geologic Atlas of Texas (Hobbs,1976 [4]; Big Spring, 1974 [5]; and Pecos, 1975 [6]). The anticlinal structures with northwest trending fold axes in the Permian Tansill, Salado*,* and Rustler Formations that occur beneath the Waste Control Specialists LLC facilities (Figure 2) are approximately coincident with the axis of the overlying red bed ridge on the buried surface of the Triassic Dockum Group.

The study by Holt and Powers in Attachment F of the SAR also demonstrates that the observed structure on the surface of the red beds is unrelated to deep dissolution of Permian salts. Figures 17 to 19 (op. cit.) use Waste Control Specialists site-specific isopachs of the Salado and Rustler Formations, and the thickness of the interval from the top of the Tansill to the base of the Salado, to show that the Permian salt beds do not rapidly thin or thicken away from the facility.

Although Lehman and Rainwater (2000 [9]*)* suggest the ridge may be related to large-scale Cenozoic structural deformation associated with subsidence further to the west and south, there is no suggestion of a lowering of the base level of Monument Draw, New Mexico, the closest surface water drainage feature west of the buried ridge. Monument Draw is an underfit stream with a very low gradient, overloaded with eolian deposits and aggrading.

In Lea County, the buried red bed ridge is approximately coincident with and beneath the Mescalero Ridge (Nicholson and Clebsch, 1961 [10]; Ash, 1963 [1]; Cronin, 1969 [2]), a prominent escarpment defined by the erosional edge of the caprock caliche, a late Tertiary/Quaternary pedogenic caliche that developed on all pre-Quat rnary formations in the southern High Plains. The Mescalero Ridge, which defines the boundary of the southern High Plains in Lea County, is retreating eastward following late Tertiary downcutting of the Pecos River. Although the red bed ridge is somewhat parallel to the Caprock escarpment and, on first inspection may seem to be a buried southeasterly extension of the escarpment, the presence of the caprock caliche over the crest of the buried red bed ridge and on both the north and south sides of the crest indicates that it is not the buried erosional edge of the escarpment.

SAR Chapter 2*,* Section 2.6.1 has been updated to include information on the origin and extent of the red-bed ridge, and *SAR* Section 2.8 has been updated to identify new references used in the changes to *SAR* Section 2.6.1.

References*:*

1. Ash, S.R., 1963, Ground-Water Conditions in Northern Lea County, New Mexico: U.S. Geological Survey Hydrologic Investigations Atlas HA-62, 2 Sheets.

2. Cronin, J.G., 1969, Groundwater in the Ogallala Formation in the Southern High Plains of Texas and New Mexico: U.S. Geological Survey Hydrological Investigations HA-330, 9 p.

3. Fallin, J.A.T., 1988, Hydrogeology of Lower Cretaceous Strata under the Southern High Plains of New Mexico: New Mexico Geology, Volume 10, No. 1, February 1988, pp. 6-9.

4. Geologic Atlas of Texas, Hobbs Sheet, 1976. Texas Bureau of Economic Geology.

5. Geologic Atlas of Texas, Big Spring Sheet, 1974. Texas Bureau of Economic Geology.

6. Geologic Atlas of Texas, Pecos Sheet, 1975. Texas Bureau of Economic Geology.

7. Hawley, J.A., 1993. The Ogallala and Gatuna Formations in the Southeastern New Mexico Region, A Progress Report: New Mexico Geological Society Guidebook, 44th Field Conference, *pp.* 261-269.

8. Holt, R. M. and *Powers* D.W., 2007. Evaluation of Halite Dissolution in the Vicinity of Waste Control Specialists Disposal Site, Andrews County, Texas. Attachment 4-2 to WCS, 2007: Submitted to NRC as Attachment F to Interim Storage Partners' License Application, Revision 2, Docket No 72-1050, First Request for Additional Information, November 16, 2018.

9. Lehman, T.M. and *Rainwater,* K., 2000. Geology of WCS – Flying "W" Ranch, Andrews County, Texas, November 2000, 95p. In WCS, 2007, as Attachment 2-1.

10. Nicholson, A., Jr. and A. Clebsch, Jr., 1961, Geology and Ground-Water Conditions in Southern Lea County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Ground-Water Report 6, Socorro, New Mexico, 123 p.

11. Waste Control Specialists LLC, Andrews, Texas, 2007. Application for License to Authorize Near-Surface Land Disposal of Radioactive Waste. License R04100, Rev 12c.

Impact:

SAR Sections 2.6.1 and 2.8 have been revised as described in the response.

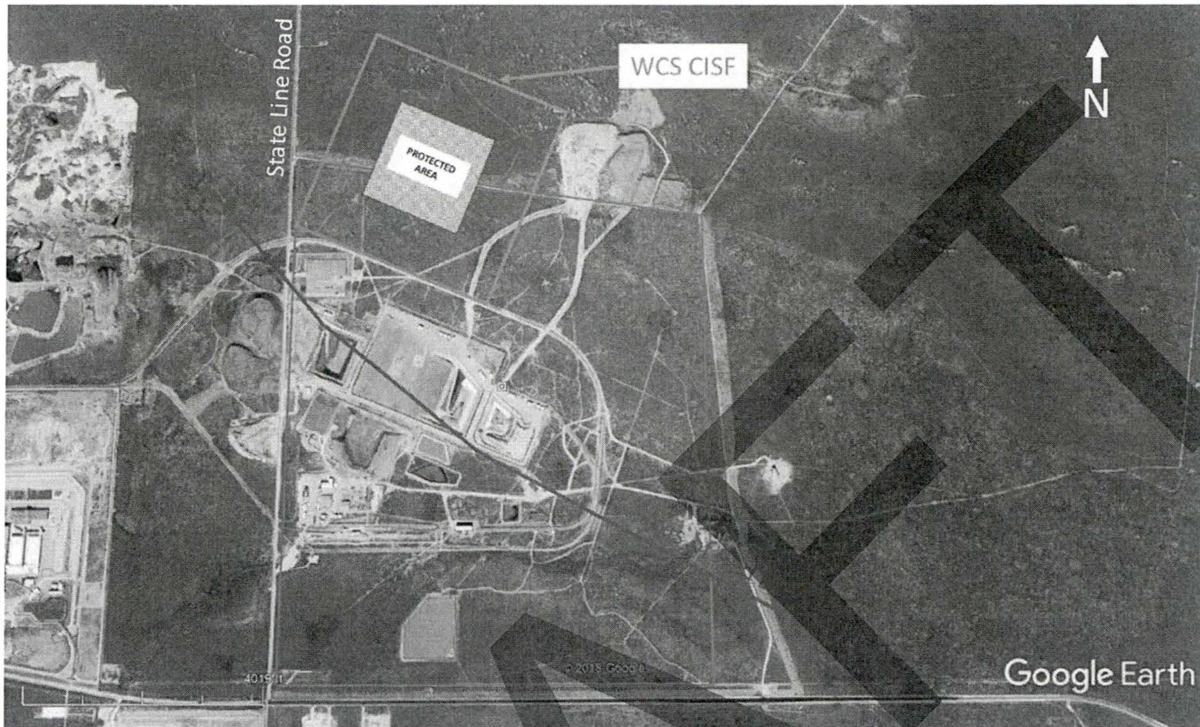

Figure RAI NP-2.6-2-1
Axis of the red bed ridge at the Waste Control Specialists facility (after Figure 4-19d, WCS, 2007, License Application to Texas Commission on Environmental Quality, May 2007, Rev 12c, Appendix 2.6.1, Geology Report [11]).

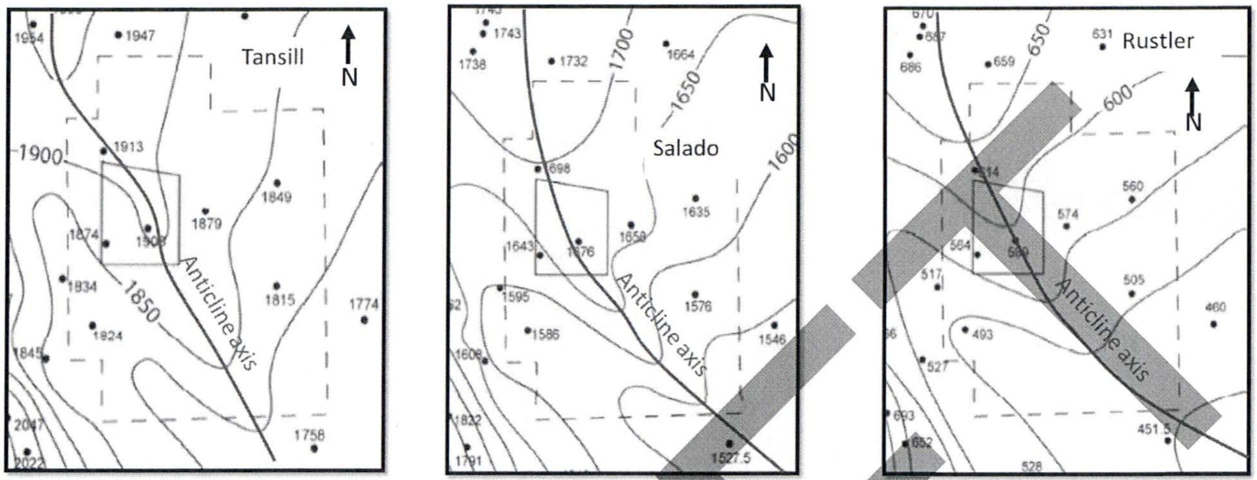

Figure RAI NP-2.6-2-2
Elevation (ft msl) of the top of late Permian Formations (from Holt and Powers, 2007 [8]: Submitted as Attachment F of the WCS CISF SAR).

2.6 Geology And Seismology

2.6.1 Basic Geology

This section discusses the regional geology and site-specific geology. Figure 2-13 is presented to identify the geologic formations of the region. This stratigraphic column adopts the nomenclature of Lehman (1994a[2-17], 1994b[2-18]) for the Dockum Group and includes the entire stratigraphic sequence typical of the Central Basin Platform of the west Texas Permian Basin (Bebout and Meador, 1985[2-2]). Figure 2-14 presents the Hobbs Sheet of the Geologic Atlas of Texas, 1:250,000 scale. The map shows surficial lithologic exposures, geologic descriptions of the formations that are exposed, topography infrastructure and governmental boundaries in the area surrounding the Waste Control Specialists permitted area.

Site Specific Geology

Two cross sections in the vicinity of the WCS CISF were created using boring logs from former site investigations. The locations of the cross sections are shown on Figure 2-15. Two cross sections in the vicinity of the WCS CISF are included as Figure 2-16 and Figure 2-17 and the associated boring logs are included in Attachment C.

The geologic formations of concern, beneath of the WCS CISF comprise, from oldest to youngest, the Triassic Dockum Group, the Late Tertiary Ogallala Formation, the Pleistocene windblown sands of the Blackwater Draw Formation, and Holocene windblown sands. A regional hard caliche pedisol, termed the Caprock caliche, developed on all pre-Quaternary formations before the Blackwater Draw sands were deposited. A less indurated caliche has also formed in portions of the upper Blackwater Draw Sands. Unlike the Caprock caliche, the Blackwater Draw caliche is not regionally extensive.

A stratigraphic column of the WCS CISF area for the above units is provided in Figure 2-37. This CISF site-specific stratigraphic column was developed from data collected from site boring logs. The boring logs are presented in Attachment C.

The WCS permitted facilities are located over a geologic feature referred to as the red bed ridge. The red bed ridge is an expression of the top of the Triassic Dockum Group. The ridge is buried beneath the late Tertiary caprock caliche, which developed on all pre-Quaternary formations on the southern High Plains. Beneath the caprock caliche is the remnant Cretaceous Antlers Formation, which is not observed in bore holes at the CISF, and the Quaternary alluvial and windblown sands of the Ogallala, Gatuña and Blackwater Draw Formations, which are in turn covered by 10 to 20 feet of recent windblown sand. WCS site investigations have followed the convention suggested by Hawley (1993) to refer to the late Tertiary to Quaternary formations south of the red bed ridge as Gatuña and those north of the ridge as Ogallala (Hawley, 1993[2-51]).

As a consequence, Gatuña is not present at the CISF site. The depth to the top of red beds at the CISF is approximately 50 to 80 feet, based on the logs of borings shown in Figure 2-15, Figure 2-16 and Figure 2-17. The northward slope gradient of the top of the red beds across the CISF ranges from approximately 0.98% (based on red bed elevations between TP-64 (3435 ft msl) and PZ-46 (3414 ft msl) and 0.84%, based on red bed elevations between TP-65 (3437 ft msl) and PZ-47 (3414 ft msl). At the CISF, the maximum apparent slope on the late Pliocene erosional surface of the red beds is 1.77%, between TP-84 (3432 ft msl) and PZ-36 (3419 ft msl).

In the immediate vicinity of the WCS facility, the axis of the red bed ridge occurs from approximately the northwest corner of the Byproduct landfill to the southeast corner of the Compact Facility, continuing southeastward beyond the WCS landfills. The axis is not located under the CISF area. The nearest location of the crest of the buried ridge to the CISF is approximately 1200 feet south along State Line Road. At this location, the depth to the crest of the red beds is about 34 ft, based on the log of boring B-1 in Figure 5-4 from WCS (Waste Control Specialists LLC, 2007 [2-43]). The elevations of the top of red beds are estimated from Figure 2-16 and Figure 2-17, with locations estimated from Figure 2-15 and Figure 2-35.

The red bed ridge is the position of a drainage divide that has separated two major fluvial systems throughout late Cenozoic time (Hawley, 1993 [2-51]; Fallin, 1988 [2-53]). This area was uplifted at the start of the Laramide Orogeny when the Cretaceous seas retreated. From the late Paleocene to near the end of the Pliocene the area was subject to erosion, removing most of the Cretaceous deposits. The relatively resistant limestones over the partially silicified Cretaceous Antlers Formation on the crest of the ridge may have effectively capped the red bed ridge, maintaining the ridge as a mesa or inter-drainage high. The axis of the red bed ridge remains coincident today with a local topographic high, between Monument Draw Texas, which drains to the Colorado River, and Monument Draw New Mexico, which drains to the Pecos River. In Andrews County, the buried red bed ridge plunges to the south/southeast at about 8 to 10 feet per mile, similar to the surface topography, and the crest of the surface water drainage divide is virtually coincident with the crest of the underlying red bed ridge.

<u>Regional Geology</u>

The WCS CISF is located over the north-central portion of a prominent subsurface structural feature known as the Central Basin Platform. The Central Basin Platform is a deep-seated horst-like structure that extends northwest to southeast from southeastern New Mexico to eastern Pecos County, Texas. The Central Basin Platform is flanked on three sides by regional structural depressions known as the Delaware Basin to the southwest and the Midland Basin to the northeast, and by the Val Verde Basin to the south.

From the Cambrian to late Mississippian, west Texas and southeast New Mexico experienced mild structural deformation that produced broad regional arches and shallow depressions (Wright, 1979[2-37]). The Central Basin Platform served intermittently as a slightly positive feature during the early Paleozoic (Galley, 1958[2-9]). During the Mississippian and Pennsylvanian, the Central Basin Platform uplifted between ancient lines of weakness (Hills, 1985[2-13]), and the Delaware, Midland, and Val Verde Basins began to subside, forming separate basins.

Late Mississippian tectonic events uplifted and folded the platform and were followed by more intense late Pennsylvanian and early Permian deformation that compressed and faulted the area (Hills, 1963[2-12]). Highly deformed local structures formed ranges of mountains oriented generally parallel to the main axis of the platform (Wright, 1979[2-37]).

This period of intense late Paleozoic deformation was followed by a long period of gradual subsidence and erosion that stripped the Central Basin Platform and other structures to near base-level (Wright, 1979[2-37]) forming the Permian Basin. The expanding sea gradually encroached over broad eroded surfaces and truncated edges of previously deposited sedimentary strata. New layers of arkose, sand, chert pebble conglomerate and shale deposits accumulated as erosional products along the edges and on the flanks of both regional and local structures. Throughout the remainder of the Permian, the Permian Basin slowly filled with several thousand feet of evaporites, carbonates, and shales.

From the end of the Permian until late Cretaceous, there was relatively little tectonic activity except for periods of slight regional uplifting and downwarping. During the early Triassic, the region was slowly uplifted and slightly eroded. These conditions continued until the late Triassic, when gentle downwarping formed a large land-locked basin in which terrigenous deposits of the Dockum Group accumulated in alluvial floodplains and as deltaic and lacustrine deposits (McGowen, et al., 1979[2-21]). In Jurassic time, the area was again subject to erosion.

During Cretaceous time, a large part of the western interior of North America (including west Texas and southeastern New Mexico) was submerged by a large continental shelf sea. A thick sequence of Cretaceous rocks was deposited over most of the area. Locally, the Cretaceous sequence of sediments was comprised of a basal clastic unit (the Trinity, Antlers, or Paluxy sands) and overlying shallow marine carbonates.

Uplift from the west and southward and eastward–retreating Cretaceous seas were coincident with the Laramide Orogeny, which formed the Cordilleran Range west of the Permian Basin. The Laramide Orogeny uplifted the region to essentially its present position, supplying sediments for the nearby late Tertiary Ogallala Formation. The major episode of Laramide folding and faulting occurred in the late Paleocene. There have been no major tectonic events in North Americas since the Laramide Orogeny, except for a brief period of minor volcanism during the late Tertiary in northeastern New Mexico and in the Trans-Pecos area. Hills (1985)[2-13] suggests that slight Tertiary movement along Precambrian lines of weakness may have opened joint channels which allowed the circulation of groundwater into Permian evaporite layers. The near-surface regional structural controls may be locally modified by differential subsidence related to groundwater dissolution of Permian salt deposits (Gustavson, 1980[2-10]).

In Figure 2-3, small circular features seen on the aerial photo began as small erosional depressions on the land surface. These depressions accumulated water, which variably dissolved surficial or near-surface pedogenic calcrete and carbonate. This process enlarged the depressions and accumulated sediment as the calcrete was dissolved (Holt and Powers, 2007a, [2-54]). They are surficial and show no signs of collapse and subsidence that would indicate dissolution of the much deeper evaporite-bearing formations. Analysis of cores and geophysical logs reveal no evidence of post-depositional dissolution of evaporites that would lead to such collapse (Attachment F). There is no evidence that human activities initiated these depressions. These features are unrelated to oil and gas exploration and extraction activities in the site area. The main part of these depressions ranges from a few hundred feet to more than 1000 feet in length and none of the localized features appear to reach a depth of 10 ft. Studies of playa fill indicate these features are thousands to tens of thousands of years old and older (Holliday et al., 1996, [2-55]). There is no indication that these features will form naturally at the site of the WCS CISF in the near geological future.

The Central Basin Platform is an area of moderate, low intensity seismic activity based on data obtained from the U.S. Geological Survey (USGS) Earthquake Data Base available from the National Earthquake Information Center (http://neic.usgs.gov/). Typical of the central U.S., there is a marked absence of mapped Quaternary faults and few of the known earthquakes can be associated with a specific geologic structure. In the 2014 U.S.G.S. National Hazard Maps, the site area was characterized as one of relatively low seismic hazard.

2.6.2 Vibratory Ground Motion

The WCS CISF lies in a region with crustal properties that indicate minimum risk due to faulting and seismicity. Crustal thickness is the most reliable predictor of seismic activity and faulting in intracratonic regions. Crustal thickness in the vicinity of the WCS CISF is approximately 30 miles (50 km), one of the three thickest crustal regions in North America (Mooney and Braile, 1989[2-22]). In comparison, the crustal thickness of the Rio Grande Rift is as little as 7.5 miles (12 km) in places.

2.8 References

2-1 Bally, A.W., C.R. Scotese, and M.I. Ross, 1989, North America; Plate-Tectonic Setting and Tectonic Elements in The Geology of North America-An Overview: Volume A, Decade of North American Geology, p. 1-15, Geological Society of America, Boulder, Colorado.

2-2 Bebout, D.G., and K.J. Meador, 1985, Regional Cross Sections — Central Basin Platform, West Texas: The University of Texas at Austin, Bureau of Economic Geology, 4 p., 11 plates.

2-3 Blandford, T.N., D.J. Blazer, K.C. Calhoun, A.R. Dutton, T. Naing, R.C. Reedy, and B.R. Scanlin, 2003, Groundwater Availability of the Southern Ogallala Aquifer in Texas and New Mexico Numerical Simulations through 2050: Texas Water Development Board Draft Report, 160 p.

2-4 Bomar, G.W., 1995, Texas Weather, 2nd edition, University of Texas Press, Austin, Texas.

2-5 Bradley, R.G., and S. Kalaswad, 2003, The Groundwater Resources of the Dockum Aquifer in Texas: Texas Water Development Board Report 359, 73 p.

2-6 Cronin, J.G., 1969, Groundwater in the Ogallala Formation in the Southern High Plains of Texas and New Mexico: U.S. Geological Survey Hydrological Investigations HA-330, 9 p.

2-7 Dutton, A.R., 1995, Groundwater Isotopic Evidence for Paleorecharge in U.S. High Plains Aquifers: Quaternary Research 43, p. 221-231.

2-8 Dutton, A.R., and W.W. Simpkins, 1986, Hydrogeochemistry and Water Resources of the Triassic Lower Dockum Group in the Texas Panhandle and Eastern New Mexico: University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 161, 51 p.

2-9 Galley, J.E., 1958, Oil and Geology in the Permian Basin of Texas and New Mexico, in Habitat of Oil: American Association of Petroleum Geologists, p. 395-446.

2-10 Gustavson, T.C., 1980, Faulting and Salt Dissolution, in Geology and Geohydrology of the Palo Duro Basin, Texas Panhandle, A Report on the Progress of Nuclear Waste Isolation Feasibility Studies (1979): The University of Texas at Austin, Bureau of Economic Geology Circular 80-7, p.83-87.

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RAI NP-2.6-3:

Provide justification for why soil boring to depths greater than 45 feet are not needed.

WCS CISF SAR Section 2.6.4 states that the WCS CISF subsurface conditions were explored with eighteen soil borings. Among the eighteen borings, four borings encountered auger refusal conditions at depths ranging from 37 to 45 feet below ground surface (bgs), and fourteen borings were terminated at 25 feet bgs. General industrial guidance for geotechnical investigations, such as US Army Corps of Engineering[1] and FHWA[2] manual/standard, recommends the boring depth, for example, (1) be at least to a depth where the increased stress due to the estimated footing load is less than 10% of the existing effective overburden stress, (2) be 1.5 times the minimum dimension of footing below the base of the footing, or (3) penetrate a minimum of 3 meters into the bedrock, if bedrock is encountered before other required depths.

References:

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This information is needed to determine compliance with 10 CFR 72.103(f)(1) and 10 CFR 72.103(f)(2)(iv).

Response to RAI NP-2.6-3:

Response will be provided with First RAI Part 2 responses

Impact:

SAR Section/Table/Figure/Drawing has been revised as described in the response.

Or

No change as a result of this RAI.

RAI NP-2.6-4:

Provide the following information with respect to the laboratory investigations:

a. Justify how the soil strength and deformation properties of the cohesive soils were determined and how the settlement potential of the clay stratum can be adequately evaluated given the absence of consolidated undrained triaxial tests and consolidated tests.

b. Provide results from the California Bearing Ratio (CBR) testing.

c. A description of the laboratory tests (including the test results) that were completed after the submittal of the Geotechnical Exploration Report (Attachment E to the SAR).

WCS CISF SAR Section 2.6.4 states the following tests were performed for this application: Atterberg Limits; Natural Moisture Content; Particle Size Analysis; Resistivity of Soil; Consolidated Undrained Triaxial Test; Standard Proctor Moisture-Density Tests; California Bearing Ratio; and Consolidation. However, Subsection 2.2 "Laboratory test program" of the Geotechnical Exploration Report (Attachment E to SAR) states that consolidated undrained triaxial tests and consolidation tests were not conducted because undisturbed Shelby tube samples could not be obtained due to the caliche. These tests are important for determining the shear strength parameters and consolidation characteristics of soil. Moreover, in the same subsection ISP indicated that one CBR test was performed. The staff reviewed ISP's soil data summary enclosed in Attachment E, Appendix B to the SAR, and the CBR testing results were not reported. Additionally, Subsection 2.2, "Laboratory test program," of the Geotechnical Exploration Report (Attachment E to SAR) states, "At the time this report was prepared, some of the laboratory testing was still on-going." In order for the NRC staff to perform a complete evaluation of the laboratory investigations, ISP should provide a complete description of the laboratory tests, including the test results.

This information is needed to determine compliance with 10 CFR 72.103(f)(1) and 10 CFR 72.103(f)(2)(iv).

Response to RAI NP-2.6-4:

Response will be provided with First RAI Part 2 responses

Impact:

ERP Section/Table/Figure/Drawing has been revised as described in the response.

Or

No change as a result of this RAI.

RAI NP-2.6-5:

Provide the basis for using 20% of the dynamic modulus for the static elastic modulus as these values are considerably higher for similar soils.

Appendix D of the Geotechnical Exploration Report (Attachment E to SAR) provides the calculated static elastic moduli used for the design and analysis for a depth of 100 ft bgs. These calculated static elastic moduli are based on derived dynamic moduli from seismic wave values determined by the refraction micro-tremor (ReMi) method. Specifically, ISP used 20% of the dynamic modulus as the static elastic modulus for design and analysis. However, these elastic moduli exceed the typical range of values for similar soils reported by various engineering literatures.

This information is needed to determine compliance with 10 CFR 72.103(f)(1) and 10 CFR 72.103(f)(2)(iv).

Response to RAI NP-2.6-5:

Response will be provided with First RAI Part 2 responses

Impact:

SAR Section/Table/Figure/Drawing has been revised as described in the response.

Or

No change as a result of this RAI.

RAI NP-2.6-6:

Provide the following information regarding the slope stability evaluation:

a. Water resources in the site vicinity along with a description of its location; such as dams, natural or manmade ponds and how the stability of their embankments might affect the site.

b. When referring to the natural or manmade slopes, define the words "close enough" relative to the WCS CISF facilities and justify why the failure of these slopes would not adversely affect WCS CIFS facilities for phase 1 or for the total area of the proposed site, whichever applies.

WCS CISF SAR Section 2.6.5 provides general information regarding the slope stability of the site. Also, SAR Section 2.7 provides additional information linked to the slope stability of the site. SAR Section 2.7 states: "There are no slopes, natural or manmade, close enough to the proposed WCS CISF facilities that their failure would adversely affect these facilities."

This information is needed to determine compliance with 10 CFR 72.103(f)(1) and 10 CFR 72.103(f)(2)(iv).

Response to RAI NP-2.6-6:

a. As indicated in SAR Sections 2.1 and 2.4, there are several nonindustrial water resources near the *WCS* CISF. These include ponds, basins, springs, and drainage features. The ponds and basins are depressions and do not have embankments preventing water from escaping. The spring and drainage features do not have embankments. They are ephemeral and precluded from impacting the *WCS* CISF due to inherent topography. Additional water resources in the site vicinity are limited to several manmade ponds. The *Waste Control Specialists* LLRW and RCRA facilities have five manmade ponds used for sedimentation control and evaporation. These ponds are identified as items 4, 5, and 6 on SAR Figure 1-1. The maximum elevation of any of the *Waste Control Specialists* pond embankment overflow structures is 3,454 ft. The minimum elevation of any structure at the *WCS* CISF is 3,488 ft. Therefore, the lowest ground elevation of any *WCS* CISF structure is over 30 feet higher than any of the *Waste Control Specialists* pond embankment elevations. In addition to the five manmade ponds on *Waste Control Specialists* property, there are a series of manmade ponds to the southwest in New Mexico owned by Sundance Services, Inc., used for their oil field waste disposal operation. The nearest of these ponds is approximately 4,000 ft from the western WCS CISF OCA Boundary. The maximum elevation of all of the overflow points is approximately 3,475 ft. *SAR* Section 2.4.4 is revised to include reference to the top of pond embankment elevations being lower than the *WCS* CISF elevation.

b. The *WCS* CISF site is generally flat with no significant embankments. The final grading of the *WCS* CISF site will include excavation to smooth out uneven features and promote overall grading and drainage as indicated in the Flood Plain analysis referenced in SAR Chapter 2. There are two significant embankments in the general area of the *WCS* CISF. Both embankments are soil material stockpiles created from construction of existing W*aste* C*ontrol* S*pecialists* landfills. These stockpiles consist of either excavated silty sand or caliche gravels. The stockpile areas vary in elevation and have different sections within each area.

The first stockpile area is to the northeast of the *WCS* CISF and is over 2,000 ft from the PA Boundary for Phase 1 and approximately 785 ft from the nearest PA Boundary of the possible future phases. Elevation at the highest point of this stockpile group is 3,544 ft, which is approximately 50 ft higher than the surrounding natural grade. This stockpile is identified as Item 8 on SAR Figure 1-1.

The second stockpile area is to the southwest of the *WCS* CISF and is over 2,100 ft from the PA Boundary of Phase 1 and the possible future phases. The elevation of the highest point of this stockpile is 3,560 ft, which is approximately 100 ft above the surrounding natural grade. This stockpile is identified as Item 7 on SAR Figure 1-1.

Side slopes for both stockpiles vary but have a maximum slope of 1:1 in some locations. Side slope of the stockpiles was established by the natural angle for the material when it was dumped on the piles. The stockpiles have been stable since their creation, and the distance from the stockpile locations and PA boundary would preclude any settlement or slope failures from adversely impacting the *WCS* CISF. In support of this conclusion, Table 2-6 of Foundation Analysis and Design by Joseph E. Bowles *has been reviewed*. This table provides a representative value of angle of internal friction for various soil materials. For an unconsolidated, undrained, loose silty sand, a value of 20 to 22 degrees is recommended. This would result in a comfortable slope inclination of approximately 2.5H:1V. Based on a maximum slope height of 50 ft at an inclination of 1H:1V, which currently exists at the northeastern stockpile, the maximum horizontal distance associated with a slope failure would result in a lateral spread of approximately 75 additional ft. At the southwestern stockpile, based on a maximum slope height of 100 ft at an inclination of 1H:1V, which currently exists, the maximum horizontal distance associated with a slope failure would result in a lateral spread of approximately 150 additional ft. Both of these potential lateral spreads are far short of having any impact on the *WCS* CISF. *SAR* Section 2.6.5, "Slope Stability," is revised to include distances from the stockpiles to the *WCS* CISF.

References

Foundation Analysis and Design Fifth Edition by Joseph E. Bowles, Table 2-6 (1988).

Impact:

SAR Sections 2.1, 2.4.4, 2.6.5, and 2.7 have been revised as described in the response.

2.1 Geography and Demography of Site Selected

The WCS CISF is situated in northwest Andrews County on the southwestern edge of the Southern High Plains. The entire Waste Control Specialists site is approximately 14,000 acres with all acreage being controlled by Waste Control Specialists. The nearest population center of 25,000 or more is Hobbs, NM about 20 miles northwest of the WCS CISF.

Land uses within a few miles of the WCS CISF include agriculture, cattle ranching, drilling for and production from oil and gas wells, quarrying operations, uranium enrichment, municipal waste disposal, and the surface recovery and land farming of oil field wastes. Surface quarrying of caliche, sand and gravel is conducted in New Mexico, approximately one mile west of the WCS CISF. The oil field waste recovery facility is adjacent to this quarry. The Lea County, New Mexico municipal solid waste landfill is located adjacent to the state line to the immediate south and west of the WCS CISF. Uranium Enrichment Company (URENCO) operates a centrifuge technology, uranium enrichment facility about one mile to the southwest of the HW-50397 RCRA landfill location.

The 15-mile radius area around the WCS CISF is very low population with some industry and mostly ranch land and very little seasonal variation in population. In the Environmental Report, Appendix A, the Socioeconomic Impact Assessment includes 2010 Census data and Figure 1.1-1 in Appendix A shows cities and towns within a 30 mile radius of the WCS CISF.

Except for a historical marker and picnic area approximately 5.5 km (3.3 mi) from the WCS CISF at the intersection of New Mexico Highways 234 and 18, there are no known public recreation areas or state or federal parks within 8 km (5 mi) of the WCS CISF.

The following nonindustrial water resources are located in the proposed WCS CISF vicinity:

- A manmade pond on the adjacent quarry property owned by Permian Basin Materials (Permian, 2016[2-29]).
- Baker Spring, an intermittent surface-water feature situated about 2,500 feet west of the WCS CISF that contains water seasonally.
- Several cattle-watering holes where groundwater is pumped by windmill and stored in aboveground tanks.
- Monument Draw, a natural shallow drainageway situated several kilometers southwest of the WCS CISF. Local residents indicated that Monument Draw only contains water for a short period of time following a significant rainstorm (LES, 2005[2-19]).

"The local PMP [probable maximum precipitation] floodplain analysis yielded the PMF elevation near the CISF site of 3488.9 ft msl. Elevations of the storage pads vary from 3490 ft msl to 3504 msl. Elevations of the foundations of the security/administration building and the Cask Handling Building are 3496 ft msl and 3493 ft msl, respectively."

The finish floor elevations of the Security and Administration building and the Cask Handling Building are 7 feet and 4 feet, respectively, above the PMF elevation and will not be impacted by the PMF. The detailed calculations for determining the water level elevations in the playa can be found in Attachment B.

2.4.2.3 Effects of Local Intense Precipitation

The Flood Plain Study in Attachment B includes calculations for a PMP using a 500-year frequency storm event and the limits of the floodplain. The results from these additional storms that were modeled describe a floodplain that is still shallow and wide that is too distant from the WCS CISF to ever be any threat.

2.4.3 Probable Maximum Flood on Streams and Rivers

There are no streams or rivers on or in the vicinity of the WCS CISF. Monument Draw, an ephemeral stream, is the closest main surface water drainage and is about 3 miles west of the WCS CISF in New Mexico, so the WCS CISF would be unaffected by flooding on streams of rivers. While Monument Draw is typically dry, the maximum historical flow occurred on June 10, 1972 and measured 36.2 cubic meters per second (1,280 cubic feet per second).

2.4.4 Potential Dam Failures (Seismically Induced)

There are no dams on or in the vicinity of the WCS CISF. The Waste Control Specialists RCRA and LLRW facilities currently have five (5) manmade evaporation ponds used for sedimentation control and evaporation. In addition to the WCS ponds, there are a series of manmade ponds to the southwest in New Mexico. As indicated in Section 2.6.5, the maximum elevation of the embankment structure of any of these ponds is lower than the minimum elevation of any structure at the CISF. If a seismic event were to cause slope failure, the inherent topography would preclude any adverse effects to the CISF.

2.4.5 Probable Maximum Surge and Seiche Flooding

Surges and seiches are typically observed on lakes or seas. There are no surface bodies of water on or near the WCS CISF where such a phenomenon would be a safety concern at the WCS CISF. There are currently five evaporation ponds at the Waste Control Specialists site and they are designed with spillways on the south side so any seiche or surge would flow south away from the WCS CISF.

2.6.5 Slope Stability

The WCS CISF site and surrounding area is nearly flat, so there is little possibility of landslides. Settling or slumping is unlikely because the geologic strata are well consolidated and surface soils have low moisture content. The semi-arid climate helps maintain low moisture content of the soils. Except for sedimentation and evaporation ponds, surface water is absent except during infrequent rainstorms.

As indicated in Sections 2.1 and 2.4, there are several nonindustrial water resources near the CISF. These include ponds, basins, springs, and drainage features. The ponds and basins are depressions and do not have embankments preventing water from escaping. The spring and drainage features do not have embankments. They are ephemeral and precluded from impacting the CISF due to inherent topography.

The WCS property has five manmade ponds used for sedimentation control and evaporation. The maximum elevation of any of the WCS pond embankment overflow structures is 3,454 ft. The minimum elevation of any structure at the CISF is 3,488 ft. Because the WCS pond embankment elevations are over 30 feet lower than the ground elevation of the CISF structures, slope failure of any of the WCS pond embankments would not adversely affect the CISF.

In addition to the five manmade ponds on WCS property, there are a series of manmade ponds to the southwest in New Mexico owned by Sundance Services, Inc. used for their oil field waste disposal operation. The nearest of these ponds is approximately 4,000 feet from the western WCS CISF OCA Boundary. The maximum elevation of all of the overflow points is approximately 3,475 feet. Because the Sundance pond embankment elevations are located at a substantial distance from the CISF and are over 10 feet lower than the ground elevation of any CISF structures, slope failure of any of these pond embankments would not adversely affect the CISF.

There are two stockpile areas, one to the southwest and one to the northeast of the CISF, created during construction of existing WCS landfills. The closest stockpile area is over 2,000 feet from the WCS CISF Phase 1 PA Boundary. This distance is sufficient to preclude any lateral spread from a potential slope failure from having any impact on the CISF.

2.6.6 Volcanism

There is minimal seismic and no volcanic activity near the WCS CISF. There is no evidence of tectonic or volcanic activity near the WCS CISF in the recent past.

2.7 Summary of Site Conditions Affecting Construction and Operating Requirements

The WCS CISF site is located on the southwestern edge of the Southern High Plains, approximately 32 miles northwest of the City of Andrews. This part of Andrews County is a gently southeastward sloping plain with a natural slope of about 8 to 10 feet per mile. The finished grade of the WCS CISF is expected to be sloped gently with an anticipated elevation of 3,485 feet above msl. The WCS CISF site is currently undeveloped and the existing land surface is fairly flat with an average slope of 0.8 percent (%). The existing maximum and minimum elevations of the site are about 3520 feet and 3482 feet msl, respectively. The cover type is desert shrub. The existing Waste Control Specialists railroad is generally aligned parallel with and south of the proposed WCS CISF site boundary.

The entire WCS CISF, including the access road, is above the 100-year flood elevation. The northern most limit of the 100-year floodplain is approximately 4,000 feet southeast of the WCS CISF while the northernmost limits of the 500-year and PMP floodplains are 3965 feet and 3895 feet southeast of the WCS CISF, respectively.

A probabilistic seismic hazard analysis was performed to determine the design basis ground motion at the WCS CISF. The peak ground acceleration for a 10,000 year return period is 0.26 g.

Subsurface soils at the WCS CISF are suitable for supporting conventional foundations under both the static and dynamic loading conditions. There is no potential for liquefaction, collapse, or excessive settlement of these soils. As described in Section 2.6.5, there are no slopes, natural or manmade, close enough to the proposed WCS CISF facilities that their failure would adversely affect these facilities.

Storage overpacks will be used to store canisters containing spent fuel and GTCC waste. The canisters are drained of all liquid prior to being shipped to the WCS CISF. Therefore, liquid releases cannot result from operation of the WCS CISF.

The shallowest water bearing zone is about 225 feet deep at the WCS CISF. The method of storage (dry cask), the nature of the storage casks, the extremely low permeability of the red bed clay and the depth to groundwater beneath the WCS CISF preclude the possibility of groundwater contamination from the operation of the WCS CISF.