DEPARTMENT OF THE AIR FORCE
377TH AIR BASE WING (AFGSC)

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SEP 08 2020

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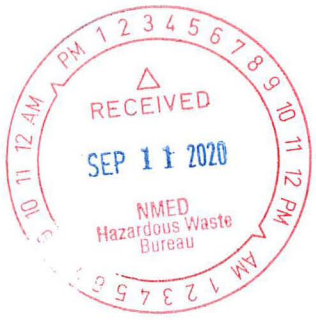

Mr. Kevin Pierard and Mr. Dave Cobrain
Hazardous Waste Bureau (HWB)
New Mexico Environment Department (NMED)
2905 Rodeo Park Drive East, Building 1
Santa Fe NM 87505

Dear Mr. Pierard

As detailed in the attached Response to Comments (RTC) table, the Air Force has a number of concerns regarding the 04 March 2020 "Disapproval Ethylene Dibromide In Situ Biodegradation Pilot Test Report Bulk Fuels Facility Solid Waste Management Units ST-106 and SS-111 Kirtland Air Force Base, New Mexico EPA ID# NM6213820974 HWB-KAFB-19-011" (ISB Pilot NOD). Our concerns fall under the following four categories:

1. Comments that contradict scope previously approved by NMED.
2. Comments unrelated to the scope of the ethylene dibromide in situ biodegradation pilot (ISB Pilot).
3. Global directions for future work that go beyond this report.
4. Technical comments and clarifying questions.

Background

A pilot test is a focused, limited-scale test of a technology that is used to determine the potential effectiveness of the technology under field conditions and the feasibility of including it in the final remedy selection. Unlike interim measures, the design and implementation of pilot tests are not a requirement in Kirtland Air Force Base's (AFB's) Hazardous Waste Treatment Facility Operating Permit (HWTF Permit No. NM9570024423 (RCRA Permit). The Air Force's voluntary implementation of pilot tests, such as the ISB and bioventing pilots, reflects our continued commitment to progressing towards a robust, data-driven Corrective Measures Evaluation (CME).

The Air Force acknowledges that the current NMED staff assigned to oversee the Bulk Fuels Facility (BFF) corrective action was not involved in the initial development of the scope for the ISB Pilot during the spring of 2016. The genesis of the ISB pilot was work performed under the Environmental Security Technology Certification Program (ESTCP). This Department of Defense program was established in 1995 to promote innovative technology transfer. From the beginning, the focus of this pilot was solely on the biodegradation of EDB. The original Air Force proposal to ESTCP was for a push-pull test in a single well to evaluate if the addition of an

amendment would stimulate bacterial growth around the well and facilitate the degradation of EDB. After several meetings in 2015 with NMED's Chief Scientist Mr. Dennis McQuillan and other technical stakeholders, the Air Force offered to pursue funding for a more robust pilot that would focus on the anaerobic degradation of EDB. This funding was subsequently secured, which led to the submittal of the ISB Pilot work plan to NMED on 26 October 2016.

As detailed in the work plan approved by NMED on 12 December 2016, the primary objective of the pilot test was to determine if the proposed amendments would enhance the anaerobic biodegradation of EDB. A secondary objective was to use data from the ISB Pilot to inform the evaluation of using in situ treatment of EDB in groundwater in the CME. The work plan detailed all aspects of the proposed pilot including, but not limited to, drilling methods, well design and monitoring activities. No additional work beyond this approved scope was anticipated by NMED or the Air Force, therefore, no funding has been allocated beyond the approved Phase 4 monitoring.

Comment Summary

The Air Force has previously emphasized the importance of being able to rely on prior commitments and direction from NMED. The ISB Pilot NOD does not reflect the discussions and agreement between Mr. Mark Correll, Deputy Assistant Secretary of the Air Force for Environment, Safety and Infrastructure, and NMED Cabinet Secretary James Kenney in our 07 January 2020 meeting that the Air Force has a right to rely on prior commitments and direction from NMED to ensure federal resources are spent appropriately to continue to move this project towards final remedy selection. It contains numerous comments that are either unrelated to the scope of work or contradict scope previously approved by NMED. For example, many of NMED's comments in the NOD focus on the "failure" of the EDB pilot to address the delineation of light non-aqueous phase liquid (LNAPL). Because the NMED-approved scope was limited to the evaluation of the anaerobic biodegradation of EDB, the lack of discussion in the report regarding the nature and extent of LNAPL is to be expected and is clearly not grounds for disapproval of the ISB Pilot Report.

The Air Force submitted a letter to NMED on 09 July 2020 regarding our request that NMED issue separate letters for global directions that go beyond a comment on an individual document. The attached RTC table highlights a number of these global comments in this NOD. Based upon a recent conversation with NMED staff, it is our understanding that NMED will be issuing a letter to address this request soon.

Additionally, the RTC table details the Air Force's responses to NMED's technical comments and questions that are related to the approved scope of work for the ISB Pilot. The Air Force looks forward to discussing these comments with NMED at the Department's convenience. The results of this meeting will facilitate the Air Force's revision of this report.

NMED approved the Air Force's 26 March 2020 extension request on 02 April 2020 and established a new ISB Pilot Report submittal date of 18 September 2020. To allow time for NMED's review of the RTC table, a meeting between NMED and the Air Force to discuss the RTC table and for the Air Force to revise the ISB Pilot report the Air Force respectfully requests an additional extension to 20 November 2020. This date was based on the assumption that the meeting would be held before the end of September.

If you have any questions or would like to schedule a call to discuss these issues further, please contact Mr. Sheen Kottkamp at 505-846-7674 or sheen.kottkamp.l@us.af.mil.

Sincerely

RYAN NYE, Colonel, USAF
Vice Commander

Attachments:
1. AF Draft Response to Comments Table and associated attachments
2. Scope of EDB ISB Pilot Test

cc:
NMED HWB (Pierard, Cobrain), letter and electronic
NMED RPD (Stringer), electronic only
EPA Region 6 (King, Ellinger), electronic only
SAF/IEE (Lynnes), electronic only
AFCEC/CZ (Cash, Kottkamp, Segura), electronic only
USACE-ABQ District Office (Moayyad, Phaneuf, Dreeland, Cordova, Kunkel), electronic only
Public Info Repository, Administrative Record/Information Repository (AR/IR) and File

40 CFR 270.11
DOCUMENT CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

RYAN NYE, Colonel, U.S. Air Force
Vice Commander, 377th Air Base Wing

8 Sep 20
Date

This document has been approved for public release.

KIRTLAND AIR FORCE BASE
377th Air Base Wing Public Affairs

8 Sep 20
Date

Ethylene Dibromide In Situ Biodegradation Pilot Test Report, Bulk Fuels Facility, Solid Waste management Units ST-106 and SS-111, Kirtland Air Force Base, New Mexico, EPA ID# NM9570024423, HWB-KAFB-19-011; letter dated March 4, 2020	
Comment Response to NMED NOD	
NMED COMMENT	**RESPONSE TO COMMENT**
1. Inconsistency in the Designations of Wells NMED Comment: The Permittee used multiple designations for wells in the Report. For instance, on Figure 2 of the Report, well KAFB-106008 is designated as KAFB-1068. Use of multiple designations for wells results in confusion for document reviewers and the public. The Permittee must use the official full designation for each well in every instance in all future documents submitted to NMED.	In order to avoid confusion and maintain consistency with recently submitted documents, well designations will be changed as appropriate throughout the revised Report (e.g., from KAFB-1068 to KAFB-106008 on Figure 2). As stated in the Air Force letter dated 16 July 2020, Air Force agrees with the global direction to consistently refer to wells by the same name. A list of wells associated with the Bulk Fuels Facility site, and a list of their current designations are included as Attachment 1 to this Response to Comments. Please note that well KAFB-106008 was not associated with the pilot test and was only included for location reference.
2. Executive Summary, page ES-3 Permittee Statement: "The modified Phase 3 was approved by the NMED in a letter dated August 7, 2018 (NMED, 2018)." NMED Comment: It should be noted that the NMED's letter dated August 7, 2018 approved the proposed modification under the following conditions: 1. Bioaugmentation shall remain as an approved, but deferred, component of the pilot test, and 2. The biochemistry/LNAPL technical working group shall meet as soon as practicable to review pilot test results and to discuss the deferral of bioaugmentation. The response letter must include details of the technical work group meeting where the deferral of bioaugmentation was discussed and along with any conclusions reached.	Comment noted. A technical working group (TWG) meeting was held on September 17, 2018 during which pilot test results were reviewed and the deferral of bioaugmentation was discussed. Given evidence of biostimulation of native bacteria and non-detectable or low EDB concentrations at pilot test wells, there was consensus that bioaugmentation was unnecessary at the time. The pilot test was conducted in accordance with the NMED-approved documents, which detail the technical approach. The TWGs established for the BFF project are not required by Kirtland AFB's Hazardous Waste Treatment Facility Operating Permit (HWTF Permit No. NM9570024423) and are solely advisory. No formal minutes are kept by either NMED or the Air Force. As stated by Ms. Stringer in BFF Stakeholder meetings, the Hazardous Waste Bureau is responsible for scheduling TWG meetings if the Department believes they will support the CME.

3. Section 1, Introduction, page 1-1 Permittee Statement: "[Anaerobic in-situ bioremediation] ISB, with and without bioaugmentation, is a common remedial approach to treat chlorinated solvents such as trichloroethene and is a promising technology for promoting the degradation of EDB to nontoxic products." NMED Comment: Anaerobic in-situ bioremediation of chlorinated solvents (e.g., trichloroethene) produces toxic byproducts such as vinyl chloride. Some byproducts are recalcitrant under anaerobic conditions. Although Section 4.5.2, *EDB, EDB Degradation Products*, pages 4-20, discusses EDB degradation products, the discussion lacks detail; therefore, it is not clear whether or not EDB produces toxic byproducts under anaerobic conditions (e.g., bromoethane, bromoethanol, vinyl bromide). Provide a more detailed discussion regarding EDB toxic degradation byproducts under anaerobic conditions in the revised Report.	The most common anaerobic degradation pathway for EDB involves dihaloelimination resulting in the formation of ethene and bromide (Wilson et al., 2008; Henderson et al., 2008; Koster van Groos et al., 2018). Sequential hydrogenolysis to bromoethane and then ethane is also possible (Henderson et al., 2008). A minor branching product of tentatively identified vinyl bromide was observed in the laboratory under slower EDB hydrolysis degradation conditions, but vinyl bromide was not detected during anaerobic biodegradation studies (Koster van Groos et al., 2018). Due to low EDB concentrations in the field, concentrations of possible vinyl bromide and bromoethane products were likely low and challenging to measure under field conditions. It was not attempted. Bromoethanol is a possible aerobic product, but unlikely to form anaerobically. Additional text will be added to Section 4.5.2 regarding degradation products.
4. Section 1.3, Site History, page 1-3 Permittee Statement: "Based on historical Air Force fuel usage, AvGas containing EDB as a lead scavenger would have been in use from approximately the 1940s to 1975." NMED Comment: Aviation fuels are known to contain additives. Clarify whether or not the fuels currently used at the site contain other potentially toxic fuel additives in the revised Report.	The Permittee Statement was included to describe to the readers of the Report when AvGas with EDB was likely to have been used at the site. Current fuel use is unrelated to BFF corrective action activities.

5. Section 1.4, Site Conditions, pages 1-3 and 1-4 Permittee Statement: "Based on data reviewed for the pilot test design, the groundwater gradient in the pilot test area was less than 0.002 foot/foot (First Quarter 2016), and the direction of groundwater flow had shifted from north-northeast to a more east-southeast direction, likely due to continuing water-conservation practices and seasonal fluctuations, as discussed in the Second Quarter 2018 Quarterly Monitoring Report (USACE, 2018b)." NMED Comment: According to Figure 2, *Site Location Map*, extraction well KAFB-106EX1 is located downgradient (east-southeast) from injection well KAFB-106INl that is consistent with current groundwater flow direction; hence, well KAFB-106EX1 is likely effective to enhance the hydraulic gradient, recirculate groundwater in the vicinity, and facilitate the distribution of the injection fluid. However, extraction well KAFB-106EX2 is located upgradient (west-northwest) from injection well KAFB-106INl. Well KAFB-106EX2 is less effective for the distribution of the injection fluid as demonstrated during the tracer test. In the response letter, provide an explanation for the purpose of using well KAFB-106EX2.	The pilot test used one injection and two extraction wells to distribute amendments in the pilot test area. The use of two extraction wells rather than one facilitated greater overall flow rates and a shorter recirculation period. All three tracers used during the pilot test (fluorescein, deuterated water, and iodide) arrived at KAFB-106EX2 (~76 feet from injection well at the surface) prior to KAFB-106EX1 (~92 feet from the injection well at the surface). The tracer data demonstrated that injected water was distributed to monitoring wells surrounding the injection well and ultimately to both extraction wells. This system design was reviewed and approved by the NMED and provided clear evidence of EDB biodegradation at multiple monitoring locations/wells. Please refer to Attachment 2 for discussion of the pilot test scope and timeline of NMED approvals. No revision to the text will be made.
6. Section 1.4, Site Conditions, page 1-4 Permittee Statement: "Additionally, treatability testing using Kirtland AFB soil and groundwater showed that bioaugmentation with a known debrominating culture (SDC-9) significantly enhanced EDB degradation rates (Figure 3). These results indicated that ISB, by stimulating the activity of indigenous EDB degrading organisms (i.e., biostimulation) or bioaugmenting with a debrominating culture (e.g., SDC-9), showed promise for enhancing EDB degradation at Kirtland AFB." NMED Comment: According to Figure 3, *Concentrations of EDB in Anaerobic Microcosms Prepared with Aquifer Samples Collected from the BFF Source Area*, the microcosm vessel augmented with the debrominating culture demonstrated EDB degradation. However, other vessels amended with nutrients but only aimed to stimulate indigenous microbes did not appear to demonstrate EDB degradation. Accordingly, the statement is inaccurate and misleading. Correct the statement for accuracy or provide an	The text will be revised to improve its clarity and accuracy. We agree that treatments without SDC-9 did not provide evidence of EDB biodegradation in microcosm tests (Figure 3). However, numerous rounds of groundwater sampling showed that organisms known to dehalogenate EDB or its chlorinated analog, 1,2-dichloroethane, were present in site groundwater, as stated in this section of the Report. Thus, the two sets of results showed promise of ISB in different manners. Regarding the treatability tests, it is possible that the native bacteria at the site did not survive sample collection and/or under microcosm conditions, thus leading to the negative data in the laboratory. It is difficult to accurately simulate subsurface conditions in a laboratory setting. The pilot test was designed specifically to take both sets of results (microcosms and molecular analysis) into account. The phased design of the pilot test allowed for initial testing of biostimulation (i.e., to determine if the native dehalogenating bacteria could biodegrade EDB) and secondary bioaugmentation with SDC-9 if biostimulation did not work. Field scale biostimulation using lactate and inorganic nutrients was extremely effective, so bioaugmentation was unnecessary. If SDC-9

additional explanation regarding other vessels/methods that did not appear to demonstrate EDB degradation in the revised Report.	was added at the beginning of the pilot test with lactate and inorganic nutrients, it would not have been possible to determine whether the SDC-9 culture or native dehalogenating bacteria were responsible for the observed biodegradation of EDB. Please refer to Attachment 2, which discusses NMED approval of the modified Phase 3 event. As noted in NMED Comment #2 above, bioaugmentation remains "as an approved, but deferred, component of the pilot test." Given successful biostimulation of native bacteria and non-detectable or low EDB concentrations at pilot test wells, there was/is little reason to bioaugment as part of the scope of the pilot test. If applicable, bioaugmentation may be considered in the CME if ISB is evaluated for larger scale application.
7. Section 2.3, Well Design and Installation, page 2-3 Permittee Statement: "Existing monitoring wells KAFB-106063 (screened from 505 to 520 feet bgs [below ground surface], with top of screen approximately 25 feet below the water table) and KAFB-106064 (screened from 485 to 505 feet bgs, with top of screen approximately 5 feet below the water table) were used for groundwater monitoring during the pilot test, along with the other newly installed wells." NMED Comment: According to Appendix A, Site Photographs, a photograph shows that light non-aqueous phase liquid (LNAPL) was detected in well KAFB-106S2. Presumably, KAFB-106S2 is the same well identified as KAFB-1068 in Figure 2, Site Location Map. In the revised Report, correct the well nomenclature in Figure 2 as necessary to be consistent. Additionally, since well KAFB-106S2 is located upgradient of the pilot test area, LNAPL may be present in the pilot test area as well. Wells with screened intervals submerged below the water table are not appropriate to evaluate the presence or absence of LNAPL. Well KAFB-106063 was used to evaluate the intermediate groundwater zone for the purpose of the pilot test; therefore, the submerged screen is acceptable. However, well KAFB-106064 was used to evaluate the shallow groundwater zone; therefore, the screened interval must not be submerged. It is critical that the extent of LNAPL plume is delineated. If this issue has not already been addressed, submit a work plan to propose to replace submerged screened intervals of all monitoring wells installed to evaluate the shallow groundwater zone in the source area (e.g., KAFB-106064).	The site photograph in Appendix A is correctly labeled, "LNAPL bailed from KAFB-106MW1-S;" however, "LNAPL" will be changed to "NAPL" to be consistent with the Report text. As described in Section 3.7 on page 3-12 of the Report, NAPL was noted in KAFB-106MW1-S during QED pump installation (after well development). KAFB-106S2 is not the same well as KAFB-1068 (or well identification KAFB-106008 which is clarified in the revised document) or KAFB-106MW1-S. KAFB-106S2 and KAFB-106008 were not sampled as part of the ISB pilot test project. KAFB-106S2 was installed as part of the Source Zone Characterization. Specific information regarding this well is documented in the Source Zone Characterization Report, which was submitted to NMED on October 25, 2019. NAPL delineation was not the intent of the pilot test (refer to Attachment 2 for a brief description of the pilot test scope). KAFB-106064 was in place before the pilot test was designed and performed. While KAFB-106064 is traditionally described as a shallow well, it is acknowledged that its screened interval was submerged at the time of the pilot test. Data from KAFB-106064 were carefully evaluated, including through examination of injected tracers, and observations from KAFB-106064 were consistent with wells KAFB-106MW1-S and 106MW2-S, both shallow groundwater monitoring wells. Both KAFB-106MW1-S and 106MW2-S are located approximately 50 feet from KAFB-106064 and their screens intersect the water table. No revisions have been made to the text. Please also note that fifteen newly installed groundwater monitoring wells that are screened across the water table have been installed since 2018. Eight of these wells

7. Continued.	were installed in the source area. Nine of these were installed during the recent coring activities and are discussed in the Source Zone Characterization Report. Additional source area wells will be installed in accordance with the NMED approved *Work Plan for Data Gap Monitoring Well Installation KAFB-106248 to KAFB-106252* (KAFB, 2019).
8. Section 2.3, Well Design and Installation, page 2-4 Permittee Statement: "The two pairs of nested groundwater monitoring wells, two extraction wells, and one injection well were installed by Cascade Drilling (formerly National Exploration Wells & Pumps) using an Air Rotary Casing Hammer (ARCH) drill rig from January through March 2017. During borehole advancement, soil cuttings were logged every 5 feet by the site geologist in accordance with the Unified Soil Classification System and American Standard Test Method International D1586-84." NMED Comment: The Air Rotary Casing Hammer (ARCH) drilling method pulverizes soil cuttings and prevents the ability to observe details in soil cores such as presence or absence of fractures and exact locations of hydrocarbon stains. Undisturbed soil cores characterize the subsurface conditions more accurately and such information can maximize the effectiveness of remediation later on. Acknowledge the shortcomings related to the drilling method used in the revised Report.	The ARCH drilling method was determined to be the best approach for the installation of the tightly spaced wells required for the pilot test. This drilling method was approved by NMED and is authorized under RCRA Permit NM9570024423, Section 6.5.9. The use of NMED-approved drilling methods is not a "shortcoming" and no revisions to the text will be made. Photoionization detector readings were collected from the drill cuttings and were recorded by the geologist on the soil boring log. Collecting and interpreting undisturbed soils cores for the presence or absence of fractures or carefully identifying hydrocarbon stains was beyond the scope of the pilot test (Attachment 2).
9. Section 2.3, Well Design and Installation, page 2-4 Permittee Statement: "Soil drill cuttings from just above and in the saturated zone were screened for presence of NAPL and volatile organic compounds (VOCs) using a photo ionization detector (PID) to collect head space measurements. Drill cuttings were also visually inspected for evidence of staining. PID readings were recorded on the soil boring logs (Appendix C)." NMED Comment: The collection of soil samples for laboratory analyses is necessary for every boring in the source area. The soil sampling data will provide useful information to determine the extent of soil contamination. The described field screening method does not provide sufficient data for site characterization. Propose to collect soil samples from every boring at the site in all future work plans.	The specific objective of this pilot test was to assess EDB biodegradation in groundwater in a well-controlled study. Wells were specifically installed for this purpose and with necessary characterization of drill cuttings to support the study design. Further characterization of soil samples from the borings was beyond the scope of the pilot test (Attachment 2). All well installation and sampling activities were performed in accordance with the NMED-approved work plan. No revisions to the text will be made. The Air Force understands that this comment and others relating to other global directives are being addressed separately by NMED.

10. Section 2.3, Well Design and Installation, page 2-4 Permittee Statement: "Table 1 presents the completion details for the wells, including surveyed elevations and coordinates, and screen depths." NMED Comment: According to Table 1, Well Completion and Survey Data, the depth to groundwater and the depth to the screened interval in injection well KAFB-1061N1 are recorded as 477.00 feet bgs and 477 -497 feet bgs, respectively. The depth to the top of the screened interval coincides with the depth of the water table. However, the depth to the top of the filter pack is recorded as 467 feet bgs according to Appendix C, Well Installation Forms, which is 10 feet above the depth to the water table. Since the filter pack is positioned above the water table, the injection fluid applied from the well is likely to follow the least resistant pathway above the water table, rather than in the aquifer matrix due to the lack of the hydrostatic pressure. The screen and filter pack intervals should have been positioned below the water table. The pilot test data obtained from the injection wells with screened intervals positioned above the water table may generate positively biased· results for the shallow groundwater zone because injection fluids will be distributed in larger lateral extent on the groundwater interface. No revision required.	Comment noted. As suggested, no revision will be made to the text. Well installation was performed in accordance with the NMED-approved work plan. NMED reviewed and approved the draft well completion diagrams generated by the field geologist prior to initiating well installation. The comment illustrates the value of using appropriate tracers during the pilot test. These tracers captured the transport and distribution of water from injection to sampling location. Tracers were observed at KAFB-106064, which did have a submerged screen, at similar concentrations and time intervals as KAFB-106MW2-S and KAFB-106MW1-S, and at the intermediate wells, where the screens are 35+ feet below the water table. These tracer results demonstrated that injected water arrived at deeper sampling locations in addition to shallower locations.
11. Section 2.3.1, Groundwater Monitoring Well Installation, page 2-5 Permittee Statement: "The two shallow monitoring wells (KAFB-106MW1-S and KAFB 106MW2-S) were constructed with 4-inch diameter, Schedule 80, polyvinyl chloride (PVC) riser pipe; and the two intermediate wells (KAFB-106MW1-I and KAFB-106MW2-1) were constructed with 3-inch diameter, Schedule 80, PVC riser pipe." NMED Comment: The screened intervals for intermediate wells KAFB-106MW1-I and KAFB-1062-I were both installed at 513 - 523 feet bgs. According to Section 1.4, Site Conditions, the deepest depths of the water table at the site ranged from 500 to 502 feet bgs in 2009, which is approximately 25 feet below the current groundwater table. According to Appendix C, Well Installation Forms, the elevated PID readings are recorded at the depths ranging from 485 feet to 510 feet bgs in the borings installed in the pilot test area.	Comment noted. As suggested, no revision will be made to the text. NAPL delineation was not the purpose of the pilot test (Attachment 2). Please also note that fifteen newly installed groundwater monitoring wells that are screened across the water table have been installed since 2018. Eight of these wells were installed in the source area. Nine of these were installed during the recent coring activities and are discussed in the Source Zone Characterization Report, which was submitted to NMED on October 25, 2019. Additional source area wells will be installed in accordance with the NMED approved *Work Plan for Data Gap Monitoring Well Installation KAFB-106248 to KAFB-106252* (KAFB, 2019).

Adsorbed and submerged LNAPL may be present at depths of 485 feet to 510 feet bgs. The PID readings corresponding with the depth of the screened intervals for the intermediate wells (513 - 523 feet bgs) are relatively low; therefore, adsorbed LNAPL is unlikely to be present at the screened depth. These intermediate wells may be useful to evaluate the distribution of the injection fluids at the deeper groundwater bearing zone during the pilot test; however, since the screened intervals of the wells do not correspond with the depths where adsorbed/submerged LNAPL is present, these wells are not suitable for future LNAPL monitoring and remediation purposes. No revision required.	
12. Section 2.4.4, Pump Installation, page 2-11 Permittee Statement: "A 6-inch sanitary well seal and a 1.5-inch-diameter threaded steel pipe were installed in the injection well casing to convey water from the piping exiting the system Conex box to the screened interval of the injection well. The injection pipe extended down into the water column and was fitted with a 4-inch diameter, custom designed and fabricated down-hole flow control valve (FCV, manufactured by Baski, Inc.) to limit risks of cavitation within the pipe, and to minimize volatilization and aeration of the anaerobic recirculation water." NMED Comment: The flow control valve was used to regulate the injection flowrate, indicating that the injection was controlled by flowrate rather than pressure. Explain whether the injection flowrate was regulated by the height of the water column or the groundwater extraction flowrate or both. In addition, during the Phase 2 and Phase 3 periods of the pilot test, the height of the water column in the injection well significantly increased due to the biofouling of the screen. Unless this issue is resolved, the tested remedial approach would not be practicable for long-term or large-scale operations due to well screens clogging from biofouling and restricting the ability to add amendments to the contaminated groundwater. Discuss potential measures to resolve the issue in the revised Report.	The injection flow rate was controlled through regulation of extraction well pumping rates and was equal to the combined flow rate of the two extraction wells. The Baski down-hole flow control valve (FCV) was installed to provide sufficient backpressure to ensure that piping would remain full of water throughout the treatment system. This limited risks of cavitation, COC volatilization, and aeration of the anaerobic recirculation water. The text will be revised to clarify this. Wells installed under the pilot test were designed to recirculate groundwater together with treatment amendments to determine whether EDB biodegradation could be stimulated. The wells were designed to perform as necessary for the study as scoped and were not sized for extended operation. Well rehabilitation was not performed during the pilot test period described in the Report as it could have impacted or complicated interpretation of collected data. Contingencies for biofouling will be addressed under the CME when assessing this technology for larger-scale operation.

13. Section 2.6, Recirculation Pilot System Equipment and Materials, page 2-13 Permittee Statement: "The system was designed to extract groundwater from the two extraction well locations and reinject that groundwater in the injection well after tracer or amendment addition, at a design flow rate of up to 24 gpm." NMED Comment: According to Figure 6, Process Flow Diagram, and Figure 5, Recirculation and Amendment System Piping and Instrumentation Diagram, an injection or transfer pump that delivers the injection fluid is not depicted in the system. Explain how the fluid is delivered to the injection well without a transfer pump in the response letter. In addition, LNAPL is present at the site; however, the components depicted in the system do not appear to have a mechanism to remove LNAPL, if present, from the recovered groundwater. Explain how LNAPL is handled by the recirculation system in the response letter. The system must have a mechanism to remove LNAPL from the recovered groundwater.	A chemical feed pump was used to pulse the concentrated amendment solution from the amendment tank into the injection well piping located within the Conex box system (labeled as "Chemical Feed Pump" in Figure 5, Process Flow Diagram). This in-line injection allowed for introduction of amendments to the recirculation water stream under pressure. Sufficient pressure from the extraction well pumps existed to deliver groundwater through the amendment system and to the injection well without the need for additional pumps. Text in Section 2.6, page 2-17 will be revised for clarification. Pump intakes were designed to be below the water surface and NAPL was not expected to be entrained in extracted water. As NAPL was not expected in the process stream, the treatment system was not designed to remove NAPL and no mechanism to remove it from the recovered groundwater was in place. During and after recirculation operations, NAPL was not observed in the filters/filter canisters of the recirculation system (for particulate removal) or at injection well KAFB-106IN1. NMED reviewed and approved the system design. Refer to Attachment 2, which summarizes the scope of the pilot test.
14. Section 3.3, Phase 1 -Tracer Testing, page 3-3 Permittee Statement: "During the entire Phase 1 recirculation period, approximately 1,024,000 gallons of water were extracted and reinjected." NMED Comment: Based on the distance from the injection well to the extraction wells, aquifer thickness, effective porosity, and volume of groundwater extracted and reinjected, provide an estimate for how many pore volumes of groundwater were exchanged in the treatment zone. Additionally, provide the estimate of pore volumes exchanged for the subsequent phases of the pilot test. Include the calculations and discussion in the revised Report.	The system was designed to recirculate water and distribute water to monitoring locations to demonstrate in situ biodegradation of EDB. Tracers were used to provide evidence regarding the distribution and mixing of injected water to monitoring locations. The suggested calculations were not included in the scope of the approved work plan and the measured evidence of distribution at field scale provided by tracers is arguably stronger. Calculation and discussion of the estimated pore volumes exchanged within the treatment zone will not be included in the revised Report. If applicable, modeling of amendment distribution in the subsurface may be considered in the CME if ISB is evaluated for larger scale application.

15. Section 3.3, Phase 1-Tracer Testing, page 3-4 Permittee Statements: "The likely cause of the inaccurate [pressure transducer] readings was electrical interference from the extraction well pumps' power leads running down the well to the pump near the drop tubes where the transducers and their control wires were housed. As a result, manual water level readings were periodically measured using the Solinst water level meter. Manual water level readings are summarized in Table 5." and, "During recirculation system operation, it became apparent that the water level readings from pressure transducers located in the extraction well drop pipes were not accurate. While the readings returned to the SCADA were erratic, the overall trends in the data were decipherable." NMED Comment: The recirculation operation during the Phase 1 period was conducted from October 2 to November 3, 2017. According to Table 5, Manual Extraction Well Water Level Measurements, only three measurements (October 17, 23, and 31, 2017) were collected during that time. The data should have been collected more frequently, particularly at the beginning of the recirculation process because the drawdown data would be useful to determine the properties of the aquifer. In the revised Report, provide the original data initially collected from the pressure transducers and demonstrate how the data is decipherable. Additionally, correlate the erratic data collected from the pressure transducers with the limited data collected manually and provide interpreted data for the missing portion of the drawdown data between October 2 and 17, 2017, if possible.	Drawdown was monitored to avoid drawing water below the top of well screens and not to assess aquifer properties in any way. This monitoring was to be performed using pressure transducers, but after the inaccurate readings of water level provided by pressure transducers in the extraction wells became apparent during Phase 1, manual water level measurements were used to track water level from that time on. Aquifer testing was not included in the NMED-approved Work Plan, and it is not the intended goal of this pilot test (Attachment 2). The reference to transducer data will be removed by removing the following statement from Section 3.3 of the revised Report, "While the readings returned to the SCADA were erratic, the overall trends in the data were decipherable."
16. Section 3.3, Phase 1- Tracer Testing, page 3-5 Permittee Statement: "The field water quality parameters, NAPL, and water level measurements were recorded on the purge logs for each well. Purge logs and sample collection logs are included as Appendix F." NMED Comment: Appendix F, Field Sampling Records, does not clearly indicate whether NAPL was detected in the wells. A photograph included in Appendix A shows the presence of LNAPL in the vicinity of the test site. In the response letter explain whether LNAPL was detected from the wells, and if so, provide the gauging data in the revised Report.	If NAPL was detected in the wells during sampling, it was recorded on the Sample Collection Log and/or the Purge Log. No NAPL was detected at the other groundwater monitoring wells after the initial observation at KAFB-106MW1-S during pump installation, or during monitoring and sampling activities conducted during the period described in the Report. NAPL was not detected at KAFB-106MW1-S after November 2017. A "Depth to NAPL" column will be added to Table 3 for measurements collected during groundwater sampling.

17. Section 3.4, Phase 2- Biostimulation, page 3-6 Permittee Statement: "During the recirculation period, groundwater was extracted and an easily fermentable sodium lactate-based substrate (WilClear Plus®, manufactured by JRW Bioremediation), nutrient (DAP), and conservative tracer (KI) were added to the recirculated process water stream." NMED Comment: Commercially available remediation products were used for the pilot test. The Report does not include information for the products. Provide all available information for the products (e.g., safety data sheets) in the revised Report.	Safety data sheets will be included in Appendix G of the revised Report and appendix callouts updated accordingly. Safety data sheets were also included in the NMED-approved work plan.
18. Section 3.4, Phase 2 - Biostimulation, page 3-7 Permittee Statement: "A pulsed amendment injection scenario was implemented in an attempt to minimize biofouling in the injection well." NMED Comment: Explain how a pulsed amendment injection scenario would minimize biofouling in the injection well in the revised Report.	Amendment delivery into the recirculation water process stream, and thus the injection well screen, was pulsed such that there were periods of time when the recirculation process water contained biostimulation amendments and other times where the flow contained only recirculated groundwater. This was intended to flush the well screen and filter pack with water less conducive to biological growth and fouling. The process of pulsing amendments into the aquifer and contingencies for biofouling were included in the NMED-approved Work Plan. The injection well performed as required to meet the objectives of the pilot test and well redevelopment/rehabilitation was not recommended as it could have impacted or complicated interpretation of the data. Additional text will be added to Section 3.4, page 3-7 to clarify this statement.
19. Section 3.4, Phase 2 - Biostimulation, page 3-7 Permittee Statement:" ... an increase in mounding (up to 9 feet above static [476 feet bgs)) at the injection well was observed." NMED Comment: The water column increased to 467 feet bgs due to the mounding in the injection well. The depth to the top of the filter pack is 467 feet bgs according to Appendix C. The mounded water laterally asserts pressure through the interval of the filter pack and spreads above the groundwater interface. Based on the inappropriate design of the injection well, the data collected from the pilot test is likely biased (see Comment 10).	Well installation was performed in accordance with the NMED-approved work plan. NMED reviewed and approved the draft well completion diagrams generated by the field geologist prior to initiating well installation. There is little evidence that data collected during the pilot test are biased. Conservative tracers injected during the study demonstrated that water was distributed to wells with differing screen intervals. Based on tracer data, it is not clear how preferential flow might account for the orders of magnitude decreases in EDB observed during the pilot test.

20. Section 3.4, Phase 2 - Biostimulation, page 3-8 Permittee Statement: "Introduction of amendments using the new concentrations began on December 29, 2017. The active portion of Phase 2 was extended until February 7, 2018 to deliver the planned mass of amendments." NMED Comment: Clarify the design (target) concentrations of the amendments in the aquifer beneath the pilot test area and explain the basis for the design concentrations. Provide the calculations and explanation in terms of the total volume of groundwater to be recirculated, the mass and volume of amendments, and the stoichiometric/theoretical requirement of the amendments in the revised Report.	The goal of the carbon substrate amendment (primarily lactate) was to facilitate its fermentation with resulting production of hydrogen, which can be limiting for dehalogenation. Similarly, bioavailability of nitrogen and phosphorus can be limited so these were also amended. Estimated concentrations of carbon substrate and DAP were outlined in the NMED-approved work plan and were adjusted in the field as necessary. The treatability test (see Figure 3) using Kirtland AFB soils and groundwater utilized 100 mg/L of lactate and 50 mg/L of DAP, which helped provide a basis for loading. Due to possible concerns regarding distribution and sorption of amended substrate, and consistent with contractor experience and typical substrate loading rates (AFCEE et al., 2004) slightly higher concentrations of fermentable substrate were targeted (~300 mg/L). As lactate makes up approximately half of the estimated fermentable content of Wilclear Plus, approximately 150 mg/L of lactate was expected, consistent with what was measured during Phase 2 recirculation activities. However, these initial amendment concentrations were intended to be adjusted, if necessary, to achieve desired conditions. Prior to any amendment additions, the site groundwater was anaerobic and low quantities of alternate electron acceptors such as nitrate and sulfate were present. Quantities of bioavailable mineral electron acceptors (e.g., Fe and Mn) are also difficult to estimate. As stoichiometric/theoretical requirements to drive anaerobic remediation are often based on the demands of alternate electron acceptors (mostly absent in the present case), the low concentrations of these electron acceptors complicated such an approach. Similarly, the low concentrations of EDB were not expected to drive amendment requirements. Instead, treatability testing, contractor experience, and typical substrate loading rates (AFCEE et al., 2004) provided the general basis for target loading rates. Further information regarding amendment concentrations will be provided in the revised Report.

21. Section 3.4, Phase 2 - Biostimulation, page 3-8 Permittee Statement: "During Phase 2, approximately 11 feet of water level drawdown was observed at KAFB-106EX2 during active Phase 2 system operations. The flowrate at KAFB- 106EX2 was incrementally reduced to 7 gpm beginning on January 8 through January 22, 2018 to prevent drawdown of water below the top of the screened interval." NMED Comment: Contrary to the action taken during the operation of the Phase 2 period, it is appropriate to reduce the water level to intersect the screened interval in the extraction well. Eleven feet of water level drawdown is sufficient to reduce the water level below the top of the screened interval and it should have been maintained. The drawdown would have allowed LNAPL that may be present at the interface to be recovered from the extraction well. However, despite the benefit of potential LNAPL recovery, the flowrate was reduced to prevent drawdown of water below the top of the screened interval. The reduction of flowrate was intended to minimize aeration of groundwater. LNAPL recovery must be a primary focus of remedial efforts and must not be compromised. The issues associated with aeration of groundwater must be resolved by other means, as necessary. No revision necessary.	Comment noted. As suggested, no revision to the text will be made. The pilot test was performed specifically to investigate the potential for anaerobic in situ bioremediation of EDB (Attachment 2). The design and operation of the extraction wells was solely for this purpose and not for NAPL recovery. Drawdown of groundwater below the screened interval of the extraction wells was avoided to minimize aeration of extracted groundwater, which could have inhibited anaerobic EDB biodegradation and increased biofouling. Further, the aboveground treatment system was not designed to remove NAPL. Additionally, NAPL recovery was not included or approved by NMED in the Work Plan.
22. Section 3.5, Phase 3- Biostimulation, page 3-9 Permittee Statement: "Therefore, similar to Phase 2, the purpose of Phase 3 was to continue to evaluate biostimulation in the subsurface after distribution of treatment amendments in recirculated groundwater. Phase 3 also consisted of two operational periods, a recirculation/mixing (active) period, and a subsequent passive monitoring period (no recirculation)." NMED Comment: Since the Permittee did not implement an evaluation of bioaugmentation during the Phase 3 period of the pilot test, the testing conducted during Phases 2 and 3 appears to be almost identical. Explain the significance of conducting Phase 3 of the pilot test in the revised Report. Revise the Report to combine the discussion of Phase 3 with that of Phase 2, as appropriate.	Sections 3.4 and 3.5 describe the operations and monitoring activities during Phase 2 and 3 respectively, and it is prudent to accurately describe these individually. Phase 2 and Phase 3 were ultimately similar in terms of amendments provided. However, initial subsurface conditions were different, with lower initial EDB concentrations and the desired microbial community likely stimulated after Phase 2. As described in the Phase 3 EDB ISB Pilot Test Notification Letter to NMED, Phase 3 was conducted to assess further possible enhancement of EDB degradation kinetics and possible expansion of the treatment zone. Phase 3 also allowed for some validation of the performance observed during Phase 2. Since the two phases were performed sequentially with different baseline conditions, separate discussions will be retained, despite their similarities. Phase 2 and 3 associated sampling events are denoted separately and, for clarity, are also described separately.

23. Section 3.5, Phase 3 -Biostimulation, page 3-10 Permittee Statement: "Increased mounding was also observed throughout the active portion of Phase 3 at the injection well (see Figure 7), increasing to approximately 35 feet above the static level by the end of Phase 3 active recirculation." NMED Comment: Since the filter pack of the injection well is set above the water table, an excessive injection pressure (35 feet of water) likely further pushed the fluid laterally above the water table, rather than within the aquifer matrix. Due to the design of the injection well, the distribution of amendments is likely limited to the interface {see Comments 10 and 19). Additionally, the issue of well screen fouling must be resolved, if this remedy is to be considered as part of a future remedy. No revision necessary.	Comment noted. As suggested, no revisions will be made. It seems likely that much of the increased head at the injection well during recirculation resulted from fouling in the immediate vicinity of the well rather than throughout the aquifer itself. As previously noted in other comments, the added conservative tracers in the recirculated water were observed at the intermediate wells and it is not clear what evidence suggests that amendments were limited to the interface as suggested here and in earlier comments. The injection well performed as required to meet the objectives of the pilot test. Given its performance, well redevelopment/rehabilitation was not recommended during the test as it could have impacted or complicated data interpretation. Wells installed under the pilot test were not intended for extended operation. If ISB is evaluated for larger scale application as part of the CME, biofouling and well maintenance will be evaluated.
24. Section 3.5, Phase 3 -Biostimulation, page 3-11 Permittee Statement: "After approximately 40 minutes of pumping, the water level in the well was manually checked and found to have drawn down below the transducer to the level of the pump intake (492 feet bgs). Thus, it seemed the loss of well capacity suggested by the increased mounding at the injection well (shown on Figure 7) was preventing groundwater from flowing into the well to sustain pumped flow to the surface; likely due to fouling of the well screen." NMED Comment: Explain whether measures to remediate the biofouling were developed during the pilot test. If so, provide a detailed explanation in the revised Report. Unless the issue is resolved, the remedial approach would not be practicable for long-term or larger scale implementation (see Comments 12 and 23).	Refer to responses to Comments # 12, 18, and 23 for discussion of fouling during the pilot test.

25. Section 3.5, Phase 3 -Biostimulation, page 3-11 Permittee Statement: "As a result, of the decreased well capacity, sample collection using the injection well pump was no longer possible, and samples from KAFB-106IN1 were collected using a 0.85-inch by 36-inch stainless steel bailer lowered to the groundwater through the transducer drop tube." NMED Comment: It should be noted that the sample collected from the injection well was not representative of groundwater conditions. The sample collected from the injection well was likely the remaining injection fluid that is stagnant in the injection well. The data obtained from the sample must not be used in any decision-making process, such as the evaluation and selection of remedial alternatives, confirmation that an area meets contaminant standards, or conclusion that a site meets the requirements for a Corrective Action Complete status. No revision necessary.	Agreed. After the sampling pump at KAFB-106IN1 ceased operating, collecting samples by bailer was the only feasible option, albeit imperfect. Samples from KAFB-106IN1 were not relied upon to arrive at the conclusions of the pilot test. No revisions will be made to the text.
26. Section 3.7, NAPL Sampling, page 3-12 Permittee Statement: "Measurable NAPL was detected in the shallow nested well KAFB 106MW1-S during QED pump installation on September 5, 2017. Three separate measurements were collected using a Solinst interface probe and confirmed a thickness of approximately 0.27 to 0.31 feet. NAPL was not detected at any other shallow monitoring wells within or around the treatment zone, or in the injection well." NMED Comment: LNAPL was also present in well KAFB-106S2 that is located near the pilot test area. Unless the extent of the LNAPL plume is delineated and eliminated, the groundwater that is treated for dissolved phase constituents (e.g., EDB) will be re-contaminated by residual LNAPL. LNAPL will act as a source of the dissolved phase contaminants. It is essential to eliminate all recoverable LNAPL from the site (see Comment 30).	Comment noted. No revisions will be made to the text. To clarify, well KAFB-106S2 is not the same well as KAFB-106MW1-S and was not used for the ISB pilot test project. Groundwater monitoring well KAFB-106S2 (screened across the water table) is located near the pilot test area and has never had any indication of NAPL. Please refer to Attachment 2 for scope of the pilot test and separate efforts to evaluate and delineate the vertical and lateral extent of NAPL.

27. Section 3.7, NAPL Sampling, page 3-12 Permittee Statement: "The extraction wells were not gauged for NAPL, as the top of the well screens were designed to be installed below the static water level." NMED Comment: A primary focus for the remedy at the site is an abatement of LNAPL. Once LNAPL is abated, the concentrations of the dissolved constituents are likely to gradually decrease. Therefore, the screened intervals of the extraction wells should not have been designed to be submerged below the water table. In the future, the screened intervals of all shallow groundwater monitoring and recovery wells must intersect the water table to capture LNAPL unless otherwise pre-approved by NMED.	Comment noted. No revisions will be made to the text. Please refer to Attachment 2 for scope of the pilot test and separate efforts to evaluate and delineate the vertical and lateral extent of NAPL. The Air Force understands that this comment and others relating to LNAPL delineation and abatement, and other global directives are being addressed separately by NMED.
28. Section 3. 7, NAPL Sampling, page 3-13 Permittee Statement: "Additional product recovery was attempted on September 13 and 14, 2017, and approximately 60 milliliters [of LNAPL] were recovered and sent to the APTIM Lawrenceville laboratory." NMED Comment: APTIM executed the pilot test and prepared the Report. APTIM should not have sent the samples to an internal corporate-owned laboratory. Industry standards provide that all laboratory analyses should have been conducted by a certified and independent third-party laboratory to avoid the perception of conflict of interest. The analytical results reported from the laboratory affiliated with the consultant must be identified as such in the Report. Revise the Report accordingly.	When NAPL was discovered in September 2017 at KAFB-106MW1-S, samples were collected and sent to Pace Analytical and Clark Testing for certified analysis. An additional NAPL sample was collected and sent to APTIM's Biotechnology Development and Applications Group (BDAG) Laboratory in Lawrenceville, New Jersey to facilitate EDB CSIA funded through a separate research grant investigating EDB attenuation and remediation (ESTCP project ER-201331). All isotope data included in the Report were collected and analyzed through this separately funded project. The results of EDB CSIA are included in the Report as they provide a supporting line of evidence of EDB degradation. The application of this method for documenting EDB degradation is also discussed in a USEPA document on natural attenuation of lead scavengers from leaded fuels (Wilson et al., 2008). The methods used for stable isotope analysis are research methods, not industry standard methods and are performed by non-accredited laboratories such as the University of Oklahoma. Additional details regarding the separately funded EDB isotope work are provided in a recent peer-reviewed journal paper: Koster van Groos, P., P.B. Hatzinger, S. Streger, S. Vainberg, P. Philip, and T. Kuder. 2018. Carbon isotope fractionation of 1,2-dibromoethane (EDB) by biological and abiotic processes. Environ. Sci. Technol. 52, 3440-3448.

28. Continued.	The VOC analyses performed at APTIM's BDAG Laboratory were shared to provide additional information regarding the NAPL, but do not otherwise affect interpretations or conclusions of the Report or pilot test. Given the concern expressed in the comment provided by NMED and that APTIM's BDAG Laboratory is not specifically certified for VOC analyses, the relevant passage will be removed from the revised Report.
29. Section 3. 7, NAPL Sampling, page 3-13 Permittee Statement: "The $\delta^{13}C$ value of the EDB in the NAPL, as determined by the University of Oklahoma, was approximately -21 ± 2 ‰." NMED Comment: In the revised Report, discuss the implication of the finding associated with the C^{13} [sic] isotope analysis for the EDB in the NAPL in comparison to the ratios of isotopes for the EDB in the groundwater samples collected during the pilot test.	A brief discussion related to the carbon isotope composition of EDB in the NAPL was provided in Section 4.5.2, which states, "[t]he $\delta^{13}C$ values of EDB in the NAPL sample and at well KAFB-106EX2 were consistently the most negative with values of -16‰ or lower, which indicates they were the least degraded," and "[t]he baseline evaluation performed with samples collected prior to the pilot test included EDB $\delta^{13}C$ values as high as -5‰, significantly higher than the EDB of the NAPL and located at KAFB-106EX2, indicating significant isotope fractionation and providing further evidence of EDB degradation under ambient conditions at the site prior to the pilot test." Text referencing this later discussion will be added to Section 3.7 for clarity and consistency.
30. Section 3.7, NAPL Sampling, page 3-13 Permittee Statement: "The fall and rise of the water table during well installation and development may have impacted the vertical transport and subsequent distribution of NAPL in the lower vadose zone, capillary fringe, and top of the unconfined aquifer; causing the measureable [sic] NAPL at KAFB-106MW1-S." NMED Comment: Section 1.4 states, "[t]he deepest depth to water, representing the lowest historical groundwater elevation, measured at groundwater wells in the BFF source area ranged from approximately 500 to 502 feet bgs in 2009. In recent years, the water table has been rising due to water-conservation efforts by the Albuquerque community and reduction of pumping of production wells by Albuquerque Bernalillo County Water Utility Authority. As a result, the current vadose zone at the BFF site is approximately 455 to 480 feet thick." At the time the LNAPL release occurred, the water table was approximately 20 to 30 feet below the current depth of the water table. Therefore, adsorbed and submerged LNAPL may also be present at depths below the current groundwater interface. Propose to submit a work plan to investigate the	Comment noted. No revisions will be made to the text. Please refer to Attachment 2 for scope of the pilot test and separate efforts to evaluate and delineate the vertical and lateral extent of NAPL. Additional source area wells will be installed in accordance with the NMED-approved *Work Plan for Data Gap Monitoring Well Installation KAFB-106248 to KAFB-106252* (KAFB, 2019) to address continued water table rise and to further delineate the source area plume. Additional soil coring will be performed as part of this field effort.

vertical and lateral extent of LNAPL at the current groundwater interface and at depths below the current water table where LNAPL was likely trapped as the water table rose.	
31. Section 3.10, Quality Control, page 3-15 Permittee Statement: "Laboratory data packages are also provided in Appendix G-2." NMED Comment: Appendix G-2 was not included in the Report. Ensure that Appendix G-2 is included in the revised Report.	Appendix G-2 (renamed as Appendix I-2) will be included in the revised Report.
32. Section 3.11.1, Soil IDW, page 3-16 Permittee Statement: "All drill cuttings were containerized in plastic-lined, steel roll-off containers pending laboratory analysis for waste characterization and disposal. Each roll-off was sampled for waste characterization." NMED Comment: Provide more detailed information regarding the sampling method for waste characterization in the revised Report. More specifically, explain the frequency of sample collection (e.g., soil volume per sample), whether composite or discrete samples were collected, and the number of subsamples in a composite sample, if collected, in the revised Report.	Additional details regarding soil IDW sampling and characterization will be included in Section 3.11.1 of the revised Report.
33. Section 3.11.2, Liquid IDW - Development and Decontamination, page 3-18 Permittee Statement: "Non-hazardous waste manifests are included in Appendix H-3. Hazardous liquid IDW generated from development and decontamination activities was disposed of by Chemical Transportation, Inc. and Clean Harbors at Clean Harbors Deer Trail, LLC in Colorado. Hazardous waste manifests are included in Appendix H-4." NMED Comment: Non-hazardous waste manifests are included in Appendix H-4 and hazardous waste manifests are included in Appendix H-3 of the Report. Correct the typographical errors in the revised Report.	The appendix callout errors will be corrected in the revised Report. Non-hazardous waste manifests will be included as Appendix J-3, and hazardous waste manifests included as Appendix J-4.

34. Section 4.2.2, Tracer Distribution During Phase 2 and 3, Phase 2, page 4-5 Permittee Statements: "Also evident in the iodide data is that final concentrations observed at the nearest monitoring wells of 17 mg/L (KAFB-106MW2-S) and 18 mg/L (KAFB- 106064) are equivalent with injected iodide concentrations (KAFB-1061N), which indicates that most of the groundwater observed at these wells was previously amended and reinjected." and, "Overall, iodide concentrations observed during the Phase 2 recirculation period indicated good distribution of injected waters, particularly within the treatment zone encompassing the shallow monitoring wells nearest to the injection well." NMED Comment: The tracer volume injection into the aquifer is estimated to be less than 30% of pore volume for the radial distance between the injection well and well KAFB-106MW2-S. Therefore, the highest concentrations of the tracer detected in the wells cannot be equivalent to the tracer concentrations of the injection fluid if uniform distribution of the injection fluid was achieved within the aquifer matrix. The top depth to the filter pack was set above the water table; therefore, the injection fluid may have migrated above the groundwater interface without being adequately mixed in the aquifer. Consequently, an undiluted or less diluted tracer solution may have reached the wells and been detected in the samples collected from the wells. The injection well construction likely provides positively biased data (see Comments 10, 19 and 23).	The comment states, "the tracer volume injected into the aquifer is estimated to be less than 30% of pore volume for the radial distance between the injection well and well KAFB-106MW2-S. Therefore, the highest concentration of the tracer detected in the wells cannot be equivalent to the tracer concentrations of the injection fluid if uniform distribution of the injection fluid was achieved within the aquifer matrix." This is inaccurate. Perhaps the distance to KAFB-106S2 rather than KAFB-106MW2-S was considered during drafting of this comment. KAFB-106MW2-S was associated with this pilot test and KAFB-106S2 was not. As demonstrated in Table 16 of the Report, 106MW2-S is located 28 feet (at the surface) from the injection well. Conservatively, assuming an average thickness of water flow of 50 feet and a reasonably conservative effective porosity of 0.33, then the pore volume between the injection well and KAFB-106MW2-S is: (28 $ft)^2 * \pi * 50 ft * 0.33 = 40{,}640\ ft^3 \sim 304{,}000\ gallons$. Similar math for KAFB-106064 results in a conservative pore volume estimate of ~373,000 gallons. Given that approximately 960,000 gallons of water containing the tracer were recirculated during Phase 2 of the pilot test, it seems extremely likely that the iodide concentrations observed at KAFB-106MW2-S and KAFB-106064 (within ~30% of the expected injected concentrations) support the conclusion that "most of the groundwater observe at these wells was previously amended and reinjected." It is unclear what evidence exists suggesting positive bias in the data. The data are accurate, and many lines of evidence supported the broader conclusions of the Report. No revisions will be made to the text.

35. Section 4.2.3, Distribution of Fermentable Substrate, page 4-7 Permittee Statement: "Recirculated groundwater during Phase 2 and Phase 3 was amended with WilClear Plus®, which served as a fermentable substrate to stimulate debrominating organisms in the subsurface during the pilot test." NMED Comment: Although the Permittee asserts that debrominating organisms are present at the site, the data provided in Figure 3, Concentrations of EDB in Anaerobic Microcosms Prepared with Aquifer Samples Collected from the BFF Source Area, indicate otherwise (see Comment 6). The result of the microcosm study appears contradictory; however, the pilot test successfully demonstrated the occurrence of in-situ EDB degradation through carbon isotope analysis of EDB. No revision necessary.	Please refer to Comment #6 and the detailed response in reference to the microcosm tests described in Figure 3. As noted, the data from the microcosms and the molecular analysis of groundwater samples were at odds (i.e., dehalogenating bacteria were present in the aquifer, but they did not active in laboratory microcosms). The field study was designed in phases, in part, because of these results. As suggested, no revision will be made.
36. Section 4.2.3, Distribution of Fermentable Substrate, page 4-8 Permittee Statement: "While lactate was introduced to the subsurface at around 110 mg/L, concentrations at monitoring wells never exceeded 4 mg/L." NMED Comment: Provide information regarding the volume of the lactate solution introduced through the injection well in the revised Report.	The volume of fermentable substrate introduced during each recirculation phase (Phases 2 and 3) were provided in Table 6, which is referenced in Sections 3.4 and 3.5.

37. Section 4.2.3, Distribution of Fermentable Substrate, page 4-8 Permittee Statement: "The observed increases in acetate and propionate strongly suggest that organic substrate capable of stimulating reductive debromination of EDB was distributed to most wells during the pilot test." NMED Comment: Lactate is fermented to acetate and propionate by various bacteria and is not limited by debrominating bacteria. The statement is speculative and can be misleading. Revise the statement for accuracy.	The relevant paragraph will be revised to provide better clarity that the fermentative conditions indicated by lactate transformation are conducive to reductive debromination of EDB. Many resources are available in the literature that explain the overall paradigm of anaerobic bioremediation of halogenated substances. While the exact mechanism for each case of reductive dehalogenation is not known, for many cases, dehalogenating organisms of interest (e.g., *Dehalococcoides* spp.) utilize dissolved hydrogen (H_2) as their electron donor and a halogenated species (e.g., TCE or EDB) as their terminal electron acceptor. Through such a mechanism these dehalogenating organisms respire or "breath" the organohalide species, much as our cells respire oxygen. Fermentation of organic substrates by separate populations of fermenting organisms (i.e., not the dehalogenating species themselves) has been identified as a suitable manner for developing hydrogen species in situ. This mechanism provides much of the foundation supporting the practice of anaerobic in situ biodegradation for halogenated compounds and many different types of substances may stimulate fermentation and hydrogen production. In the source area at Kirtland AFB, it is almost certain that some fuel related hydrocarbons are fermented resulting in elevated H_2 concentrations which may be utilized by naturally occurring dehalogenating organisms. As noted in the Report, baseline data provided some evidence that this "natural" attenuation process, stimulated by the co-occurring fuels has likely attenuated EDB at the site without significant intervention. Through study and practical experience, lactate has found use as an effective substrate to rapidly stimulate hydrogen production. Many fermenters can utilize it resulting in quick and efficient production of hydrogen, as well as acetate and propionate products. The statement in the Report was intended as an observation of evidence (through elevated concentrations of lactate fermentation daughter products acetate and propionate) that the overall EDB debrominating system was likely stimulated at most wells through distribution of lactate. The text will be revised to clarify the discussion.

38. Section 4.3, Microbial Analysis, page 4-9 Permittee Statement: "This increase in EBAC [eubacteria] after Phase 1 recirculation activity may be the result of organic carbon and nutrient redistribution in the treatment zone along with the increased groundwater flows due to recirculation." NMED Comment: Although the carbon substrate and nutrients were not distributed during the Phase 1 period of the pilot test, the measured microbial population increased approximately two orders of magnitude. The increase in microbial population occurred before the biostimulation period was implemented. The observation indicates that microbial population can be increased with or without biostimulation amendments. Since hydrocarbon constituents (e.g., benzene, toluene) are ubiquitous in the groundwater, they may also be utilized as carbon substrates by anaerobic bacteria. In this case, an amendment of appropriate electron acceptors (e.g., sulfate) may further increase microbial populations and enhance biodegradation of the contaminants. Figure 19, APS Concentrations-All Wells, indicates that the population of sulfate reducing bacteria in groundwater samples collected from all wells except injection well KAFB-106IN plateaued during the Phase 2 and Phase 3 biostimulation period of the pilot test; sulfate may be a limiting factor for the population growth. Evaluate whether an amendment of appropriate electron acceptors enhances biodegradation of contaminants without compromising EDB degradation. Provide the discussion in the revised Report.	The quoted Permittee Statement is focused on redistribution of carbon and nutrients that were present in the subsurface prior to the introduction of amendments. Increased groundwater flows and groundwater extraction from differently impacted depth intervals during the recirculation periods of the pilot test will have facilitated redistribution of these materials within the aquifer without provision of amendments. We acknowledge that extra mixing/redistribution in the subsurface likely increased the nutrients and bioavailability of hydrocarbons that can be fermented to support reductive debromination of EDB, which has likely been occurring at the site without significant intervention for some time. The pilot test was specifically focused on EDB degradation and discussion of benzene and toluene was provided to place observed EDB degradation in context. Introduction of supplemental electron acceptors (such as sulfate) to enhance hydrocarbon degradation and impacts of elevated concentrations of such competing electron acceptors upon EDB degradation was outside the scope of the pilot test. The Report will not be revised to include a discussion of these issues.

39. Section 4.3, Microbial Analysis, page 4-9 Permittee Statement: "As with the high cell numbers prior to recirculation and amendments at the site, the large numbers of organisms capable of reductive debromination (10^5 to 10^6 cells/ml for DHBt, and around 10^5 cells/ml for DSB) after biostimulation, suggest that EDB debromination activity may have been stimulated during the pilot test." NMED Comment: According to Figure 21, DHBt Concentrations -All Wells, and Figure 24, 058 Concentrations -All Wells, the populations of DHBt and DSB appear to have plateaued during the Phase 2 and Phase 3 biostimulation period of the pilot test in all wells. These figures suggest that EDB debromination activity may not be stimulated by carbon substrate and nutrient amendments. The increase of the DHBt and DSB population was observed in groundwater samples collected from intermediate wells KAFB-106063, KAFB-106MW1-I and KAFB-106MW2-I during the Phase 1 period that was not related to biostimulation. Correct the statement for accuracy, discuss the implication of the observed population growth, acknowledge that other conclusions could be reached, and state that the data is not conclusive in the revised Report.	The text discussing cell populations of likely debrominating organisms will be revised. We agree that such data do not provide conclusive evidence of degradation activity, and must be supported by other lines of evidence Bacterial counts of DHBt, DSB, etc., quantified through qPCR analyses of DNA are imperfect measures of activity. Little change in already high numbers should not be interpreted as evidence of no change in overall debromination activity. While large population numbers typically correspond to greater activity, the presence of cell DNA itself doesn't indicate whether the organisms are actively expressing genes of interest or otherwise performing the roles associated with their presence. It does suggest, however, that they may be stimulated to activity, if not active already. The enumerated organisms are also representative of a likely more diverse community of dehalogenating organisms and are only quantified through the use of qPCR probes of varying specificity. It is probable that other organisms facilitating dehalogenating processes were not specifically quantified using this tool. Overall, the presence of the organisms at high numbers provide a strong line of evidence that supports the conclusion that observed EDB decreases were the result of anaerobic biodegradation. Increased counts at the intermediate wells were noted for many different organisms and were likely indicative of more oligotrophic conditions at these wells (e.g., lower hydrocarbon concentrations) prior to any recirculation. Given such conditions, recirculation of labile hydrocarbons to these deeper locations during Phase 1 likely increased microbial activity at these intervals.

40. Section 4.4, Geochemistry, pages 4-10 and 4-11 Permittee Statement: "DO [dissolved oxygen] concentrations were below 1 mg/L at all wells, with most concentrations below 0.5 mg/L." and, "The low DO concentrations within the treatment zone reflect favorable conditions for reductive debromination of EDB." NMED Comment: The site groundwater is anaerobic due to the presence of hydrocarbons which favors reductive debromination of EDB. Hydrocarbons in the aquifer may serve as carbon substrate to degrade EDB anaerobically. When dissolved hydrocarbons are utilized for EDB debromination, the concentrations of hydrocarbons may also decrease which provides synergistic degradation. However, carbon substrates (e.g., lactic acid) that were amended to stimulate indigenous bacteria are more readily utilized in comparison to hydrocarbons. Subsequently, the degradation of hydrocarbons may potentially be hindered. Since EDB may be naturally degrading due to the current site conditions (e.g., anaerobic conditions, presence of hydrocarbons), the amendment of the carbon substrate may not be useful. Evaluate the necessity of the amendment to balance the EDB and hydrocarbon constituents degradation and provide the discussion in the revised Report.	This comment is partially addressed in response to Comment #37 above. The supplied carbon substrate (lactate) likely increased dissolved hydrogen concentrations in the groundwater more rapidly than fermentation of the more complex hydrocarbons otherwise present at the site. This elevated hydrogen likely resulted in the enhanced EDB biodegradation that was observed. We acknowledge, however, that EDB is very likely attenuating in the source area without intervention, facilitated by the fermentation of hydrocarbons in the subsurface as suggested in the NMED comment. Evaluating tradeoffs between degradation of EDB and hydrocarbons as suggested by the comment was beyond the scope of the pilot test (Attachment 2).No revision to the text will be made.
41. Section 4.4, Geochemistry, page 4-11 Permittee Statement: "With the exception of KAFB-106EX2 (25 mg/L), sulfate concentrations in shallow wells were low (<5 mg/L) under baseline conditions presumably due to past sulfate reduction to sulfide." NMED Comment: Sulfate is a critical component for anaerobic biodegradation of dissolved hydrocarbon constituents. Since hydrocarbons are present in addition to EDB at the site, hydrocarbons must be remediated as well. According to Figure 19, APS Concentrations -All Wells, the population of sulfate reducing bacteria is abundant; however, sulfate concentrations appear to be insufficient to increase the activity of the sulfate reducing bacteria. Evaluate the viability of sulfate amendment to promote biodegradation of dissolved phase hydrocarbons in the revised Report (see Comment 38) and propose to submit a work plan for a pilot test to evaluate the effect of sulfate amendment, as appropriate.	The objective of this pilot test was to stimulate in situ anaerobic biodegradation of EDB (Attachment 2). Sulfate concentrations were evaluated as they are indicative of biogeochemical conditions. While the fate of other dissolved organics was tracked, the primary focus was EDB. Evaluating relationships between sulfate and hydrocarbons was beyond the scope of the pilot test. See response to Comment #38. No revisions will be made to the text.

42. Section 4.4, Geochemistry, page 4-11 Permittee Statement: "The low sulfate concentrations within the treatment zone reflect favorable conditions for reductive debromination of EDB." NMED Comment: Clarify whether elevated sulfate levels inhibit reductive debromination of EDB in the revised Report. Also, propose to submit a work plan to evaluate the sulfide concentrations in the groundwater; if sulfide levels are too high in the groundwater, sulfate amendment may not increase the activity of sulfate reducing bacteria.	Sulfate was monitored during the pilot test as a general geochemical indicator. The Permittee Statement has been revised to clarify that low sulfate concentrations, or the observed decrease in sulfate concentrations, at the site are reflective of reducing conditions which were favorable for reductive debromination. Impacts of differing sulfate or sulfide concentrations on EDB biodegradation were outside the scope of the study and were not specifically investigated. Site specific comments on these factors would be speculative and no revisions will be made to the text.
43. Section 4.4, Geochemistry, page 4-12 Permittee Statement: "Due to the low solubility of ferric (Fe(III)) iron under circumneutral conditions as found at the site, dissolved iron concentrations are often assumed to reflect concentrations of more reduced ferrous (Fe(II)) iron. Minerals containing oxidized Fe(lll) are fairly ubiquitous and elevated dissolved iron concentrations are usually indicative of iron reducing environments. Baseline measurements at the site indicated dissolved iron concentrations ranging from 1 mg/L (KAFB-106MW1-S) to 12 mg/L (KAFB-106MW2-S) in shallow wells, but concentrations at deeper, less impacted wells were all less than 1 mg/L." NMED Comment: According to Figure 27, Iron (Dissolved) Concentrations -All Wells, the dissolved iron concentration in the baseline groundwater sample collected from intermediate well KAFB-106MW2-I exceeds 11 mg/L. Accordingly, the statement is not accurate. Correct the statement or Figure 27 to resolve the discrepancy in the revised Report. Additionally, the dissolved oxygen concentration in the baseline groundwater sample collected from the same intermediate well KAFB-106MW2-I is recorded as approximately 1.8 mg/L, which is higher than the most wells according to Figure 25, Dissolved Oxygen -All Wells. The inverse relationship between the levels of dissolved iron and oxygen is not clearly demonstrated by the data collected during the pilot test. Remove or revise the statement, as appropriate.	The Report and figure are both correct. It is possible that NMED misread the figure due to similar color and symbol between 106MW2-S and 106MW2-I? Baseline concentrations for KAFB-106MW2-I are provided in Table 14, and indicate results of 0.053 mg/L and 0.0514 mg/L for parent and field duplicate samples, respectively.

44. Section 4.4, Geochemistry, page 4-12 Permittee Statement: "During the Phase 2 recirculation period when lactate amendments were introduced, methane concentrations generally fell again, but increased by many OOM [(orders of magnitude)] at several wells during the following passive period, with concentrations exceeding 10,000 µg/L at the injection well and KAFB-106MW2-S." NMED Comment: Methane may be beneficial to EDB remediation since it is considered a viable substrate for similar halogenated compounds (e.g., chlorinated ethenes). However, methanogens are known to produce ethene and ethane under the presence of brominated compounds (e.g., EDB). If methanogens produce more ethene and ethane which are main end products of EDB, they may potentially hinder degradation of EDB (e.g., via Le Ch atelier's principle). Regardless, the increased methane production is merely an indicator of bacterial activity but not necessarily effective remediation. No revision or response required.	The Permittee Statement is a factual presentation of the methane concentrations observed. No revisions will be made to the text. Methane may indeed be a viable substrate for aerobic EDB degradation by methanotrophs, as demonstrated by Koster van Groos et al. (2018), through a process called aerobic co-metabolism. Although microaerophilic conditions and contributions from this degradation pathway may occur, this is not an anaerobic process, and is very unlikely to outweigh the contributions from known anaerobic degradation pathways in an anaerobic environment. The comment states, "methanogens are known to produce ethene and ethane under the presence of brominated compounds (e.g., EDB)." The current scientific consensus and EPA guidance (Wiedemeier et al., 1998) indicates that ethene and ethane are known and expected daughter products of reductive dehalogenation, and important indicators of degradation, even in the presence of methane and presumably methanogenesis. Some early literature (Belay and Daniels, 1987; Holliger et al., 1992) suggests that methanogens may dehalogenate some chlorinated and brominated ethanes, forming ethene and ethane as daughter products. However, these studies predated the discovery of true dehalogenating strains (e.g., Dehalococcoides and Dehalogenimonas) and may be inaccurate. Even if correct, this observation confirms formation of ethene/ethane as daughter products of halogenated compounds, rather than production from CO_2 or methane. We agree that increased methane production is expected and not an indicator of effective EDB remediation.

45. Section 4.5.1, Benzene and Toluene, page 4-14 Permittee Statements: "With the exception of the injection well (KAFB-1061N1) and monitoring well KAFB-106MW1-S, benzene concentrations in shallow monitoring wells for the remainder of the pilot test ranged in concentration from 1,680 µg/L at KAFB-106MW2S to 4,400 µg/L at KAFB-106EX2, indicating limited losses due to biodegradation or abiotic mechanisms (e.g., volatilization, dilution)." and, "Interestingly, benzene increased during the passive periods at the shallow well KAFB-106MW1-S to concentrations as high as 9,800 µg/L. The higher concentration at KAFB-106MW1-S is similar to baseline conditions prior to recirculation and may be the result of increased mass transfer from residual NAPL phases, as NAPL had previous[ly] been observed at that location." NMED Comment: Unless LNAPL is eliminated, LNAPL constituents will constantly leach into the groundwater and re-contaminate the aquifer. In order to abate LNAPL, the extent of LNAPL plume must be delineated laterally and vertically (see Comment 30). The reduction of all dissolved phase constituent concentrations will likely occur once the bulk of LNAPL is removed from the site.	Comment noted. No revisions will be made to the text. Please refer to Attachment 2 for scope of the pilot test and separate efforts to evaluate and delineate the vertical and lateral extent of NAPL
46. Section 4.5.1, Benzene and Toluene, page 4-15 Permittee Statement: "Interestingly, toluene concentrations decreased during Phase 4 passive monitoring at shallow wells KAFB-106MW2-S to 150 µg/L (from 4,900 µg/L in the previous sampling event) and KAFB-106064 to 960 µg/L (from 11,000 µg/L in the previous sampling event). These decreases were far greater than for benzene and may indicate some anaerobic biodegradation of toluene." NMED Comment: Toluene is known to be more bioavailable as a carbon substrate than benzene. Presumably, anaerobic bacteria responsible for hydrocarbon degradation depleted the amended carbon substrates (e.g., lactate) during the Phase 4 passive monitoring period and initiated utilization of subsequently bioavailable hydrocarbon constituent, toluene. Further decline of toluene levels may be expected along with the decline of benzene level later in the passive monitoring period. Clarify whether the passive	Comment noted. No revisions will be made to the text. The pilot test was focused on EDB biodegradation (Attachment 2). Toluene and benzene were discussed to place EDB degradation in context. Anaerobic degradation of toluene coupled to a variety of electron acceptors is a well-known process and the decrease in toluene was evident, so it was factually presented. Long-term monitoring is on-going. Samples were collected in March and May 2020. Analytical results will be presented in the Q2 2020 Quarterly Monitoring Report.

monitoring is on-going at this time and provide a reference that presents the most recent analytical data in the revised Report.	
47. Section 4.5.2, EDB, EDB Degradation Products, pages 4-20 and 4-21 Permittee Statements: "Based the assumption of reductive debromination and its stoichiometry, equivalent quantities of EDB degraded can be estimated using measured concentrations of ethene and ethane ... "and, "During and after the Phase 2 recirculation period, estimates of EDB equivalents degraded based on ethene and ethane increased to magnitudes similar to initial EDB concentrations, suggesting substantial conversion. The highest estimate of EDB equivalents degraded occurred at KAFB-106MW1-S after Phase 3 biostimulation efforts with an estimated concentration of approximately 270 µg/L." NMED Comment: According to Tables 7 through 15, the concentrations of ethane, ethene, and methane were detected in the baseline groundwater samples collected from the pilot test wells. These dissolved gas constituents may or may not be degradation products of EDB. Since other hydrocarbon constituents (e.g., benzene and toluene) are concurrently present with EDB and the degradation products (ethane, ethene, and methane) are not exclusive to EDB biodegradation products, the quantity of degraded EDB cannot be estimated by measured concentrations of ethene and ethane. It should be noted that methanogens produce ethane and ethene under the presence of halogenated compounds and the presence of brominated compounds drives methanogens to produce even more ethane and ethene from small organic compounds such as carbon dioxide. Remove the statements from the revised Report.	The text will be revised to indicate that estimates of EDB degraded using ethene and ethane product concentrations assumed stoichiometric conversion as well as negligible contributions of ethene and ethane from sources other than EDB. Of the three gases discussed in NMED's comment, only ethene and ethane are anaerobic degradation products of EDB. Laboratory studies have demonstrated near complete dehalogenation of EDB to form ethene. Production of ethane from ethene or from bromoethane under reducing conditions also has been demonstrated (e.g., Henderson et al., 2008). The comment states, "it should be noted that methanogens produce ethane and ethene under the presence of halogenated compounds and the presence of brominated compounds drives methanogens to produce even more ethane and ethene from small organic compounds such as carbon dioxide." This statement is inconsistent with the current scientific consensus and EPA guidance (Wiedemeier et al., 1998) that ethene and ethane are daughter products of reductive dehalogenation, even in the presence of methane and methanogenesis. It would be helpful if NMED provided information that demonstrates widespread ethene and ethane synthesis from carbon dioxide by methanogens. As previously noted, early scientific literature (prior to discovery of *Dehalococcoides* sp.) suggested that methanogens may dehalogenate some chlorinated and brominated compounds to ethane and ethene (Belay and Daniels, 1987; Holliger et al., 1992); but this is very different than de novo synthesis of ethane or ethane from carbon dioxide. Rather, they are daughter products of the halogenated compounds and a critical line of evidence of their biodegradation as per our conclusion and per EPA guidance. Laboratory results indicating near stoichiometric conversion of EDB to ethene, and EPA guidance and environmental practice of utilizing ethene and ethane as daughter products for mass balance determinations of chlorinated solvents in methanogenic environments support the Air Force's statements. In fact, the presence of ethene and ethane provide strong evidence of the processes described.

48. Section 4.5.2, EDB, EDB Degradation Products, page 4-22 Permittee Statement: "The largest apparent increase in bromide to chloride ratio occurred during and after the Phase 3 recirculation period. This coincided with use of a new certified analytical laboratory after the original analytical laboratory measuring bromide ceased operations. Several of the increases in bromide appear to be on the order of 1 mg/L, which corresponds to degradation of approximately 1,200 µg/L of EDB- much more than was observed in aqueous phase measurements during the pilot test." NMED Comment: Since the notable increase occurred when an analytical laboratory was changed, the data generated from the new laboratory may or may not be accurate. Even if the analytical method is consistent and the new laboratory is certified for the analysis, the observed increase may potentially be caused by changes associated with various differences among laboratories. The samples should have been analyzed by two independent certified laboratories to confirm the results. Incorporate this measure when an analytical laboratory is to be changed during the course of periodic groundwater monitoring and sampling in the future. No revision required.	Comment noted. No revisions will be made to the text. Closure of the analytical laboratory was not anticipated during the course of the study. Duplicative laboratory analysis was not required in the NMED-approved work plan. The replacement laboratory met all project data quality objectives.
49. Section 4.5.2, EDB, Carbon Isotope Analysis of EDB, page 4-22 Permittee Statement: "As EDB degrades, its carbon (C) stable isotope composition can change as EDB with a heavy C isotope substitution (^{13}C) degrades slightly slower than EDB with only ^{12}C (Koster van Groos et al, 2018)." NMED Comment: Provide information regarding the difference in degradability of EDB with ^{12}C and ^{13}C in the revised Report. Additionally, according to Figure 38, EDB $\delta^{13}C$-Shallow Wells, EDB $\delta^{13}C$ values notably increased in groundwater samples collected from wells KAFB-106MW2-S and KAFB-106064 prior to Phase 2 of the pilot test, in which biostimulation was initiated. Provide an explanation for whether the occurrence of abiotic degradation (e.g., hydrolysis, oxidation) can also increase the fraction of ^{13}C EDB in the revised Report.	The reference provided in the Report (Koster van Groos et al, 2018) discusses biological and abiotic isotope effects associated with EDB degradation. The will be revised to indicate that relative differences in ^{12}C and ^{13}C degradation rates are less than 4%, and that both biological and abiotic degradation result in isotope fractionation. The Report will also be updated to specifically identify the shift in isotope composition at wells KAFB-106064 and KAFB-106MW2-S noted in the NMED comment and will share that this increase was consistent with the decrease observed in EDB at the same locations. Further, the Report will be revised to indicate that while isotope information itself only provides evidence of degradation and not the mechanism, the shift in isotope composition was likely a biologically facilitated process due to the relative speed and other lines of evidence noted during the pilot test.

50. Section 5.1, Conclusions, pages 5-1 and 5-2 Permittee Statements: "Baseline measurements indicated that EDB was likely degrading prior to the pilot test." and, "ISB appears to be a promising approach targeting EDB source areas in Kirtland AFB groundwater. While debromination may be occurring at Kirtland AFB without additional support, the addition of biostimulation amendments and mixing of water appeared to enhance reductive debromination." NMED Comment: The degradation of hydrocarbon constituents (e.g., benzene and toluene) appeared to be hindered by the amended carbon substrates (see Comment 46). The pilot test demonstrated in-situ anaerobic biodegradation of EDB in the most pilot test wells; however, future remediation must focus on the abatement of LNAPL. Once the LNAPL plume is delineated and remediated, EDB levels will likely reduce naturally. The vertical and lateral extent of LNAPL must be investigated (see Comment 30).	It is not clear which data appear to indicate that benzene or toluene degradation is hindered by lactate addition. Please refer to response to Comment #46. The comment further discusses the need for addressing NAPL at the site, which is outside the scope of the pilot test. Please refer to Attachment 2 for scope of the pilot test and separate efforts to evaluate and delineate the vertical and lateral extent of NAPL. No revisions will be made to the text.
51. Figure 9, Fluoroscein [sic] Concentrations -Shallow Wells NMED Comment: The tracer concentrations in injection well KAFB-106IN1 are depicted below 10 ug/L during the baseline, Phase 1 Tracer Test, and Non-pumping Passive Phase according to Figure 9. Section 4.2.1, Tracer Distribution During Phase 1, page 4-2, states that three measurements of fluorescein concentrations of injected water collected directly from the KAFB-106IN1 sample port averaged 570 µg/L during the 24 hours of tracer injection, while background concentrations were not detected. The data presented in the figure is therefore not accurate. Revise the figure to show that the tracer concentration in the injection well was 570 ug/L during the injection period.	Data indicated for KAFB-106IN1 are from samples collected by the sample pump located within the well below the injection flow control (Baski) valve, or by bailer after the sample pump no longer functioned. Thus, during the injection process, samples were not collected from the KAFB-106IN1 sampling location. The dotted line connecting data from before and after recirculation periods for KAFB-106IN1 will be removed from Figure 9 to help clarify the issue. The line connecting data from before and after recirculation suggests that interpolation between the two may be appropriate, which it is not.

52. Figure 11, δ^2H Concentrations-Shallow Wells NMED Comment: The δ^2H values of deuterium labeled water in injection well KAFB-106IN1 are depicted between -80‰ and -100‰ during the baseline, Phase 1 Tracer Test, and Non-pumping Passive Phase according to Figure 11. Section 4.2.1, Tracer Distribution During Phase 1, page 4-3, states that three measurements of δ^2H values of the injected water averaged +590‰ during the 24 hours of tracer injection, while background δ^2H values at the test area ranged from -97‰ to -92‰. The data presented in the figure is therefore not accurate. Revise the figure to show that the δ^2H value in the injection well was +590‰ during the injection period.	See response to Comment #51. Similarly, the dotted lines connecting data from before and after recirculation periods will be removed from Figure 11 for KAFB-106IN1.
53. Figure 13, Iodide Concentrations - Shallow Wells NMED Comment: The tracer concentrations in injection well KAFB-1061N1 are depicted below 9 mg/L during the Phase 2 and 3 Biostimulation Recirculation, Non-pumping Passive Phase according to Figure 13. Section 4.2.2, Tracer Distribution During Phase 2 and 3, page 4-4, states that iodide results from the injectate ranged from 18 to 26 mg/L. The data presented in the figure is therefore not accurate. Revise the figure to show that the tracer concentration in the injection well was 18 to 26 mg/L during the injection period.	See response to Comment #51. Similarly, the dotted lines connecting data from before and after recirculation periods will be removed from Figure 13 for KAFB-106IN1.
54. Figure 15, Lactic Acid Concentrations -All Wells (Except 1061N1) NMED Comment: The lactic acid concentrations were positively detected in groundwater samples collected from wells KAFB-106MW2-S, KAFB-106MW2-I, KAFB-106MW1-S, and KAFB-106064 prior to Phase 1 Tracer Recirculation according to Figure 15 although lactic acid was not amended to the injection fluid during Phase 1. Provide an explanation for the detections in the revised Report.	The detection of low concentrations of lactic acid in the aquifer prior to amendment is interesting. One explanation is low-level bacterial fermentation of organics in the aquifer and the text has been revised to introduce this possibility. The fermented organics could be petroleum hydrocarbons, bacterial exopolysaccharides (EPS), and/or dead biomass. Such lactate would then be expected to further ferment to acetate and propionate, which were also detected in situ.

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ATTACHMENT 1 TO RTC TABLE

CURRENT WELL DESIGNATIONS

Attachment 1
Current Well Designations

Current Database ID	Previous Database ID (if different)
KAFB-003	KAFB-3, KAFB003
KAFB-015	KAFB-15, KAFB015
KAFB-016	KAFB-16, KAFB016
KAFB-106001	KAFB-1061
KAFB-106002	KAFB-1062
KAFB-106003	KAFB-1063
KAFB-106004	KAFB-1064
KAFB-106005	KAFB-1065
KAFB-106006	KAFB-1066
KAFB-106007	KAFB-1067
KAFB-106008	KAFB-1068
KAFB-106009	KAFB-1069
KAFB-106010	KAFB-10610
KAFB-106011	KAFB-10611
KAFB-106012R	KAFB-10612R
KAFB-106013	KAFB-10613
KAFB-106014	KAFB-10614
KAFB-106015	KAFB-10615
KAFB-106016	KAFB-10616
KAFB-106017	KAFB-10617
KAFB-106018	KAFB-10618
KAFB-106019	KAFB-10619
KAFB-106020	KAFB-10620
KAFB-106021	KAFB-10621
KAFB-106022	KAFB-10622
KAFB-106023	KAFB-10623
KAFB-106024	KAFB-10624
KAFB-106025	KAFB-10625
KAFB-106026	KAFB-10626
KAFB-106027	KAFB-10627
KAFB-106028	KAFB-10628-510
KAFB-106029	No change
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KAFB-106031	No change
KAFB-106032	No change
KAFB-106033	No change
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KAFB-106038	No change
KAFB-106039	No change
KAFB-106040	No change
KAFB-106041	No change
KAFB-106042	No change

Attachment 1
Current Well Designations

Current Database ID	Previous Database ID (if different)
KAFB-106043	No change
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KAFB-106046	No change
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KAFB-106085	No change
KAFB-106086	No change
KAFB-106087	No change
KAFB-106088	No change

Attachment 1
Current Well Designations

Current Database ID	Previous Database ID (if different)
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KAFB-106097	No change
KAFB-106098	No change
KAFB-106099	No change
KAFB-106100	No change
KAFB-106101	No change
KAFB-106102	No change
KAFB-106103	No change
KAFB-106104	No change
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KAFB-106107	No change
KAFB-106148-484	No change
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KAFB-106151-484	No change
KAFB-106152-484	No change
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KAFB-106214	No change
KAFB-106215	No change
KAFB-106216	No change
KAFB-106217	No change
KAFB-106218	No change
KAFB-106219	No change

Attachment 1
Current Well Designations

Current Database ID	Previous Database ID (if different)
KAFB-106220	No change
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KAFB-106222	No change
KAFB-106223	No change
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KAFB-106226	No change
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KAFB-106229	No change
KAFB-106228	No change
KAFB-106230	No change
KAFB-106231	No change
KAFB-106232	No change
KAFB-106233	No change
KAFB-106234	No change
KAFB-106235-438	KAFB-106235-463
KAFB-106235-472	KAFB-106235-492
KAFB-106235-501	KAFB-106235-521
KAFB-106236-436	KAFB-106236-461
KAFB-106236-470	KAFB-106236-490
KAFB-106236-499	KAFB-106236-519
KAFB-106240-449	No change
KAFB-106241-428	No change
KAFB-106242-418	No change
KAFB-106243-425	No change
KAFB-106244-445	No change
KAFB-106245-460	No change
KAFB-106247-490	No change
KAFB-106S1-447	No change
KAFB-106S2-451	No change
KAFB-106S3-449	No change
KAFB-106S4-446	No change
KAFB-106S5-446	No change
KAFB-106S7-491	No change
KAFB-106S8-491	No change
KAFB-106S9-447	No change
KAFB-3411	KAFB3411
ST106-VA2	VA HOSPITAL WELL

ATTACHMENT 2

SCOPE OF EDB ISB PILOT TEST

Attachment 2 –Scope of EDB ISB Pilot Test

Pilot Test Scoping and Development

In 2013, Department of Defense's (DoD) Environmental Security Technology Certification Program (ESTCP) funded a demonstration project (ER-201331) to better understand natural attenuation of 1,2-dibromoethane (EDB) and the potential to enhance EDB biodegradation. Multiple DoD sites were considered for the demonstration and ultimately Kirtland Air Force Base (AFB) was selected based on its history of EDB groundwater contamination. Separately, a Treatability Study Work Plan was submitted to the New Mexico Environment Department (NMED) on May 2, 2014 and NMED approval was received via email communication on May 7, 2014 (Blaine, 2014). Microbial community analyses and bench-scale treatability studies were performed using Kirtland AFB soils and groundwater, and the results indicated that *in situ* bioremediation (ISB) showed promise for enhancing EDB biodegradation at Kirtland AFB, either through biostimulation of native debrominating organisms or through bioaugmentation with an exogenous debrominating culture (e.g., SDC-9).

Results of these studies were presented to the NMED and the Bulk Fuels Facility (BFF) Biogeochemistry/LNAPL Technical Working Group (TWG)[1] in May 2015 (Hatzinger, 2015). This presentation also proposed the demonstration of *in situ* EDB biodegradation through a single-well bio-sparging test funded through ESTCP project ER-201331. In response to a request from NMED's Chief Scientist, the Air Force agreed to expand the scope of the pilot test to provide more meaningful results regarding ISB of EDB. A conceptual pilot test memo (white paper; KAFB, 2015) was provided to NMED in July 2015, and the pilot test was discussed at an August 2015 meeting of the LNAPL/Biogeochemical TWG. NMED's Chief Scientist concurred with the conceptual approach and requested that the Air Force seek funding for the pilot test. The ESTCP contracting office was unable to process the request to expand the scope of the pilot test prior to the funding expiration date, but funding of the effort was successful through an alternate contract vehicle in September 2015 (USACE Rapid Response).

With the exception of isotope analyses performed with ESTCP funding, the proposed expanded pilot test was funded through the USACE Rapid Response contract. Discussions regarding the scope and design of the pilot test continued for another year and included a presentation in April 2016 to the Biogeochemistry/LNAPL TWG of a nearly complete design (Koster van Groos, 2016). Suggested changes by NMED, including the request for nested monitoring wells that included both shallow and intermediate wells, were incorporated into the final pilot test design. The *Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan* (Work Plan; KAFB, 2016a) was submitted to NMED for review in October 2016.

As described in the Work Plan (KAFB, 2016a), the scope of the pilot test was to investigate anaerobic ISB of EDB:

> *The primary objective of this pilot test is to evaluate the extent to which potential treatment amendments for in situ biostimulation and bioaugmentation enhance anaerobic EDB*

[1] The Biogeochemistry/LNAPL TWG was involved in the development of the scope of work for the ISB Pilot at the direction of NMED's Chief Scientist. The TWGs established for the BFF project are not required by Kirtland AFB's Hazardous Waste Treatment Facility Operating Permit (HWTF Permit No. NM9570024423) and no formal minutes are kept by either NMED or the Air Force. TWGs are part of the stakeholder engagement program for BFF and are solely advisory. All regulatory decisions regarding work plan scope, well construction, and other issues were made solely by NMED.

biodegradation processes. Evaluation of the test will be completed through a comprehensive groundwater sampling regimen that assesses direct and indirect indicators of EDB biodegradation. This pilot test is primarily designed to inform whether the proposed amendments can stimulate enhanced anaerobic EDB biodegradation. Information regarding the distribution of amendments in the subsurface will be collected primarily to aid interpretation of biodegradation effectiveness, but may provide some insight into how similar systems may be scaled up for larger scale bioremediation treatments.

NMED Involvement and Approvals

As the regulator, NMED was actively involved throughout the pilot test, from its conception, design, and work planning, through field activities, and most recently with evaluation of results in the Report. A timeline of approved documents and permits is summarized below, as well as a discussion of NMED's involvement during field activities.

The design and installation methods of the pilot test system, the phased approach to system operation, and the associated sampling plan were discussed at various stages (Hatzinger, 2015; Koster van Groos, 2016) and reviewed by the NMED in the Work Plan (KAFB, 2016a). NMED approved the Work Plan with conditions in a letter dated December 12, 2016 (NMED, 2016a), which also recognized the scope of the pilot test scope:

The work plan addresses activities to be performed at the Bulk Fuels Facility (BFF) site to evaluate the extent to which potential treatment amendments enhance anaerobic ethylene dibromide (EDB) biodegradation processes.

As requested, responses to the seven conditions listed in the approval letter, along with a revised Work Plan, were provided to NMED within 30 days of receipt on December 22, 2016. No further comments were received from NMED.

Prior to submitting the Work Plan (KAFB, 2016a), a Notice of Intent to Discharge was submitted to the NMED Ground Water Quality Bureau on November 7, 2016 (KAFB, 2016b). It was determined that a discharge permit would not be required for injection and recirculation activities associated with the pilot test, as stated in the NMED letter dated December 16, 2016 (NMED, 2016b).

During well installation, lithologic logs were sent to NMED for review. Additionally, the final design for each well was provided to NMED for review and approval prior to the start of well construction. NMED also signed off on all well construction details for the newly installed groundwater monitoring, extraction, and injection wells. Throughout the pilot test, NMED and stakeholders were briefed regarding the test at various Stakeholders Meetings held in January, March, and June 2018. Weekly updates were also sent to NMED via email to summarize all field activities.

Light non-aqueous phase liquid (LNAPL) was discovered during pump installation at groundwater monitoring well KAFB-106MW1-S in September 2017. NMED was notified, as outlined in the Work Plan (KAFB, 2016a) and a meeting was held in September 2017. In an email correspondence sent on September 25, 2017 (NMED, 2017), NMED communicated that it had no concerns or remaining questions regarding the start of Phase 1 of the pilot test.

After evaluation of Phase 2 data, it was evident that the rate of anaerobic biodegradation of EDB was significantly enhanced as a result of biostimulation and that bioaugmentation was not warranted at that time. As a result, Kirtland AFB submitted the Phase 3 EDB ISB Pilot Test Notification Letter (KAFB, 2018) to NMED, which outlined a revised plan for the third phase (Phase 3) of the pilot test. The

modified Phase 3 (i.e.: continued biostimulation rather than bioaugmentation) was previously agreed upon during a technical meeting among representatives from NMED, the Secretary of the Air Force's office, the Air Force Civil Engineer Center, APTIM and USACE on June 7, 2018. NMED approved the Phase 3 EDB ISB Pilot Test Notification Letter with two conditions in a letter dated August 7, 2018 (NMED, 2018). The conditions included scheduling a TWG meeting to review pilot test results and discuss the deferral of bioaugmentation and that bioaugmentation should remain as an approved, but deferred, component of the pilot test. A biogeochemistry TWG meeting was held on September 17, 2018 to give an update on pilot test results to date and discuss the deferral of bioaugmentation. During that TWG meeting most participants agreed that bioaugmentation was not warranted.

LNAPL Delineation and Additional Work

Numerous comments in the Notice of Deficiency indicate that the ISB Pilot Test did not adequately consider LNAPL in the source area. As noted above, the NMED-approved scope was focused on the evaluation of the anaerobic biodegradation of EDB. Measurement of LNAPL, if any was observed, was intended to help inform the evaluation of EDB ISB and was not a separate study objective. In fact, measurable LNAPL was not expected at the pilot test location, as noted in the NMED-approved Work Plan:

> *LNAPL is not expected in the area of the pilot test, as LNAPL has not been measured (or determined by sheen) in groundwater monitoring wells in the test area or immediately upgradient since Q4 2011. It is also noted that LNAPL was not observed at wells in this area prior to the submergence of the top of screen at KAFB-106064 (a total of 12 quarterly measurements between Q1 2012 and Q4 2014; screen was submerged by Q1 2015). However, newly installed wells will be monitored for presence of LNAPL several days after installation. If LNAPL is observed during well monitoring, a conference call will be initiated among USACE, CB&I, USAF, and the New Mexico Environment Department (NMED) to discuss whether the project should move forward at the planned location.*

As described above, a conference call to discuss observed LNAPL was held in September 2017 and NMED communicated afterwards that it had no concerns regarding the start of the pilot test at the planned location.

The Air Force is addressing the nature and extent of LNAPL through the vadose zone coring that was performed in 2018 and summarized in the October 25, 2019 Source Zone Characterization Report. Additional source area wells will be installed in accordance with the NMED approved Work Plan for *Data Gap Monitoring Well Installation KAFB-106248 to KAFB-106252* (KAFB, 2019) to address the problem of continued water table rise and to further delineate the EDB and benzene plumes. Soil coring will also be performed as part of this field effort. The proposed wells will be gauged for LNAPL, and thickness reported to NMED in Quarterly Monitoring Reports. Long-term or larger-scale viability of anaerobic ISB for EDB can be evaluated together with all appropriate alternatives as larger scale and more comprehensive remedies are considered at the site.

References

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Hatzinger, P., 2015. "Results from Laboratory Microcosm Studies and Microbial Community Analysis." May.

Koster van Groos, P., 2016. "ESTCP Project Meeting: EDB Recirculation Pilot Test Work Plan." April.

NMED, 2016a. December 12, 2016 correspondence from Ms. Kathryn Roberts, Director, Resource Protection Division, to Colonel Eric H. Froelich, Base Commander, 377 ABW/CC, Kirtland AFB, NM and Mr. John Pike, Director, Environmental Management Services, 377 MSG, Kirtland AFB, NM, *re: Ethylene Dibromide In Situ Bioremediation Pilot Test Work Plan, Bulk Fuels Facility, Solid Waste Management Units ST-106/SS-111, Kirtland Air Force Base, EAP ID# NM9570024423, HWB-KAFB-13-MISC.*

NMED, 2016b. December 16, 2016 correspondence from Ms. Michelle Hunter, Chief, Ground Water Quality Bureau, to Colonel Dawn A. Nickell, Vice Commander, 377 ABW/CV, Kirtland AFB, NM, *re: Response to Notice of Intent to Discharge, Ethylene Dibromide In-Situ Biodegradation Pilot Test Work Plan, Discharge Permit Not Required to Inject Specific Tracers and Amendments.* December.

NMED, 2017. Email correspondence from Diane Agnew (NMED) to Brian Renaghan (AFCEC) et al. September 25, 2017.

NMED, 2018. August 7, 2018 correspondence from Mr. Juan Carlos Borrego, Deputy Secretary, Environment Department, to Colonel Richard W. Gibbs, Base Commander, 377 AB/CC, Kirtland AFB, NM and Mr. Chris Segura, Chief, Installation Support Section, AFCEC/CZOW, Kirtland AFB, NM, *re: Phase 3 Ethylene Dibromide In Situ Biodegradation Pilot Test, Notification letter, Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-11, Kirtland Air Force Base, EPA ID# NM9570024423, HWB-KAFB-13-MISC.*

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KAFB, 2016b. *New Mexico Environment Department Ground Water Quality Bureau Notice of Intent to Discharge.* October 26.

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KAFB, 2019. *Work Plan for Data Gap Monitoring Well Installation KAFB-106248 to KAFB-106252, Bulk Fuels Facility, Solid Waste Management Units ST-106 and SS-111, Kirtland Air Force Base, New Mexico.* December.