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NMED
Hazardous Waste Bureau

Mr. John E. Kieling, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
P.O. Box 5469
Santa Fe, New Mexico, 87502-5469

Re: Review of Kirtland Air Force Base RCRA Facility Investigation (RFI) Report for the Bulk Fuels Facility Release, Solid Waste Management Unit ST-106/SS-111

Dear Mr. Kieling:

Please find enclosed our review comments on the January 2017 Kirtland RFI for the Bulk Fuels Facility (BFF) release. We have reviewed the sections of the RFI where we have detailed knowledge of site conditions, and provided general and specific comments where appropriate. General comments relate to how well the RFI accomplishes the goals of the site investigation, and specific comments are mainly intended to improve report clarity. Our overall impression is that the RFI has accomplished the goals of the site investigation. It is our understanding that the risk assessment part of the RFI is forthcoming; therefore, we anticipate providing additional comments on that portion when it becomes available.

If you have any questions, please contact me at 214-665-6771. For questions on individual comments please contact Scott Ellinger at 214-665-8408.

Sincerely,

Laurie F. King
Chief, RCRA Corrective Action Section
Hazardous Waste Branch

Enclosure

Kirtland Air Force Base RFI for the Bulk Fuels Facility Release
Solid Waste Management Unit ST-106/SS-111

3-30-2017

General Comments

The following general comments are related to RFI goals, objectives, and conclusions. The stated goals of the RFI Report are "to summarize the investigation of fuel releases discovered in 1999", and to "summarize all investigation activities and interim measures performed between November 11, 1999 and December 31, 2015" (p. ES-1). These general comments are based on information contained in the Executive Summary, Introduction, Conclusions and Recommendations, Chapter 6 (Groundwater Investigation Methods and Results), Chapter 7 (Conceptual Site Model), and the related tables and figures. This review did not include chapters on the vadose zone and light non-aqueous phase liquid (LNAPL) investigations.

The RFI's stated objectives (p. ES-1) are to:

(i) Characterize the nature and extent of fuel-related contamination in the vadose zone (soil and soil vapor), (LNAPL), and groundwater within the Site, and

(ii) Provide adequate characterization of the Site to evaluate and select the applicable corrective measures required to address soil, soil vapor, and groundwater fuel-related contamination as necessary.

To evaluate whether the RFI met objectives (i) and (ii), and met the overall RFI goals, the reviewer considered the following set of technical questions related to the effectiveness of the RFI site investigation and interpretations.

1. Are the site-specific depositional environments in the Santa Fe group understood, and did the RFI include this knowledge in determining formation and member stratigraphy, sedimentary patterns, variations in aquifer properties, and contamination pathways?
2. Has the RFI resulted in a sufficient understanding of the physical flow processes taking place between the bulk fuels facility and the Ridgecrest well field, the Veterans Administration (VA) well, and Kirtland water supply wells?
3. Did the RFI accurately determine groundwater flow gradients and velocity for interim measures to be effective?
4. How do groundwater production wells influence ethylene dibromide (EDB) mass transport?
5. Are there sufficient numbers of groundwater monitoring wells and are they properly located and constructed for the geological conditions?
6. Is there a sufficient understanding of the history of contamination releases?
7. How did the RFI investigate the fate and transport of EDB and the other fuel related contaminants with respect to sorption, retardation, dispersion, and degradation?
8. Does the RFI consider possible future changes to the groundwater flow regime?

9. Did the process to determine recovery well locations for interim measures include a detailed and thorough scientific analysis?

Each of these questions is addressed below.

1. **Are the site-specific depositional environments in the Santa Fe group understood, and did the RFI include this knowledge in determining formation and member stratigraphy, sedimentary patterns, variations in aquifer properties, and contamination pathways?**

   A number of organizations have produced both published and unpublished reports that describe the geologic and hydrogeologic setting and conditions of the affected area (e.g. reports from the US Geological Survey, New Mexico Bureau of Geology and Mineral Resources, the New Mexico State Engineer, the New Mexico Geological Society, Sandia National Labs, the Albuquerque Bernalillo County Water Utility Authority, the City of Albuquerque, and others). Information from these organizations was used in developing the RFI, and presented during working group technical discussions, to understand the significance of the Santa Fe group depositional environments, stratigraphy, and contamination pathways. In addition, a detailed sequence stratigraphy analysis was performed by AECOM Inc. in 2015 that provided an in-depth understanding of the depositional environments with detailed cross-sections showing areas of more and less permeability. The reviewer believes that the depositional environments are understood, as well as, how the associated sediments affect groundwater flow and mass transport.

2. **Has the RFI resulted in a sufficient understanding of the physical flow processes taking place between the bulk fuels facility and the Ridgecrest well field, the VA well, and Kirtland water supply wells?**

   Kirtland has investigated the physical flow processes between the spill site and public drinking water supply wells. This includes installing approximately 134 groundwater monitoring wells, performing slug tests and pumping tests, obtaining production well pumping rates, installing data-gap wells, regularly collecting water level and contaminant concentration data, assessing how local flow conditions connect to sub-regional and basin-wide flow, and other related work. Groundwater modeling was also performed to provide information on groundwater flow directions and how they change by season. An analysis has not been performed, however, with transient modeling that combines the effects of rising groundwater levels, seasonal changes to pumping rates, and long-term groundwater use projections.

   Aquifer slug and pumping tests performed by Kirtland, along with published data on aquifer properties from other sources, indicate a wide-range of hydraulic conductivity (K) at the site. A zone of relatively higher K, oriented north to south, corresponds with the axis of ancestral Rio Grande braided stream deposits. Kirtland has successfully performed aquifer tests, evaluated sequence stratigraphy, and made interpretations about depositional environments with regard to the high K zone. In the reviewer's opinion, the interpretations made by Kirtland are consistent with what is reported in literature and with what outside experts (non-Kirtland affiliated) have reported during technical working group meetings.

Some uncertainty exists about how site groundwater flow has been affected by the Love well field and the Charles well field, versus the Ridgecrest well field. At times, the groundwater flow direction seems to have been more northward, possibly being caused by influences from the Love and Charles wells. Another area of uncertainty is whether faults and off-set strata are flow boundaries. Faults are major features of the basin and the RFI refers to faults with regard to basin formation. More study on the Love well field and the Charles well fields, and on whether basin faults influence site groundwater flow, would be informative.

3. **Did the RFI accurately determine groundwater flow gradients and velocity for interim measures to be effective?**

The existing set of monitoring wells and groundwater level measurements, aquifer property information, and modeling studies are adequate to determine horizontal and vertical flow that are important for designing effective interim measures. Groundwater levels are measured on a certain schedule depending on the type of well (extended well network, newly installed wells, VA proximal wells, downgradient proximal wells, source area wells, and signal wells). There are well clusters with multi-level wells useful for determining vertical gradients. Capture analyses have been made that show recovery wells are providing adequate capture under current conditions.

A draft recommendation from the Albuquerque-Bernalillo County Water Utility Authority recommended that modeling should be based on a worst-case scenario with continued EDB migration towards the Ridgecrest well field (Future Water Authority Pumping Forecast, draft, 2014). Although groundwater levels have been rising and gradients have become flatter, a worst-case scenario should still be utilized for determining recovery well pumping rates, unless the water utility authority makes a different recommendation.

The RFI has adequately determined groundwater flow gradients and velocity for determining interim measures. Final corrective measures should use a worst-case scenario as noted above, and will probably require transient modeling.

4. **How do groundwater production wells influence EDB mass transport?**

The influence and protection of groundwater production wells (Ridgecrest wells, VA, and Kirtland wells) has been a central theme throughout Kirtland's work, including the RFI. The influences of production wells on groundwater flow and plume movement have been discussed during many technical meetings. Kirtland's quarterly monitoring reports contain potentiometric surface maps and plume maps, and show the locations of production wells. Kirtland has included input from other organizations and experts who have studied local groundwater conditions and production wells. During modeling work, extensive data sets provided by the water utility authority on production well pumping rates were incorporated into model simulations, as well as pumping data from the VA and Kirtland. Kirtland has installed groundwater monitoring wells between the downgradient edge of the EDB plume and the Ridgecrest well field recognizing the cone of depression caused by the Ridgecrest wells. Kirtland has also installed deeper monitoring wells near the production zone of the Ridgecrest wells to intercept plume movement.

5. **Are there sufficient numbers of groundwater monitoring wells and are they properly located and constructed for the geological conditions?**

Approximately 134 groundwater monitoring wells have been installed in different phases since 2000. Altogether, these wells provide good aerial coverage of the plume and monitor the depth profile (shallow, intermediate, and deep zones). Prior to the installation of monitoring wells, there was little subsurface information on the plume scale. Early published information available from the water utility authority, obtained during aquifer testing conducted at production wells, provided aquifer property data for southeast Albuquerque. This data showed a general north-south orientation of ancestral Rio Grande deposits where the plume is now located.

Because the EDB plume is believed to be moving through braided stream deposits, and given the complex sinuous overlapping nature of these deposits, it is important to understand stratigraphy in detail. The AECOM analysis provides detailed stratigraphy. Geologic information collected during monitoring well installation also informs the conceptual model which guided subsequent well installation.

The geologic and hydraulic data collected over time indicates that monitoring wells are properly located. The number of monitoring wells is reasonable to detect contamination in braided stream deposits. Kirtland has also optimized the monitoring well program to emphasize monitoring where needed and to increase monitoring efficiency.

6. **Is there a sufficient understanding of the history of contamination releases?**

Kirtland has developed a conceptual model that describes how the releases of fuel occurred. Releases occurred through broken underground pipelines when fuel was being transferred from rail cars. Unknowns still remain about the volumes of fuel released and about the dates of releases. Kirtland has attempted to narrow down when the releases occurred (1970s-1999). Estimates of the total volume released are not provided in the RFI.

7. **How did the RFI investigate fate and transport of EDB and other fuel components with respect to sorption, retardation, dispersion, and degradation?**

Kirtland considered the processes of sorption, retardation, and dispersion through use of the EPA model and updates to the U. S. Environmental Protection Agency (EPA) model made by CB&I Inc. It was important to simulate these processes to provide an indication of whether they are actually occurring at the site. Modeling was initially performed without sorption/retardation because there was little or no evidence it was occurring when the EPA model was first developed. During model updates, CB&I included a retardation factor which seemed to improve model performance and plume matching. Dispersion was the same in the different versions of the model.

Kirtland has collected data on concentrations of microbial degradation indicators (dissolved oxygen, nitrate/nitrite, iron, manganese, sulfate, bromide, excess bromide, alkalinity, oxidation reduction potential, and methane). These indicators suggest that microbial

degradation has been occurring within and just downgradient of the footprint of the benzene plume. Further, Kirtland has reported that microbial communities and compound-specific isotope analysis indicates that EDB is being degraded in the up gradient anaerobic area of the plume by reductive debromination. In the downgradient aerobic portion of the plume, Kirtland believes that abiotic degradation processes such as hydrolysis may be a significant factor in the degradation of EDB.

8. **Does the RFI consider possible future changes to the groundwater flow regime?**

The main near-term change expected to the groundwater flow regime is that groundwater levels will continue to rise. Over the last several years the groundwater gradient from the BFF to the Ridgecrest well field has flattened, and groundwater recovery wells should be more effective when they pump from a flatter gradient, assuming their pumping rates are not reduced. However, the water utility authority points out several important factors in their draft future water pumping forecast which are not part of the RFI report.

The water authority states that future supply and demand scenarios over the next 75 years will be affected by several unknown factors: climate variability, Rio Grande/San Juan-Chama flow, and population growth and development patterns. They also point out that because of cross-connections and flexibility of the drinking water system, supply and demand projections do not necessarily inform pumping rates at a particular well field. Further, the locations where production wells exist today may not exist over time because of well replacement and water resource management strategy needs (although discharge from Ridgecrest well field is still a worst-case scenario). The water authority also states that increased conservation and San Juan-Chama water dependence could shift the pumping center/cone of depression from its current location to another location in the basin. These factors should be considered when determining final corrective measures, unless updated recommendations are provided by the water utility authority.

9. **Did the process to determine recovery well locations for interim measures include a detailed and thorough scientific analysis?**

Section 6.2.1 of the RFI discusses the installation of groundwater recovery wells. It states that a contaminant fate and transport model developed in 2013 by EPA Region 6 for the NMED was updated to evaluate plume-scale proposed extraction wells placement to maximize EDB plume capture. Technical reports developed by EPA (for NMED) and CB&I Inc. explain the modeling steps that were performed in order to construct the model used for well location selection purposes. In addition, meeting notes from the modeling technical working group demonstrate scientific understandings that were developed during the modeling process and how locations were selected. The process used to determine recovery well locations was detailed and thorough, which was combined with other factors such as site access and citizen concerns.

Specific Comments - The following comments are intended to provide clarity to sections of the RFI report including text, figures, and tables. For each comment below, the relevant RFI text is provided in bold and labeled according to the RFI page and line number, which is then followed by comments from the EPA reviewer.

EXECUTIVE SUMMARY

ES-1, line 5: The Report summarizes all investigation activities and interim measures performed between November 11, 1999 and December 31, 2015.

Comment: The RFI should include a description of the technical working groups. Important discussions, interpretations, and decisions were made during working group meetings.

ES-3, line 34: In addition, fuel gain and loss records from 1996 through 1999 (the facility was only required to keep records for the previous three years) indicated a total loss for 1999, but a total gain for the years 1996 and 1998.

Comment: Please explain, generally, what is meant by fuel gain and loss, and what the records contain.

Figure ES-3: The RFI Report uses nine areas of interest (AOI) to subdivide the Site by method of investigation. The specific location of each AOI is illustrated in Figure ES-3.

Comment: Figure ES-3 does not label area AOI 9.

Figure ES-6: Refer to figure.

Comment: Areas AOI 6 and AOI 7 are not shown on the map, but are included in the map legend.

ES-19, line 21: The releases at the Site occurred sometime prior to 1975 through 1999, but were not continuous.

Comment: The releases may have occurred at regular times, although not continuously. Regular releases may have occurred assuming railcar unloading occurred on a regular basis. The RFI should provide an indication of the frequency of rail car unloading, if known, and the length of time to unload fuel.

ES-19, line 22: Remaining fuel left in the line would drain into the subsurface through holes in the pipelines after the vacuum was shutoff.

Comment: The RFI should provide any information on the sizes of holes in the pipelines, if known, to help estimate the length of time it would take for fuel lines to drain.

ES-21, line 4: Groundwater flow was originally to the southwest, but reoriented 180 degrees to the northeast in the late 1970s due to Water Authority pumping regimes.

Comment: Using the precise direction of 180 degrees seems more accurate than records can verify. A more realistic explanation would be to say that the groundwater flow direction changed to be approximately northeast.

ES-21, line 15: The releases were discovered in 1999. BFF infrastructure from the FFOR to the pump house was taken off-line at this time, which removed the source jet fuel contamination.

Comment: This sentence leaves the impression that the contaminant mass/LNAPL source was removed. Because the main concern at the site is groundwater contaminated with EDB, which originates from the LNAPL, the source or source area should be referred to in terms of LNAPL, not pipelines.

ES-24, line 19: The source of the jet fuel releases, the underground pipeline from the FFOR to the pump house, has been removed.

Comment: Similar to comment above. The LNAPL has not been removed entirely.

ES-25, lines 6 and 14: (line 6) The following recommendations are made to close the remaining data gaps and continue the implementation of interim measures at the Site. (line 14) Install at least one additional GWM well cluster north and west of KAFB-10626 in order to fully delineate the dissolved-phase EDB plume in AOI 9 and provide an additional sentinel well in that area.

Comment: In the event that additional recovery wells are needed, and additional modeling is performed for that purpose, more information should be collected about the hydrogeology along model boundaries. This is especially important if transient modeling is performed because of changes to site groundwater flow caused by changes to boundary conditions. This would close a data gap in terms of groundwater flow.

GROUNDWATER INVESTIGATION METHODS AND RESULTS

P 6.1, line 13: Five GWM wells were installed between 2000 and 2007 and sampled quarterly to determine the nature and extent of any groundwater contamination resulting from the release as prescribed in the *Stage 1 and Stage 2 Abatement Plans* and their addendums (AFCEE, 2000; 2002).

Comment: (a) This early phase of the investigation did not determine the nature and extent. (b) It would be informative to explain why Kirtland installed only five monitoring wells over a period of seven years.

P. 6.1, line 16: These compounds were detected periodically at selected wells between 2000 and 2006 (AFCEE, 2006c).

Comment: An explanation should be given for why compounds were detected periodically. The early monitoring wells were probably not in the right places at that time to obtain consistent detections.

P. 6.1, line 25: In 2010, NMED directed the installation of 78 additional GWM wells (NMED, 2010c) to further delineate the extent of groundwater contamination.

Comment: The RFI should explain Kirtland's site investigation activities that took place between 2006/2007 and 2010.

P. 6.1, line 35: In addition to plume characterization and routine monitoring activities, an interim measure was implemented in 2015 to collapse and hydraulically control the EDB plume.

Comment: The RFI should discuss the collaborative efforts of the Air Force, the diverse memberships of technical working groups, contractors, etc. in determining interim measures. Efforts to determine the

locations of recovery wells, numbers of wells, pumping rates, capture zones, stratigraphy, pumping tests, and other activities leading to interim measures were at one time or another part of technical working group activities.

P. 6.2, line 9: In accordance with the *Groundwater Investigation Work Plan* (USACE, 2011c), installed GWM wells have been screened in one of three zones — Shallow Zone, Intermediate Zone, and Deep Zone.

Comment: (a) The RFI should describe how these three zones are hydraulically connected to the production zones used by water utility wells, Kirtland wells, and the VA well. Kirtland's potentiometric surface maps that show that shallow groundwater is influenced by the Ridgecrest well field. (b) The RFI should discuss basin architecture and stratigraphy, including the differences and similarities in depositional environments between the three zones and production well zones, to indicate the degree of physical connection between them.

P. 6.2, line 44: The cuttings were lithologically logged and were described according to the USCS; ASTM D2487 (2011 and previous versions). Soil boring logs and construction diagrams for each well are included in Appendix D.

Comment: (a) In academic terms, the RFI incorrectly refers to stream sediment deposits and alluvial fan deposits as soil. The RFI should state how deep the actual soil profile is at the site, so that readers do not confuse soil with deeper unweathered sediments. (b) The logs in Appendix D are incorrectly referred to as Soil Boring Logs. It is understood that sometimes in practice deep sediment is referred to as soil, but there are clear differences. (c) Line 44 and 45 are inconsistent because lithology and soil are not the same. If the USCS system is used to describe geological material deeper than the soil profile, then the RFI needs to explain any limitations of using the USCS for that purpose at the site.

P. 6-9, line 41: Subsurface Investigation Methods

Comment: The role of the technical working groups during the subsurface investigation, including determining investigation methods and related outcomes, should be described.

P. 6-13, line 4: The goal of the slug testing was to refine estimates of the spatial variability of the hydraulic conductivity of the aquifer system at the Site.

Comment: The saturated units occurring within the limited range of monitoring well depths, that is the interval from the shallow to the deep zone, do not form an aquifer system by itself. Within this small vertical interval, the saturated units lack the characteristics that allow them to be defined as an aquifer system.

P. 6-15, line 18: This section discusses the results of groundwater sampling performed from 2000 through Q4 2015. The discussion includes examination of results by analytical constituent, an analysis of the nature and extent of fuel-related contamination, and analysis of the nature and extent of fuel-related contamination over time.

Comment: When discussing the extent of fuel-related contamination, it would be informative to explain how the axial channel deposits affect plume extent, because the working concept is that EDB (at least) is

migrating through a set of braided stream deposits that both restrict and facilitate EDB movement. The deposits restrict movement in the transverse direction (east-west), but cause relatively increased movement along the longitudinal channel axis (north-south). Some of this would be caused by channel dimensions and channel boundaries, and some caused by anisotropic conditions.

P. 6-15, line 24: Understanding of the nature and extent of the fuel-related contaminants has developed over time as the well network and monitoring program have been expanded, as illustrated in Figure 6-3.

Comment: The exterior plume concentration on figure 6-3 should be labeled (0.05 ppb).

P. 6-16, line 1: EDB was detected in 30 of the 60 Shallow Zone GWM wells as shown in Figure 6-4.

Comment: Has it been verified that rising groundwater levels and submerged monitoring well screens are not in any way related to decreases in EDB concentrations? The RFI needs to say whether it has been verified or not.

P. 6-16, line 30: Figure 6-7 presents the EDB plume in cross-section in Q4 2015.

Comment: Given all the detailed work on stratigraphy performed by AECOM, has the Air Force or consultants developed any isopach maps, aquifer property maps, or other types of maps illustrating the aerial patterns of braided stream deposits believed to be transmitting EDB? If so, it would be good to include them in the report, or in any related supporting background documents.

P. 6-16, line 33: The non detect result for EDB at KAFB-106212, which was screened from 85 to 100 feet below the water table at this location bounds the vertical extent of the EDB plume (Figure 6-6).

Comment: (a) The cross-section on figure 6-7 does not show KAFB-106212 being non-detect, and therefore does not bound the vertical extent of the plume. (b) The cross-section on figure 6-7 shows that KAFB-106212 is not screened from 85-100 feet below the water table.

P. 6-26, line 15: Aerobic microbial respiration results in the release of CO2 into groundwater which dissolves carbonate minerals from the soil into the aquifer and increases groundwater alkalinity concentrations.

Comment: (a) Please explain how the presence of carbonate minerals was verified. (b) Is the RFI referring to carbonate minerals in soil, or carbonate minerals in alluvial fan and/or Rio Grande sediments, or all three?

P. 6-29, line 12: Alkalinity (as calcium carbonate) increases when there is an increased rate of mineral dissolution (USACE, 2016b). Microbial degradation of organic compounds causes an increase in CO2 concentrations, which results in the lowering of the pH, which in turn, causes an increased rate of mineral dissolution.

Comment: Assuming that carbonate minerals are present, what work has the Air Force or consultants performed to determine whether there is enough carbonate mineral mass within plume sediments to cause alkalinity to increase substantially?

P. 6-32, line 7: Appendix N includes historical water level elevations collected at the Site.

Comment: Tables throughout the RFI that contain coordinates of monitoring wells list the northing and easting coordinates using two different coordinate systems, or perhaps use different units.

P. 6-32, line 15: As discussed below, this is due to reductions in pumping rates at Water Authority drinking water supply wells.

Comment: (a) It is more appropriate to say this results from reductions in volumes of water extracted, not rates. (b) City well pumping changes a great deal from season to season and well to well. Include information that shows well production information over time, to document decreases in pumping volume and increased aquifer levels. (c) Explain related effects of regional aquifer recharge.

P. 6-33, line 4: This figure also illustrates that the northernmost wells are most responsive to changes in the pumping rates at the Water Authority Ridgecrest well field, the closest Albuquerque drinking water supply wells to the Site.

Comment: The April-June 2016 Quarterly groundwater monitoring report says that the regional aquifer does not include any of the BFF groundwater monitoring network wells. However, this contradicts the RFI, which includes figures showing hydraulic connection between the EDB plume and deeper sections of the aquifer, supplying water to production zones in the Ridgecrest well field.

Table 6-11: Groundwater Elevations in Comparison with Screen Depths, Q4 2015

Comment: No footnote is given for the far right column (Difference/feet).

P. 6-33, line 13: The Water Authority predicts that based on current and planned conservation practices water levels in Albuquerque's aquifer will continue to rise into the 2020s (See Section 7; Water Authority, 2016).

Comment: Given the expected continual rise in groundwater levels, the RFI should discuss how recovery well pumping rates may need to change in order to account for changes in groundwater gradients towards the Ridgecrest well field.

Page 6-34, line 28: However, these data are still be useable as a secondary source in conjunction with more robust data to define the stratigraphy at SWMU ST-106/SS-111 (see Section 7).

Comment: (a) The expert review of geophysical logs by NMED, done via EPA contractor, indicated problems with logging instrument calibration so uses of logs are limited. (b) Wording error.

Page 6-37, line 22: GWTS interim measure tasks were performed in the following timeline.

Comment: Groundwater modeling was performed before any of the listed tasks.

CONCEPTUAL SITE MODEL

Page 7-2, line 13: The primary parent bedrock is granite from the Sandia Mountains, which produce sandy soils (80 to 100% sand) as erosion occurs.

Comment: The main soil forming processes are most likely mechanical and chemical weathering, not erosion. Erosion is a means of transport of soil and other material.

Page 7-3, line 22: Two fine-grain clay-rich layers called A1 and A2 are regionally present within the axial Ancestral Rio Grande fluvial deposits. These layers are present throughout the Albuquerque area. (AECOM, 2015).

Comment: It would be better to reference the original published author when referring to the regional presence of A1 and A2. Check Connell (1998) to see if the original author for A1 and A2 is referenced there.

Page 7-3, line 38: Figure 7-4 illustrates regional sediments of the Upper Santa Fe Group, which are associated with the alluvial fan and Ancestral Rio Grande deposits.

Comment: Figure 7-4 is not a regional cross-section and it does not show regional stratigraphy. Figure 7-4 is a cross-section through a relatively small part of southeastern Albuquerque. The figure title is also incorrect.

Page 7-5, line 9: The braided-type nature of Ancestral Rio Grande deposits, combined with the structural dip of thin laterally discontinuous fine-grained zones within, has resulted in migration of the dissolved phase EDB plume parallel to general groundwater flow.

Comment: This sentence makes a conclusion without acknowledging that there are still unknowns about why the plume has its unusually long and narrow shape. Depositional patterns may be one cause, but it is unclear how much past influence the Love and Charles well fields vs. Ridgecrest have had on plume movement. There are plumes in braided stream deposits in other parts of the country that are wide, suggesting that braided patterns alone do not limit solute migration to be only parallel to groundwater flow.

Page 7-5, line 13, line 16: The regionally present A1 and A2 clay layers (Section 7.5.1) are also present at the Site as laterally continuous fine-grained zones.

Comment: (a) The clay layers should be referred to as clay-rich layers. (b) The RFI needs to define regional, sub-regional, local, and site to more accurately describe the extent of geologic formations and members. (Please see the comment at Page 7-8, line 18, for more information on the use of the term site.)

Page 7-5, line 17: These confining beds play a key role in the transport of dissolved-phase contaminants by reducing the potential for downward transport, as discussed in Section 7.6.2.

Comment: (a) The RFI needs to explain that the Ridgecrest wells and other production wells still have a major influence on EDB plume migration regardless of the A1 and A2. (b) Another factor the RFI

should describe is the degree of cementation of sediments above the A1 and A2. When looking at outcrops during field trips, it has been observed that some deposits of larger particle sizes (e.g. gravels) can be more well cemented than smaller particle sizes (e.g. sand), so the ordinary relationship of particle size to hydraulic conductivity may be different because of cementation. (If the cement is calcite cement, that would also help answer the question about the occurrence of carbonate mineral dissolution.)

Page 7-5, line 26: The sands of the Santa Fe Group in the Albuquerque Basin (Section 7.5.1) provide the majority of the groundwater resources for Albuquerque and Kirtland AFB.

Comment: This statement limits the major water producing zones to only strata containing sand sized particles. Braided stream deposits tend to have mostly silt, sand, and gravel size ranges. If sands are actually producing most of the water, please provide the supporting information. There are a few published reports on borehole flow logging that may provide the necessary supporting information.

Page 7-5, line 31: The majority of Lower Santa Fe Unit has low permeability and poor water chemistry; thus, the groundwater is primarily withdrawn from the Upper Santa Fe and Middle Santa Fe hydrostratigraphic units (Hawley et al, 1996).

Comment: Suggest changing the word chemistry to quality.

Page 7-6, line 1: 7.6.1.1 Regional Groundwater Recharge

Comment: (a) The discussion should also include aquifer discharge, including wells and natural discharge boundaries. (b) At one time there was recharge to the regional aquifer from the perched aquifer on the base property located southeast of the BFF. (See: Balleau Groundwater, Inc., 2002, Model of a perched zone of saturation at Sandia National Laboratories, New Mexico.)

Page 7-2, line 10: This rise in groundwater elevations due to both the San Juan-Chama project and decreases in water use practices of Albuquerque citizens has been documented during the Site investigation as described in Sections 5 and 6, and is projected to continue into the 2020s (Water Authority, 2016).

Comment: The currently decreased groundwater gradient towards Ridgecrest wells should not be a reason to minimize corrective measures. In 2014, the water utility authority provided a written statement saying that a worst-case scenario should be the basis for the remediation strategy. The worst-case should account for continued EDB migration towards the Ridgecrest well field, with future pumping expected to be similar to the irrigation and non-irrigation seasons from 2009-2011. The water utility authority basis should be used unless the authority provides a different recommendation.

Page 7-7, line 30: Where drinking water supply wells in the vicinity of the Site are screened at and belowA1 and A2 (Figure 7-3), the layer acts as an aquitard between the contaminant plumes and confined groundwater used for water supply.

Comment: (a) Figure 7-3 is the wrong figure. (b) The shallower EDB plume has moved in the direction of the Ridgecrest wells because of hydraulic connection between shallow and deeper strata. Some parts of the aquifer used for production wells may not be confined or may be partially confined. Short term

water level measurements may indicate a lack of connection, but long-term flow suggests connection between shallow and deeper parts of the aquifer.

Page 7-7, line 40: Investigation results indicate that physical aquifer properties such as hydraulic conductivity are highly variable at the Site.

Comment: The spatial variability in K occurs on a relatively small scale compared to the larger and consistent pattern of K throughout the aquifer. There is an overall pattern of high K extending from north to south, and K decreases from east to west. This pattern of K was used by NMED for its conceptual model, and is consistent with published work. This north-south high K pattern should be recognized when designing corrective measures.

Page 7-8, line 18: According to the current Kirtland AFB's *Installation Development Plan*, the Site is located within the "Flightline District." The Flightline District is primarily industrial, with facilities and land uses dedicated to the support of airfield operations. As a result, current and anticipated future land use is primarily industrial for the Site, with limited, restricted administrative use (KAFB, 2016b).

Comment: (a) The vicinity of the off-base EDB plume is a mixed use area containing many residences and small businesses. That area is not primarily industrial, and it does not appear to support airfield operations. (b) The RFI defines the term "Site" as the location of jet fuel leaks that occurred over an unknown period of time at Kirtland AFB. However, the RFI uses the term Site inconsistently through the report. There are places when Site refers to only the area on-base where the leaks occurred, and there are places when Site refers to off-base EDB plume. This inconsistency is present in the RFI text as well as in figures and tables.

Page 7-10, line 10: As discussed in Section 2.2, three failure points were identified in the transfer pipelines, indicating that a small volume of LNAPL was released to the subsurface during each fuel transfer.

Comment: Kirtland has stated that the total volume of the release cannot be estimated. The RFI should then refrain from using other volume related terms (small) for describing releases even if they are just for fuel transfer periods. If the RFI still needs to say small, then the RFI should state that the total release was large, so that readers can keep the relative sizes of individual and total release in perspective.

Page 7-14, line 1: At the Site, the water solubility is a major factor as to why the EDB plume extends further downgradient then the BTEX plume as shown in Figure 6-4.

Comment: Figure 6-4 does not show the BTEX plumes.

Page 7-17, line 17: In addition to advective contaminant transport created by the cone of depression around the Ridgecrest well field, the heterogeneous lithology of the QTsa influence fuel related contaminant flow in groundwater (AECOM, 2016).

Comment: QTsa is notation used on geologic maps and cross-sections. The RFI needs to say what QTsa is.

Page 7-17, line 21: The EDB plume migrates within the regional groundwater system, which consists of coarse-grained, braided stream-type deposits with northeast-southwest oriented channel axes as described in Section 7.5.

Comment: (a) Stating that the EDB plume migrates within the regional groundwater system is inconsistent with some Kirtland quarterly monitoring reports. (b) Referring to braided stream deposits as braided stream-type deposits suggests that the Air Force is uncertain about the environment of deposition. The RFI should say braided stream deposits. (c) The axis of the paleo-channels could be more northward, and there have been concerns/questions expressed in meetings about plume movement being northward at times.

Page 7-17, line 23: The braided nature of these channel deposits, combined with the structural dip of the thin floodplain clay units within the aquifer system, has resulted in lateral spreading of the plume in directions parallel and perpendicular to general groundwater flow. (AECOM, 2015)

Comment: (a) This sentence is inconsistent with the sentence at RFI Page 7-5, line 9 (*The braided-type nature of Ancestral Rio Grande deposits, combined with the structural dip of thin laterally discontinuous fine-grained zones within, has resulted in migration of the dissolved phase EDB plume parallel to general groundwater flow.* (b) This sentence should also include the process of dispersion to be consistent with the last section on page 7-17. (c) Punctuation error at end of sentence.

Page 7-20, line 21: There are two types of sediments of the Santa Fe group that comprise the geology of the Site: east-west oriented alluvial fan deposits derived of sediments eroded from the Sandia and Manzanita mountains, and north-south oriented Ancestral Rio Grande deposits.

Comment: There are more than just two types of sediment. This should be restated to say there are two main depositional environments at the site, or say that sediments are derived from alluvial fans and Rio Grande deposits.

Page 7-21, line 29: The releases were discovered in 1999. BFF infrastructure from the FFOR to the pump house 30 was taken off-line at this time, which removed the source jet fuel contamination.

Comment: This sentence leaves the impression that the contaminant mass/LNAPL source was removed. Because the main concern at the site is groundwater contaminated with EDB, the source or source area should be referred to in terms of the presence of remaining LNAPL, not pipelines.

CONCLUSIONS AND RECOMMENDATIONS

Page 8-1, line 33: As groundwater flowed around the edges of the LNAPL, the soluble constituents were dissolved into groundwater and moved downgradient through advection.

Comment: Usually both advection and dispersion are used to describe solute transport, not just advection.

Page 8-2, line 20: As of Q4 2015, the nature and extent of groundwater contamination at the Site has been characterized with the exception of the northwestern most area of the dissolved-phase EDB plume, where concentrations at KAFB-10626 are below the MCL, but have been increasing.

Comment: This contradicts earlier statements in the RFI about plume movement to the northeast.

GENERAL COMMENT:

The report contains a number of writing mistakes including misspellings, punctuation, wording, etc. that should be corrected.