Ethylene Dibromide In Situ Biodegradation Pilot (ISB) Test Report, Bulk Fuels Facility, Solid Waste Management Units ST-106 and SS-111, Kirtland Air Force Base (AFB), New Mexico, EPA ID# NM9570024423, HWB-KAFB-19-011; Notice of Disapproval (NOD) letter dated March 4, 2020.
New Mexico Environment Department (NMED) due date: March 19, 2021

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 have been changed as appropriate throughout the revised Report (e.g., from KAFB-1068 to KAFB-106008 on Figure 2). Air Force agrees with the global direction to consistently refer to wells by the same name, as required in the NMED letter dated September 2, 2020 (NMED, 2020). 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 (RTC) table (Appendix A of the revised Report). 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.	The pilot test was conducted in accordance with the NMED-approved documents, which detail the technical approach. Given evidence of bio-stimulation of native bacteria and non-detectable or low ethylene dibromide (EDB) concentrations at pilot test wells, NMED agreed that bio-augmentation could be deferred (NMED, 2018). Because the administrative record documents this change to the Work Plan it is not necessary to reference the technical working group (TWG) so this reference was deleted. A TWG meeting was held on September 17, 2018 during which pilot test results were reviewed and the deferral of bio-augmentation was discussed. The TWGs established for the Bulk Fuels Facility (BFF) project are not required by Kirtland AFB's Hazardous Waste Treatment Facility Operating Permit (HWTF Permit Number 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 NMED Hazardous Waste Bureau is responsible for scheduling TWG meetings if the Department believes they will support the Corrective Measures Evaluation (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.	In addition to this specific comment, uncertainties regarding possible EDB degradation products were also raised in the 02 April 2020 letter issued by NMED as an important consideration effecting decisions about moving forward with this technology. 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 therefore not attempted. Bromoethanol is a possible aerobic product, but unlikely to form anaerobically. Additional text has been 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 identify the source of the EDB and the length of time fuel containing EDB was used at Kirtland AFB. This corrective action addresses historical release from the BFF. Construction of the updated fuels facility was completed on March 18, 2011. At this time, fuel receipt became fully automated and required balance of fuel delivery and receipt to the gallon. The current operation of the fueling facility is not relevant to corrective action under the Resource Conservation and Recovery Act (RCRA) permit.

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 (NMED, 2016) and provided clear evidence of EDB biodegradation at multiple monitoring locations/wells. Please refer to Attachment 2 of the RTC Table (Appendix A of the revised Report) for discussion of the pilot test scope and timeline of NMED approvals. No revision to the text has been 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 has been 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 of Report). 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 was added at the beginning of the pilot test with lactate and inorganic nutrients, it

6. Section 1.4, Site Conditions, page 1-4 (continued) additional explanation regarding other vessels/methods that did not appear to demonstrate EDB degradation in the revised Report.	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 of the RTC Table (Appendix A of the revised Report), 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	The site photograph in Appendix B (formally Appendix A) is correctly labeled, "LNAPL bailed from KAFB-106MW1-S" ("LNAPL" has been changed to "NAPL" to be consistent with the Report text). 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 was installed as part of the Source Zone Characterization. Specific information regarding this well is documented in the Source Zone Characterization Report, that will be revised for NMED delivery in April 2021. KAFB-106S2 and KAFB-106008 were not sampled as part of the ISB pilot test project NAPL delineation was not the intent of the pilot test (refer to Attachment 2 of the RTC Table [Appendix A of the revised Report] 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. This pilot test is not the appropriate vehicle for directing the Air Force to develop a work plan to define the nature and extent of NAPL. NMED acknowledged this in its 02 April 2020 letter "…that the scope of the pilot was not to determine the extent of LNAPL". The Air Force agrees that it is important to understand the nature and

7. Section 2.3, Well Design and Installation, page 2-3 (continued) intervals of all monitoring wells installed to evaluate the shallow groundwater zone in the source area (e.g., KAFB-106064).	extent of NAPL to the extent necessary to support the CME. 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 will be discussed the Revised Source Zone Characterization Report to be submitted in April 2021. Additional source area wells were 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 air rotary casing hammer (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 (NMED, 2016) and is authorized under RCRA Permit NM9570024423, Section 6.5.9. No revisions to the text have been 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 of the RTC Table [Appendix A of the revised Report]).
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)."	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 of the RTC Table [Appendix A of the revised Report]). All well installation and sampling activities were performed in accordance with the NMED-approved Work Plan (KAFB, 2016). No revisions to the text have been made.

9. Section 2.3, Well Design and Installation, page 2-4 (continued) 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.	As detailed in the 09 July 2020 letter from the Air Force to Mr. Pierard, the Air Force has respectfully requested that NMED cease including global comments for future unrelated work in individual notices of disapproval.
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 has been made to the text. It is important to note that well installation was performed in accordance with the NMED-approved Work Plan (KAFB, 2016). NMED reviewed and approved via email 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. 11. Section 2.3.1, Groundwater Monitoring Well Installation, page 2-5 (continued) 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. 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.	Comment noted. As suggested, no revision has been made to the text. As detailed in the response to Comment #7 above, NAPL delineation was not the purpose of the pilot test (Attachment 2 of RTC Table [Appendix A of the revised Report]).

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 backpressure to ensure piping remained full of water throughout the treatment system. This limited the risk of cavitation within the pipe, minimized constituent volatilization, and minimized aeration of the anaerobic recirculation water. The text in Section 2.4.4 has been 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 2.6has been 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 of the RTC Table (Appendix A of the revised Report), 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 (KAFB, 2016) 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 unnecessarily 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 (KAFB, 2016), and it is not the intended goal of this pilot test (Attachment 2 of the RTC Table [Appendix A of the revised Report]). The reference to transducer data has been removed by removing the following statement from Section 3.4 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 prior to 2020. NAPL was not detected at KAFB-106MW1-S after November 2017. NAPL was observed in both extraction wells during a video survey of the wells in January 2020. Text discussing more recent well maintenance activities and 2020 NAPL removal activities has been included as Section 3.7.1 and 3.7.2 in the revised Report. A “Depth to NAPL” column has been 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 (Kl) 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 have been 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 (KAFB, 2016).
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 (KAFB, 2016). 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 has been added to Section 3.5 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 (KAFB, 2016). NMED reviewed and approved via email 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 diammonium phosphate (DAP) were outlined in the NMED-approved Work Plan (KAFB, 2016) and were adjusted in the field as necessary. The treatability test (see Figure 3) using Kirtland AFB soils and groundwater utilized 100 milligrams per liter (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., iron and manganese) 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 has been provided in Section 3.5 of 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 has been made. This pilot test was performed specifically to investigate the potential for anaerobic in situ bioremediation of EDB (Attachment 2 of the RTC Table [Appendix A of the revised Report]). 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 (KAFB, 2016). A pilot test is a focused, limited-scale test of a technology that is used to determine potential effectiveness under field conditions and the feasibility of including the technology in the final remedy. It is not intended to be used as a remediation tool. As this pilot is nearing the end of its NMED-approved scope, any evaluation of reduction of aeration are moot. The evaluation of NAPL recovery will be included in the CME.
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 3.5 and 3.6 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 (KAFB, 2018), 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 have been 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 have been 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 response to comments (Comments #5, 10, 19), 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. Downhole equipment and pumps were removed from the two extraction wells and injection well in January 2020 to assess condition and to conduct video surveys of the wells. Section 3.7.1 of the revised Reports summarizes the well maintenance activities performed in 2020. 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 further.
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-106INl 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 have been 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 have been 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 of the RTC Table (Appendix A of the revised Report) for scope of the pilot test and separate efforts to evaluate and delineate the vertical and lateral extent of NAPL. As detailed in the response to Comment #21 above, the evaluation of NAPL recovery will be included in the CME.

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 have been made to the text. Please refer to Attachment 2 of the RTC Table (Appendix A of the revised Report) for scope of the pilot test and separate efforts to evaluate and delineate the vertical and lateral extent of NAPL. As detailed in response to Comment #7, NAPL delineation was not the intent of the pilot test.
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 compound-specific isotope analysis (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 U.S. Environmental Protection Agency (EPA) 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. Section 3.7, NAPL Sampling, page 3-13 (continued)	The volatile organic compound (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 has been 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 has been added to Section 3.2 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 vertical and lateral extent of LNAPL at	Comment noted. No revisions have been made to the text. Please refer to Attachment 2 of the RTC Table (Appendix A of the revised Report) for scope of the pilot test and separate efforts to evaluate and delineate the vertical and lateral extent of NAPL. Additional source area wells were 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 was performed as part of this field effort, as discussed in response to Comment #7.

30. Section 3.7, NAPL Sampling, page 3-13 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-3) has been 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 investigation-derived waste sampling and characterization has been 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 have been corrected in the revised Report. Non-hazardous waste manifests have been 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 have been 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 to the text has been 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 3.5 and 3.6.

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 has been 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 has been 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 has not been revised to include a discussion of these issues. As stated previously, the potential expansion of this technology beyond the biodegradation of EDB will take place in the CME, if appropriate.

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 has been 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 *Dehalobacter* spp.(DHBt), *Desulfitobacterium* spp. (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 of the RTC Table [Appendix A of the revised Report]). As stated previously, the potential expansion of this technology beyond the biodegradation of EDB will take place in the CME, if appropriate. No revisions have been made to the text.
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 of the RTC Table [Appendix A of the revised Report]). 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. As stated previously, the potential expansion of this technology beyond the biodegradation of EDB will take place in the CME, if appropriate. No revisions have been 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. As stated previously, the potential expansion of this technology beyond the biodegradation of EDB will take place in the CME, if appropriate. Site-specific comments on these factors would be speculative and no revisions have been 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 have been 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 carbon dioxide 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 have been made to the text. Please refer to Attachment 2 of the RTC Table (Appendix A of the revised Report) 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 monitoring is on-going at this time and provide a reference that presents the most recent analytical data in the revised Report.	Comment noted. No revisions have been made to the text. The pilot test was focused on EDB biodegradation (Attachment 2 of the RTC Table [Appendix A of the revised Report]). 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. After collection of Phase 4 samples in January 2019, sampling of the groundwater monitoring, extraction, and injection wells resumed in March 2020 after the extraction and injection well pumps were removed and the wells surveyed with a camera to assess downhole equipment and well conditions. Starting in 2020, samples were collected quarterly and analyzed for the same constituents as approved in the Work Plan (KAFB, 2016). Monitoring and sampling activities performed in 2020, along with analytical results and data interpretations, have been incorporated into this 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 has been 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 have been 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 (KAFB, 2016). The replacement laboratory met all project data quality objectives. As detailed in the 09 July 2020 letter from the Air Force to Mr. Pierard, the Air Force has respectfully requested that NMED cease including global comments for future unrelated work in individual notices of disapproval.
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 text has been 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 has been 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 of the RTC Table (Appendix A of the revised Report) for scope of the pilot test and separate efforts to evaluate and delineate the vertical and lateral extent of NAPL. No revisions have been 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-l06IN1 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 has been 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 have been 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 have been 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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KAFB, 2016. *Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan, Bulk Fuels Facility, Kirtland Air Force Base, New Mexico*. Prepared by CB&I Federal Services, LLC. for the USACE Albuquerque District under USACE Contract No. W9128F-12-D-0003, Task Order 0025. December.

KAFB, 2018. *Phase 3 Ethylene Dibromide In Situ Biodegradation Pilot Test, Notification letter, Bulk Fuels Facility, Kirtland Air Force Base, New Mexico.* Prepared by Aptim Federal Services, LLC for Kirtland AFB under USACE Contract No. W9128F-12-D-0003, Task Order 0025. July.

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NMED, 2016. December 12, 2016 correspondence from Ms. Kathryn Roberts, Director, Resource Protection Division, to Colonel Eric H. Froelich, Base Commander, 377 AB/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 Unit St-106/SS-11, Kirtland Air Force Base, EPA ID# NM9570024423, HWB-KAFB-13-MISC.*

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.*

NMED, 2020. Letter from Mr. Kevin M. Pierard, Chief, Hazardous Waste Bureau to Colonel David S. Miller, Base Commander, 377 ABW/CC, Kirtland Air Force Base and Lt. Colonel Wayne J. Acosta, Civil Engineer Division, Kirtland Air Force Base, *RE: Reporting Requirements for All Document Submittals, Kirtland Air Force Base, New Mexico, EPA ID# NM6213820974. JWB-KAFB-20-MISC*. September.

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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
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KAFB-106018	KAFB-10618
KAFB-106019	KAFB-10619
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Attachment 1
Current Well Designations

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Attachment 1
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Attachment 1
Current Well Designations

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KAFB-106235-472	KAFB-106235-492
KAFB-106235-501	KAFB-106235-521
KAFB-106236-436	KAFB-106236-461
KAFB-106236-470	KAFB-106236-490
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KAFB-106247-490	No change
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KAFB-106S2-451	No change
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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.

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KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

FINAL
ETHYLENE DIBROMIDE *IN SITU* BIODEGRADATION PILOT TEST REPORT, REVISION 1
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

~~April 2019~~March 2021

377 MSG/CEI
2050 Wyoming Boulevard SE
Kirtland Air Force Base, New Mexico 87117-5270

KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

FINAL
ETHYLENE DIBROMIDE *IN SITU* BIODEGRADATION PILOT TEST REPORT, REVISION 1

BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111

~~April 2019~~March 2021

Prepared for
U.S. Army Corps of Engineers
Omaha District
1616 Capitol Avenue
Omaha, Nebraska 68102

USACE Contract No. W9128F-12-D-0003
Task Order 0025

Prepared by
Aptim Federal Services, LLC
17 Princess Road
Lawrenceville, New Jersey 08648

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(08-11-2019)*
March 2021

2. REPORT TYPE
Final, Revision 1

3. DATES COVERED *(From - To)*
September 2016 – October 2020

4. TITLE AND SUBTITLE
Ethylene Dibromide *In Situ* Biodegradation Pilot Test Report, Bulk Fuels Facility, Solid Waste Management Units ST-106 and SS-111, Kirtland Air Force Base, Albuquerque, New Mexico

5a. CONTRACT NUMBER
W912DY16D0022
Delivery Order W912PP19F0053

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Aptim Federal Services, LLC

5d. PROJECT NUMBER
500433/501397

5e. TASK NUMBER

5f. WORK UNIT NUMBER
Not Applicable

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Aptim Federal Services, LLC
17 Princess Road
Lawrenceville, New Jersey 08648

8. PERFORMING ORGANIZATION REPORT NUMBER
KAFB-~~ROS~~-019-0001

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

USACE Albuquerque District
4101 Jefferson Plaza NE
Albuquerque, New Mexico 87109-3435

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This Ethylene Dibromide *In Situ* Biodegradation Pilot Test Report has been prepared to describe activities and data associated with the ethylene dibromide (EDB) *in situ* biodegradation pilot test. The pilot test described herein was conducted to investigate anaerobic *in situ* bioremediation (ISB) of 1,2-dibromoethane (i.e., ethylene dibromide; EDB). 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. The efforts described herein evaluated the extent to which potential treatment amendments for *in situ* biostimulation enhanced anaerobic EDB biodegradation processes.

EDB degradation was evident during the pilot test with a greater than three-log reduction (99.9 percent) to below the United States Environmental Protection Agency maximum contaminant level of 0.05 micrograms per liter at wells KAFB-106MW2-S and KAFB-106064 after biostimulation efforts. EDB degradation was evident through comparison with benzene and toluene concentrations, and the production of EDB degradation products ethene, ethane, and bromide suggested that this degradation occurred by reductive debromination. Higher EDB ~~δ13C~~ delta carbon-13 values (observed to be as high as +5‰ or per mil~~e~~) provided additional isotopic evidence of EDB degradation.

15. SUBJECT TERMS
Bulk Fuels Facility; Pilot Test Report; well installation; well development; surveying; treatment system design, construction, and operation; groundwater sampling; analytical results.

16. SECURITY CLASSIFICATION OF:

a. REPORT
UNCLASSIFIED

b. ABSTRACT
UNCLASSIFIED

c. THIS PAGE
UNCLASSIFIED

17. LIMITATION OF ABSTRACT
ABSTRACT

18. NUMBER OF PAGES
133

19a. NAME OF RESPONSIBLE PERSON
Sheen Kottkamp

19b. TELEPHONE NUMBER *(include area code)*
(505)-846-7674

40 CODE OF FEDERAL REGULATIONS 270.11
DOCUMENT CERTIFICATION
~~APRIL 2019~~

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DAVID S. MILLER, Colonel, U.S. Air Force
Commander, 377th Air Base Wing

Date

This document has been approved for public release.

KIRTLAND AIR FORCE BASE
377th Air Base Wing Public Affairs

Date

PREFACE

This Ethylene Dibromide *In Situ* Biodegradation Pilot Test Report has been prepared by Aptim Federal Services, LLC (APTIM) for Kirtland Air Force Base under~~the~~ U.S. Army Corps of Engineers (USACE), ~~under~~ Contract Number ~~W~~W912DY16D0022, Delivery Order W912PP19F0053~~9128F-12-D-0003, Task Order 0025~~. It pertains to the Kirtland Air Force Base Bulk Fuels Facility, Solid Waste Management Units ST-106 and SS-111 located in Albuquerque, New Mexico. This report was prepared in accordance with applicable federal, state, and local laws and regulations, including the New Mexico Hazardous Waste Act, New Mexico Statutes Annotated 1978, the New Mexico Water Quality Act, New Mexico Hazardous Waste Management Regulations, Resource Conservation and Recovery Act, and the Water Quality Control Commission Regulations.

This Pilot Test Report presents and describes all activities and data associated with the ethylene dibromide *in situ* biodegradation pilot test. ~~Mr. Larry Woscyna is the Contracting Officer's Representative for the USACE Omaha District, Mr. Matthew Ellender is the USACE Omaha District Project Engineer; Mr. Scott Clark is the Kirtland Air Force Base Restoration Interim Section Chief; and Mrs. Kathleen Romalia is the APTIM Project Manager.~~

Kathleen E Romalia

Kathleen Romalia
Aptim Federal Services, LLC
Project Manager

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FIGURES (concluded)

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ACRONYMS AND ABBREVIATIONS

%	percent
µg/L	microgram per liter
µm	micron
‰	per mil~~e~~
^{13}C	carbon-13, stable isotope of carbon
$^{2}H_2O$	deuterium oxide, deuterated water
AFB	Air Force Base
APS	sulfate reducing bacteria
APTIM	Aptim Federal Services, LLC
ARCH	Air Rotary Casing Hammer
AvGas	aviation gasoline
BFF	Bulk Fuels Facility
bgs	below ground surface
Calcon	Calcon Systems Inc.
cells/mL	cells per milliliter
CSIA	compound-specific isotope analysis
DAP	diammonium phosphate
DCM	*Dehalobacter* DCM
DHBt	*Dehalobacter* spp.
DHC	*Dehalococcoides*
DHG	*Dehalogenimonas* spp.
DI	deionized
DO	dissolved oxygen
DSB	*Desulfitobacterium* spp.
DTIC	Defense Technical Information Center
EBAC	total eubacteria
EDB	ethylene dibromide/1,2-dibromoethane
EPA	United States Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
FCV	flow control valve
Fe	iron
FFOR	Former Fuel Offloading Rack
gpm	gallon per minute
IDW	investigation-derived waste
ISB	*in situ* bioremediation
JP-4	jet propellant fuel grade 4
JP-8	jet propellant fuel grade 8

KAFB	Kirtland Air Force Base
KI	potassium iodide
~~LNAPL~~	~~liquid non-aqueous phase liquid~~
MCL	maximum contaminant level
mg/kg	milligram per kilogram
mg/L	milligram per liter
MGN	methanogens
NAPL	non-aqueous phase liquid
NMED	New Mexico Environment Department
No.	number
OOM	order of magnitude
ORP	oxidation-reduction potential
OSE	Office of the State Engineer
P&ID	piping and instrumentation diagram
Pace	Pace Analytical®
PID	photo ionization detector
PM	Project Manager
PVC	polyvinylchloride
QED	QED Environmental Systems
RCRA	Resource Conservation and Recovery Act
Report	Ethylene Dibromide *In Situ* Biodegradation Pilot Test Report
SCADA	Supervisory Control and Data Acquisition
SDC-9	debrominating culture
SWMU	Solid Waste Management Unit
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VOC	volatile organic compound
Work Plan	Ethylene Dibromide *In Situ* Biodegradation Pilot Test Work Plan
$\delta^{13}C$	delta carbon-13 (measure of carbon isotope composition)
$\delta^{2}H$	delta deuterium (measure of hydrogen isotope composition)

EXECUTIVE SUMMARY

This Ethylene Dibromide *In Situ* Biodegradation Pilot Test Report (Report) was prepared to describe activities and data associated with the pilot test conducted at the Bulk Fuels Facility (BFF) on Kirtland Air Force Base (AFB) in accordance with the New Mexico Environment Department (NMED) letter dated February 25, 2019 (NMED, 2019). The BFF site was the location of an accidental leak of aviation gasoline and jet propellant fuel grades 4 and 8 that was discovered in 1999. Based on historical Air Force fuel usage, aviation gasoline containing ethylene dibromide/1,2-dibromoethane (EDB) as a lead scavenger would have been in use from approximately the 1940s to 1975 (~~United States Army Corps of Engineers [USACE]~~Kirtland AFB, 2011a). The investigation and remediation of the BFF leak (Solid Waste Management Units ST-106 and SS-111) is being implemented pursuant to the Resource Conservation and Recovery Act (RCRA) corrective action provisions in Part 6 of the Kirtland AFB Hazardous Waste Treatment Facility Operating Permit (Permit ~~No.~~Number NM9570024423, referred to as the RCRA Permit) (NMED, 2010). This pilot test was performed pursuant to the NMED-approved Ethylene Dibromide *In Situ* Biodegradation Pilot Test Work Plan (Work Plan; ~~USACE~~Kirtland AFB, 2016a) and Phase 3 Notification Letter (~~USACE~~Kirtland AFB, 2018a).

This stand-alone Executive Summary briefly summarizes the pilot test objectives, construction activities, results, and conclusions of this Report. Sections 1 through 3 of the main ~~report~~ Report describe the activities performed during the implementation of the pilot test. Section 4 describes pilot test analytical results and performance. Section 5 provides conclusions.

The pilot test was conducted to investigate anaerobic *in situ* bioremediation of EDB in groundwater associated with the BFF site. *In situ* bioremediation, 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. The pilot test was primarily designed to evaluate the extent to which potential treatment amendments for *in situ* biostimulation and bioaugmentation enhance anaerobic EDB biodegradation processes.

Site preparation activities, mobilization, and installation of the Pilot Test System were performed from September 2016 through May 2017. Construction of the Pilot Test System consisted of the installation and development of seven wells; construction of underground piping, conduit, and direct buried electrical lines, and the installation of the system control building with required electrical service and components.

The pilot test utilized one injection, two extraction, and six monitoring wells, including existing monitoring wells KAFB-106064 and KAFB-106063 (nine wells total) (Figure ES-1). Well KAFB-106IN1 was installed and used as an injection well for recirculated groundwater and amendment injection; wells KAFB-106EX1 and KAFB-106EX2 were installed and used as groundwater extraction wells; and existing wells KAFB-106064 and KAFB-106063, and new nested wells KAFB-106MW1-S, KAFB-106MW1-I, KAFB-106MW2-S, and KAFB-106MW2-I were used as monitoring wells. The new shallow groundwater monitoring wells (KAFB-106MW1-S and KAFB-106MW2-S) are screened with 15 feet above the static water table and 20 feet extending below the water table, as measured at the time of well installation. The new intermediate wells (KAFB-106MW1-I and KAFB-106MW2-I) were installed within the intermediate groundwater zone are screened 35 feet below the water table.

The system for amending and recirculating groundwater was designed by Aptim Federal Services, LLC, together with subcontractors, and was fabricated by Calcon Systems Inc. The system is contained within a 20-foot long Conex box. The Conex box has a partition wall, separating the enclosure into two spaces. The smaller of the two spaces is the system control room that houses the supervisory control and data acquisition system with integrated computer, electrical control panel, Baski flow control valve controls and associated nitrogen cylinder, and a combination air conditioner/heater. The larger space houses system process components. Shakedown testing was performed on May 16 through 17, 2017 prior to full system start-up.

The pilot test was implemented in four phases, each briefly described below:

- Phase 1—Evaluation of baseline conditions and the distribution of recirculated water using tracer amendments.
- Phase 2—Evaluation of biostimulation in the subsurface after distribution of treatment amendments in recirculated groundwater.
- Phase 3— Additional evaluation of biostimulation in the subsurface after distribution of treatment amendments in recirculated groundwater.
- Phase 4—~~Continued~~ Extended ~~long-term~~ monitoring with no ~~active extraction/injection~~ addition of amendments or recirculation of groundwater.

Groundwater samples were collected intermittently at extraction, injection, and the six groundwater monitoring wells during the active and the passive portions of the phases, except for Phase 4, which did not include an active recirculation portion. Samples were sent to numerous analytical laboratories for analysis.

Per the Work Plan (~~USACE~~Kirtland AFB, 2016a), Phase 3 was to consist of both biostimulation and bioaugmentation with a known debrominating culture (SDC-9); however, after review of field results from both Phase 1 and Phase 2, it was determined that bioaugmentation was not yet warranted. Due to the success of biostimulation during Phase 2, Phase 3 was modified to further evaluate biostimulation and a Phase 3 Notification Letter was submitted to the NMED on July 26, 2018. The modified Phase 3 was approved by the NMED in a letter dated August 7, 2018 (NMED, 2018), which also stated that “bioaugmentation shall remain as an approved, but deferred component of the pilot test.”~~.~~

Placeholder for Figure ES-1.

The results for the four phases of the pilot test are summarized below:

- EDB concentrations at shallow monitoring wells during the baseline evaluation ranged from 20.1 micrograms per liter (µg/L) at ~~Kirtland AFB (~~KAFB~~)~~-106IN1 to 432 µg/L at KAFB-106MW1-S, and among the intermediate wells EDB was only detected at KAFB-106MW2-I with a concentration of ~~approximately~~ 0.122 µg/L. EDB concentrations are shown on Figure ES-2. Baseline microbial results indicated that the subsurface was biologically active prior to pilot test activities.

- EDB concentrations at shallow monitoring wells during the Phase 1 (tracer test) recirculation period ranged from 50.4 µg/L (KAFB-106EX1) to 137 µg/L (KAFB-106EX2) (Figure ES-2). EDB concentrations at the shallow monitoring wells decreased during the following Phase 1 passive period, with EDB reductions of approximately 75 percent (%) observed at wells KAFB-106064 (20.1 µg/L), KAFB-106EX1 (12.9 µg/L), and KAFB-106MW2-S (15 µg/L) after the one-month passive period (Figure ES-2). Biostimulation amendments were not added during Phase 1. The results from tracer test during Phase 1 indicated that the targeted treatment zone encompassing the shallow groundwater monitoring wells were hydraulically connected with the injection well. Distribution of tracers to groundwater sampled by monitoring wells nearest to the injection well (KAFB-106MW2-S and KAFB-106064) occurred within 5 days of operation, suggesting a high likelihood of successfully distributing biostimulation amendments ~~to~~ that ~~favor~~ help facilitate reductive debromination of EDB.

- During the Phase 2 (biostimulation) recirculation period, the range of EDB concentrations observed at shallow monitoring wells was less variable, ranging from 66.4 µg/L at KAFB-106MW1-S to a maximum of 90.9 µg/L at KAFB-106EX2 (Figure ES-2). EDB was detected at the intermediate monitoring wells during the Phase 2 recirculation period. Except for KAFB-106EX2, EDB concentrations decreased during the Phase 2 passive period by approximately 90 percent (%) or more with concentrations down to below detection limits (KAFB-106IN1, KAFB-106MW2-S).

- During the Phase 3 (biostimulation) recirculation period, the range of EDB concentrations observed at shallow monitoring wells was more variable than during the Phase 2 recirculation period, ranging from approximately 3 µg/L at KAFB-106064 to a maximum of 97 µg/L KAFB-106EX2 (Figure ES-2). Except for KAFB-106EX2, EDB concentrations during the subsequent passive period decreased by 95% or more relative to maximums observed during the preceding recirculation period, with concentrations ranging down to 0.019 µg/L (KAFB-106MW2-S).

- ~~No significant rebound in EDB concentrations~~There was little evidence of significant increases in EDB concentrations (i.e., rebound) ~~was noted~~ during ~~the~~ Phase 4 sampling events, which concluded in October 2020. Based on iodide tracer concentrations, groundwater transport in the vicinity of the pilot test appeared limited during this period. During Phase 4, EDB concentrations ranged from 0.016 µg/L at KAFB-106MW2-S to 62 µg/L at KAFB-106EX2. EDB decreased ~~by an additional 80%~~ at KAFB-~~106MW1-S~~106EX2 ~~since the last passive sampling event of~~ relative to the concentration measured during the ~~Phase 3~~first Phase 4 sampling event in January 2019 (62 µg/L) with a final EDB concentration of 0.36 µg/L measured during the October 2020 sampling event.

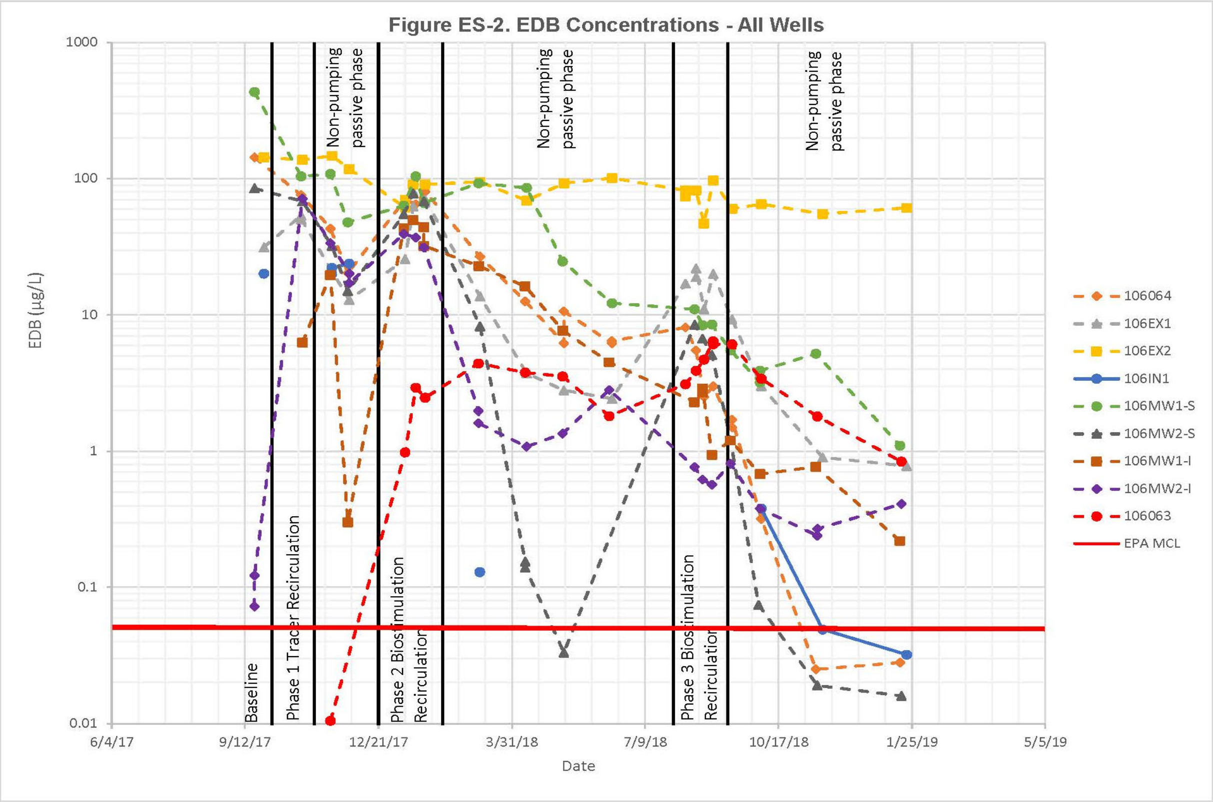

Figure ES-2. EDB Concentrations - All Wells

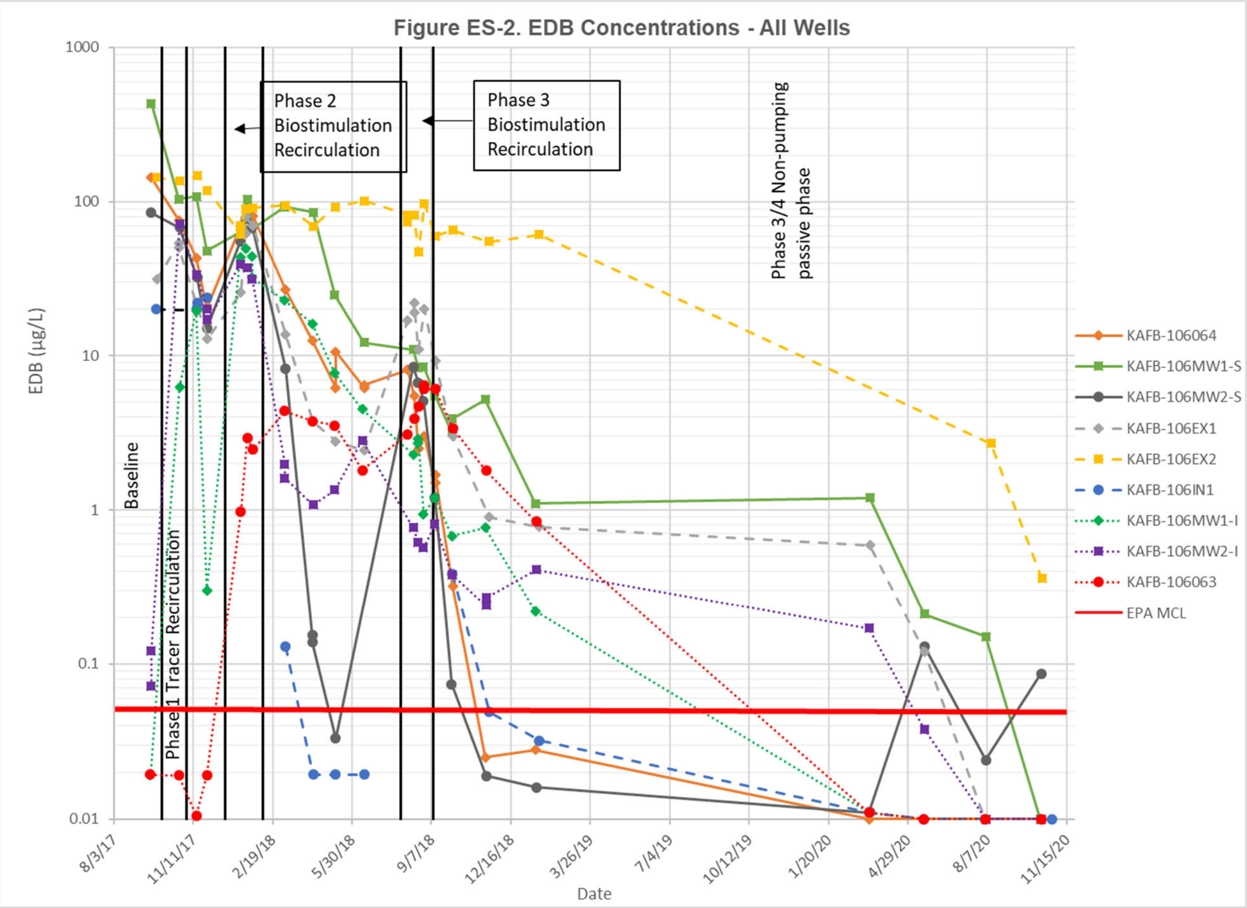
Figure ES-2. EDB Concentrations - All Wells

EDB degradation was evident during the pilot test with a greater than ~~three~~two-log reduction (≥99~~.9~~%) at all wells examined. In October 2020, EDB concentrations at all but two wells were ~~to~~ below the United States Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 0.05 µg/L (EPA, 2009). The two wells exceeding the EPA MCL for EDB in October 2020 were ~~at wells~~ KAFB-106MW2-S (0.087 µg/L) and ~~and~~ KAFB-~~106064~~ 106EX2 (0.36 µg/L)~~after biostimulation efforts~~. EDB degradation was evident through comparison with benzene and toluene concentrations, and the production of EDB degradation products ethene, ethane, and bromide suggested that this degradation occurred by reductive debromination. Dissolved oxygen, sulfate, iron, and methane concentrations observed throughout much of the pilot test indicated that bulk anaerobic conditions generally considered to be necessary for reductive debromination were present. Higher EDB delta carbon-13 ~~(δ^{13}C)~~ values (observed to be as high as +5 per mil~~le~~) provided additional isotopic evidence of EDB degradation.

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1. INTRODUCTION

This *Ethylene Dibromide In Situ Biodegradation Pilot Test Report* (Report) has been prepared by Aptim Federal Services, LLC (APTIM) for Kirtland Air Force Base (AFB) under the U.S. Army Corps of Engineers (USACE)~~, Omaha District, under~~ Contract Number (No.) W912DY16D0022, Delivery Order W912PP19F0053~~W9128F-12-D-0003, Task Order 0025~~. The test described in this Report was implemented at the Kirtland ~~Air Force Base (~~AFB~~)~~ Bulk Fuels Facility (BFF) site, Solid Waste Management Units (SWMUs) ST-106 and SS-111. The investigation and remediation of the BFF leak (SWMUs ST-106 and SS-111) is being implemented pursuant to the Resource Conservation and Recovery Act (RCRA) corrective action provisions in Part 6 of the Kirtland AFB Hazardous Waste Treatment Facility Operating Permit (Permit No. NM9570024423, referred to as the RCRA Permit) (New Mexico Environment Department [NMED], 2010). This pilot test was performed pursuant to the *Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan* (Work Plan; ~~USACE~~Kirtland AFB, 2016a) and the Phase 3 Notification Letter (Kirtland AFB~~USACE~~, 2018a).

This pilot test was conducted to investigate anaerobic *in situ* bioremediation (ISB) of 1,2-dibromoethane (i.e., ethylene dibromide [EDB]). 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. This pilot test was designed to evaluate the use of *in situ* biostimulation to enhance anaerobic EDB biodegradation processes.

1.1 Pilot Test Objectives

The primary objective of this pilot test was to evaluate the extent to which potential treatment amendments for ISB enhance anaerobic EDB biodegradation processes. Evaluation of the test was completed through comprehensive groundwater sampling that assessed both direct and indirect indicators of EDB biodegradation.

1.2 Site Description

Kirtland AFB is located in Bernalillo County, in central New Mexico, southeast of and adjacent to the City of Albuquerque and the Albuquerque International Sunport (Figure 1). The approximate area of the base is 52,287 acres, and it is bordered by Albuquerque to the north and west, the Isleta Pueblo Reservation to the south, and the Cibola National Forest to the east. The BFF site is located in the northwestern part of Kirtland AFB, and is comprised of two SWMUs, designated as ST-106 and SS-111. The pilot test was performed near the EDB contaminant source in an undeveloped area just south of Randolph Road, at the location identified on Figure 2.

The pilot test area included groundwater injection, extraction, and monitoring wells installed near the existing monitoring well cluster that includes Kirtland AFB (KAFB)-106062, KAFB-106063, and KAFB-106064, approximately 300 feet to the east of Building 1024 (Figure 2). The water table at the test location occurs at approximately 480 feet below ground surface (bgs), and the pilot test groundwater wells are screened in the shallow and intermediate zones of the aquifer within the Santa Fe Group. Well screens of the shallow monitoring wells were placed to target the highest EDB concentrations (i.e., approximately the top 20 feet of the aquifer), located in a zone of inter-bedded sands and gravels with occasional finer layers, and groundwater extraction and injection primarily facilitated flow in the soil materials of greatest hydraulic conductivity.

1.3 Site History

The BFF site was the location of a historical, accidental release of aviation gasoline (AvGas) and jet propellant fuel grades 4 (JP-4) and 8 (JP-8). Historical aerial photography revealed that the area was used for fuel storage and processing as early as 1951 (CH2M HILL, 2001). From 1953 to late 1975, the primary fuel stored and used at the BFF was AvGas. The use of AvGas and JP-4 at Kirtland AFB was phased out in 1975 and 1993, respectively (Kirtland AFB~~USACE~~, 2011a). JP-8 was handled through the Former Fuel Offloading Rack (FFOR) until the leak was discovered in 1999.

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. EDB is a suspected human carcinogen that was historically added to leaded fuels to prevent the build-up of lead oxide deposits in engines, including aircraft engines.

The fuels are thought to have leaked undetected over approximately 3 to 4 decades at the FFOR through leak points during fuel transfer. The released fuel migrated through the vadose zone to eventually reach the water table. The migration followed a disjointed, meandering path caused by subsurface heterogeneity, where frequent changes in the alluvial lithology and confining layers created preferential flow pathways. This resulted in non-uniform residual contamination of the vadose zone and measurable non-aqueous phase liquid (NAPL) on the surface of the underlying unconfined aquifer. The presence of NAPL fuel hydrocarbons on the water table indicated that substantial releases had occurred.

1.4 Site Conditions

The historical water table in the vicinity of Kirtland AFB was estimated to be approximately 350 feet bgs before extensive groundwater pumping from the regional aquifer occurred. Throughout the history of the BFF site, the water table has fallen due to groundwater pumping to supply drinking water to the residents of Albuquerque. The 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.

The background gradient at the pilot test location is small and pumping of wells and reinjection during pilot test operations induced gradients exceeding that of the background. 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 (Kirtland AFB~~USACE~~, 2018b).

Prior to the pilot test during quarterly sampling in 2014 and 2015, groundwater samples were collected from 13 monitoring wells to analyze the *in situ* microbial community at Kirtland AFB using Microbial Insight's QuantArray-Chlor protocol. ~~Four consecutive quarters of samples were collected from the 13 monitoring wells, from the Fourth Quarter 2014 through the Third Quarter 2015.~~ The method of collection and analysis has been discussed in previous quarterly reports, which can be found on the Air Force Administrative Records site (http://afcec.publicadmin-record.us.af.mil/Search.aspx). Results indicated that microorganisms likely to dehalogenate EDB, or its chlorinated analog 1,2-dichloroethane, are present in the subsurface. EDB biodegradation activity, however, was not readily stimulated during ex situ treatability tests, but bioaugmentation ~~Additionally, treatability testing using Kirtland AFB soil and groundwater showed that bioaugmentation~~ with a known debrominating culture (SDC-9) significantly enhanced EDB degradation rates during the same tests (Figure 3). The inability to stimulate biodegradation activity during treatability tests may have resulted from the lack of viable debrominating organisms in the collected samples or other challenges simulating subsurface conditions in the lab. The success with a bioaugmentation culture, however, demonstrated that viable debrominating organisms could degrade EDB in the presence of site soils and groundwater. 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, ~~,~~ either through stimulation of the ~~by stimulating the activity of~~ indigenous ~~EDB-degrading~~dehalogenating organisms that were observed to be present *in situ*, ~~(i.e., biostimulation)~~ or through bioaugmentati~~ng~~on with an exogenous debrominating culture (e.g., SDC-9)~~,~~. The pilot test performed here was designed to test both biostimulation and bioaugmentation options, as appropriate.

Biostimulation was successful at pilot test scale in the field and bioaugmentation with an exogenous culture was not performed.~~.~~

1.5 Report Organization

This Report contains a detailed summary of the pilot test implementation, including design considerations, field activities, and a comprehensive documentation of results. The remainder of this Report contains the following sections:

- Section 2 – Pilot System Design and Construction
- Section 3 – Pilot System Operation and Monitoring
- Section 4 – Pilot Test Results
- Section 5 – Conclusions

Figures, tables, and appendices are available following the body of this Report.

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2. PILOT SYSTEM DESIGN AND CONSTRUCTION

Site preparation activities, mobilization, and installation of the Pilot Test System were performed from September 2016 through May 2017. Construction of the Pilot Test System consisted of well installation and development; installation of underground piping, conduit, and direct buried electrical lines; and installation of the system control building with required electrical service and components. Appendix ~~A~~ B includes 20 representative photographs of various site activities.

2.1 Permitting

Prior to initiating construction activities, the following permits were obtained:

- Kirtland AFB Dig Permit (utility clearance)
- Kirtland AFB Civil Engineer Work Permit
- Office of the State Engineer (OSE) Drill and Install Permit
- OSE Change of Water Rights
- Albuquerque Environmental Health Department Fugitive Dust Permit

One dig permit (Air Force Form 103) was submitted to Kirtland AFB on July 20, 2016 for well installation and trenching for utilities associated with the system. The dig permit was approved on August 15, 2016, and a permit number was issued (1607-014).

Surface disturbances at the pilot test location totaled an area greater than ¾ acre and required submittal of a Fugitive Dust Permit Application, which was submitted to the Albuquerque Environmental Health Department on May 12, 2014, prior to initiation of excavation activities, in accordance with 20.11.20

New Mexico Administrative Code. The permit application was approved, and the Fugitive Dust Permit (6621-C) was issued on May 14, 2014.

Two separate permits to "Drill a Well with No Consumptive Use of Water" were submitted to the OSE for monitoring wells, and extraction and injection wells, respectively. Permits were issued for the monitoring wells on November 17, 2016 and for the extraction and injection wells on August 15, 2016. An "Application for Permit to Change an Existing Water Right" was also submitted to the OSE for the extraction and injection wells. The intention of the change of water rights permit was not to increase the allowable groundwater diversion described in RG-1579 through RG-1589, but rather to change the purpose of use to pollution control and recovery, and by adding places of use not currently described in the Kirtland AFB water rights (RG-1579 through RG-1589) for the extraction and injection wells. The change of water rights application was approved by the OSE on December 7, 2016.

Additionally, a Notice of Intent was submitted to the NMED Ground Water Quality Bureau on October 26, 2016 to determine whether a Discharge Permit was required, in accordance with the requirements found in 20.6.2.1201.A New Mexico Administrative Code. NMED Ground Water Quality Bureau determined that a Discharge Permit was not required for pilot test activities in a letter dated December 16, 2016. Appendix ~~B~~ C includes all relevant permits.

2.2 Utility Clearance

Prior to the initiation of construction activities, a utility clearance was undertaken at the pilot test site by High Mesa Consulting Group (under subcontract to APTIM) in September 2016. Kirtland AFB utility representatives also performed a utility locate in order to process the submitted dig permits.

2.3 Well Design and Installation

The pilot test utilized one injection, two extraction, and six monitoring wells, including existing monitoring wells KAFB-106064 and KAFB-106063 (nine wells total). Well KAFB-106IN1 was installed and used as an injection well for recirculated groundwater, tracer, and amendment injection; wells KAFB-106EX1 and KAFB-106EX2 were installed and used as groundwater extraction wells; and existing wells KAFB-106064 and KAFB-106063, and new nested wells KAFB-106MW1-S, KAFB-106MW1-I, KAFB-106MW2-S, and KAFB-106MW2-I were used as groundwater monitoring wells. The pilot test wells, which included KAFB-106063, KAFB-106064, and the seven newly installed wells, are shown on Figure 2. A cross-sectional view illustrating the depths of the pilot test wells is shown on Figure 4.

The pilot test wells were sited to accommodate existing well infrastructure, site utilities, and to facilitate use of existing wells for monitoring. The two extraction wells were located 75 to 92 feet from the single injection well, as shown in Figure 2. As detailed later in this Report, the extraction wells were used to periodically recirculate groundwater during individual phases of the pilot test. The periods of active groundwater recirculation were designed to facilitate the distribution of amendments at the test location. Pumping was halted after sufficient amendment distribution and ISB treatment performance was monitored.

Existing monitoring wells KAFB-106063 (screened from 505 to 520 feet bgs, 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. The design and locations of the new wells were selected to evaluate EDB biodegradation and were located near the injection well to facilitate evaluating the impacts of biostimulation amendments. The four new monitoring wells were installed within two boreholes utilizing a nested configuration with two wells in each borehole in accordance with the Work

Plan (Kirtland AFB~~USACE~~, 2016a). Each borehole contained a shallow well with approximately 15 feet of screen in the vadose zone and 20 feet of screen in the aquifer, along with a deeper well (intermediate) with the top of a 10-foot screen set approximately 35 feet below the water table. Well screen intervals were isolated within the borehole using bentonite seals. Well construction diagrams are presented in Appendix ~~C~~ D and general construction information for each well is summarized in Table 1.

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. 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 headspace measurements. Drill cuttings were also visually inspected for evidence of staining. PID readings were recorded on the soil boring logs (Appendix ~~C~~D). Staining was not observed during drilling activities; however, elevated PID readings and fuel-like odors were recorded from depths ranging from 473 feet bgs to 515 feet bgs at the wells.

Soil boring logs and well construction diagrams for monitoring, extraction, and injection wells installed during the pilot test are located in Appendix ~~C~~D. Soil borings were reviewed by a professional geologist and submitted to the OSE, in accordance with well permit requirements. Table 1 presents the completion details for the wells, including surveyed elevations and coordinates, and screen depths. All newly installed well locations are depicted on Figure 2.

2.3.1 Groundwater Monitoring Well Installation

Drilling of groundwater monitoring wells began on January 8, 2017, and was completed on February 16, 2017, using Cascade's ARCH drill rig. The four monitoring wells were installed within two boreholes, utilizing a nested well design in accordance with the Work Plan (Kirtland AFB~~USACE~~, 2016a). Well construction diagrams are presented in Appendix ~~C~~ D and general construction information for each well is summarized in Table 1.

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-I) were constructed with 3-inch diameter, Schedule 80, PVC riser pipe. The shallow and intermediate monitoring wells are nested within a telescoping borehole (13-3/8-inch upper and 11-3/4-inch lower diameter) to a depth of approximately 535 feet bgs. The shallow wells were fitted with 35-foot screens, set with 15 feet of screen in the vadose zone and 20 feet in the aquifer. The placement of the shallow monitoring well screens ~~is~~ was intended to account for potential water table rise and allow for future monitoring and characterization activities after the completion of this pilot test in the event it is necessary to support the Corrective Measures Evaluation. The intermediate wells are fitted with 10-foot screens, with top of screen installed approximately 35 feet below the water table. Monitoring wells were equipped with a Schedule 80 PVC flush-threaded end cap installed below the screened interval. Additional well construction details are summarized in Table 1 and Appendix ~~C~~D.

2.3.2 Borehole Deviation and Borehole Abandonment

Upon achievement of total depth at the intended borehole location for KAFB-106MW2 (see Figure 6 of the Work Plan), borehole deviation was evaluated using several tools, including a Reflex EZ-Trac 6122 digital field instrument, a mechanical drift detector (Eastman Whipstock Eastco), and a gyroscopic deviation tool. The deviation was measured and evaluated while the drive casing was in the borehole prior to any well installation activities. The bottom of the borehole was measured to be deviated 26.35

feet, on an azimuth of 113.5 degrees from the north, using the gyroscopic deviation tool. The results from this gyroscopic deviation survey are included in Appendix ~~D~~E. The deviation was likely caused by the casing entry angle, coupled with a change in lithology at 225 feet bgs. Because this borehole was determined to have too large of a vertical deviation, no well infrastructure was installed, and it was abandoned on January 30, 2017. The Borehole Abandonment Activity Report (Kirtland AFB~~USACE~~, 2017a) and NMED approval letter have been included in Appendix ~~D~~E.

A second borehole was drilled for well KAFB-106MW2 approximately 10 feet to the northwest of the original, abandoned borehole. The deviation of this second borehole at 520 feet bgs was measured to be 89.7 degrees, which ~~is~~ was approximately 3 feet from plumb, within the project specifications of less than 5 feet deviation over the entire depth of the borehole. All other pilot test boreholes were advanced with minor, acceptable deviations that met specifications.

2.3.3 Extraction Well Installation

Drilling of the extraction wells (KAFB-106EX1 and KAFB-106EX2) began on February 21, 2017 and was completed on March 12, 2017, using Cascade's ARCH drill rig. Well construction was completed in accordance with the Work Plan (Kirtland AFB~~USACE~~, 2016a). Well construction diagrams are presented in Appendix ~~C~~ D and general construction information for each well is summarized in Table 1.

Each extraction well was installed to a total depth of approximately 537 feet bgs. To minimize the likelihood of aeration of extracted water through water table depression during system operation, the two extraction wells were installed with 15-foot long screens, the top of which are located 10 feet below the static groundwater level. Additional design and construction details for the extraction wells are provided in Table 1 and Appendix ~~C~~D. Well vaults are discussed in Section 2.3.5. A KSPI 700 submersible hydrostatic level transducer was installed in the 1.25-inch PVC drop tube at each extraction well.

2.3.4 Injection Well Installation

Drilling of the injection well (KAFB-106IN1) began on March 16, 2017 and was completed on March 20, 2017, using Cascade's ARCH drill rig. The injection well was constructed in the same manner as the extraction wells (see Section 2.3.3) in accordance with the Work Plan (Kirtland AFB~~USACE~~, 2016a); however, the injection well was installed with 20 feet of Schedule 80 PVC, 0.010-inch machine slotted screen, with the top of screen at the static groundwater level and extending 20 feet into the water column. A well construction diagram is presented in Appendix ~~C~~ D and general construction information for the well is summarized in Table 1. Similar to the extraction wells, a KSPI 700 submersible hydrostatic level transducer was installed in the 1.25-inch PVC drop tube at the injection well.

2.3.5 Extraction and Injection Well Vaults

Fiberglass well vaults were installed to house extraction and injection wellheads, plumbing, fittings, and remote instrumentation necessary for operation and monitoring of the recirculation system. The floor of each vault consists of a poured concrete slab to provide water containment in the event of a leak. An integrated leak detection sensor was installed in each of the three well vaults, to automatically alert system operators and shut down the system in case of a leak. Each vault is approximately 5 feet long, 4 feet wide, and 3.8 feet deep. Each wellhead is located approximately 6 inches from the wall of the vault, and the top of the sanitary seal is located approximately 8 inches from the concrete floor.

Due to the location of the pilot test area being in an open field, traffic-rated vaults were not required. The upper edge of each vault extends approximately 4 inches above grade to protect the vault from surface runoff water intrusion, and has a hinged, locking cover. The well vaults are protected by four steel concrete bollards located at each corner of the vaults.

2.4 Well Development

Development of the groundwater monitoring, extraction, and injection wells was initiated after drilling and construction of all new wells was completed. Because development close to active drilling could cause poor or incomplete well development of the wells, NMED approved postponement of well development until after completion of all well installation activities in an email dated January 30, 2017 (NMED, 2017). Details regarding development of the monitoring, extraction, and injection wells are discussed in the sections below. Well development logs are provided in Appendix ~~C~~D.

2.4.1 Groundwater Monitoring Well Development

Groundwater monitoring well development was conducted in accordance with the Groundwater Investigation Work Plan (Kirtland AFB~~USACE~~, 2011b). Well development consisted of surging, bailing, and pumping to remove fine sediment using a small drill rig equipped with a surge block, stainless steel bailer, and electric submersible pump. Development was considered complete when a turbidity of less than 10 nephelometric turbidity units was achieved for water clarity, at least five well volumes were removed from the well plus any additional water that was added to the well during drilling, and field parameters had stabilized. Field water quality parameters were monitored at regular (5- to 10-minute) intervals during pumping and were considered stabilized when the following criteria were met for three consecutive readings: pH within 0.1 pH units, temperature within 1 degree Celsius, and specific conductance within 10 percent (%). Field data were recorded on well development forms by APTIM scientists, as presented in Appendix ~~C~~D.

Liquid investigation-derived waste (IDW) generated during monitoring well development was stored in 275-gallon totes. Waste management and disposal are discussed in Section 3.11.

2.4.2 Extraction Well Development

The extraction wells were developed using Cascade's well development rig. Wells were developed using a combination of methods including bailing, surging, and pumping. Initial bailing was conducted to remove sediment from the borehole and filter pack prior to beginning well development. After initial bailing, mechanical surging and over-pumping was conducted. Field tests for total solids (by Imhoff cone method) were performed, water levels were monitored, and water quality parameters including turbidity measurements were monitored during development. A constant rate test was performed after initial development was completed. Each well was pumped at approximately 20 gallons per minute (gpm) for a period of no less than 180 minutes. Water levels in the extraction well were manually measured to estimate the specific capacity. Additionally, water levels were manually measured in one observation well to monitor drawdown during constant rate testing.

The extraction wells were developed until well efficiency met at least 70% and had a specific capacity of 3 to 5 gpm per foot, at the discretion of the APTIM scientist. Field data were recorded on well development forms by APTIM scientists, as presented in Appendix ~~C~~D.

Purge water IDW generated during development was transferred to 19,000-gallon Baker storage tanks located within the construction yard. Waste management and disposal are discussed in Section 3.11.

2.4.3 Injection Well Development

The injection well was developed using Cascade's well development rig in the same manner as the extraction wells, as described in Section 2.4.2; however, based on the limited effectiveness and low specific capacity (2.3 gpm per foot) achieved after 120 minutes pumping at a rate of 20 gpm, jetting was conducted to further develop the well. The jetting device consisted of four jets and an extraction pump that was attached to the bottom of the device. Jetting was conducted in 1-foot intervals starting at the top of the saturated screen, working downward. Each 1-foot section of screen was jetted for at least 1 minute.

Imhoff cone and water level readings were collected at a frequency of one minute during jetting activities. A 120-minute constant rate test was performed at the injection well after jetting was completed and indicated that the specific capacity of the well had improved. Field data were recorded on well development forms by APTIM scientists, as presented in Appendix ~~C~~D.

Purge water IDW generated during development was transferred to 19,000-gallon Baker storage tanks located within the construction yard. Waste management and disposal are discussed in Section 3.11.

2.4.4 Pump Installation

Dedicated stainless steel Geotech bladder sampling pumps were originally installed in each of the six groundwater monitoring wells being used for the pilot test (KAFB-106064, KAFB-106063, KAFB-106MW1-S, KAFB-106MW1-I, KAFB-106MW2-S, and KAFB-106MW2-I) in March 2017. Multiple failure points were observed on the Geotech pumps during initial pump testing. After numerous unsuccessful attempts to pull, repair, and/or replace faulty pumps, a decision was made to replace the pumps with QED Environmental Systems (QED) MicroPurge® Model P1101HM bladder pumps with PVC bodies. These new QED pumps were installed in the monitoring wells in September 2017 and baseline samples were recollected (Section 3.~~2~~3). No operational issues were observed from that point forward, except for minor decreases observed in discharge volumes. Decreased discharge volume is common with bladder pumps as the Teflon™ bladder creases overtime with use and is not able to open to full capacity during recharge/filling.

The QED bladder pumps were hung on a poly-coated stainless steel hanging cable such that the pump intake area ~~is~~ was set at approximately the middle point of the saturated screen interval. The top of the pump string includes a single aluminum well cap with access to the discharge line, hanging cable, and air-line. This hanging well cap fits into the top of the sanitary well seal. Well tubing is twin-bonded, Teflon™-lined polyethylene tubing and consists of a ¼-inch outside diameter air supply line and a 3/8-

inch outside diameter water discharge line. During pump installation at KAFB-106MW1-S, measurable NAPL was detected. A discussion of the NAPL and sampling that occurred is discussed in Section 3.~~7~~2.

In March 2017 following the successful well development, multi-stage centrifugal stainless steel submersible pumps (Grundfos 25S50-26, 5.5 horsepower) were installed in each extraction well. The extraction well pump intakes were set at 497 feet bgs, approximately 20 feet below the water table (as measured during well installation) and 10 feet above the total depth of the well to allow sufficient room for drawdown during pumping. The pumps are attached to approximately 500 feet of 1.5-inch threaded steel pipe, which ~~is~~ were attached to a 6-inch sanitary well seal at the top of each well casing. Corrosion of the pumps and pipe materials was minimized through use of corrosion resistant materials and the installation of sacrificial zinc anodes on the drop pipes.

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.) which provided backpressure to ensure that piping remained full of water throughout the treatment system. This ~~to limit~~limited the risk~~s~~ of cavitation within the pipe, ~~and to~~ minimized volatilization of constituents, and minimized aeration of the anaerobic recirculation water. A check valve was installed at the base of the FCV, with an electric submersible pump (Grundfos 5SQE-10-410, 2.3 horsepower) with variable speed frequency drive installed underneath to sample groundwater in the vicinity of the injection well (when the recirculation system ~~is~~ was off, and water ~~is~~ was not being injected). The injection well sampling pump intake was set at 492 feet bgs, approximately 10 feet above the total depth of the well. Corrosion of the FCV was also minimized through use of corrosion resistant materials and the installation of sacrificial zinc anodes on the drop pipe.

The extraction and injection well pumps were connected to the control room via power supply lines that were run up along-side the drop pipe within the well casing, through the well vault and underground to a conduit stuck-up adjacent to the Conex box. These power supply cables then entered the Conex box and landed on the terminals of the appropriate variable frequency drives. In 2020, downhole equipment (drop pipe, valves, and transducer) and Grundfos pumps were removed from extraction and injection wells (KAFB-106EX1, KAFB-106EX2, and KAFB-106IN1) to assess the condition of the wells and equipment. The well maintenance performed at the extraction and injection wells is discussed in Section 3.7.

2.5 Well Survey

The location and elevation of each well casing was surveyed by a New Mexico-licensed professional land surveyor from High Mesa Consulting Group in accordance with the United States Geological Survey Standard Operating Procedure developed for all monitoring wells on Kirtland AFB (U.S. Geological Survey [USGS], 2016).

Coordinates are based on the North American Datum of 1983 New Mexico State Plane Coordinate System. Elevations are based on the North American Vertical Datum of 1988. The elevation and horizontal location measurements were made to an accuracy of 0.01 and 0.1 foot, respectively. Results of the survey are summarized in Table 1.

2.6 Recirculation Pilot System Equipment and Materials

The pilot test involved multiple test phases requiring recirculation of anaerobic groundwater and addition of tracers and amendments to this water. The equipment necessary to perform the pilot test was installed in the appropriate wells (as detailed above) and a portable shipping (Conex-type) container, and included the necessary pumps, filters, mixers, meters, electrical, and piping to add tracers/amendments and distribute them in the subsurface (as detailed in this section). The container was also used for security and environmental control and was located adjacent to the well field test area, see Figure 2.

The system for amending and recirculating water was designed by APTIM, together with subcontractors, and was fabricated by Calcon Systems Inc. (Calcon). As discussed in Section 3.1, APTIM and the Calcon performed all necessary system installation, shakedown verification testing (including, but not limited to, pressure testing and alarm functionality testing), and start-up tasks. The system as-built drawings and component specification sheets are presented in Appendix ~~E~~F.

A 20-ft long Conex box was used to house the recirculation and tracer/ amendment delivery system components. Figure 5 presents a schematic of the Conex box treatment system. The box has a partition wall, separating the enclosure into two spaces. The smaller of the two spaces is the system control room, which is rated as a non-hazardous atmosphere, and houses the supervisory control and data acquisition (SCADA) system with integrated computer, electrical control panel, Baski FCV controls and associated nitrogen cylinder, and a combination air conditioner/heater. The larger space, which includes the recirculation water piping/fittings, flowmeters, pressure transmitters, tracer/amendment tanks, chemical feed pump, and other system process components, is rated as a Class 1, Division 2 atmosphere, due to the possible presence of fuel hydrocarbons in the recirculation water flowing through the piping in this portion of the enclosure. All electrical components and connections in this portion of the enclosure are intrinsically safe to meet the hazardous atmosphere classification. This space also contains a floor leak sensor, which continuously monitors for water on the floor of the enclosure (in the case of a pipe failure or other leak), having the ability to shut down the system and notify appropriate personnel in the case of an alarm condition.

The main components of the recirculation system are identified on a process flow diagram (see Figure 6), while a more detailed design is presented on the piping and instrumentation diagram (P&ID), which is shown on Figure 5. To maintain the anaerobic conditions of the groundwater and aquifer and to prevent the loss of volatile components within the groundwater, the system was designed to minimize gas exchange between the recirculated groundwater and the atmosphere. 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. This design flow rate was achieved by the system, but operational flowrates changed during the pilot test based on tracer results and other site conditions, as discussed further in Section 3.

Electrical power for system operation ~~is~~ was supplied by on-base grid power through an electrical line that runs from the power source on the east side of the site to the recirculation system (see Figure 2). A 480-volt, 3-phase electrical service ~~is~~ was required to operate the 60-horsepower extraction well pump motors. APTIM worked with base civil engineering personnel and a licensed electrical subcontractor to procure and install the necessary transformer and underground service line to the main disconnect switch on the system enclosure (Conex box). Trenching of the main power supply cable to the Conex box was required. Appropriate dig and base civil engineer permits were acquired prior to starting. Trenching and installation of the electrical power line was completed from April 17 to April 21, 2017. The electrical line was installed in a 3-foot deep trench. The route of the electrical power line is presented on Figure 2.

The treatment system includes a SCADA system for remote monitoring of flow rates and other parameters, to compliment on-site adjustments and regular operation and maintenance. Process instrumentation, including pressure, level, and flow gauges/switches, were installed at critical locations in the system, as shown on the P&ID (Figure 5), to ensure safe and controlled operation. The programmable SCADA and logic controllers contain the process control logic to monitor and regulate the operation of the various system components, both locally and remotely. The SCADA enables the application of power to the pumps, regulates flowrates, pressures and operation of the FCV, while continuously monitoring the system safety interlocks and making emergency call outs when the system ~~is~~ was offline or in alarm mode.

Water conveyance pipelines connecting the Conex box to the extraction and injection wells were installed in trenches approximately 4 feet deep (below the frost line). The underground conveyance piping consists of double containment system that houses the 2-inch piping. The conveyance piping, injection valve pneumatic tubing, pump electrical leads, well vault leak detection wire, Baski nitrogen line, and water level transducer wire leading from the Conex box to the wells are all located within the trenches. Where extraction and injection well piping breaches the ground surface and enters the container (above grade), the piping transitions to 1.5-inch single-walled Schedule 80 PVC, and ~~is~~ was insulated to prevent freezing. Trenching began in April 2017 and well pipelines were connected to the system container and pressure tested on April 20, 2017.

Groundwater extraction occurred through the use of electric submersible well pumps (Grundfos 25S50-26) with variable speed frequency drives. Each of the two 4-inch-diameter pumps are fully submersible and capable of maintaining design flows. The variable speed frequency drives were controlled by input values from the SCADA system to fine tune motor operation to adjust flow rates, as needed. Once groundwater was extracted from each of the two extraction wells, it was directed through a pair of particle filters prior to combining flows. These filters were used to prevent undesired particulates from entering the amendment and reinjection portions of the system. Generally, 100-micron (µm) polyethylene woven (poly-woven) filters were used in the lead canisters, while 50-µm poly-woven filters were used in the lag canisters. During system operation, it was determined that the 100- and 50-µm filters had a longer operation lifetime. Earlier use of 50- and 20-µm pleated cellulose filters at the onset of the demonstration resulted in frequent filter changes and quick pressure build-up. The change to poly-woven filters with larger nominal pore sizes significantly improved filter runtimes.

Bourdon tube pressure gauges and switches ~~are~~ were installed on the upstream side of the particle filters (as shown on the P&ID, Figure 5), between filters, and on the downstream side of the filters to sense back pressure on the filters. The SCADA system had two alarm set points associated with these pressure switches. The first (high pressure alarm) ~~is~~ was an indicator to the system operator that the filters are in need of cleaning/changing, while the second (high-high pressure alarm) shuts-down the system until the filters are cleaned/changed and the system ~~is~~was manually restarted. The poly-woven filters ~~are~~ were housed within 20-inch polypropylene Pentek canisters that are pressure rated to 100 pounds per square inch. ProSense® pressure transmitters are installed along the aboveground extraction well piping, upstream of the filters. Additionally, a pressure transmitter ~~is~~ was connected to the injection well manifold within the well vault. These monitored the pressures of the system and are connected to the SCADA. Once the groundwater exits the filters from each pipeline, the flows from each extraction well ~~are~~ was combined into one 2-inch Schedule 80 PVC pipeline that discharged~~s~~ to the injection well.

Signet 2551 Magmeter flow meters were installed along each extraction and injection well pipeline, just downstream of the filters (three flow meters, one on each pipeline). Totalizing meter installation reports, calibration documentation, and specification sheets were submitted to the OSE, as required by the Change of Water Rights Conditions of Approval for permitted wells RG-1579 POD316 through POD318. This documentation is contained in Appendix ~~B~~C.

Prior to reaching the injection well, extracted groundwater was mixed with either tracers or other amendments (depending on the phase of operation, as discussed in Section 3) using an amendment delivery system consisting of a 550-gallon amendment tank, control valves, pressure gauges, positive displacement variable speed metering pumps (chemical feed pump; LMI E711-368SI), and a pressure regulating tank.

The amendment tank ~~is~~ was fitted with an EchoSonic® ultrasonic level sensor that ~~is~~ was programmed with the SCADA. The level sensor ~~is~~ was a non-contact sensor ~~that is~~ installed on the top of the amendment tank. The tank has an 8-inch opening with vented lid. Mixtures of water and fluorescein/deuterated water tracer or water and sodium lactate, diammonium phosphate (DAP), and potassium iodide (KI) were batched/mixed within the amendment tank prior to distribution, via the chemical feed pump, into the injection well piping. Tracer/amendment storage and mixing is further discussed in Section 3. The amendment tank ~~is~~ was fitted with an outlet port and tubing that connects to the chemical feed pump and calibration column (4,000 milliliter graduated cylinder). The calibration column ~~is~~ was connected to the chemical feed pump via a gate valve and tubing connections. Pump tests were performed using the calibration cylinder and deionized (DI) water to determine and dial-in the appropriate flowrate of the chemical feed pump. The chemical feed pump was used to pulse concentrated amendment solution from the amendment tank into the injection well piping. This in-line injection allowed for introduction of amendments to the recirculation water stream under pressure.

After ~~the~~ concentrated amendment solution ~~enters~~ entered the injection well piping, it ~~flows~~ flowed through a 19-inch PVC static mixer to help ~~blend~~ dilute and mix the amendments with the groundwater (Figure 6). A 31.8-gallon HydroPro pressure tank ~~is~~ was connected to the recirculation piping within the system container, to regulate the pressure spikes within the recirculation system. A wall-mounted Rosemount™ pressure transmitter ~~is~~ was connected to the pressure tank piping.

A down-hole FCV and submersible pump, both installed in the injection well (as discussed in Section 2.4.4), ~~is~~ was controlled by input values from the SCADA system, as needed. The system was designed to shut down automatically if the water level transducer in the injection well indicated that the water level in the well casing has risen to a predetermined level, or if the water level transducer in one or both of the extraction wells indicated that the water level has dropped to within approximately 2 feet of the top of the extraction well screen.

The Conex box was pre-fabricated by Calcon at their facility in San Ramon, California and delivered on April 13, 2017 to the pilot test site. Final design as-builts and specification sheets for system components are included in Appendix ~~E~~F.

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3. PILOT SYSTEM OPERATION AND MONITORING

The pilot testing was performed in four phases. The duration and a timeline of each of these phases are summarized in Table 2. Data were collected and evaluated during each phase of the pilot test and the results were used to adjust each phase duration, as needed. The first phase (Phase 1) started after installation, development, and testing of the wells and equipment associated with the Pilot Test System. Phase 1 included an evaluation of baseline conditions, and operation of the recirculation system while performing a tracer test to evaluate distribution of injected water in the subsurface. The second phase (Phase 2) included an evaluation of biostimulation on EDB degradation through operation of the recirculation system and the addition of nutrients and a fermentable substrate to the subsurface. The third phase (Phase 3) of the pilot testing was originally proposed to include bioaugmentation with an exogenous debrominating culture (SDC-9), and an evaluation of enhanced EDB degradation. However, as discussed in Section 3.~~5~~6, bioaugmentation was deemed not necessary based on results during Phase 2, and a further evaluation of biostimulation was performed as Phase 3. The modified Phase 3 was approved by the NMED in a letter dated August 7, 2018 (NMED, 2018), which also stated that "bioaugmentation shall remain as an approved, but deferred component of the pilot test". The fourth and final phase (Phase 4) continued groundwater monitoring without recirculation or addition of amendments.~~The fourth and final phase (Phase 4) of the pilot test consists of post-treatment monitoring and assessment and is ongoing. Activities during this final phase focus on longer-term performance of ISB~~Phase 4 monitoring was concluded in October 2020. For reference, Safety Data Sheets (SDSs) for all tracers and amendments used during the pilot test are included in Appendix G.

3.1 Pilot System Start-up Testing

Final electrical and piping connections, including power and control wiring between the Conex box control panel and the extraction/injection well pumps and vault control components/sensors, and final pipe connections between the stubbed-up extraction/injection well piping and the Conex box were made by Calcon and APTIM from May 11 through 16, 2017. Shakedown testing of the Pilot Test System, which included testing the extraction well pumps; pressure and flow transmitters; leak detection and level sensors; chemical feed pump; Baski FCV and control system; injection well sample pump; remote telemetry; and alarm interlocks was performed on May 16 and 17, 2017 prior to full system start-up. There were no notable operational issues with the system during shakedown testing, with all interlocks and associated alarms working properly. The Pilot Test System was started on June 29, 2017 during the first baseline sampling event at the extraction and injection wells. The Pilot Test System was restarted and retested on September 26, 2017, after a three-month project delay caused by faulty monitoring well sampling pumps (discussed in Section 2.4.4) and just prior to initiation of tracer testing (Phase 1).

3.2 2017 NAPL Sampling

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 oil-water 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 on September 5, 2017. The extraction wells were not gauged for NAPL at this time, as the top of the well screens were designed to be installed below the static water level. Well KAFB-106MW1-S was bailed on September 8, 2017 and approximately 60 milliliters of product were recovered. The product was containerized and submitted to Pace Analytical® (Pace) for the following analysis:

- C3-C12 PIANO Quantitative Molecular Characterization by gas chromatography-mass spectrometry (VOC Fingerprinting)
- C8-C40 Full Scan Qualitative Molecular Characterization by gas chromatography-mass spectrometry (semivolatile organic compound Fingerprinting)
- Density and Viscosity

Density and viscosity analyses were subcontracted to Clark Testing. Additional product recovery occurred on September 13 and 14, 2017, and approximately 60 milliliters sent to the APTIM Biotechnology Development and Applications Group in Lawrenceville, New Jersey to facilitate EDB compound-specific isotope analysis (CSIA) efforts funded under Environmental Security Technology Certification Program (ESTCP). NAPL has not been detected in KAFB-106MW1-S since October 2017 (Table 3), but KAFB-106MW1-S was continually monitored for its presence on a weekly basis.

The NAPL analysis by Pace indicated a great variety of hydrocarbons, but notably benzene (31.8 milligrams per kilogram [mg/kg]) and EDB (20.5 mg/kg) concentrations were low compared to toluene (7,396 mg/kg) and ethylbenzene (6,098 mg/kg). This laboratory report is included in Appendix I-3. The delta carbon-13 ($\delta^{13}C$) value of EDB in the NAPL, as determined by the University of Oklahoma, was approximately -21±2 per mil (‰). Brief discussion of the carbon isotope composition of EDB in the NAPL is provided in Section 4.5.2.

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 measurable NAPL at KAFB-106MW1-S.

~~3.2~~3.3 Baseline Sampling

Initial baseline sampling occurred from June 29 through August 16, 2017 using Geotech dedicated bladder pumps at the monitoring wells and submersible Grundfos pumps at the extraction and injection wells. During this time, KAFB-106MW1-S was not sampled due to numerous pump failures (Section 2.4.4). Baseline samples were recollected for all analyses except for Microbial Insights QuantArray-Chlor from September 18 through September 26, 2017. All pilot test wells were sampled prior to Phase 1 recirculation activities to establish pre-test baseline conditions. Purged groundwater was passed through a flow-through cell equipped with a YSI™ ProDSS multi-parameter water quality meter for evaluation of geochemical stabilization parameters (pH, dissolved oxygen [DO], oxidation-reduction potential [ORP], temperature, and specific conductivity). Turbidity was measured with a Hach™ Model 2100Q turbidity meter. Water quality meters were calibrated prior to each sampling event, in accordance with manufacture's recommendations. Table 3 summarizes the field water quality measurements collected prior to sampling. Table 4 presents the suite of analytes that were measured by the certified analytical laboratories and the sampling frequency. An evaluation of baseline and other analytical testing results are presented in Section 4.

~~3.3~~3.4 Phase 1 – Tracer Testing

The purpose of Phase 1 was to evaluate baseline conditions and the distribution of recirculated water using tracer amendments. Groundwater (without biostimulation or bioaugmentation amendments) was extracted from the two extraction wells at flow rates of 10 gpm from each well, combined, and after tracers were added (during a 24-hour period), the water was reinjected back into the subsurface at the injection well. The recirculation portion of Phase 1, which was conducted for four weeks from October 2 to November 3, 2017, distributed injected water throughout the pilot testing zone and established new experimental baseline measurements for comparison to later biostimulation phases. The passive portion of Phase 1 began on November 3, 2017, upon shutdown of the recirculation system, and concluded on December 21, 2017.

During Phase 1, two conservative (i.e., non-reactive) tracers of water flow were used to evaluate subsurface transport characteristics. The two tracers used were fluorescein and water labeled with additional deuterium, a stable isotope (i.e., non-radioactive) of hydrogen (Appendix G). Prior to injection, the fluorescein and deuterated water were homogenized with 22 gallons of deionized water in a 55-gallon drum. The drum was plumbed to the inlet of the chemical feed pump via 3/8-inch diameter polyethylene tubing. Over a period of approximately 24 hours, from October 2 through 3, 2017, approximately ~~54~~ 54 grams of fluorescein and 15 kilograms of deuterium oxide (^2H_2O) were injected into the treatment zone through the recirculated groundwater. During the entire Phase 1 recirculation period, approximately ~~1,024,000~~887,000 gallons of water were extracted and reinjected.

During Phase 1 recirculation system operation, increased back pressure upstream of the sediment filters at pressure transmitters PIT-103 and PIT-109 (Figure 5) was observed, caused by an increased loading on the filters, resulting in more frequent filter changes than was originally anticipated, with KAFB-106EX1 experiencing a faster sediment loading rate. Initially, sediment was observed on the 10-inch long pleated cellulose filters CF-1-1 and CF-1-3; though this diminished in the short-term. A number of what appeared to be biological masses were also observed on filters during this time. Several approaches were used to mitigate the heavy filter loading and frequent filter change-out rate by increasing the effective filter surface area. The 10-inch long canister housings at CF-1-1 through CF-1-4 were replaced with 20-inch long canister housings, and woven polyethylene filter cartridges replaced the existing pleated cellulose. During the majority of Phase 1, 100- and 50-µm woven polyethylene filters were ultimately used on both extraction well lines in the lead and lag positions, respectively, with much improved runtimes.

Water level readings in the extraction and injection wells were continuously monitored by the SCADA system and monitored manually periodically. 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.~~ The likely cause of the inaccurate 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 to avoid unnecessarily drawing down below the top of the screened interval in the extraction wells. Manual water level readings are summarized in Table 5.

Eight groundwater sampling events designed to quantify transport properties during active recirculation were conducted during Phase 1, with two additional sampling events conducted approximately 2 and 4 weeks after recirculation activities ceased. Groundwater fluorescein concentrations and delta deuterium (measure of hydrogen isotope composition) (δ^2H) values were determined for these samples. In addition, groundwater measurements were collected during one subset of the recirculation sampling events (Day 23, collected on October 24 and 25, 2017) to determine baseline conditions for the other analytes presented in Table 4.

Groundwater samples were collected intermittently at extraction, injection, and the six groundwater monitoring wells during the active portion of Phase 1, and biweekly during the passive portion. KAFB-106MW1-S/I, KAFB-106MW2-S/I, KAFB-106064, KAFB-106063, KAFB-106EX1, KAFB 106EX2, and KAFB-106IN1 were sampled using either dedicated QED MicroPurge® Model P1101HM bladder pumps (monitoring wells) or the down-hole extraction pumps or injection well sampling pump (the injection well was not sampled during active recirculation). Prior to purging, depth to water measurements and depth to NAPL (if present) were collected at groundwater monitoring wells KAFB-106MW1-S, KAFB-106064, and KAFB-106063; extraction wells, and the injection well. Water level measurements were also collected during purging to monitor for drawdown. Water levels were measured using a portable water level indicator and interface probe (Solinst). Both manual water level measurements (Solinst probe) and transducer measurements were collected from extraction and injection wells. Due to the size of the well casing and placement of the dedicated tubing bundle, water level measurements could not be obtained from KAFB-106MW1-I, KAFB-106MW2-I, and KAFB-106MW2-S. 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~~H.

Each well was purged to remove stagnant water from the well in order to collect a representative groundwater sample. Purged groundwater passed through a flow-through cell equipped with a YSI™ ProDSS multi-parameter water quality meter for evaluation of geochemical stabilization parameters (pH, DO, ORP, temperature, and specific conductivity). Turbidity was measured with a Hach™ Model 2100Q turbidity meter. Purging continued until three stable field measurements for DO, pH, ORP, specific conductivity, temperature, and turbidity were obtained. Stabilization criteria for field measurements were three consecutive readings within 10% of each other. Water quality meters were calibrated prior to each sampling event, or after anomalous readings were observed. Samples from the extraction and injection wells were collected from sample ports located along the system piping, upstream of the sediment filters. Table 3 summarizes the field water quality measurements collected prior to sampling. Table 4 presents the suite of analytes that were measured by the certified analytical laboratories. Both hydrogen and carbon isotopes were reported using (δ) notation, where δ^{2}H or δ^{13}C = $R_{sample}/R_{standard}-1$ and R is the ^{2}H/^{1}H or ^{13}C/^{12}C ratio of the sample and the standard (Vienna Standard Mean Ocean Water for δ^{2}H, and Vienna Pee Dee Belemnite for δ^{13}C), respectively. Note that the commonly included multiplier of 10^{3} has been omitted from the equation but should be incorporated to report δ values as ~~per mille (~~‰~~)~~. CSIA of EDB ~~CSIA)~~ in samples was performed ~~ere analyzed~~ by Dr. Tomasz Kuder at the University of Oklahoma, through funding provided by ESTCP Project ER-201331.

Ten sampling events were conducted during Phase 1. Additionally, three samples were collected from the injection well sampling port, which was representative of the groundwater being injected on October 2 and 3, 2017. Fluorescein and δ^{2}H data suggested good hydrologic control and connectivity at the test site. Tracer testing results are further discussed in Section 4.

~~3.4~~3.5 Phase 2 – Biostimulation

The purpose of Phase 2 was to evaluate biostimulation in the subsurface after distribution of treatment amendments in recirculated groundwater. Phase 2 consisted of two operational periods, a recirculation/mixing (active) period, and a subsequent passive monitoring period (no recirculation). 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. The amended water was reinjected to distribute the amendments throughout the pilot testing zone. The goal of these amendments was to stimulate activity of native microbial populations capable of debrominating EDB. For reference, SDSs for the amendments are included in Appendix G.

Upon completion of the passive Phase 1 monitoring period, the recirculation system was restarted on December 11, 2017 and allowed to run at extraction rates of 10 gpm (each well) prior to introducing amendments. The active portion of Phase 2 began on December 21, 2017 with the injection of treatment amendments for biostimulation and continued until February 7, 2018. A concentrated solution of the amendments was prepared in the amendment mixing tank (AT-1, see Figure 5) and added to the process stream by the chemical feed pump manufactured by LMI (P-2-1).

The concentrated amendment solution was prepared using water obtained from the Kirtland AFB potable water plant located on Texas Drive and transferred to the project site in 275-gallon totes. The water was transferred from the totes into the amendment tank via a sump pump and garden hose. Volume marks on the tank were used to bring the water up to the desired level. DAP and KI were weighed using a kitchen scale and poured into the tank. The sodium lactate was pumped from 55-gallon drums into the tank using a drum pump and tubing. A Goulds submersible mixing pump was deployed within the amendment tank to mix the amendments and keep the constituents in solution. During this homogenization, specific conductivity in the tank was measured at regular intervals until it was determined that the readings had stabilized. After reaching stabilization, the chemical feed pump was turned on to start amendment injection. During operation, amendment delivery into the recirculation water process stream, and subsequently delivered to the injection well, was pulsed such that there were periods of time when the recirculation process water contained amendments and other times flow contained only recirculated groundwater. ~~A~~ The pulsed amendment injection scenario was implemented ~~in an attempt to~~to minimize biofouling in the injection well by flushing the well screen and filter pack with water less conductive to biological growth and fouling. Additional batches of amendments were mixed once the level within the amendment tank reached a predetermined low level. A new batch was typically mixed every 4 to 7 days during recirculation. Over the approximately 7-week active injection period in Phase 2, approximately 290 gallons of WilClear Plus®, 150 kilograms of DAP, and 71 kilograms of KI were injected into the treatment zone. Table 6 summarizes the injected quantities for each Phase of the pilot test. The targeted concentration of fermentable substrate (300 mg/L) was consistent with that outlined in Work Plan (Kirtland AFB, 2016a), albeit using broader diversity of fermentable substrates rather than lactate alone. The targeted concentration of DAP (50 mg/L) was approximately half that of the Work Plan due to concerns regarding precipitation of solids. These targeted concentrations were consistent with contractor experience, typical substrate loading rates (AFCEE et al., 2004), and treatability testing performed using site materials (100 mg/L lactate and 50 mg/L DAP). The targeted KI concentration was consistent with the Work Plan (Kirtland AFB, 2016a). During the entire Phase 2 recirculation period, approximately 1,~~468~~467,000 gallons of water were extracted~~, amended,~~ and ~~then~~ reinjected, but due to testing of the system and the challenges described in the following paragraph, only approximately 927,000 gallons were recirculated during the period that carbon substrate, DAP, and KI were introduced.~~.~~

Approximately two hours after amendment injection began on December 21, 2017, a leak was observed originating from the chemical feed pump. The system was shut down and the chemical feed pump head and four-way valve were dismantled to determine the cause of the leak. Small crystals were observed within the check ball housings and on the check balls within the four-way valve. The affected areas were cleaned with cotton swabs and deionized water, reassembled, and the system was restarted. During a system check on December 23, 2017, it was observed that while the chemical feed pump was running, no amendment fluid was being conveyed through the tubing to the injection point on the recirculation process piping. Coincident to this, an increase in mounding (up to 9 feet above static [476 feet bgs]) at the injection well was observed. The system was shut down to diagnose and rectify the crystallization issue. It was determined that amendment concentrations needed to be decreased in the amendment tank. Lower amendment concentrations and running the ~~AT-1 submersible mix~~chemical feed pump more frequently rectified the crystallization issue, and facilitated the introduction of amendments at target rates.~~allowing the chemical feed up to operate properly.~~ 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.

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. Extraction well KAFB-106EX1 did not display a similar drawdown trend, and thus, remained at 10 gpm throughout Phase 2. Table 5 presents the measured water levels and flowrates for the two extraction wells during Phase 2.

The passive portion of Phase 2 began on February 7, 2018, when the recirculation system was shut down, and concluded in July 2018. After the chemical feed pump was turned off and injection of the amendments ceased, the extraction wells were allowed to run for several hours to flush the injection well screen and filter pack. During the passive period of Phase 2, groundwater in the treatment zone was monitored for approximately ~~3~~ 4 months to evaluate whether EDB degradation was enhanced (as further described in Section 4).

Groundwater samples were collected on a weekly basis during active recirculation and on a monthly basis during the passive portion of Phase 2 at extraction, injection, and monitoring wells, to evaluate the effectiveness of biostimulation. An additional passive sampling event was conducted, resulting in seven total sampling events for Phase 2. Groundwater sampling was performed as described in Section 3.~~3~~4. Table 3 summarizes the field water quality measurements collected prior to sampling. Table 4 presents the suite of analytes measured by the certified analytical laboratories. An evaluation of the Phase 2 sampling results is presented in Section 4.

~~3.5~~3.6 Phase 3 – Biostimulation

As described in the Work Plan (Kirtland AFB~~USACE~~, 2016a), Phase 3 originally included a recirculation period that included both biostimulation and bioaugmentation. The Work Plan proposed that the biostimulation-portion of Phase 3 be similar to Phase 2 and that a debrominating bioaugmentation culture (SDC-9) would be injected into KAFB-106IN1 and distributed with the recirculation system. As presented in the *Phase 3 Ethylene Dibromide In Situ Biodegradation Pilot Test Notification Letter, Bulk Fuels Facility, Kirtland AFB, New Mexico* (Kirtland AFB~~USACE~~, 2018a), after evaluating analytical data from the passive period for Phase 2, it became evident that the rate of anaerobic EDB biodegradation was significantly enhanced as a result of biostimulation, and that bioaugmentation was not warranted as a part of Phase 3. Analytical results from the passive period of Phase 2 were discussed in the letter. NMED approved removal of bioaugmentation from Phase 3 in their letter dated August 7, 2018 (NMED, 2018), concluding that bioaugmentation remain an approved, but deferred, component of the pilot test.

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). During the recirculation period, groundwater was extracted and WilClear Plus® and DAP were added to the process water stream before reinjecting it to distribute the amendments throughout the pilot testing zone.

Upon completion of the passive Phase 2 monitoring period, the active portion of Phase 3 began on July 30, 2018, with the groundwater extraction rates of 10 gpm at KAFB-106EX1 and 7 gpm at KAFB~~-~~-106EX2. The injection of treatment amendments for biostimulation continued until September 9, 2018. A concentrated solution of the amendments was prepared in a similar fashion to that in Phase 2 (discussed in Section 3.~~3.1~~5). A pulsed amendment injection scenario was again implemented in an attempt to minimize biofouling in the injection well. Over the approximately 5-week active injection period in Phase 3, approximately 340 gallons of WilClear Plus® and 143 kilograms of DAP were injected into the treatment zone. Table 6 summarizes the actual injected quantities for each Phase of the pilot test. During the entire Phase 3 recirculation period, approximately ~~924~~926,000 gallons of water were extracted, amended, and then reinjected.

The water table drawdown measured at KAFB-106EX2 during the active portion of Phase 2 became apparent again during Phase 3 system operations (as shown on Figure 7). The extraction flow rate at KAFB-106EX2 was incrementally reduced from 7 to 4 gpm during Phase 3 (beginning on August 6 through August 30, 2018) to prevent drawdown of water below the top of the screened interval. Extraction well KAFB-106EX1 remained at 10 gpm during Phase 3. 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.

The recirculation system was shut down on September 9, 2018, initiating the passive portion of Phase 3 that concluded on November 19, 2018. After the chemical feed pump was turned off and injection of the amendments ceased, the extraction wells were allowed to run for several hours to flush the injection well screen and filter pack. During the passive period of Phase 3, groundwater in the treatment zone was monitored for approximately 3 months to evaluate whether EDB degradation was enhanced (as further described in Section 4).

Groundwater samples were collected weekly during active recirculation and monthly during the passive portion of Phase 3 at extraction, injection, and monitoring wells to evaluate the effectiveness of biostimulation. An additional recirculation sampling event was conducted, resulting in seven sampling events for Phase 3 (Table 4).

During the first Phase 3 passive sampling event (September 2018), the injection well sampling pump mounted below the FCV failed to pump water to the surface. 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. Fine sand, silt, and grey biological-like growth were observed on the transducer cable and probe when it was pulled to collect manual water level measurement. 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. Samples were collected with the bailer during the Phase 3 passive sampling events conducted on October 4 and November 19, 2018.

Groundwater sampling methods were performed as described in Section 3.~~3~~4. Table 3 summarizes the field water quality measurements collected prior to sampling. Table 4 presents the suite of analytes measured by the certified analytical laboratories. An evaluation of Phase 3 sampling results is presented in Section 4.

~~3.6~~3.7 Phase 4 – ~~Long-Term~~Extended Monitoring

Phase 4 ~~consists~~ consisted of continued groundwater monitoring with no active recirculation and began upon completion of the final Phase 3 sampling event on November 19, 2018. The recirculation system was not operated during Phase 4, except briefly during extraction well sampling during the January 2019 monitoring event. During this Phase and in accordance with the Work Plan (Kirtland AFB~~USACE~~, 2016a), groundwater samples are to be collected ~~on a bi-monthly basis~~regularly at extraction, injection, and monitoring wells to evaluate the performance of the technology and quantify any rebound of EDB. ~~Only o~~One sampling event ~~has been~~ was conducted as a part of Phase 4 in 2019, from ~~under the current contract, on~~ January 16 through January 21~~, 2019~~. This sampling event occurred approximately 2 months after the Phase 3 passive period was concluded, in accordance with the Work Plan (Kirtland AFB~~USACE~~, 2016a). After a period of time that allowed for greater water infiltration into the pilot test area, ~~Continued~~ sampling of the groundwater monitoring, extraction, and injection wells ~~is planned~~resumed ~~under a separate contract~~in March 2020 after the extraction and injection well pumps were removed and the wells surveyed with a camera to assess downhole equipment and well conditions. Starting in 2020, samples were collected quarterly and analyzed for the same constituents as approved in the Work Plan (Kirtland AFB, 2016a). Extraction and injection well maintenance activities are discussed in the following subsections. Phase 4 monitoring continued through October 2020 and a total of five sampling events were conducted during Phase 4. Groundwater sampling methods were performed as described in Section 3.~~3~~4; however, samples were collected using dedicated bladder pumps rather than Grundfos pumps at the two extraction wells and injection well in 2020. Table 3 summarizes the field water quality measurements collected prior to sampling. Table 4 presents the suite of analytes measured by the certified analytical laboratories. An evaluation of Phase 4 sampling results ~~to date~~through 2020 is presented in Section 4.

3.7.1 Extraction and Injection Well Maintenance

To assess the condition of extraction and injections wells of the pilot test (KAFB-106EX1, KAFB-106EX2, and KAFB-106IN1), well manifolds and all downhole equipment (drop pipe, valves, transducer, and pump) were removed and video camera survey was performed.

The downhole well infrastructure from KAFB-106EX1, KAFB-106EX2, and KAFB-106IN1 were removed by a drilling subcontractor using a pump rig from January 27 through January 30, 2020. All three wells were video surveyed on February 13, 2020. The video showed that KAFB-106IN1 had moderate to severe build-up of viscous semi-solid materials throughout most of the screened interval. Video logs from the two extraction wells (KAFB-106EX1 and KAFB-106EX2) showed minor build-up on the screen slots. This type of buildup is commonly observed with *in situ* remedial projects, as a result from microbial growth. Both extraction wells contained a yellow-orange liquid floating on the water surface, which was interpreted to be NAPL. The thickness of the suspected NAPL was visually estimated during video logging to be 0.5 feet at KAFB-106EX1 and 12 feet at KAFB-106EX2. The presence of NAPL was confirmed with a Solinst oil-water interface probe on February 17, 2020, when the NAPL thickness was measured at 11.2 feet at KAFB-106EX2 and 0.65 feet at KAFB-106EX1. No NAPL was present in KAFB-106IN1. A dedicated QED MicroPurge® Model P1101HM bladder pump ~~dedicated bladder pump of the same model~~ was ~~also~~ installed in KAFB-106IN1 on March 4, 2020.

3.7.2 2020 NAPL Removal Activities

NAPL was bailed by hand from KAFB-106EX1 and a dedicated QED MicroPurge® Model P1101HM bladder pump was installed on March 4, 2020 to resume quarterly sampling activities. The pump was subsequently removed from KAFB-106EX1 to allow for NAPL removal via a large mechanical bailer. Pump installation and groundwater sampling was delayed at KAFB-106EX2 to avoid coating the dedicated pump with NAPL and to allow for collection of representative groundwater samples without bias that can be caused by an NAPL source present in the well.

~~A dedicated bladder pump of the same model was also installed in KAFB-106IN1 on March 4, 2020.~~

On June 30 and July 1, 2020 a large bailer operated by a pump rig was used to remove NAPL from extraction wells KAFB-106EX1 and KAFB-106EX2. NAPL was effectively removed using the large bailer, with less than a tenth of a foot remaining. Approximately one gallon was removed from KAFB-106EX1 and 16 gallons were removed from KAFB-106EX2. A dedicated QED MicroPurge® Model P1101HM bladder pump was installed in KAFB-106EX2 on July 1, 2020 and sampling of KAFB-106EX2 resumed during third quarter 2020. KAFB-106EX2 was not sampled during previous quarters in 2020 to avoid coating the dedicated pump with NAPL during pump installation and to allow for collection of representative groundwater samples without bias that can be caused by an NAPL source present in the well. The dedicated bladder pump was also reinstalled in KAFB-106EX1 on July 1, 2020.~~.~~

Once mechanical NAPL removal activities were completed, the shallow groundwater monitoring wells and injection well (KAFB-106IN1) were gauged for NAPL using a Solinst Model 122 oil-water interface probe. Two of the three shallow groundwater monitoring wells (KAFB-106MW1-S and KAFB-106MW2-S) and the injection well (KAFB-106IN1) are screened within the vadose zone (screens intersect the current water table). Groundwater monitoring well KAFB-106064 has a submerged screen. NAPL was not observed during this gauging event at the injection well or surrounding shallow groundwater monitoring wells.

To further remove possible trace NAPL from extraction wells KAFB-106EX1 and KAFB-106EX2, absorbent socks were installed in both wells on September 22, 2020 and socks remained emplaced for several weeks. The absorbent socks were removed from both extraction wells on October 1, 2020 and a Solinst oil-water interface probe was used to evaluate NAPL presence. NAPL was not detected in either KAFB-106EX1 or KAFB-106EX2 after the absorbent socks were removed.

It should be noted that the goal of the pilot test was not to treat or characterize the nature and extent of NAPL. NAPL characterization efforts are included in the Source Zone Characterization Report that will be revised for delivery to NMED in April 2021.

~~3.7 NAPL Sampling~~

~~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. 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. Well KAFB-106MW1-S was bailed on September 8, 2017 and approximately 60 milliliters of product were recovered. The product was containerized and submitted to Pace Analytical® (Pace) for the following analysis:~~

- ~~C3-C12 PIANO Quantitative Molecular Characterization by gas chromatography-mass spectrometry (VOC Fingerprinting)~~
- ~~C8-C40 Full Scan Qualitative Molecular Characterization by gas chromatography-mass spectrometry (semivolatile organic compound Fingerprinting)~~
- ~~Density and Viscosity~~

~~Density and viscosity analyses were subcontracted to Clark Testing. Additional product recovery was attempted occurred on September 13 and 14, 2017, and approximately 60 milliliters were recovered and sent to the APTIM Lawrenceville laboratoryDevelopment and Applications Groupto facilitate EDB CSIAefforts . NAPL has not been detected in KAFB-106MW1-S since that time, but KAFB-106MW1-S has was been continually monitored for its presence on a weekly basis.~~

~~The NAPL analysis by Pace indicated a great variety of hydrocarbons, but notably benzene (31.8 milligrams per kilogram [mg/kg]) and EDB (20.5 mg/kg) concentrations were low compared to toluene (7,396 mg/kg) and ethylbenzene (6,098 mg/kg). This laboratory report is included in Appendix G.~~

~~The NAPL received by APTIM was noted to contain similar quantities of toluene (7,190 milligrams per liter [mg/L]) and ethylbenzene (5,340 mg/L) and was presumed to have similar composition to that evaluated by Pace. The NAPL sample received by APTIM was also equilibrated with water at 1:1 and 1:10 ratios, and equilibrated aqueous concentrations for EDB, benzene, and toluene were approximately 150 micrograms per liter (µg/L), 160 µg/L, and 8,200 µg/L, respectively. The EDB and toluene concentrations are similar to that observed during baseline testing as described in Section 4.1, but the equilibrated benzene concentrations were smaller. The δ^{13}C value of the EDB in the NAPL, as determined by the University of Oklahoma, was approximately --21±2‰. Brief~~

3.8 ~~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 measureablemeasurable NAPL at KAFB-106MW1-S.~~Sample Analysis

All sampling activities were conducted in accordance with Sections 5.2.4 and 5.2.5 of the Groundwater Investigation Work Plan (Kirtland AFB~~USACE~~, 2011b), and the site-specific Quality Assurance Project Plan, which is an appendix to the Groundwater Investigation Work Plan. Evaluation of EDB carbon isotopes was performed by CSIA as part of a U.S. Department of Defense ~~Environmental Security Technology Certification Program~~ ESTCP Project ER-201331 entitled, "Natural Attenuation and Biostimulation for *In Situ* Treatment of 1,2-Dibromoethane (EDB)." The monitoring, extraction, and injection wells were sampled for baseline conditions in June 2017. Samples were submitted for the following analyses:

- VOCs (United States Environmental Protection Agency [EPA] Method 8260B)
- EDB (EPA Method 8011)
- Dissolved iron and manganese (EPA Method 6010C)

- Anions – bromide, nitrate, nitrite, chloride, and sulfate (EPA Method 9056A)
- Nitrate and nitrite as nitrogen (EPA Method 353.2)
- Iodide (EPA Method 300.0)
- Reduced Gases (RSK SOP-175; EPA 3810)
- Volatile Fatty Acids (EPA Method 300 Modified)
- Alkalinity (Standard Method 2320B)
- Microbial Community (QuantArray-Chlor)
- Dissolved ortho-phosphate (Standard Method 4500 PE and EPA Method 9056A)
- EDB CSIA (Kuder et al, 2012)
- δ^2H (Hydrogen/H_2O Equilibration Isotope Ratio Mass Spectrometry)
- Fluorescein Dye Tracer (Spectrofluorophotometry)

Due to ultimate replacement of the Geotech bladder pumps with the QED MicroPurge® Model P1101HM bladder pumps in September 2017, baseline samples were recollected from September 18 through 26, 2017. Baseline samples were not originally collected at KAFB-106MW1-S in June 2017 due to repeated pump failures. Analytical results from baseline samples are discussed in Section 4.0. Table 4 presents the suite of analytes that were measured by the analytical laboratories and the sampling frequency for the remaining phases of the pilot test.

3.9 Sample Documentation

Sample collection logs, purge logs, and chain-of-custody form were completed by field personnel during monitoring and sampling activities. Sample collection logs and purge logs are included in Appendix ~~F~~H. Chain-of-custody forms are included with the laboratory reports (Appendix ~~G~~I-3).

3.10 Quality Control

Field quality control samples were collected as part of each sampling event and included field duplicate and trip blank samples. Duplicate samples were analyzed to estimate the overall reproducibility of the sampling and analysis process and were collected immediately after the original/parent sample to reduce variability. Trip blank samples were used to evaluate potential contamination by VOCs during sampling, shipment, and laboratory processing. Additionally, internal laboratory quality control samples, including laboratory control samples, replicates, matrix spikes, matrix spike duplicates, and surrogate spike samples were analyzed concurrently with the groundwater samples.

The groundwater analytical data were validated for precision, bias, accuracy, representativeness, comparability, and completeness, and appropriate data qualifiers were appended to the analytical data in the project database. The data validation results are presented in the Data Quality Evaluation Reports, which ~~is~~ are included as Appendix ~~G~~I-1 (June 2017 through January 2019 data) and Appendix I-2 (March 2020 through October 2020 data). Laboratory data packages are also provided in Appendix ~~G~~I-~~2~~3.

3.11 Waste Management

IDW generated during the pilot test included soil generated from drilling activities~~ and~~; liquid IDW generated during drilling operations, well development, equipment decontamination, and groundwater sampling; solid and liquid IDW generated during NAPL removal activities at the extraction wells. All ~~soil and liquid~~ IDW generated during implementation of the pilot test was handled and disposed of in accordance with the Waste Management Plan of the Groundwater Investigation Work Plan (Kirtland AFB~~USACE~~, 2011b) and the Work Plan (Kirtland AFB~~USACE~~, 2016a). Kirtland AFB Landfill disposal letters and approvals; waste profiles; and hazardous and non-hazardous waste manifests for liquid IDW are provided in Appendix ~~H~~J.

3.11.1 Soil IDW

Soil IDW was generated during drilling and well installation activities at two nested monitoring wells, two extraction wells, and one injection well. All drill cuttings were containerized in plastic-lined, steel roll-off containers pending laboratory analysis for waste characterization and disposal. The field geologist collected soil cuttings from each 5 to 10-foot interval during drilling activities, which represented a composite of the depth interval contained within the specific roll-off container. The cuttings were stored in sealable gallon-sized bags which were labelled with the associated depth interval and roll-off. The sealable bags were stored on ice in a cooler until they were sampled for waste characterization to provide protection from loss of volatiles, despite the roll-off being exposed during the same time period. ~~Each~~ A sample was collected from each sealable gallon-sized bag (representing soil contained in a specific roll-off) ~~was sampled~~ without homogenization for waste characterization. IDW soil samples collected for VOC analysis were collected in jars, filled with no headspace. Approximately 16 ounces were collected per composite sample. Once the analytical results were received, reviewed, and determined to meet landfill requirements, a “Request for Disposal” letter was provided to Kirtland AFB for approval to dispose of the contents of each container. Analytical results for all roll-off containers confirmed that the drill cuttings were not a hazardous waste, and they met the requirement for disposal at the Kirtland AFB Construction and Demolition Landfill. Soil IDW disposal letters generated for the roll-off containers and associated approval letters are provided in Appendix ~~H~~J-1.

On January 25, 2017 at 12:30 p.m. approximately ¼ to ½ cubic yards of semi-saturated soil was released to the ground surface within the pilot test construction area while attempting to move a roll-off bin. The spill was reported by Kirtland AFB both verbally and in written format to the NMED Hazardous Waste Bureau within twenty-four hours. A Corrective Action Report was submitted to both the NMED

Hazardous Waste Bureau and Ground Water Quality Bureau on February 9, 2017 (Kirtland AFB~~USACE~~, 2017b) and is included in Appendix ~~H~~J-2.

3.11.2 Liquid IDW – Development and Decontamination

Liquid IDW was generated during decontamination resulting from drilling activities, and during development. The following steps were followed during IDW liquid handling, storage, and characterization for liquid IDW generated during drilling and well development activities:

1. Development and decontamination water were transferred into appropriately sized storage tanks located at the drill site for temporary accumulation, pending laboratory analysis.
    a. For monitoring wells, liquid IDW generated from development activities was typically accumulated in 275 gallons totes. During development of the pilot test monitoring wells, an average of two totes were filled per well. Water from different wells was not combined.
    b. For extraction and injection wells, liquid IDW was accumulated in 19,000-gallon Baker tanks, since the development procedures for these tanks are more intensive and produced a greater amount of water. During development of the extraction and injection wells, one Baker tank was filled for each extraction well, and two Baker tanks were filled for the injection well. Jetting was performed at the injection well as part of the development process and the procedure created a greater volume of liquid IDW.
2. Storage tank and totes were labeled with pending analysis stickers containing the dates of accumulation, well identification, and generator point of contact information.
3. Once development of a specific well was complete, a composite water sample was collected from the storage container(s) using a disposable bailer and analyzed for the following: anions

(EPA Method 300), nitrate (EPA Method 353.2), dissolved metals (EPA Method 6010), total lead (EPA Method 6010), semivolatile organic compounds (EPA Method 8270), VOCs (EPA Method 8260), and EDB (EPA Method 8011).

4. Liquid IDW containerized in totes (from monitoring well development) that was determined to be hazardous was transferred into 55-gallon drums and moved to the less than 90-day accumulation area. Hazardous waste labels were affixed to the drums showing generator information, accumulation dates, waste numbers, and the Kirtland EPA identification number. Drums were stored on appropriately sized secondary containment.

Non-hazardous liquid IDW generated from development and decontamination activities was disposed of by Chemical Transportation, Inc. and Clean Harbors at their respective facility located in Albuquerque, New Mexico. Non-hazardous waste manifests are included in Appendix ~~H~~J-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~~J-4.

3.11.3 Liquid IDW – Purge Water

Analytical data from groundwater sampling was incorporated with the data collected during liquid IDW sampling of the development/decontamination water to generate both hazardous and non-hazardous waste profiles for disposal of purge water (Appendix ~~H~~J-5). The highest concentrations observed in IDW and groundwater samples were used to generate the waste profiles, thus eliminating the need to frequently sample liquid IDW generated during sampling activities. Hazardous purge water was transferred into 55-gallon, open-top metal drums placed on secondary containment pads located within the less than 90-day accumulation area. Non-hazardous purge water was placed in a single 275-gallon tote.

Hazardous liquid IDW generated from groundwater sampling activities conducted prior to 2020 was disposed of by Chemical Transportation, Inc. and Clean Harbors at Clean Harbors Aragonite, LLC in Grantsville, Utah and by Advanced Chemical Transportation at their local facility. The non-hazardous liquid IDW generated from groundwater sampling activities conducted prior to 2020 was disposed of by Advanced Chemical Transportation at their local facility on March 19, 2019. Hazardous liquid IDW generated from groundwater sampling activities conducted from March through October 2020 was disposed of by ACTenviro (formerly Advanced Chemical Transportation) at their Albuquerque facility.

3.11.4 NAPL IDW

Liquid IDW consisting of groundwater and NAPL bailed from extraction wells KAFB-106EX1 and KAFB-106EX2 in June/July 2020 was transferred into two 55-gallon, open-top metal drums placed on secondary containment pads located within the less than 90-day accumulation area. A new profile was generated for the waste consisting of NAPL comingled with groundwater (Appendix J-5) and the waste was removed by ACTenviro on September 29, 2020. The hazardous waste manifest is included in Appendix J-4.

The absorbent socks used to remove residual NAPL remaining in the extraction wells were contained within a U.S. Department of Transportation-approved 5-gallon pail on a secondary containment pad located within the less than 90-day accumulation area. The absorbent sock waste was removed on December 26, 2020 by ACTenviro under a new profile (Appendix J-5). The hazardous waste manifest is included in Appendix J-4.

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4. PILOT TEST RESULTS

This section describes the analytical results associated with the pilot test. Analytical data tables for each well are included as Tables 7 through 15.

4.1 Baseline Conditions

All pilot test wells were sampled prior to Phase 1 recirculation activities to establish pre-test baseline conditions, including measures of various tracers used, microbial community, geochemistry, contaminants (e.g., benzene and EDB), EDB degradation products (e.g., ethene, ethane, bromide), and EDB CSIA. As noted in Section 3.~~7~~2, NAPL was observed at KAFB-106MW1-S during this period, and a sample of the NAPL was collected for analysis.

The pilot test was sited near existing well KAFB-106064, which contained EDB at concentrations of 17 µg/L (Second Quarter 2016; Kirtland AFB~~USACE~~, 2016c) and 9.3 µg/L (Fourth Quarter 2016; Kirtland AFB~~USACE~~, 2017c) and benzene at concentrations of 1,100 µg/L (Second Quarter 2016) and 1,000 µg/L (Fourth Quarter 2016) prior to installation of the new pilot test wells. After installation and development of the new pilot test wells, EDB and benzene concentrations of baseline groundwater samples at KAFB-106064 were measured at 143 µg/L and 4,730 µg/L, respectively. These increases at KAFB-106064 may have been the result of different types of sample pumps (bladder pumps) placed at different depths, heterogenous distribution of EDB and benzene in the subsurface, or perhaps due to increased mass transfer from residual NAPL during well installation and development. Higher concentrations were also observed at the other newly installed wells, where EDB ranged from 20.1 µg/L (KAFB-106IN1) to 432 µg/L (KAFB-106MW1-S) and benzene ranged from 586 µg/L (KAFB-106MW2-S) to 7,320 µg/L (KAFB-106MW1-S). The highest EDB and benzene concentrations observed were at KAFB-106MW1-S where NAPL was previously observed and collected (September 2017). EDB concentrations from baseline sampling and during the most recent sampling during the pilot test (Phase 4) are presented in Figure 8.

As will be further described below, representative microorganisms likely capable of EDB debromination were present in large numbers at shallow wells during the baseline evaluation, together with a reducing environment favorable for reductive debromination. Elevated concentrations of the EDB degradation products ethene, ethene, and bromide, together with more positive EDB $\delta^{13}C$ values (up to -5‰) at wells during the baseline evaluation, indicated that EDB degradation was likely ongoing or had previously occurred at the pilot test location. In ~~this~~ a phased approach, the pilot test evaluated whether EDB degradation could be enhanced through addition of biostimulation amendments.

4.2 Amendment Distribution

Various tracers were amended to the recirculated groundwater to evaluate and verify the distribution and transport times between wells during the pilot test. These tracers included fluorescein dye (Phase 1), deuterium labeled water (^2H_2O, Phase 1), and iodide (Phase 2). Fluorescein is a fluorescent tracer often used in studies of groundwater flow in karst systems, ^2H_2O occurs as approximately 0.03% of water, and iodide is perhaps best known as an additive in iodized table salt, albeit at low concentrations. In addition to these tracers, biostimulation amendments added to the groundwater included a fermentable sodium lactate-based substrate with nutrients (WilClear Plus®) and DAP.

4.2.1 Tracer Distribution During Phase 1

Fluorescein was added together with deuterated water over a period of 24 hours while the recirculation system operated at 20 gpm (10 gpm at KAFB-106EX1, and 10 gpm at KAFB-106EX2). 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 non-detectable.

Figures 9 and 10 show measured fluorescein concentrations in samples collected from shallow and intermediate wells, respectively. The average transport times for the anaerobic shallow wells with high EDB concentrations, as indicated by the date of maximum tracer contribution, were of primary interest and are provided in Table 16. These indicate that transport times increased with increasing distance, and no strong indications of preferential flow were apparent. Decreases in maximum concentrations with increasing distances from the injection well were indicative of dispersion within the subsurface as expected. After the 30 days of groundwater recirculation and ~~, the added~~ fluorescein ~~was re~~distribut~~ed~~ion, ~~in the groundwater and~~ fluorescein concentrations among the shallow wells of the pilot test ranged from 3.7 µg/L (KAFB-106EX1) to 8.2 µg/L (KAFB-106EX2). After an additional month without groundwater recirculation (passive portion of Phase 1), fluorescein concentrations in the groundwater ranged from 4.1 µg/L (KAFB-106MW1-S) to 5.5 µg/L (KAFB-106064) among the shallow wells. Among the intermediate monitoring wells, fluorescein was observed at a maximum of 92 µg/L at KAFB-106MW2-I after 7 days of recirculation, and at a maximum of 50 µg/L at KAFB-106MW1-I after 30 days of recirculation. No fluorescein was observed at the existing intermediate monitoring well KAFB-106063 during Phase 1.

Deuterium labeled water was added at the same time as the fluorescein to ensure that at least one tracer was measurable during the tracer test. 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‰. Figures 11 and 12 show measured δ^2H values of the water samples collected from shallow and intermediate wells. There is clear agreement between the fluorescein and δ^2H data, which provides confidence in observed transport times and water distribution. After the 30 days of groundwater recirculation, the deuterated water was redistributed in the groundwater and δ^2H values among the shallow wells of the pilot test ranged from -90‰ (KAFB-106EX1) to -84‰ (KAFB-106EX2). After an additional month without groundwater recirculation (passive portion of Phase 1), δ^2H values in the groundwater ranged from -89‰ (KAFB-106MW1-S) to -86‰ (KAFB-106MW2-S) among the shallow wells. Among the intermediate monitoring wells, δ^2H was observed at a maximum of +19‰ at KAFB-106MW2-I after 7 days of recirculation, and at a maximum of -62‰ at KAFB-106MW1-I after 30 days of recirculation. For reference, Vienna Standard Mean Ocean Water has a δ^2H value of 0‰, by definition. As with fluorescein, no significant shift in δ^2H values was observed at the existing intermediate monitoring well KAFB-106063 during Phase 1.

The results from the Phase 1 tracer test indicated that the targeted treatment zone encompassing the shallow groundwater monitoring wells were hydraulically connected with the injection well. Additionally, it was evident that amendments were distributed in the treatment zone under the planned operating conditions. In particular, distribution of amendments to groundwater sampled by monitoring wells nearest to the injection well (KAFB-106MW2-S and KAFB-106064) occurred within 5 days of operation, suggesting a high likelihood of successfully distributing biostimulation amendments ~~to~~ that favor reductive debromination of EDB. Based on these observations during Phase 1 operations, the recirculation system was operated similarly to distribute biostimulation amendments during Phases 2 and 3.

4.2.2 Tracer Distribution During Phase 2, 3, and ~~3~~4

Phase 2

Iodide, introduced as KI, was used as conservative tracer to verify distribution of water containing biostimulation amendments, and to allow for distinction between recirculated waters and background water. During the Phase 2 recirculation period, four samples of the injected groundwater were collected directly from the KAFB-106IN1 sample port while the chemical feed pump was operating. Iodide results from the injectate ranged from 18 to 26 mg/L. Adjusting for the timing of amendment cycles, the average concentration of iodide in reinjected water ranged from 15 to 18.6 mg/L.

Figures 13 and 14 show iodide concentrations of samples collected from shallow and intermediate wells, respectively, during the pilot test. The iodide data are consistent with observations made using other tracers during Phase 1, showing more rapid transport to the shallow monitoring wells nearest to the injection well (KAFB-106MW2-S and KAFB-106064), with amendments arriving at the more distant extraction wells last. 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-106IN), which indicates that most of the groundwater observed at these wells was previously amended and reinjected. Groundwater at the more distant shallow groundwater monitoring well (KAFB-106MW1-S) was measured at 11 mg/L during the recirculation period, slightly lower than injected concentrations, indicating that a fraction of that water represented background conditions, or water that had previously been recirculated (during Phase 1) without iodide amendments. Lower concentrations of iodide observed at the extraction wells, 2.7 mg/L at KAFB-106EX2 and 1.3 mg/L at KAFB-106EX1, indicate longer transport times and dispersion consistent with Phase 1 results, and dilution due to extraction of water from both inside and outside the treatment zone. Consistent with Phase 1 tracer study results, elevated iodide concentrations up to 7.3 mg/L were observed at the nearest intermediate monitoring well (KAFB-106MW2-I), while transport to the other intermediate monitoring wells were slower, with an iodide measurement of 1.2 mg/L at KAFB-106MW1-I and no detections of iodide at KAFB-106063. 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.

After recirculation of amendments at the start of Phase 2, a passive period without recirculation, but with continued monitoring, commenced and lasted more than four months and included four sampling events. Changes in iodide concentrations during the Phase 2 passive period were also informative. Iodide concentrations among the shallow groundwater monitoring wells nearest the injection well were fairly constant, with concentrations ranging from 17 to 22 mg/L for wells KAFB-106064 and

KAFB-106MW2-S, and concentrations ranging from 13 to 16 mg/L for KAFB-106MW1-S. These iodide concentrations indicated that the sampled groundwater remained heavily influenced by treatment activities. Interestingly, iodide concentrations at KAFB-106EX1 increased from 1.3 mg/L at the end of recirculation to 8.3 mg/L during the Phase 2 passive period, and iodide concentrations at KAFB-106EX2 decreased from 2.7 mg/L at the end of recirculation to 0.3 mg/L during the Phase 2 passive period. While a decrease in iodide concentrations can result from iodide oxidation to iodate, the reducing conditions present at the site suggest this process should be limited. Rather the shifts in iodide concentrations at the outer boundaries of the treatment zone provide evidence that groundwater from outside the treatment zone is entering the treatment zone at KAFB-106EX2, and that groundwater with higher iodide concentrations from within the treatment zone are continuing to flow toward KAFB-106EX1. These data are consistent with a general west to east groundwater flow at the pilot site under ambient conditions at the time of the pilot test. A similar decrease in iodide concentrations was also observed at the intermediate monitoring well KAFB-106MW2-I, indicating that this well may also be located close to the upgradient edge of the treatment zone and influenced by groundwater from outside the treatment zone during passive periods.

Phase 3

During Phase 3 amendment and recirculation activities, no additional iodide was added to the aquifer as KI; however, iodide already present in the subsurface after Phase 2 was redistributed. As such, the presence of iodide still served as a conservative tracer to allow for distinction between recirculated waters (from either Phase 2 or 3) and background groundwater with low iodide concentrations. At the end of the Phase 3 recirculation period, iodide concentrations among the shallow groundwater monitoring wells ranged from 4.5 mg/L (KAFB-106MW2-S) to 6.2 mg/L (KAFB-106MW1-S). This tight range indicates that amendments continued to be distributed well in the treatment zone during Phase 3. Interestingly, iodide concentrations of the intermediate monitoring wells increased during Phase 3 recirculation, with concentrations increasing to 15 mg/L (KAFB-106MW1-I), 10 mg/L (KAFB-106MW2-I), and 5.2 mg/L (KAFB-106063). While some redistribution of iodide was apparent during Phase 2 passive periods, these increases in iodide concentrations at the intermediate monitoring wells indicate that transport to these locations generally took longer than the period of active recirculation with iodide amendments during Phase 2 and continued to be redistributed to deeper locations during Phase 3 recirculation activities. This is logical considering the shallower screen intervals of both the injection well and extraction wells.

As during Phase 2, a passive period without recirculation, but with continued monitoring, commenced after recirculation ended. Iodide concentrations among the shallow groundwater monitoring wells nearest to the injection well varied little, with concentrations ranging from 6.3 mg/L (KAFB-106MW1-S) to 3.6 mg/L (KAFB-106MW2-S). These concentrations of iodide during the passive period indicated that the sampled groundwater remained heavily influenced by treatment activities. As before, iodide concentrations at KAFB-106EX1 increased from 4.6 mg/L at the end of recirculation to 6.2 mg/L during the Phase 3 passive period, and iodide concentrations at KAFB-106EX2 decreased from 4.6 mg/L at the end of recirculation to 0.5 mg/L during the Phase 3 passive period. These data remain consistent with a general west to east groundwater flow at the pilot site under ambient conditions. As during Phase 2, a similar decrease in iodide concentrations was also observed at the intermediate monitoring well KAFB-106MW2-I, again indicating that this well may be located close to the upgradient edge of the treatment zone and influenced by groundwater from outside the treatment zone during passive periods.

Phase 4

As described previously, Phase 4 of the pilot test did not include any groundwater recirculation efforts, or introduction of additional amendments to the subsurface. The presence of iodide served as a conservative tracer of groundwater that had previously been amended and recirculated. During Phase 4, iodide concentrations among the shallow monitoring wells ranged from 3.8 mg/L (KAFB-106064) to 6.3 mg/L (KAFB-106MW2-S); iodide concentrations at KAFB-106EX1 ranged from 6.8 mg/L (August 2020) to 10 mg/L (March 2020); iodide concentrations at KAFB-106EX2 ranged from non-detections to 0.35 (October 2020); and iodide concentrations at the injection well (KAFB-106IN1) ranged from 2.6 mg/L

(October 2020) to 5.1 mg/L (August 2020). Detectable concentrations of iodide among the intermediate groundwater monitoring wells ranged from 0.35 mg/L (KAFB-106MW2-I) to 13 mg/L (KAFB-106MW1-I) during Phase 4.

Iodide concentrations observed at shallower wells during Phase 4 passive period were consistent with those observed during Phase 3. This consistency indicates limited groundwater flux across the pilot test location over the approximately two-year period that passed since water was last recirculated. The sampled groundwater remained heavily influenced by treatment activities. During Phase 4, iodide concentrations at intermediate depth groundwater monitoring wells were more variable and a decrease in iodide concentrations was evident in at least two (KAFB-106MW1-I and KAFB-106MW2-I) of the three wells (Figure 14). Sulfate and methane concentrations at KAFB-106MW1-I and KAFB-106MW2-I during Phase 4 (see Section 4.4) indicate less reducing conditions at these wells, and the decrease in iodide at these wells may have resulted from possible oxidation of iodide to iodate, or influx of groundwater from outside the treatment zone.

4.2.3 Distribution of Fermentable Substrate

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. As noted in the discussion of tracers above, reinjected groundwater was distributed throughout the treatment zone of the pilot test. However, due to possible sorption and retardation of organic compounds, the distribution of this fermentable substrate may have been slower than that of the tracers and observations of substrate and its immediate transformation products (e.g., acetate and propionate) provide additional insight regarding substrate distribution. During the Phase 2 recirculation period, three samples of the injected groundwater were collected directly from the KAFB-106IN1 sample port while the chemical feed pump was operating. Lactate concentrations of the injectate ranged from 140 to 154 mg/L. Adjusting for the timing of amendment cycles, the average concentration of lactate in reinjected water was approximately 110 mg/L. While measurements of reinjected substrate concentrations at KAFB-106IN1 were not made during Phase 3 recirculation activities, the system was operated under similar conditions, and lactate concentrations likely averaged ~~near~~ between 100 and 150 mg/L as observed during Phase 2 recirculation.

Figures 15, 16, and 17 show~~s~~ measured lactate, acetate, and propionate concentrations of samples collected at all the monitoring wells during the pilot test. All three compounds were observed in baseline samples, perhaps as a result of low-level fermentation of organics present in the aquifer. While lactate was introduced to the subsurface at ~~around 110~~ concentrations between 100 and 150 mg/L, concentrations at monitoring wells never exceeded 4 mg/L. Biological transformation of lactate, however, results in the production of both acetate and propionate. While acetate and propionate ~~, which~~ were ~~generally not~~ detected in the amended and reinjected ~~injected~~ groundwater at concentrations of less than 30 mg/L during Phase 2, significantly higher concentrations were observed at monitoring wells, presumably as a result of *in situ* transformation of the amended carbon substrate. ~~Figures 16 and 17 show measured acetate and propionate concentrations, respectively, from samples collected at all the monitoring wells during the pilot test.~~ All wells showed clear increases in acetate concentrations, ranging from a lowest maximum of 44 mg/L in KAFB-106EX2 to a highest maximum of 151 mg/L in KAFB-106MW2-S. Likewise, propionate concentrations ~~clearly~~ increased ~~due~~ after~~to~~ biostimulation amendments, with only KAFB-106063 having no detections. Propionate concentrations in the wells ranged from a lowest maximum of 6.8 mg/L in KAFB-106MW1-I to a highest maximum of 74.9 mg/L in KAFB-106064. The observed decrease in lactate concentrations, together with increases in acetate and propionate ~~strongly~~ suggest that lactate fermentative conditions ~~organic substrate capable of stimulating~~ conducive to reductive debromination of EDB were present ~~as distributed to~~at most wells during the pilot test. As expected, concentrations of acetate and propionate decreased at many of the wells during passive periods~~, and extended monitoring to evaluate whether stimulated debrominating activity is sustained may be beneficial in the evaluation of the potential viability of this technology in the Corrective Measures Evaluation.~~.

4.3 Microbial Analysis

As described in Section 4.2.3, amendments were supplied in the treatment area during Phase 2 and 3 to stimulate biological activity capable of reductive debromination of EDB. Figures 18 to 24 show populations of total eubacteria (EBAC), sulfate reducing bacteria (APS), methanogens (MGN), *Dehalobacter* spp. (DHBt), *Dehalobacter* DCM (DCM), *Dehalogenimonas* spp. (DHG), and *Desulfitobacterium* spp. (DSB) as determined by Microbial Insights' QuantArray-Chlor assay analysis. Generally, the results indicated that the groundwater contained large populations of microorganisms prior to pilot test activities, with EBAC counts ranging from around 10^6 cells per milliliter (cells/mL) to 10^7 cells/mL, APS counts ranging from 10^4 cells/mL to 10^5 cells/mL, and representative organisms likely capable of EDB debromination (i.e., DHBt and DSB) ranging from around 10^4 to 10^5 cells/mL in baseline samples. This is consistent with microbial analyses from at KAFB-106064 in 2015 and an order of magnitude (OOM) or greater than observed at a background well in 2015 (Kirtland AFB~~USACE~~, 2016b). Given the large release of hydrocarbons at the site that can provide energy for diverse microbial communities, this high level of activity is not surprising. With one exception during Phase 4 (KAFB-106IN1), populations of *Dehalococcoides* spp. (DHC), a well-known dehalogenating species, were below 30 cells/mL throughout the pilot test and these DHC populations were not expected to contribute to EDB degradation during the pilot test without bioaugmentation. Fortunately, for the pilot test, the high number of other likely debrominating organisms suggested that biostimulation to increase their activity was possible.

During the various phases of the pilot test, the measured populations increased by as much as two OOM depending on the organism and monitoring well examined. Increased microbial populations were particularly apparent at the deeper wells (i.e., KAFB-106063, KAFB-106MW1-I and KAFB-106MW2-I), likely because conditions at these locations were more oligotrophic prior to recirculation. For populations of EBAC, much of the observed increase in population size occurred during Phase 1 recirculation activities. As with the deeper wells, this increase in EBAC 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. As with the high cell numbers prior to recirculation and amendments at the site, the large numbers of organisms likely capable of reductive debromination (10^5 to 10^6 cells/mL for DHBt, and around 10^5 cells/mL for DSB) observed after biostimulation~~, suggest~~ indicated that the microbial capacity for EDB debromination remained very prevalent ~~activity may have been stimulated~~ during the pilot test. Unfortunately, the microbial analyses performed do not provide direct information regarding the biodegradation activity of the microbial community. Such activity must be inferred from other lines of evidence collected during the pilot test, such as changes in EDB concentrations, products of EDB degradation, and shifts in isotope composition of residual EDB.

Three microbial populations that increased by more than 2 OOM during pilot test activities are MGN, DHG, and DCM. Stimulation of methanogens was also evident from increases in methane within the treatment zone, as discussed below in Section 4.4. The increases in DHG and DCM occurred only after the addition of biostimulation amendments, but it is unclear whether these directly impacted EDB degradation. DHG are known to reductively dehalogenate 1,2-dichloroethane (Moe et al., 2009), the chlorinated analog of EDB, and DHG likely also dehalogenate EDB. DCM are particularly known for their ability to grow using dichloromethane (Justicia-Leon et al., 2012), but are also a species of Dehalobacter (DHBt) that may include the ability to reductively dehalogenate other compounds. ~~As with the larger numbers of DHBt and DSB present at the site, t~~The growth of DHG and DCM suggest that EDB debromination activity may have been stimulated during the study, but, as with the other microbial data, these data are not conclusive in isolation.~~.~~

4.4 Geochemistry

DO, sulfate, iron, and methane were monitored during the pilot test as indicators of *in situ* redox conditions (Figures 25 to 28). DO was monitored during purging activities using a water quality meter (YSI™ ProDSS). Samples for sulfate, iron, and methane were collected from pilot test wells and submitted for laboratory analysis. All four parameters indicate that intended anaerobic conditions favoring reductive debromination of EDB occurred during the pilot test.

The pilot test was sited within a zone significantly impacted by hydrocarbons. DO concentrations at the shallow wells most impacted were low (less than 1 mg/L) under baseline conditions presumably due to past aerobic degradation of some of these hydrocarbons. Intermediate wells were not as impacted by hydrocarbons and generally had greater DO concentrations ranging from 1.7 mg/L at KAFB-106MW2-I to 7.4 mg/L at KAFB-106MW1-I. During Phase 1 recirculation without biostimulation amendments, DO decreased to less than 0.5 mg/L in the wells, except for extraction well KAFB-106EX1 (2.1 mg/L) and intermediate wells KAFB-106MW1-I (8.4 mg/L) and 106063 (1.9 mg/L). Extraction well KAFB-106EX1 is located near the eastern edge of the hydrocarbon and EDB plume and pumping may have drawn in more oxygen rich and less impacted groundwater from greater depths or from further east. As indicated by tracer tests, intermediate wells KAFB-106MW1-I and KAFB-106063 were less impacted by recirculated water during the Phase 1 recirculation period. During and after Phase 2 and Phase 3 recirculation periods in which amendments were introduced to groundwater, DO concentrations were below 1 mg/L at all wells, with most concentrations below 0.5 mg/L. Occasional DO concentrations above 1 mg/L were observed at the extraction wells KAFB-106EX1 and KAFB-106EX2 during passive periods. The extraction well samples were collected by briefly turning on the recirculation pumps and the slightly elevated DO concentrations may have resulted from minor introductions of oxygen during this sampling process, or it may have resulted from collection of more oxygenated waters occurring *in situ*. During Phase 4, DO concentrations remained below 1 mg/L except at extraction wells KAFB-106EX1 and KAFB-106EX2 during the final sampling event (October 2020). The elevated DO at the two extraction wells is unexplained and other parameters and analytes at these wells generally appear consistent with previous observations. Overall, t~~T~~he low DO concentrations within the treatment zone reflect favorable conditions for reductive debromination of EDB.

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. Sulfate reduction is indicative of bulk reducing conditions in the aquifer that favor EDB debromination and, under site conditions, the resulting sulfide ~~typically~~ might ~~precipitates together with dissolved~~interact with other subsurface elements ~~metals~~ (e.g., iron) to form sulfide minerals. Prior to Phase 4 of the pilot test, ~~Throughout the pilot test,~~ sulfate concentrations at KAFB-106EX2 always exceeded 10 mg/L with a maximum concentration of 39.7 mg/L (Phase 2 passive), perhaps as a ~~and may be the~~ result of extracting groundwater richer in sulfate from outside the treatment zone. Intermediate wells were not as impacted by hydrocarbons and generally had greater sulfate concentrations under baseline conditions ranging from 16.4 mg/L at KAFB-106063 to 23.8 mg/L at KAFB-106MW1-I. During Phase 1 recirculation without biostimulation amendments, there was an increase in sulfate concentrations among the shallow wells as sulfate was redistributed at the site with concentrations ranging from 13.8 mg/L at KAFB-106064 to 28.5 at KAFB-106EX1, and among the intermediate wells with concentrations ranging from 15.4 mg/L at KAFB-106MW2-I to 26 mg/L at KAFB-106063. During the subsequent Phase 1 passive period, sulfate generally decreased in the wells to less than 5 mg/L due to sulfate reduction, but concentrations exceeding 10 mg/L were still observed at the extraction wells and two of the three intermediate wells (KAFB-106063 and KAFB-106MW1-I). During and after Phase 2 and Phase 3 recirculation periods, sulfate concentrations were below 5 mg/L in the wells (except for KAFB-106EX2) and were often not detected. During the recirculation events themselves, both extraction wells had sulfate concentrations exceeding 5 mg/L, and it is likely that much of this observed sulfate was drawn to the extraction wells from outside the treatment zone. During Phase 4, after observation of NAPL in KAFB-106EX2 and KAFB-106EX1, its subsequent removal, and installation of new sampling pumps, lower sulfate concentrations of less than 1 mg/L were noted in KAFB-106EX2, consistent with more reducing conditions observed at other locations. During Phase 4, sulfate concentrations at intermediate wells KAFB-106MW1-I and KAFB-106MW2-I increased to more than 5 mg/L, perhaps indicating somewhat more oxidized conditions. Overall, the low sulfate concentrations (below 20 mg/L), and observed decreases in sulfate concentrations within the treatment zone reflected reducing ~~favorable~~ conditions favorable for reductive debromination of EDB.

Due to the low solubility of ferric (Fe(III)) iron under circumneutral conditions as found at the site, dissolved iron concentrations are often considered indicative ~~assumed to reflect concentrations~~ of more reduced ferrous (Fe(II)) iron. Minerals containing oxidized Fe(III) 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. During and after Phase 2 and Phase 3 recirculation periods, dissolved iron concentrations increased due to iron reduction and maximum concentrations at individual wells ranged from 4.2 mg/L in KAFB-106EX2 to 22.1 mg/L in KAFB-106MW2-I. During Phase 4, dissolved iron concentrations ranged from 0.885 mg/L in KAFB-106MW2-I to 15.2 mg/L in KAFB-106MW2-S. Generally, t~~T~~he~~se~~ elevated dissolved iron concentrations observed during the pilot test are consistent with bulk reducing conditions that facilitate ~~in the aquifer that are generally viewed as necessary for~~ reductive debromination of EDB.

High methane concentrations in the subsurface are frequently indicative of methanogenesis that occurs under anaerobic conditions. Methane was observed during baseline measurements among shallow wells with concentrations ranging from 2 µg/L at KAFB-106MW1-S to 179 µg/L at KAFB-106064. The higher concentrations support the interpretation that the treatment zone was anaerobic prior to pilot test activities. During the Phase 1 recirculation period, methane concentrations dropped to less than 10 µg/L suggesting mixing from less methanogenic regions, increased abiotic losses (e.g., due to degassing under flow conditions), or methane oxidation. During the Phase 1 passive period, methane concentrations rebounded with a maximum concentration of 350 µg/L at KAFB-106MW2-S. During the Phase 2 recirculation period when lactate amendments were introduced, methane concentrations generally fell again, but increased by many OOM at several wells during the following passive period, with concentrations exceeding 10,000 µg/L at the injection well and KAFB-106MW2-S. After the Phase 3 recirculation period where lactate amendments were introduced, methane concentrations increased further and all wells, except for KAFB-106MW1-I, exceeded 100 µg/L. Shallow wells KAFB-106MW2-S and KAFB-106064 exceeded 10,000 µg/L. During Phase 4, while elevated methane concentrations were noted throughout the pilot test area, the lowest methane concentrations were observed at KAFB-106MW1-I and KAFB-106MW2-I, and may indicate somewhat more oxidized conditions at these locations. Methane concentrations measured during Phase 4 were above 100 µg/L in all wells except KAFB-106MW1-I and KAFB-106MW2-I; and exceeded 10,000 µg/L in shallow monitoring wells KAFB-106MW2-S and KAFB-106064. It should ~~also~~ be noted that the aqueous solubility of methane at 1 atmosphere is in the range of 20,000 µg/L, so it is feasible that minor pockets of gas-phase methane existed near wells with highest methane concentrations. These elevated methane concentrations are consistent with the increased populations of methanogens discussed in Section 4.3 and are indicative of reducing conditions favorable for EDB debromination.

4.5 Selected Contaminants of Interest

The primary objective of this pilot test was to evaluate the potential for enhanced anaerobic EDB biodegradation. Degradation of ~~O~~other contaminants co-located with EDB due to the nature of their common sources, including benzene and toluene, was ~~ere~~ not the objective of ~~targeted by~~ this pilot test. However, benzene and toluene ~~can be~~were used to help evaluate the fate of EDB. Both benzene and toluene are slightly less water soluble and more volatile than EDB, and their behavior helps constrain expectations for some abiotic EDB loss mechanisms, such as volatilization. Additionally, benzene and toluene are generally less susceptible than EDB to degradation under anaerobic conditions. As such, it is helpful to discuss the behaviors of benzene and toluene prior to discussing EDB degradation observed during the pilot test. Figures 29 to 31 show concentrations of benzene, toluene, and EDB, respectively for all wells of the pilot test, and Table 17 shows the reduction of benzene, toluene, and EDB associated with each Phase of the pilot test, as well as from baseline evaluation to the most recent Phase 4 sampling.

4.5.1 Benzene and Toluene

Benzene concentrations in shallow monitoring wells during the baseline evaluation ranged from 586 µg/L at KAFB-106MW2-S to 8,240 µg/L at KAFB-106MW1-S; benzene was not detected in the intermediate wells during baseline measurements. The measured benzene baseline concentrations were somewhat higher than those measured prior to pilot test well installation and development activities (benzene concentrations were approximately 1,000 µg/L at well KAFB-106064). This increase may have been the result of different types of sample pumps (bladder pumps) placed at different depths, heterogenous distribution of benzene in the subsurface, or perhaps due to increased mass transfer from residual NAPL during well installation and development. It should be noted that the highest benzene concentration was observed at KAFB-106MW1-S where NAPL was present at the start of the pilot test (September 2017). During the Phase 1 recirculation period, benzene concentrations at shallow monitoring wells were more evenly distributed throughout the site and ranged from 2,730 µg/L (KAFB-106MW2-S) to 3,630 µg/L (KAFB-106MW1-S). With the exception of the injection well (KAFB-106IN1) 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~~ 500 µg/L at KAFB-~~106MW2S~~ 106MW2-S to ~~4,400~~6,700 µg/L at KAFB-106EX2, indicating limited losses due to biodegradation or abiotic mechanisms (e.g., volatilization, dilution). Benzene concentrations as low as ~~750~~ 590 µg/L were observed at the injection well during Phase 4 sampling~~, but as noted in Section 3.4, this well was sampled using a bailer later in the pilot test after the dedicated submersible pump at the well stopped operating~~. 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 been observed at that location.

Relative to the shallower monitoring wells, benzene concentrations at the intermediate wells during the pilot test were more variable and interpreting changes in these benzene concentrations is more challenging. As noted earlier, benzene was not detected at the intermediate wells during baseline measurements, but benzene concentrations increased after recirculation activities mixed groundwater over a greater depth. During Phase 2 and Phase 3 recirculation periods, benzene concentrations ranged from 1,200 µg/L to 3,600 µg/L at the intermediate wells. However, these benzene concentrations decreased to approximately 50 µg/L during the Phase 2 passive period at KAFB-106MW1-I and 106MW2-I~~,~~ ; and to ~~approximately 130 µg/L~~0.67 µg/L at KAFB-106MW2-I ~~during~~ by the end of Phase 4 passive monitoring. No significant decrease in benzene concentrations was noted at KAFB-106063. The observed decreases in benzene concentrations may be due to sorption in the soils or degradation, but may also be attributed in part to the influx of groundwater not impacted by benzene as decreases in the iodide tracer were also observed in KAFB-106MW2-I.

Toluene concentrations in shallow monitoring wells during the baseline evaluation ranged from 1,540 µg/L at KAFB-106MW2-S to 13,200 µg/L at KAFB-106MW1-S, and toluene concentrations were less than 10 µg/L in all three intermediate monitoring wells, significantly less than the EPA maximum contaminant level (MCL) of 1,000 µg/L (EPA, 2009). As with benzene, the highest toluene concentration was observed at KAFB-106MW1-S where NAPL was present at the start of the pilot test. During the Phase 1 recirculation period, toluene concentrations at shallow monitoring wells were more evenly distributed throughout the site and ranged from 4,740 µg/L (KAFB-106MW2-S) to 9,330 µg/L (KAFB-106MW1-S). Toluene concentrations in the shallow monitoring wells for the remainder of Phases 1 through 3 ranged in concentration from 3,300 µg/L at the injection well to 19,500 µg/L at KAFB-106064, indicating limited losses due to biodegradation or abiotic mechanisms during this time (e.g., volatilization, dilution). Interestingly, toluene concentrations decreased during Phase 4 passive monitoring at many shallow wells (see Figure 30). These decreases were far greater than for benzene and may indicate some anaerobic biodegradation of toluene.

As with benzene, toluene concentrations at the intermediate wells during the pilot test were more variable and interpreting changes in these toluene concentrations is challenging. Toluene impacts at the intermediate wells were limited during the baseline evaluation, but toluene concentrations increased after recirculation activities mixed groundwater over a greater depth. During Phase 2 and Phase 3 recirculation periods, toluene concentrations increased to concentrations as high as 19,000 µg/L at the intermediate wells, but as observed with benzene, toluene concentrations decreased during the following passive periods at wells KAFB-106MW1-I and KAFB-106MW2-I, decreasing to below ~~concentrations as low as 7.4 µg/L~~detectable concentrations at KAFB-106MW2-I during Phase 4 passive monitoring. ~~No significant decreases in toluene concentrations were noted at KAFB-106063.~~Toluene concentrations decreased during Phase~~-~~ 4 passive monitoring at KAFB-106063 to a concentration of 1,800 µg/L (from 19,000 µg/L during Phase 3 passive period). As noted with benzene, the observed decreases in toluene concentrations at the intermediate wells may be due to sorption in the soils or degradation, but may also be attributed in part to the influx of groundwater not impacted by toluene as decreases in iodide tracer were also observed in KAFB-106MW2-I and KAFB-106MW1-I.~~.~~

Overall, the trends among benzene and toluene concentrations suggest that losses during and after recirculation were limited at the shallower wells, but interpretation of trends at the intermediate wells is more challenging. With the exception of toluene decreases noted among shallow monitoring wells during Phase 4 monitoring, the reasonably constant benzene and toluene concentrations observed in the shallow zone throughout the pilot test provide a good point of comparison to help evaluate EDB degradation. ~~As noted below, d~~Decreases in EDB concentrations much greater than observed for benzene and toluene provide ~~strong~~ evidence of EDB degradation, as other abiotic ~~loss~~ mechanisms leading to lower concentrations would likely be mirrored in benzene and toluene data.

4.5.2 EDB

EDB Concentrations

EDB was the ~~primary~~ contaminant targeted by these pilot test efforts. EDB concentrations in shallow monitoring wells during the baseline evaluation ranged from 20.1 µg/L at KAFB-106IN1 to 432 µg/L at KAFB-106MW1-S, and among the intermediate wells EDB was only detected at KAFB-106MW2-I with a concentration of approximately 0.1 µg/L. These baseline EDB concentrations were somewhat higher than that measured prior to pilot test well installation, when EDB concentrations at KAFB-106064 were 9.3 µg/L (Fourth Quarter 2016 Kirtland AFB~~USACE~~, 2017c) and 17 µg/L (Second Quarter 2016; Kirtland AFB~~USACE~~, 2016c). This increase may have been the result of different types of sample pumps (bladder pumps) placed at different depths, heterogenous distribution of EDB in the subsurface, or perhaps due to increased mass transfer from residual NAPL during well installation. As with benzene and toluene, the highest EDB concentration during the baseline evaluation was observed at KAFB-106MW1-S where NAPL was present at the start of the pilot test.

EDB concentrations at shallow monitoring wells were more evenly distributed during the Phase 1 recirculation period and ranged from 50.4 µg/L (KAFB-106EX1) to 137 µg/L (KAFB-106EX2), with EDB concentrations at wells closer to the injection well ranging from 68 µg/L (KAFB-106MW2-S) to 104 µg/L (KAFB-106MW1-S). Compared to the EDB concentrations observed during Phase 1 recirculation, concentrations at the shallow monitoring wells decreased during the following Phase 1 passive period, with EDB reductions of approximately 75% observed at wells KAFB-106064 (20.3 µg/L), KAFB-106EX1 (12.9 µg/L), and KAFB-106MW2-S (15 µg/L) after the one-month passive period. This is slightly less than a one-log reduction (i.e., 90%), as indicated in Table 17. Decreases of similar magnitude were not observed for benzene and toluene, where losses were less than 25% and, in most cases, less than 10% with some increases in concentration. These observations are consistent with some ongoing EDB degradation that may have been further stimulated by groundwater recirculation and nutrient redistribution from other locations within the aquifer. Whether this apparent EDB degradation would have been sustained for longer periods was not assessed during this pilot test as Phase 2 recirculation and biostimulation activities commenced as planned after the approximately one-month passive period. Decreases in EDB concentrations were observed at the intermediate monitoring wells too, with losses up to 95%. However, these EDB reductions were mirrored in benzene and toluene data, and may be due to degradation or other processes, such as sorption in the soils or influx of unimpacted groundwater.

During the last sampling of the Phase 2 recirculation period, the range of EDB concentrations observed at shallow monitoring wells was less variable, ranging from 66.4 µg/L at KAFB-106MW1-S to a maximum of 90.9 µg/L at KAFB-106EX2. This indicated ~~good~~ some redistribution of EDB within the treatment zone and provides a ~~good~~ point of comparison for changes during the subsequent passive period. Except for KAFB-106EX2, where no change in EDB concentration was observed, EDB concentrations decreased during the Phase 2 passive period by approximately 90% or more. As indicated in Table 17, this corresponds to one-log (90%) to three-log reduction (99.9%) relative to maximum concentrations measured during Phase 2 recirculation. Notably, EDB was not detected at the injection well (KAFB-106IN1) or KAFB-106MW2-S at the end of the passive period, with detection limits of approximately 0.02 µg/L. As mentioned earlier, no significant decreases of benzene and toluene were observed, providing evidence that abiotic losses (e.g. volatilization) were limited, and that anaerobic EDB degradation was stimulated during this passive period. As during the Phase 1 passive period, decreases in EDB concentrations were observed at the intermediate monitoring wells, but decreases in benzene and toluene were also observed, such that changes were not exclusive to EDB. In addition to EDB, benzene, and toluene degradation, other possible explanations leading to these decreases at intermediate wells include sorption in the soils or influx of unimpacted groundwater.

Due to the large decrease in EDB concentrations during Phase 2 and apparent *in situ* biodegradation activity of indigenous debrominating organisms, a decision was made to delay the planned bioaugmentation of the treatment zone with exogenous debrominating organisms (Kirtland AFB~~USACE~~, 2018a). Instead, additional recirculation with more organic substrate and nutrients was performed during

Phase 3 with the goal of expanding the biological treatment zone. I~~nteresterestingly, and i~~n contrast to Phase 1 and Phase 2 recirculation activities and in contrast to other solutes (e.g., iodide, benzene, toluene), EDB concentrations observed during Phase 3 recirculation exhibited a new pattern. Measured EDB concentrations at the extraction wells were reasonably constant during this recirculation period, with concentrations at KAFB-106EX1 ranging from 11 µg/L to 20 µg/L, and concentrations at KAFB-106EX2 ranging from 47 µg/L to 97 µg/L. Based on flows through the treatment system from the extraction wells, EDB in the reinjected groundwater ranged from approximately 35 µg/L to 45 µg/L, yet concentrations at the monitoring wells were less, ranging from approximately 3 µg/L at KAFB-106064 to 11 µg/L at KAFB-106MW1-S. Notably, EDB concentrations also decreased at the shallow wells during this recirculation period with time. Observing concentrations lower than injected concentrations and decreasing EDB concentrations during the recirculation period suggests that EDB degradation was stimulated and occurred between the injection well and the shallow monitoring wells during the Phase 3 recirculation period. Similar decreases in concentrations were not observed for benzene or toluene. Except for KAFB-106EX2 and KAFB-106MW1-S, where changes in EDB concentrations were less, EDB concentrations during the subsequent passive period decreased by 95% or more relative to maximums observed during the preceding recirculation period. As indicated in Table 17, these decreases corresponded to one-log (90%) to three-log reduction (99.9%) relative to maximum concentrations measured during Phase 3 recirculation, and EDB was detected at concentrations less than the EPA MCL of 0.05 µg/L (EPA, 2009) at the injection well (KAFB-106IN1) and wells KAFB-106MW2-S and KAFB-106064. As mentioned earlier, no significant losses of benzene and toluene were observed, providing evidence that abiotic losses (e.g. volatilization) were limited, and that anaerobic EDB degradation was stimulated during this passive period. Overall, the footprint of enhanced EDB degradation appeared larger after Phase 3 activities than during Phase 2. As during the Phase 1 and 2 passive periods, decreases in EDB concentrations were observed among the intermediate monitoring wells during Phase 3, but because similar decreases in benzene and toluene were also observed, such changes were not exclusive to EDB and could not be solely attributed to reductive debromination.

Phase 4 extended monitoring of the pilot test performance commenced after Phase 3, and ~~one~~ five sampling rounds were performed ~~has been completed to date that~~, the first of which occurred approximately four months after Phase 3 recirculation activities were halted. ~~While~~ There was no significant rebound in EDB concentrations ~~was noted~~ during ~~this sampling event~~Phase 4.~~,~~ During Phase 4, EDB decreased ~~by an additional 80% at KAFB-106MW1-S since the last passive sampling event during Phase 3~~to non-detectable concentrations at all wells except KAFB-106EX2 and KAFB-106MW2-S. Concentrations of EDB have decreased in KAFB-106EX2 from 55 µg/L (last Phase 3 passive sampling event) to 0.36 µg/L at the end of Phase 4. Concentrations of EDB have increased slightly in KAFB-106MW2-S from 0.019 µg/L (last Phase 3 passive sampling event) to 0.087 µg/L at the end of Phase 4. Figure 8 shows the EDB concentrations measured during baseline and Phase 4 sampling events at all pilot test wells. Table 17 and Figure 32 show the overall extent of reduction in EDB, benzene, and toluene from baseline measurements (or the highest observed concentrations for intermediate wells) to the most recent Phase 4 sampling event (October 2020). ~~With the exception of KAFB-106EX2,~~ EDB reductions were greater than ~~97~~99% in ~~the~~ all six shallow wells, with five ~~our of the wells exhibiting greater than two-log reductions (99%), and two~~ of the wells exhibiting greater than three-log reductions (99.9%). Further, ~~three~~ four of the shallow wells were below the EPA MCL of 0.05 µg/L (EPA, 2009) for EDB during their most recent sampling event (Figure 8). ~~Except for decreases of toluene at two shallow wells during the most recent sampling, and at intermediate wells, r~~Reductions of benzene and toluene were ~~much~~ more limited. The large and rapid reductions in EDB concentrations in an environment conducive to reductive debromination strongly suggests that *in situ* anaerobic biodegradation of EDB occurred.

EDB Degradation Products

Reductive debromination of EDB by various debrominating organisms often results in stoichiometric production of one mole of ethene and two moles of bromide for each mole of EDB reduced (Koster van Groos et al, 2018). Under reducing conditions, ethene can also be further transformed to ethane, and both gases as well as bromide are reasonably stable under anaerobic conditions. Elevated concentrations of these degradation products can provide additional evidence of reductive debromination of EDB under both baseline conditions and during pilot test efforts. During laboratory studies (Koster van Groos et al, 2018), a minor branching product of tentatively identified vinyl bromide was observed during slower EDB hydrolysis conditions, but vinyl bromide was not detected during anaerobic biodegradation studies. Sequential hydrogenolysis of EDB to bromoethane and then ethane is also possible (Henderson et al., 2008). Accurate measurement of trace concentrations of vinyl bromide or bromoethane products, as might be expected given relatively low parent EDB concentrations, is challenging and was not attempted during this pilot test.

~~Based~~ Assuming~~the assumption of~~ stoichiometric conversion of EDB to ethene and ethane during reductive debromination and that contributions of ethene and ethane from sources other than EDB were negligible, ~~and its stoichiometry, equivalent~~ quantities of EDB degraded by this mechanism were~~can be~~ estimated using measured concentrations of ethene and ethane:

$$\boldsymbol{C_{EDB-degraded} = MW_{EDB} * \left(\frac{C_{ethene}}{MW_{ethene}} + \frac{C_{ethane}}{MW_{ethane}}\right)}$$

w~~W~~here *C* indicates concentrations in units of mass per volume, and *MW* indicates the molecular weights of the respective compounds. Figures 33 and 34 show estimated ~~equivalents~~ quantities of EDB degraded through this mechanism based on the formation ~~quantities~~ of ethene and ethane products observed at the shallow and intermediate wells, respectively. In shallow wells, estimates of~~d~~ ~~equivalents of~~ EDB degraded ~~converted~~ to ethene and ethane during the baseline evaluation ranged from approximately 20 μg/L at KAFB-106EX1 to over 130 μg/L at both KAFB-106064 and KAFB-106MW2-S, indicating that there was likely EDB debromination occurring prior to any pilot test activities. During the Phase 1 recirculation period, these estimates of EDB ~~equivalents~~ degraded decreased and ranged from 5 μg/L (KAFB-106MW2-S and KAFB-106EX2) to 24 μg/L (KAFB-106064). Many geochemical measures (e.g., sulfate, iron, methane) indicated more oxidizing conditions during this recirculation period, which may be attributed to redistribution of the low concentrations of DO observed at KAFB-106EX1 throughout the treatment zone. The small quantities of DO introduced during this process may have helped facilitate some ethene and ethane consumption. During the Phase 1 passive period, increases in estimates of EDB ~~equivalents~~ degraded based on ethene and ethane were noted, which is consistent with the decreases in EDB concentrations during this period described earlier, providing further evidence of EDB degradation prior to biostimulation efforts.

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 such estimate of EDB ~~equivalents~~ degraded occurred at KAFB-106MW1-S after Phase 3 biostimulation efforts with an estimated concentration of approximately 270 µg/L. This is also the location where the highest initial EDB concentrations were noted during the baseline evaluation with a concentration of over 400 µg/L. During Phase 4, the highest estimate of EDB degraded occurred at KAB-106EX2 with an estimated maximum concentration of approximately 309 µg/L. Extraction well KAFB-106EX2 also had a high initial EDB concentration of 143 µg/L measured during the baseline evaluation, and NAPL was observed in this well during Phase 4. ~~Interestingly, d~~Decreases in ethene and ethane occurred with time at several wells ~~the injection well (KAFB-106IN1) and KAFB-106MW2-S~~ during ~~the Phase 2 and Phase 3~~ passive periods, despite large EDB reductions at these locations. This decrease in ethene and ethane could indicate slowed production of these compounds due to the lower parent EDB concentrations, together with some ethene or ethane degradation or partitioning into gas-phase pockets that may be present due to methanogenesis. As described in Section 4.4, very high methane concentrations were observed at ~~these~~ several wells that could reflect the presence of gas-phase methane.

Reductive debromination of EDB ~~often~~ can result~~s~~ in the production of two moles of bromide for each mole of EDB degraded. ~~However, t~~Two challenges for examining bromide released during this process are the presence of bromide in background water and that expected bromide released from EDB could be quite small. For example, degradation of 100 µg/L of EDB results in release of just 0.085 mg/L of bromide, which may be challenging to measure. One method for distinguishing the release of bromide from background water is to examine the ratio of bromide to chloride as these anions are typically correlated due to their frequent common sources. Deviation from a constant ratio in favor of greater bromide might indicate a unique source of bromide, such as EDB debromination.

Figure 35 shows concentrations of bromide vs. chloride for all the wells of the pilot test, and Figures 36 and 37 show the bromide to chloride ratio with time for the shallow and intermediate wells, respectively. The dashed red line in each of these figures approximates the background ratio of 0.~~0089~~ 0079 based on previous studies (Kirtland AFB~~USACE~~, 2016b). Examining these figures, very few samples were enriched in chloride relative to bromide compared to the background, but many samples were enriched in bromide. 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. There was also a significant increase in bromide to chloride ratio in shallow wells KAFB-106EX1, KAFB-106MW2-S, and KAFB-106MW1-S towards the end of Phase 4. 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. One explanation for this large excess of bromide could be stimulation of debrominating organisms within the treatment zone and continuing release and degradation of EDB from a separate phase source (e.g. NAPL), which would certainly be of interest.

Carbon Isotope Analysis of EDB

Examining the isotope composition of pollutants provides a novel measure of their degradation (Hunkeler et al., 2008, Wilson et al., 2008). 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). Biological and abiotic degradation of EDB both result in changes in the isotope composition of EDB, and differences in reaction rates between the two EDB species are generally within 4% of each other. The isotope composition of EDB does not shift as a result of dilution and volatilization is expected to have negligible impact on isotope composition under site conditions. As such, a shift in EDB δ^{13}C from more negative values to more positive values (corresponding to an increase in relative ^{13}C abundance) provides additional evidence of EDB degradation. Figure 38 shows δ^{13}C values of EDB sampled at shallow monitoring wells during the pilot test, as well as of EDB extracted from the NAPL recovered at well KAFB-106MW1-S during baseline studies. Unfortunately, it was not possible to measure the isotope composition of each sample, as low EDB concentrations and high concentrations of other VOCs, such as benzene and toluene complicated the analyses.

The δ^{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. This is consistent with the other measures of EDB degradation discussed earlier and as shown in Table 17 and Figure 32. The baseline evaluation performed with samples collected prior to the pilot test included EDB δ^{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. δ^{13}C values of EDB during passive periods of the pilot test were typically more positive than preceding recirculation periods, providing further evidence of enhanced degradation during passive periods. δ^{13}C of EDB at KAFB-106064 and KAFB-106MW2-S increased between baseline measurements and the first passive period, suggesting EDB degradation after initial recirculation efforts prior to the introduction of biostimulation amendments, consistent with observed decreases in EDB concentration at these locations. The highest δ^{13}C value of EDB (+5‰) was from a sample collected at KAFB-106EX1 during the Phase 2 passive period and represents a large shift in isotope composition and significant EDB degradation. ~~, yet w~~We suspect, however, that if isotope analyses were feasible with lower concentration samples, even higher δ^{13}C values would have been observed at several of the wells. Overall, the increases in δ^{13}C values of EDB observed provide strong supporting evidence that EDB degraded during the pilot test. Additionally, while isotope fractionation can result from both biological and abiotic degradation mechanisms, the relatively rapid shifts and other lines of evidence noted during the pilot test suggest that the shift in isotope composition was likely the result of biodegradation processes. ~~Overall, the increases in δ^{13}C values of EDB observed provide strong supporting evidence that EDB degraded during the pilot test.~~

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5. CONCLUSIONS

5.1 Conclusions

The primary objective of this pilot test was to demonstrate anaerobic ISB as a treatment technology targeting EDB in impacted groundwater at Kirtland AFB. Based on the pilot test data reviewed here, the following conclusions regarding the effectiveness of ISB for EDB treatment were made:

- Enhanced ISB of EDB was successfully demonstrated (see Figure 32 and Figure 8). EDB degradation was evident during the pilot test with a greater than two-log reduction (>99%) at all wells examined.~~EDB degradation was evident during the pilot test with a greater than three-log reduction (99.9%) to below the EPA MCL of 0.05 µg/L at wells KAFB-106MW2-S and KAFB-106064 after biostimulation efforts.~~ While meeting the EPA MCL of 0.05 µg/L was not a specific objective of the pilot test, only two of the wells, KAFB-106MW2-S (0.087 µg/L) and KAFB-106EX2 (0.36 µg/L), exceeded this level ~~EDB~~ during the October 2020 sampling event. EDB degradation was evident through comparison with benzene and toluene concentrations, and the production of EDB degradation products ethene, ethane, and bromide suggested that this degradation occurred by reductive debromination. Higher EDB $\delta^{13}C$ values (observed to be as high as +5‰ at KAFB-106EX1) provided additional isotopic evidence of EDB degradation.

- Baseline measurements indicated that EDB was likely degrading prior to the pilot test. QuantArray-Chlor analyses indicated that microorganisms likely capable of degrading EDB were present during the baseline assessment and throughout the pilot test. During the baseline assessment, degradation products of reductive debromination (e.g., ethene, ethane, bromide) were present in the groundwater and EDB was observed to have more positive $\delta^{13}C$ values (up to -5‰). These all indicate EDB degradation prior to ISB treatment.

- Tracer and biostimulation amendments were distributed throughout the treatment zone, with highest concentrations of iodide and propionate observed at wells KAFB-106MW1-S, KAFB-106MW2-S, and KAFB-106064 (see Figure 13 and 17). The continued presence and consistency among iodide concentrations through Phase 4 indicates that groundwater influx at the site has been limited.
- Measurements of DO, sulfate, iron, and methane indicate that reducing conditions favorable for reductive debromination of EDB were achieved throughout the site.

During the pilot test, the performance of one extraction well (KAFB-106EX2) and the injection well (KAFB-106IN1) deteriorated, but the performance of these wells remained sufficient to finish the pilot test. Well maintenance such as mechanical and/or chemical rehabilitation may be required for long-term viability.

- ~~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.~~

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- Continued quarterly monitoring at all nine pilot test wells for the parameters specified in the Work Plan (Kirtland AFB, 2016a) may be unnecessary, and it is recommended that future monitoring proceed only at wells KAFB-106063 and KAFB-106064 in accordance with the most recently approved groundwater monitoring work plan. Based on recent groundwater results and in accordance with the Work Plan (Kirtland AFB, 2016a), sampling at seven wells associated with the pilot test should be complete (KAFB-106MW1-S, KAFB-106MW1-I, KAFB-106MW2-S, KAFB-106MW2-I, KAFB-106EX1, KAFB-106EX2, and KAFB-

106IN1). Significant rebound of EDB was not observed during Phase 4 passive monitoring and sampling a subset of pilot test groundwater monitoring wells consistent with site-wide monitoring efforts can provide representative information regarding long-term pilot test performance.

- The pilot test is complete and it is recommended that aboveground components of the groundwater recirculation system and other infrastructure be removed from the site. No final remedy has been selected at this time for the BFF site and this equipment is currently not required. All groundwater monitoring, extraction, and injection wells associated with the pilot test will remain in place.

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NMED. 2019. February 25, 2019 correspondence from Mr. John Kieling, Bureau Chief 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: Bulk Fuels Facility Spill, Solid Waste Management Unit ST-106/SS-11, Kirtland Air Force Base, EPA ID# NM9570024423,*

HWB-KAFB-19-MISC.

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NEW MEXICO
ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6313
Phone (505) 476-6000 Fax (505) 476-6030
www.env.nm.gov

Michelle Lujan Grisham
Governor

Howie C. Morales
Lt. Governor

James C. Kenney
Cabinet Secretary

Jennifer J. Pruett
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

MAR 04 2020

Colonel David S. Miller
Base Commander
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB, NM 87117

Lt. Colonel Wayne J. Acosta
Civil Engineer Office
377 Civil engineer Division
2050 Wyoming Blvd SE, Suite 116
Kirtland AFB, NM 87117

RE: 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

Dear Colonel Miller and Lt. Colonel Acosta:

The New Mexico Environment Department (NMED) is in receipt of the Kirtland Air Force Base (Permittee) *Ethylene Dibromide In Situ Biodegradation Pilot Test Report* (Report), dated April 2019. NMED has reviewed the Report and hereby issues this Disapproval. Although the Permittee demonstrated that in-situ biodegradation of 1,2-dibromoethane (EDB) had occurred during the pilot test, deficiencies were identified throughout the Report. This should not be construed to mean that the approach would be an effective remedial option, but simply that biodegradation of EDB was observed to occur during the pilot test.

The attached comments are related to general inadequacies and inaccuracies, technical inadequacies and inaccuracies, and direction for future light nonaqueous phase liquids (LNAPL) delineation and mitigation. Determining the extent of LNAPL is necessary for establishment of an effective monitoring system and the evaluation of future remedial alternatives. The Permittee must address the attached comments.

The Permittee must submit a revised Report that addresses all comments contained in the attachment to this Disapproval. Two hard copies and an electronic version of the revised Report must be submitted to the NMED. The Permittee must also include a redline-strikeout version in electronic format showing where all revisions to the Report have been made. The revised Report must be accompanied with a response letter that details where all revisions have been made, cross-referencing NMED's numbered comments. The Revised Report must be submitted to NMED no later than **June 5, 2020**.

Should you have any questions or wish to meet with us to discuss these comments, please contact me at (505) 476-6035 or have your staff contact Michiya Suzuki of my staff at (505) 476-6046.

Sincerely,

Kevin M. Pierard, Chief
Hazardous Waste Bureau

cc: D. Cobrain, NMED HWB
B. Wear, NMED HWB
M. Suzuki, NMED HWB
L. King EPA Region 6 (6LCRRC)
S. Clark, KAFB
K. Lynnes, KAFB

File: KAFB 2020 Bulk Fuels Facility Spill and Reading

Attachment

GENERAL 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.

SPECIFIC COMMENTS

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.

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.

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.

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-106IN1 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-106IN1. 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.

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 additional explanation regarding other vessels/methods that did not appear to demonstrate EDB degradation in the revised Report.

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).

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.

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 headspace 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.

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-106IN1 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.

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-I) 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. 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.

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.

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.

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.

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.

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.

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.

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).

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.

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.

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.

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.

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).

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.

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).

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.

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.

29. Section 3.7, NAPL Sampling, page 3-13

Permittee Statement: "The δ^{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} 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.

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 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.

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.

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.

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-106IN), 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 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 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).

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.

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.

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.

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.

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, *DSB 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.

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.

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.

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.

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(III) 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.

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 Chatelier's principle). Regardless, the increased methane production is merely an indicator of bacterial activity but not necessarily effective remediation. No revision or response required.

45. Section 4.5.1, Benzene and Toluene, page 4-14

Permittee Statements: "With the exception of the injection well (KAFB-106IN1) 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.

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 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.

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.

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.

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).

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.

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 δ2H 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.

53. Figure 13, Iodide Concentrations – Shallow Wells

NMED Comment: The tracer concentrations in injection well KAFB-106IN1 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.

54. Figure 15, Lactic Acid Concentrations – All Wells (Except 106IN1)

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.

NEW MEXICO
ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6313
Phone (505) 476-6000 Fax (505) 476-6030
www.env.nm.gov

Michelle Lujan Grisham
Governor

Howie C. Morales
Lt. Governor

James C. Kenney
Cabinet Secretary

Jennifer J. Pruett
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

APR 0 2 2020

Colonel Christopher J. King
Vice Commander
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB, NM 87117

RE: REQUEST FOR EXTENSION
RESPONSE TO DISAPPROVAL FOR THE
ETHYLENE DIBROMIDE IN-SITU BIODEGRADATION REPORT
BULK FUELS FACILITY SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO
EPA ID# NM6213820974
HWB-KAFB-20-001

Dear Colonel King:

Thank you for your letter of March 26, 2020, regarding the NMED Disapproval of the EDB Bioremediation Report for KAFB. Our Disapproval cited several deficiencies in the report as well as several observations concerning the study itself. The intent of the pilot study was not only to determine if the bioaugmentation and biostimulation enhanced EDB biodegradation, but also to ascertain the scalability of the approach and its potential inclusion of this option in any array of feasible remedial alternatives.

At the conclusion of the pilot study many questions remained. It was clear that EDB biodegradation had occurred, but the study also raised other questions concerning breakdown products and the physical design of the wells that are important considerations in any decision to move forward with the technology. This does not represent a failure of the pilot. In fact, it is to be expected that pilots such as this answer the immediate question, provide insights for future work, and identify additional questions that must be answered before a decision is made on the acceptability of the approach.

We agree, as I mentioned in a follow up e-mail to your staff, that the scope of the pilot was not to determine the extent of LNAPL. However, the presence or absence of LNAPL is very important to the success or failure of biodegradation and was prominently highlighted in the workplan. As you mention, the presence and distribution of LNAPL in the vadose and saturated zones is critical to defining the nature and extent of contamination and evaluating potential corrective measures. Bioremediation can be one potential component of any corrective measure. Understanding the limits of this technology and how the technology could be most efficiently deployed must be a goal during the study phase. Understanding such issues at an early stage will allow us to efficiently and cost effectively proceed to a remedy evaluation and ultimate remedy selection. To that end, our comments in the March 4, 2020 Disapproval included questions and concerns that remain regarding the implementation and potential success of this technology. If some of our comments were misinterpreted by your staff, a teleconference would be helpful to resolve any misunderstandings. Your letter requests a meeting with NMED to discuss the Disapproval. We will reach out to your staff to arrange this teleconference.

Regarding the continuation of monitoring associated with this pilot, I want to acknowledge receipt of the In-Situ Bioremediation Long Term Monitoring Workplan and advise that this plan does not require NMED approval. We hope that you will use the information provided in our March 4, 2020 Disapproval to support the ongoing assessment of the efficacy of bioremediation. Once the results from this continued monitoring effort are available, please submit them as a supplement to the existing Report. This approach should make any extension of time for submittal of the revised report unnecessary. However, in order to assure KAFB has sufficient time to make the necessary changes to the Report and, in light of workload challenges associated with the COVID-19 pandemic, we are extending the due date for a response to our Disapproval to September 18, 2020.

I appreciate your dedication to this project, and we look forward to continued work with you and your staff toward its completion. Should you or your staff have any questions, please contact me at (505) 476-6035.

Sincerely,

Kevin M. Pierard, Chief
Hazardous Waste Bureau

cc: Stephanie Stringer, Director NMED RPD
Colonel David S. Miller, Base Commander KAFB
D. Cobrain, NMED HWB
B. Wear, NMED HWB
M. Suzuki, NMED HWB
L. King EPA Region 6 (6LCRRC)
S. Kottkamp, KAFB
K. Lynnes, KAFB

File: KAFB 2020 Bulk Fuels Facility Spill and Reading

NEW MEXICO
ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6313
Phone (505) 476-6000 Fax (505) 476-6030
www.env.nm.gov

Michelle Lujan Grisham
Governor

Howie C. Morales
Lt. Governor

James C. Kenney
Cabinet Secretary

Jennifer J. Pruett
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

September 25, 2020

Colonel Ryan S. Nye, USAF
Vice Commander
377th Air Base Wing
2000 Wyoming Blvd SE
Kirtland AFB NM 87117

RE: APPROVAL - REQUEST FOR EXTENSION
RESPONSE TO COMMENTS FOR THE MARCH 4, 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

Dear Colonel Nye:

The New Mexico Environment Department (NMED) has received Kirtland Air Force Base (Permittee) *Response to Comments for the March 4, 2020 Disapproval Ethylene Dibromide In Situ Biodegradation Pilot Test Report, Bulk Fuels Facility, Solid Waste Management Units ST-106/SS-111* (RTC)*,* dated September 8, 2020 and received on September 11, 2020.

The RTC raises several points of concern that I would like to address. The first and second issues pertain to concerns regarding the scope of the Ethylene Dibromide (EDB) Biodegradation Pilot Test. This issue was raised previously and responded to by NMED. Rather than restating our response I have enclosed an e-mail to your staff as well as a letter to Colonel King that speaks to this issue. NMED concluded that the comments in the Notice of Disapproval (NOD) were consistent with the scope of the approved work plan.

The RTC goes further to suggest that the NOD does not reflect the agreement that the

Permittee may rely upon commitments and directions from NMED. The comments contained in the NOD relate directly to the NMED approved work plan and, as such, are consistent with our agreement. The NOD does not contain comments unrelated to the scope of the approved work plan nor is the NOD based on a "failure" of the pilot to address delineation of light non-aqueous phase liquid (LNAPL) as suggested in the RTC. In fact, in NMED's letter to Colonel King, it was noted that the questions and concerns raised during the pilot do not represent a failure of the pilot. Addressing these issues and concerns early in the process will allow NMED to collaboratively consider the viability, scalability, and potential deployment of this technology in a robust, data-driven corrective measures evaluation (CME).

The third issue raise in the RTC is the inclusion of "global issues" for future work. This issue was raised by your staff in regard to other NMED correspondence related to the Facility. NMED agreed to provide a consolidated, stand alone, listing of such issues to assure they can be broadly addressed in future correspondence to NMED. This letter was issued by NMED in September 2, 2020.

Regarding the fourth issue associated with technical comments and clarifying questions, NMED is anxious to discuss these items in order to assist the Permittee in responding to the NOD.

Finally, the RTC states, "[t]o 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 [In Situ Biodegradation] Pilot [R]eport 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." Although we welcome the opportunity to discuss the response to comments contained in the RTC, NMED is not able to commit to a meeting on this topic in September due to the late request and competing priorities at NMED. My staff will work with your staff to set up a call focused on the technical issues raised in our NOD. Your request for an extension of time to submit the revised report to **November 20, 2020** is approved.

If you have any questions, please contact me at (505) 476-6035.

Sincerely,

Kevin M. Pierard, Chief
Hazardous Waste Bureau

Enclosures

cc: D. Cobrain, NMED HWB

B. Wear, NMED HWB
M. Suzuki, NMED HWB
L. King EPA Region 6 (6LCRRC)
S. Kottkamp, KAFB
K. Lynnes, KAFB
C. Cash, KAFB

File: KAFB 2020 Bulk Fuels Facility Spill and Read

NEW MEXICO
ENVIRONMENT DEPARTMENT

Harold Runnels Building
1190 Saint Francis Drive, PO Box 5469
Santa Fe, NM 87502-5469
Telephone (505) 827-2855
www.env.nm.gov

Michelle Lujan Grisham
Governor

Howie C. Morales
Lt. Governor

James C. Kenney
Cabinet Secretary

Jennifer J. Pruett
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

January 25, 2021

Colonel David S. Miller
Base Commander
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB, NM 87117

Lt. Colonel Wayne J. Acosta
Civil Engineer Office
377 Civil engineer Division
2050 Wyoming Blvd SE, Suite 116
Kirtland AFB, NM 87117

RE: APPROVAL – SECOND REQUEST FOR EXTENSION TO SUBMIT THE RESPONSE TO COMMENTS FOR THE MARCH 4, 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

Dear Colonel Miller and Lt. Colonel Acosta:

The New Mexico Environment Department (NMED) has received the Kirtland Air Force Base (Permittee) second request for an extension of time to submit the revised *Ethylene Dibromide In Situ Biodegradation Pilot Test Report*, (Report)dated November 11, 2020. The revision was required by NMED's March 4, 2020 Disapproval Ethylene Dibromide In Situ Biodegradation Pilot Test Report, Bulk Fuels Facility, Solid Waste Management Units ST-106/SS-111 (NOD). A Draft Response to Comments (RTC) table addressing NMED's comments and the Permittee's first request for an extension of time was submitted to NMED on September 11, 2020. The time extension was approved by NMED on September 25, 2019. The current request for an extension of time also includes a request for a meeting to discuss the Permittee's draft comments.

NMED has expressed, for several months, its willingness to meet to discuss the NOD in further detail. We remain willing to meet with you and your staff.

The Air Force's request for a second extension of time to submit the revised report to NMED is hereby approved. The revised Report and response to comments must be submitted no later than **March 19, 2021.**

If you have any questions, please contact me at (505) 629-6494.

Sincerely,

Kevin M. Pierard, Chief
Hazardous Waste Bureau

cc: D. Cobrain, NMED HWB
B. Wear, NMED HWB
M. Suzuki, NMED HWB
L. Andress, NMED HWB
S. Kottkamp, KAFB
K. Lynnes, KAFB
C. Cash, KAFB
D. Agnew, ABCWUA
A. Tafoya, VA

File: KAFB 2020 Bulk Fuels Facility Spill and Reading

Description: High Mesa potholing for utilities at KAFB-106IN1.

Description: Cascade drilling with ARCH rig; lifting drive casing and drill string.

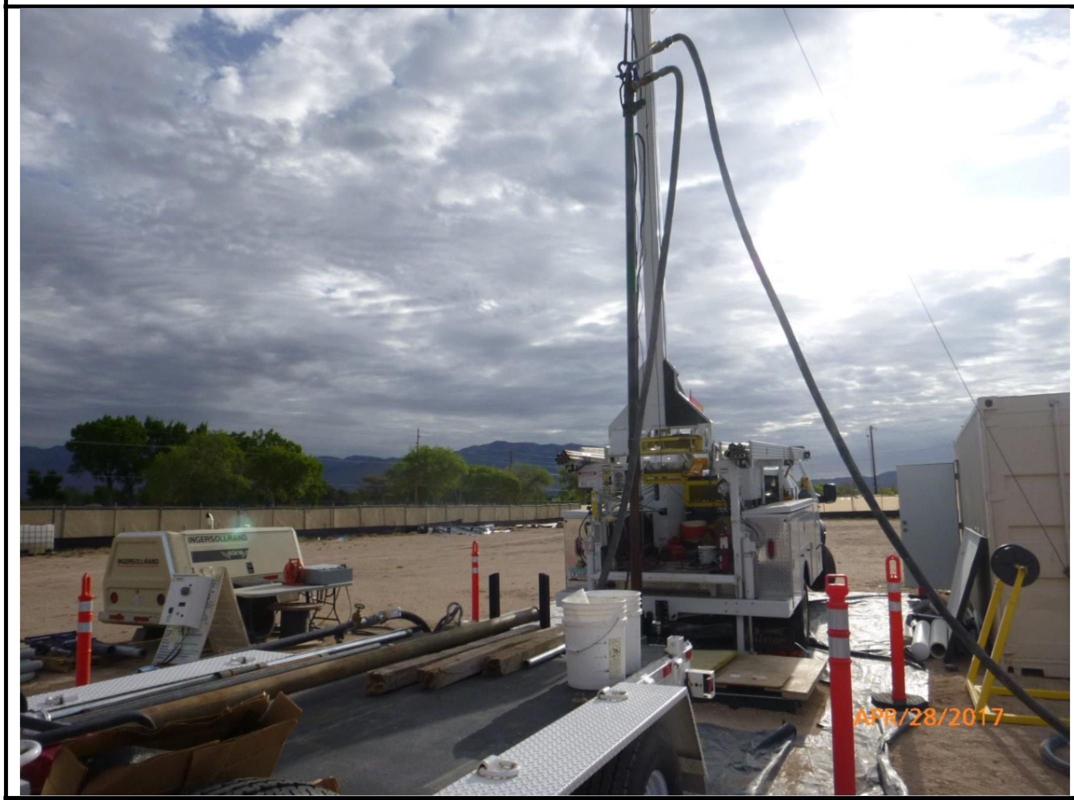
Description: Geologist collecting soil cuttings from hopper during drilling operations for lithologic classification.

Description: EZ Trac ready for downhole deviation testing.

Description: Cascade installing PVC casing during well installation activities.

Description: ACT removing roll-off containing soil cuttings.

Description: Cascade well development rig setup.



Description: Well development setup at KAFB-106IN1, with jetting tool.

Description: Installing KAFB-106EX1 well vault and trenching for utilities/pipeline.

Description: Installing Grunfos pump at KAFB-106EX2.

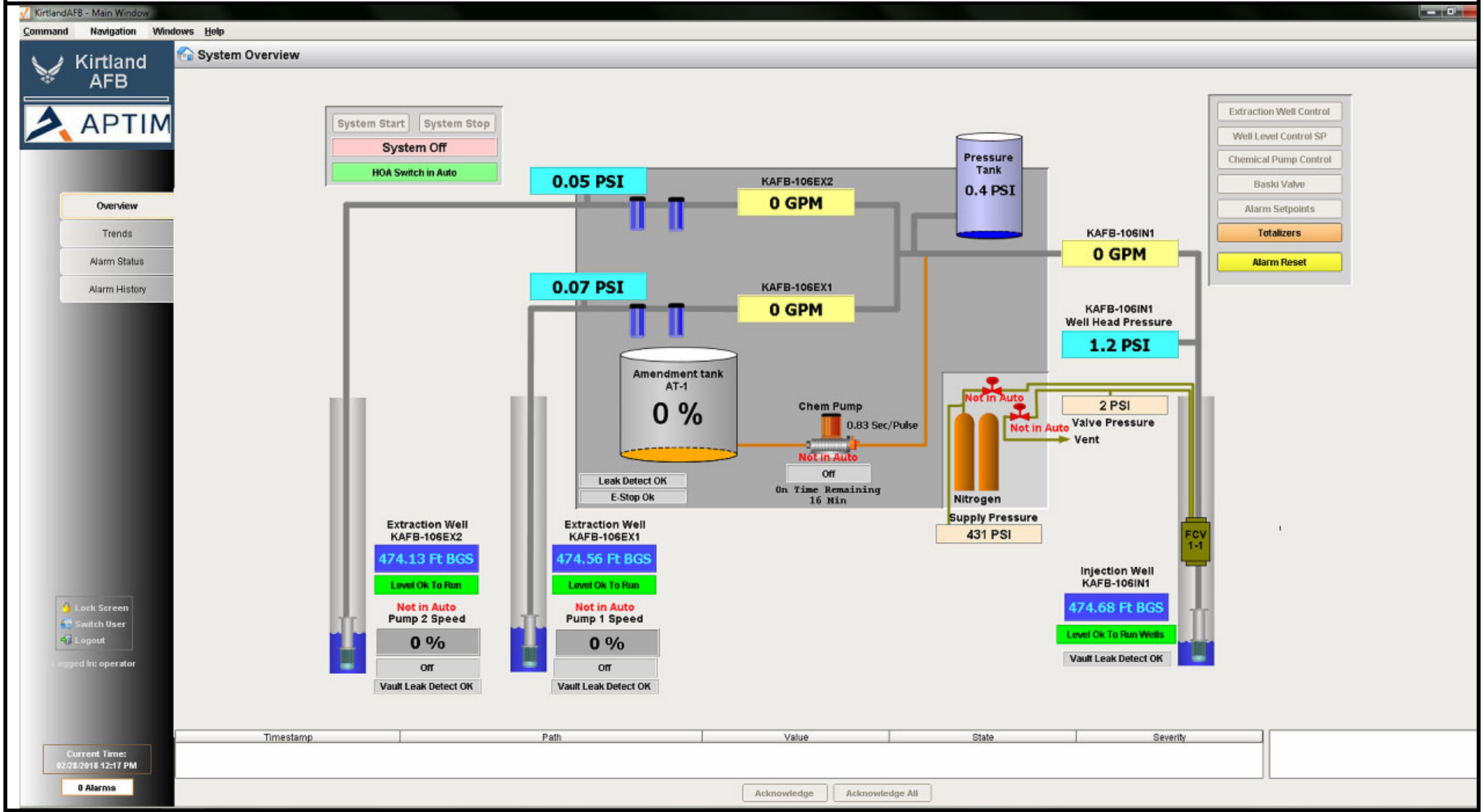
Description: Recirculation system conex box prior to connection to electrical and conveyance piping.

Description: Trenching to place conveyance piping.

Description: Interior of conex box recirculation system (wet side); showing extraction and injection well piping, amendment tank, flow meters (yellow), pressure transmitters, emergency stop button, and blue filter canisters.

Description: Interior of recirculation system control room.

Description: Working on the main electrical disconnect and meter wiring.

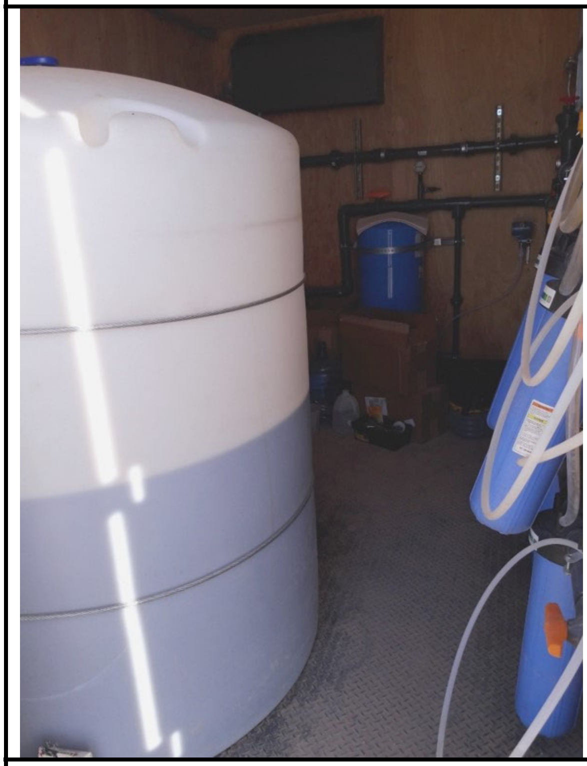


Description: SCADA system main control screen, allowing both local and remote access and control of the recirculation system.

Description: Description: Fluorescein being introduced to the recirculated groundwater through the injection port, and flowing through the static mixer during Phase 1 tracer test.

Description: Chemical feed pump (right) and calibration column.

Description: Weighing amendments for Phase 2 recirculation.



Description: Treatment amendments homogenized in tank and ready for injection.

Description: Completed extraction/injection well vault and wellhead manifold.

Description: NAPL bailed from KAFB-106MW1-S.

Description: Groundwater sampling at KAFB-106MW2.

Description: Groundwater sampling setup with high pressure controller for bladder pump.

BASE CIVIL ENGINEER DIGGING PERMIT REQUEST

DATE 7/20/16

Dig Permit #: 1607-014

LOCATION: Kirtland AFB NOV Response Contract

CONTRACT NO., WORK ORDER NO., ECT: W9128F-12-D0003

IMMEDIATE EMERGENCY ____________ NORMAL X

PLANNED DIG DATE August 15, 2016

Detailed description of work (holes, trenching, etc):
- Install 5 wells to approx. 510 feet bgs.
- Trench to 3 feet bgs to install utilities. (250 feet)

PRINTED NAME OF RESPONSIBLE REQUESTOR: CAITLIN LACHANCE

CONTACT INFORMATION:
Primary: 505.328.4710
Alternate: 505.262.8942

Organization/Company Name: CB:I Federal Services

I understand that that authorization to dig is conditional upon completing the entire form and compliance with the guidelines briefed as well as compliance with applicable OSHA, AFI and AFOSH requirements. I understand the exact location of a buried line may be located approximately four (4) feet on either side of the marked location.

COORDINATING ORGANIZATION		COORDINATORS ACTIONS & REMARKS			COORDINATORS NAME & PHONE
UTILITIES	ELECTRICAL DISTRIBUTION 846-8145	☐ Marked ☑ Clear	Remarks:		
	DOMESTIC AND RAW WATER 846-7863 / 846-1552	☐ Marked ☑ Clear	Remarks:	Pothole	
	SEWER MAINS 846-7863 / 846-1552	☑ Marked ☐ Clear	Remarks:		
	GAS MAINS 846-7863 / 846-1552	☐ Marked ☑ Clear	Remarks:		
OPERATIONS	PAVEMENTS & STORM DRAINS 846-5650 / 846-2994	☐ Marked ☑ Clear	Remarks:		
	IRRIGATION 846-1803	☐ Marked ☑ Clear	Remarks:		
	ELECTRICAL 853-6493	☐ Marked ☑ Clear	Remarks:		
	CATHODIC PROTECTIONS CECX 846-4633	☐ Marked ☑ Clear	Remarks:		
	TRAFFIC & ALARMS 853-6495	☐ Marked ☑ Clear	Remarks:		
	FUEL/POL LINES 934-2733	☑ Marked ☐ Clear	Remarks:		
	LP GAS, WATER AND SEWER SERVICE LINES/LATERALS 846-5293 / 934-9664	☑ Marked ☐ Clear	Remarks:	Pothole	
	FIRE PROTECTION SYSTEMS 846-5293 / 934-9664	☑ Marked ☐ Clear	Remarks:		
CEC	ENVIRONMENTAL Bldg 20685 846-3774	☐ Marked ☑ Clear	Remarks:	See notes - Env	
OTHER BASE AGENCIES	BIO-ENVIRONMENTAL Bldg 589 846-2670	☐ Marked ☑ Clear	Remarks:	See notes - Bio	
	EOD Bldg 20413 846-2229	☐ Marked ☑ Clear	Remarks:		
	COMMUNICATIONS Bldg 20420 846-8411	☐ Marked ☑ Clear	Remarks:		
	SECURITY POLICE Resource Protection Bldg 20220 846-6209	☐ Marked ☑ Clear	Remarks:		
	FIRE DEPARTMENT 846-8305	☐ Marked ☑ Clear	Remarks:		
	WEAPONS SAFETY 841-4229	☐ Marked ☑ Clear	Remarks:		
	GROUND SAFETY 853-0268	☐ Marked ☑ Clear	Remarks:	See notes - SEG	
	OTHER AS REQUIRED	☐ Marked ☐ Clear	Remarks:	NA	
	HUNT COMPANIES (PRIVATIZED HOUSING)	☐ INITIALS ☐ DATE		Applicant acknowledges that they must contact Hunt corporations for locating Hunt utilities prior to excavation.	
	COMMERCIAL UTILITIES New Mex ONE CALL 260-1990 48 Hours before digging				

CLEARANCE IS : ☐APPROVED (For 30 Days from Approval date) ☐DISSAPPROVED (Reason)

APPROVING CIVIL ENGINEERING SIGNATURE

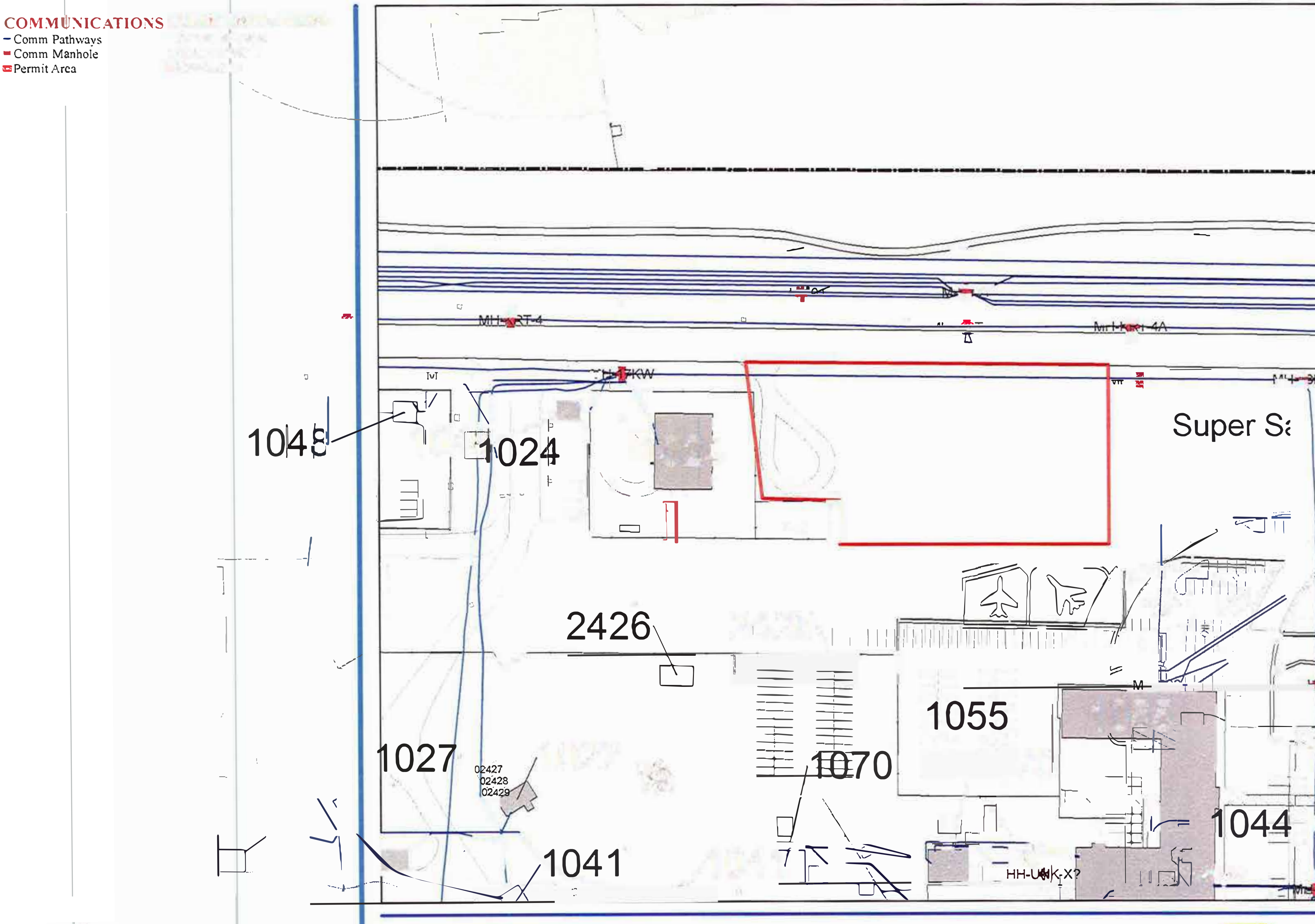
APPROVAL DATE 8/15/16

EXPIRATION DATE 9/15/16

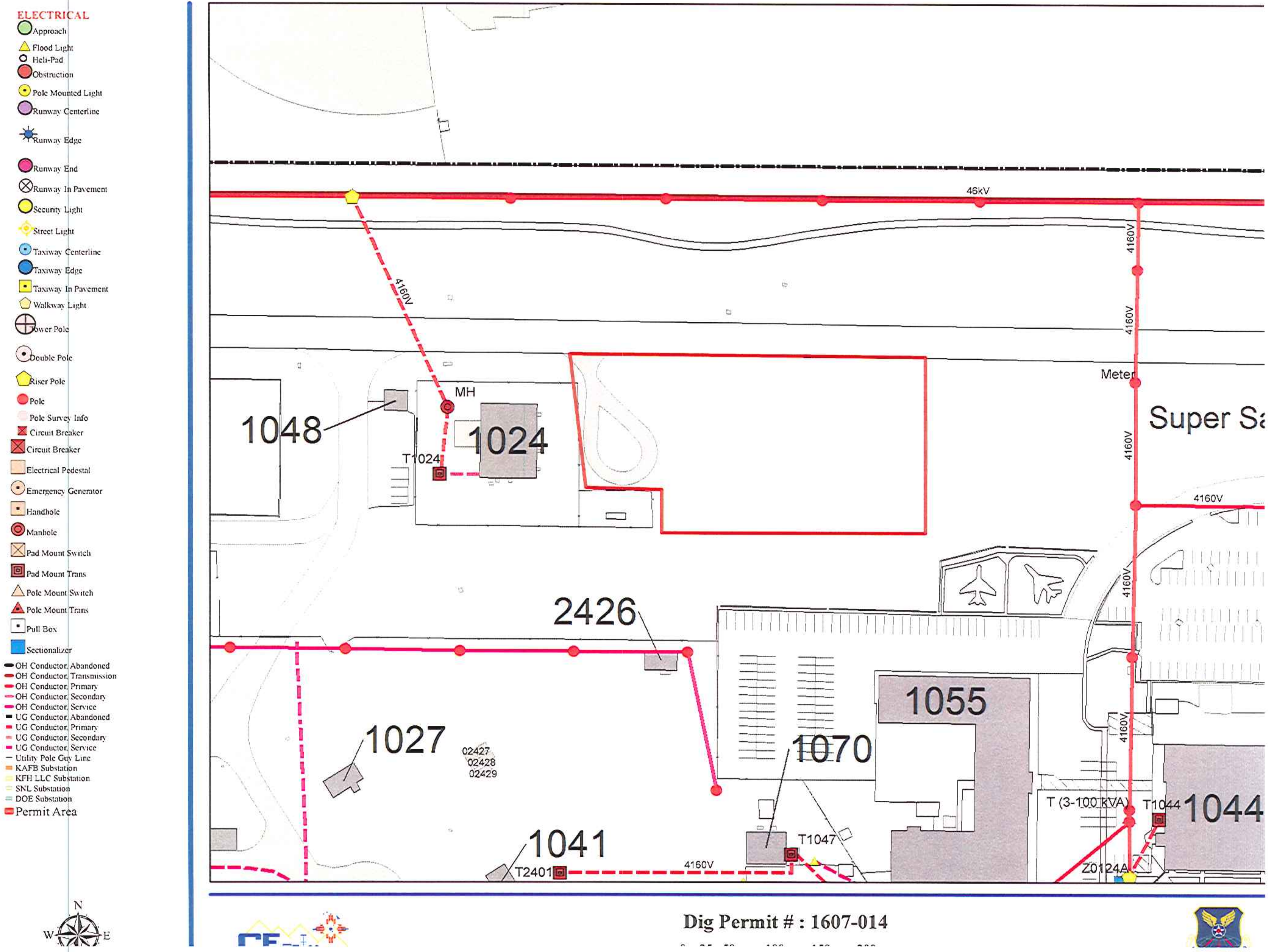
A COPY OF THIS APPROVED FORM MUST BE AT THE DIGGING SIGHT UNTIL COMPLETE

DIG PERMIT FORM 103
KAFB SPECIFIC

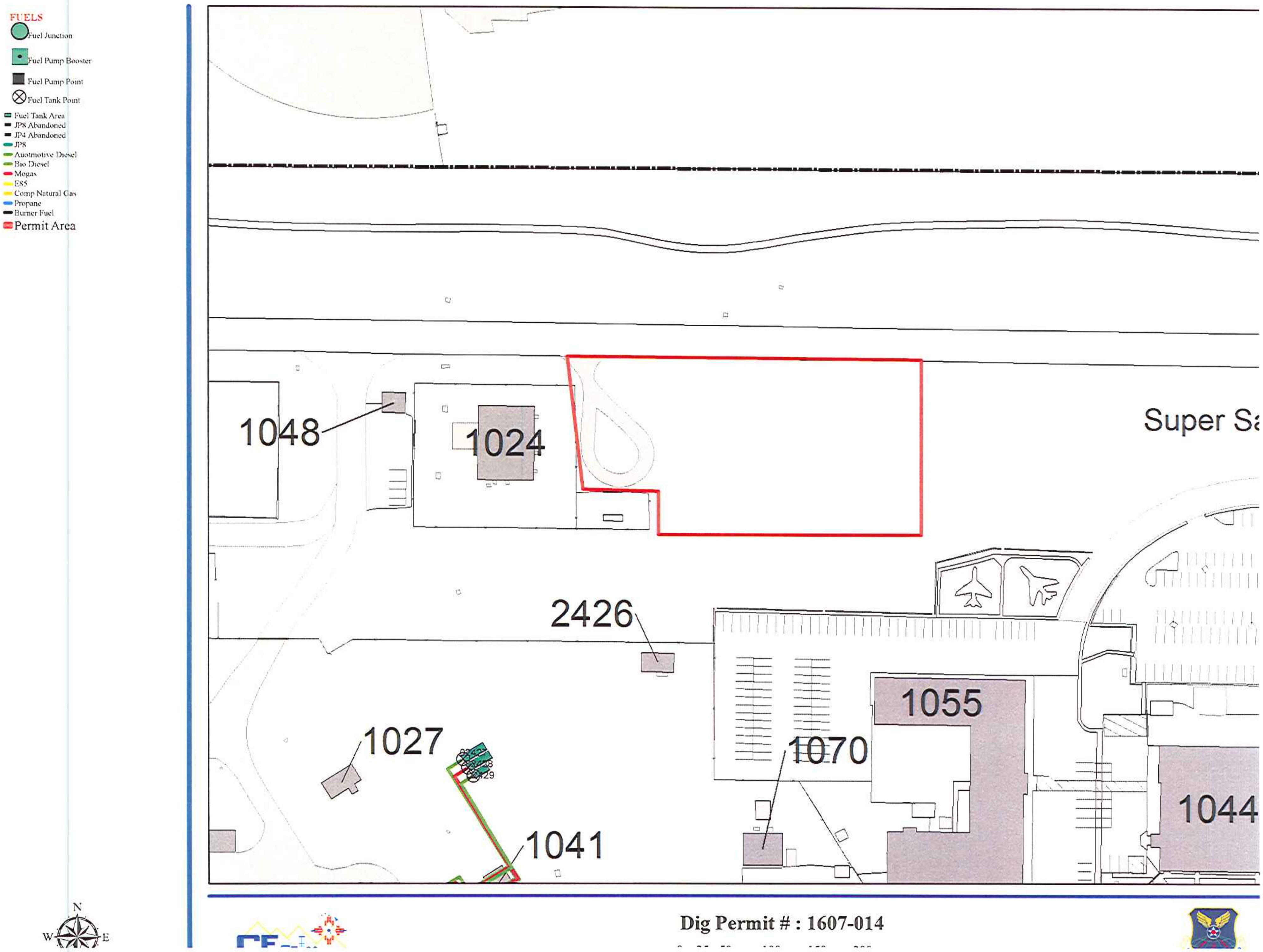
CHANGE 4
DATE: March 2014



Dig Permit # : 1607-014



Dig Permit # : 1607-014


FUELS
Fuel Junction
Fuel Pump Booster
Fuel Pump Point
Fuel Tank Point
Fuel Tank Area
JP8 Abandoned
JP4 Abandoned
JP8
Auotmotive Diesel
Bio Diesel
Mogas
E85
Comp Natural Gas
Propane
Burner Fuel
Permit Area
1048
1024
Super Sa
2426
1055
1027
1070
1044
1041
N
W
E
Dig Permit # : 1607-014

GAS

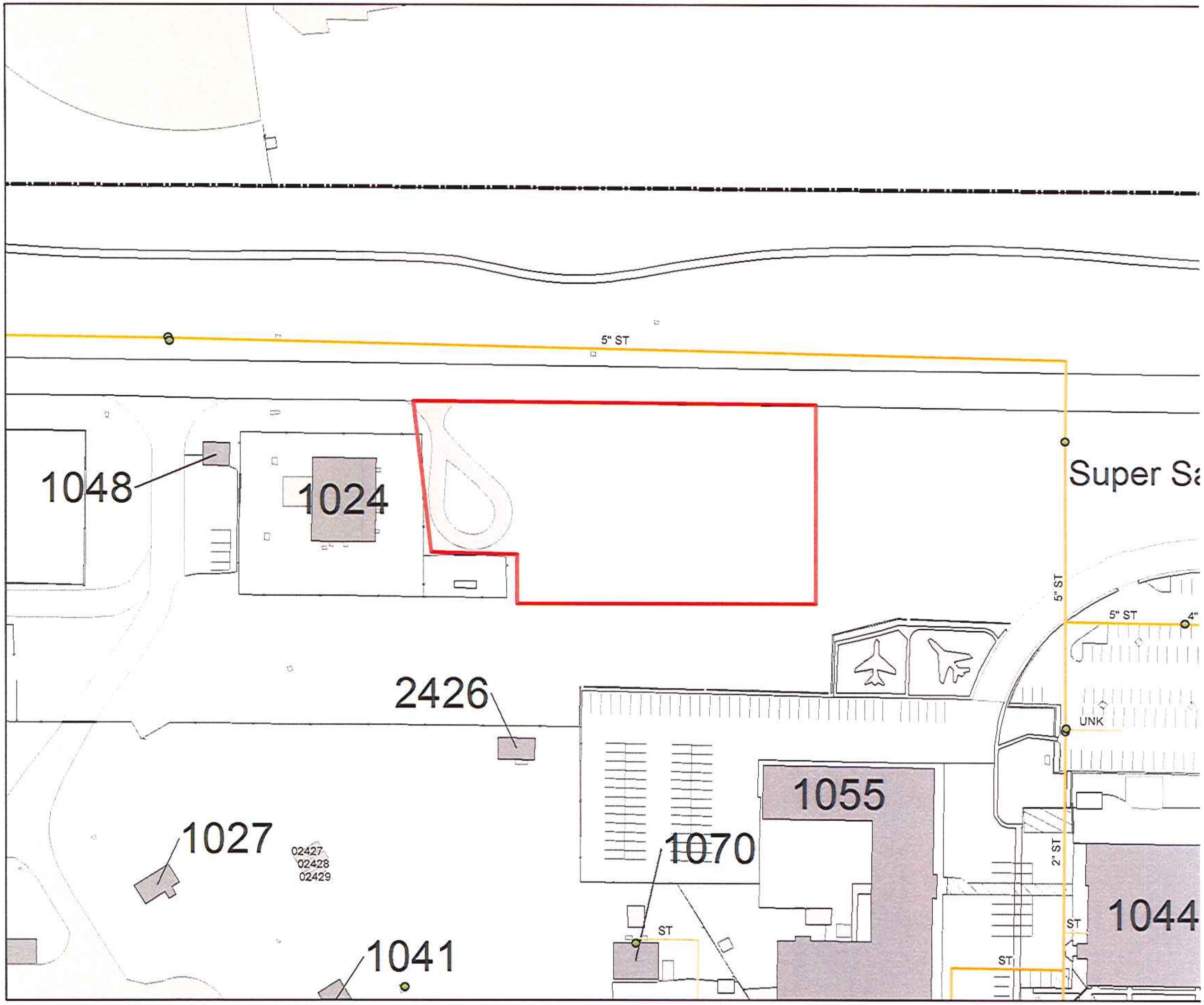
● Gas valves

— Abandoned

— Main

— Service

🟥 Permit Area



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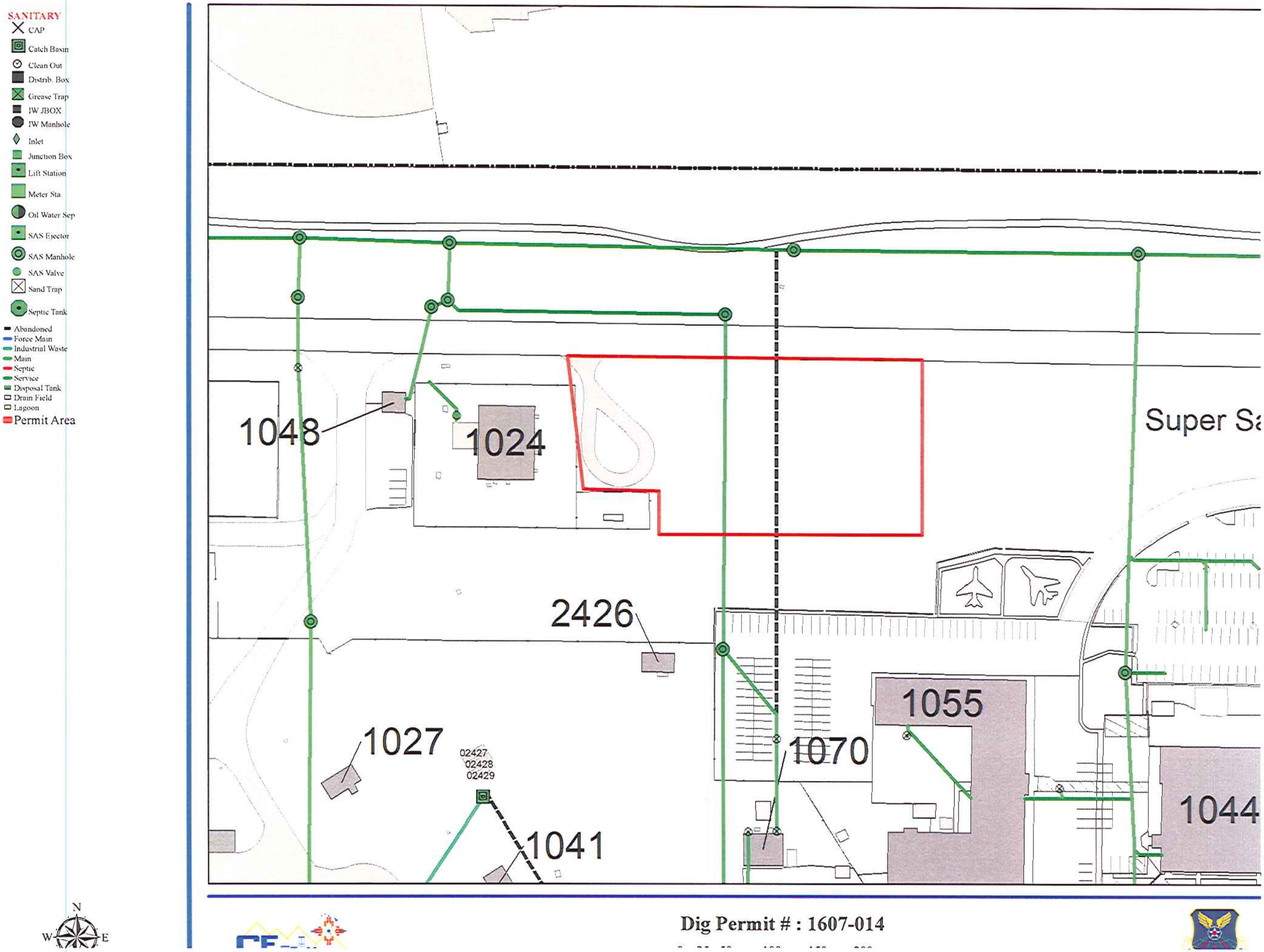
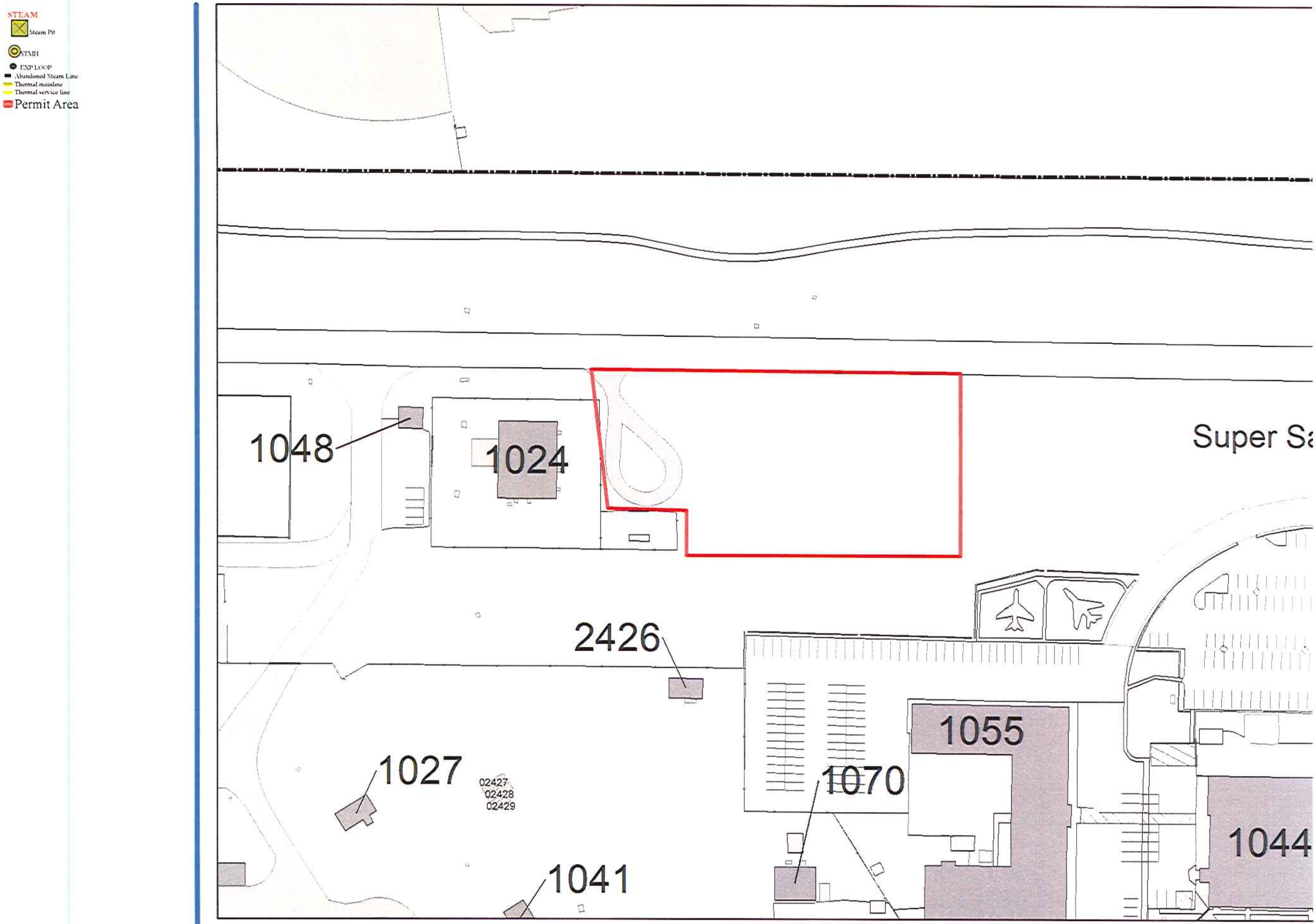


Dig Permit # : 1607-014



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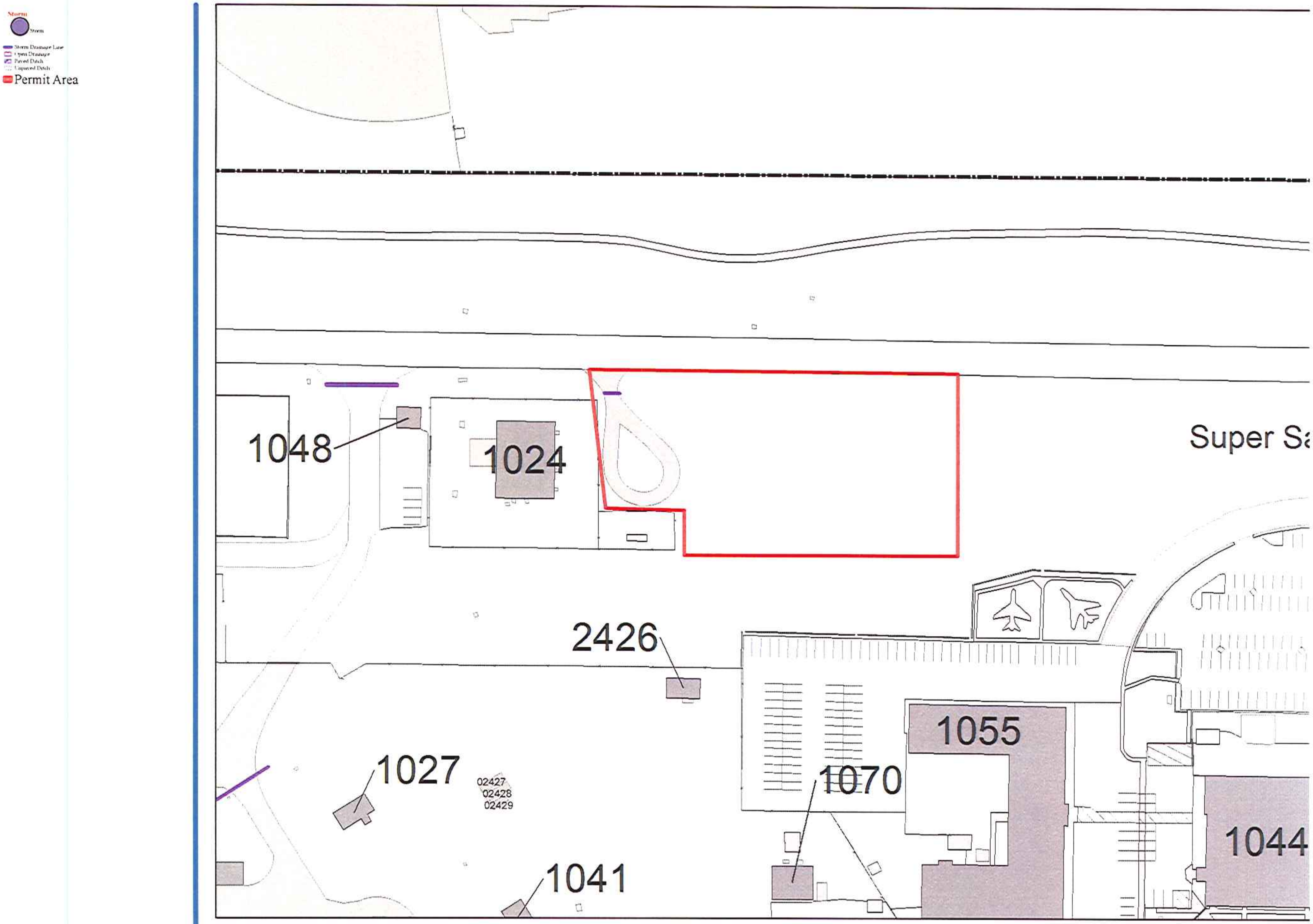
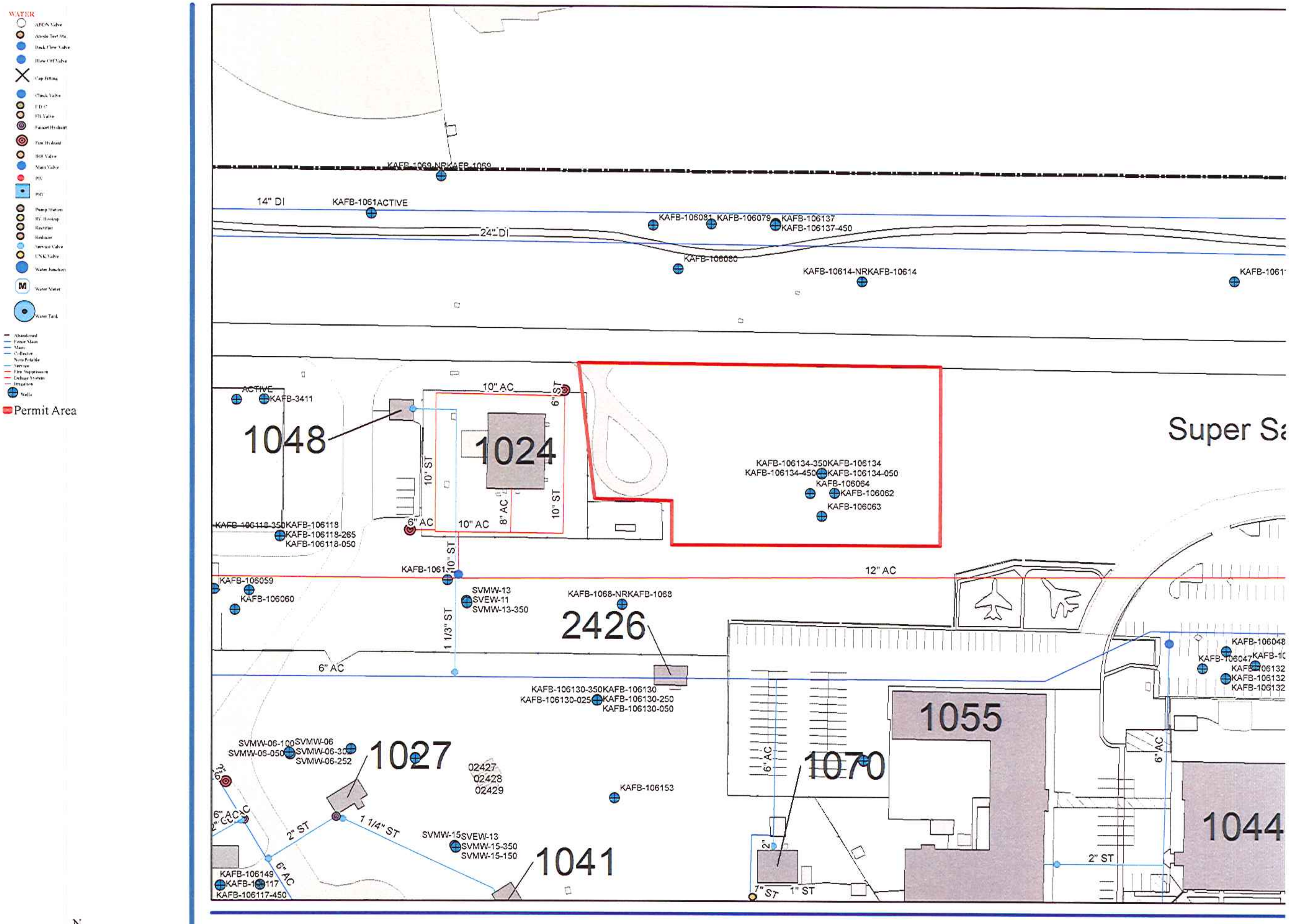


Dig Permit # : 1607-014



N
W E

Dig Permit # : 1607-014

Work Order No:____________________
RCS No:____________________
Dig Permit No: 1607-014
MHMV No:____________________

Kirtland AFB Checklist of Environmental Requirements for Proposed Project

	Air Quality Program – POC: Ms. Andria Cuevas @ 846-2522 or via e-mail: kirtlandairquality@us.af.mil
AQ 1	**Asbestos:** Due to the age of the building, asbestos-containing material (ACM) may be present. NO RENOVATION/DEMOLITION SHALL BEGIN PRIOR TO CE APPROVAL OF AF FORM 332 AND ASBESTOS SAMPLING, AS REQUIRED. If suspected ACM is encountered and will be disturbed, then asbestos abatement of the area to be renovated must be completed prior to starting the proposed work on the building. ***NOTE:*** NESHAP Notification to the AEHD in accordance with 20.11.20.22 NMAC is required for ACM disturbance. Additional guidance and forms can be found at the City of Albuquerque's website: http://www.cabq.gov/airquality/documents/AsbestosDemoRenoNoticationInstructionsandForm_2015.xls
AQ 2	**Lead Based Paint:** Due to the age of the building, LBP may be present; files are available for review. Contact Air Quality Program personnel to coordinate access to files. If suspected LBP is encountered and will be disturbed, LBP sampling should be performed by the contractor with abatement as necessary prior to commencing the proposed work on the building. ***Coordination/Consultation with Air Quality Program POC required.***
[✓ AQ 3]	**Ground Disturbance:** • If the total ground disturbance is ***greater than or equal to ¾ acre***, then a Fugitive Dust Permit will be required. ***Fugitive Dust Permits must be submitted to the Air Quality Program for review***, and 377 ABW/CC signature, five (5) weeks prior to the anticipated start date of soil disturbance. ***NOTE***: AEHD AQD requires all Fugitive Dust Permits be submitted to their office 10 business days prior to anticipated start date of soil disturbance and will require a site inspection prior to issuing the permit. • If the total ground disturbance is ***less than ¾ of an acre***, then a fugitive dust permit is not required; however, the contractor must still comply with the following general provisions from 20.11.20.12 NMAC: "Each person shall use reasonably available control measures or any other effective control measure during active operations or on inactive disturbed surface areas, as necessary to prevent the release of fugitive dust, whether or not the person is required by 20.11.20 NMAC to obtain a fugitive dust control permit. It shall be a violation of 20.11.20 NMAC to allow fugitive dust, track out, or transported material from any active operation, open storage pile, stockpile, paved or unpaved roadway, disturbed surface area, or inactive disturbed surface area to cross or be carried beyond the property line, right-of-way, easement or any other area under control of the person generating or allowing the fugitive dust if the fugitive dust may: (1) with reasonable probability injure human health or animal or plant life; (2) unreasonably interfere with the public welfare, visibility or the reasonable use of property; or (3) be visible for a total of 15 minutes or more during any consecutive one hour observation period using the visible fugitive dust detection method in 20.11.20.26 NMAC or an equivalent method approved in writing by the department. Failure to comply with 20.11.20.12 NMAC, a fugitive dust control permit, plan, term or condition shall be a violation of 20.11.20 NMAC." *NOTE: If any ground disturbance other than what is identified in the initial project is to occur, then you MUST re-coordinate with the Air Quality Program personnel prior to commencing work.*
AQ 4	**Boilers:** Natural gas boilers/hot water heaters of size greater than five (5) million BTU (MMBTU) require Stationary Source Air Permitting. If planning to install a boiler fueled by anything other than natural gas, contact Air Quality Program personnel immediately to determine if a permit is needed. If an air permit is required, the permit must be issued prior to purchase of the boiler(s) and can take up to seven (7) months to accomplish. The Air Quality Program is required to track boilers of all sizes/fuel types to comply with the basewide air permit (Title V Operating Permit). ***Coordination/Consultation with Air Quality Program POC required.***
AQ 5	**Refrigerant:** Ensure all equipment containing refrigerant and all HVAC technicians comply with the requirements in 40 CFR Part 82. If you hire an outside contractor, other than Chenega, you must: 1) maintain all invoices and work orders for work on refrigeration equipment for a minimum of 3 years; and 2) maintain an inventory of refrigeration equipment to include: make, model, serial number, refrigerant type, and total refrigerant charge in pounds.
AQ 6	**Generators:** All emergency generators are required to have a 20.11.41 NMAC construction permit from the Albuquerque Environmental Health Department (AEHD) Air Quality Division (AQD). The permit must be in place prior to "commencing construction", which means prior to purchasing the unit (20.11.41.7.C NMAC). It may take as long as 7 months from the initiation of the permit application preparation process to receive a permit from the AEHD AQD. The project is expected to pay for the cost of preparing the permit application and the associated AEHD AQD permit fees. The organization must plan to pay annual emission fee assessed by the AEHD AQD. Contact Air Quality Program personnel to discuss the timeline for the project. AFCEC approval of generator sizing and design is required prior to permitting. ***Coordination/Consultation with Air Quality Program POC required.***
AQ 7	**Building Renovation/Demolition:** If the building to be renovated/demolished is more than 75,000 cubic feet of space then a Fugitive Dust Permit will be required prior to renovation/demolition (***refer to AQ3 – first bulleted item***). An asbestos notification form must be submitted for all building renovation/demolition activities, even if no regulated ACM is present in the building or structure (***refer to AQ1***).
AQ 8	**Air Quality Permitting for New Sources:** An air quality permit from the AEHD AQD may be required for the proposed equipment prior to construction. ***Coordination with the Air Quality POC is required*** to ensure the appropriate measures are taken in the event the source must obtain an air quality permit. It may take as long as 7 months from the initiation of the permit application preparation process to receive a permit from AEHD AQD. The project is expected to pay for the cost of preparing the permit application and the associated AEHD air quality permit fees. The organization must also plan to pay emission fees for the permitted source on an annual basis.
AQ 9	**Permitting and/or Reporting Requirements Exist for Activity:** Activities require Open Burn/Open Detonation permitting through the City of Albuquerque **OR** there is requirement to report munition items expended during event. ***Prior Coordination with the Air Quality POC is required.***

	Hazardous Waste Program – POCs: Ms. Rebecca Clines and Ms. Katrina Wheelock @ 846-0003 or via e-mail: kirtlandhazwaste@us.af.mil
HW 1	**Contracted Construction Projects:** All wastes generated must be characterized by the contractor. Any wastes characterized as Universal (lamps, batteries, etc.) or Hazardous must be properly disposed of by the contractor in accordance with (IAW) all federal and state regulations. Transformers, capacitors, and ballasts being removed/replaced must also be characterized and disposed of by the contractor IAW all federal, state, and local regulations. ***Ensure Scope of Work (SOW) and contract funding accurately account for these requirements.***
HW 2	**Self-Help / In-House Projects:** Any Universal (lamps, batteries, etc.) or Hazardous wastes generated must be properly characterized and disposed of IAW all federal and state regulations. Transformers, capacitors, and ballasts being removed/replaced must be characterized and disposed of in accordance with (IAW) all federal, state, and local regulations. Characterization may require fluid sampling. ***Contact the Hazardous Waste program prior to project start for guidance.*** Once project is complete, ***contact Hazardous Waste POCs for proper management of unused/unwanted materials (paints, sealants, etc.).***
HW 3	**TDYs:** Kirtland AFB manages the following items as hazardous waste: used oil, oily rags, rags contaminated with solvent, batteries, paint, sealants, etc. These items must be disposed of IAW federal, state, and local regulations. ***Contact 377 MSG/CEIE Hazardous Waste Program POCs 4 weeks prior to your TDY.***
HW 4	**New/Updated Mission Requirements:** Proposed new/updated activities may introduce or alter a waste stream. ***Contact the Hazardous Waste program to ensure wastes are properly characterized.***
	Hazardous Materials Program – POC: Program Manager: Ms. Lori Crump @ 846-8781 Program Support: Mr. Rickey Spence @ 846-2509 or via e-mail: 377msg@us.af.mil
HM 1	Any hazardous materials used in the proposed project needs to be identified either by authorizing the material(s) under a shop in EESOH-MIS or by filling out, submitting, and following the guidelines in the short term contractor Memo and worksheet. Please turn in the worksheet, inventory list, and manufacture specific SDS(s) to the 377th MSG/CEIEC Hazardous Material program office or email to 377 MSG/CEIEC Hazardous Materials mail box. ***Please contact Hazardous Materials POCs for Memo and worksheet.***
HM 2	Any hazardous materials used in the proposed deployment need to be identified by filling out, submitting, and following guidelines in the deployment memo and worksheet. Please turn in the worksheet, inventory list, and manufacturer specific SDS(s) to the 377 MSG/CEIEC Hazardous Material program office or email to the 377 MSG/CEIEC Hazardous Materials mail box. ***Please contact Hazardous Materials POCs for Memo and worksheet.***
	Solid Waste/Recycling – POC: Program Manager: Ms. Katrina Wheelock @ 853-2486
SW 1	**Reporting:** Document weight/volume of all waste disposed, recycled, or salvaged off-base. Submit documentation to 377msg.ceanc.12@us.af.mil. ***Contact the Solid Waste/Recycling Program Manager for guidance.***
SW 2	**Furniture/Equipment Disposal:** ***Coordinate with DRMO (853-2269 or 846-6396)*** to establish whether furniture/equipment needs to be turned in. ***Contact your Unit Equipment Manager*** to remove equipment from supply/asset inventories prior to turning in or disposing. If disposal is authorized by DRMO and a roll-off is required, submit request on an AF Form 332.
SW 3	**Minor Construction/Demolition:** If using Kirtland AFB C&D Landfill for disposal, segregate scrap metal and corrugated cardboard for recycling at the landfill's recycling area. If a dumpster/roll-off is needed for recycling larger amounts of scrap metal or cardboard, submit request on an AF Form 332.
SW 4	**Major Construction/Demolition:** Ensure that Section 01 74 19 (Construction Waste Management, updated 06/2012) is included in project specifications.
SW 5	**Explosive Testing Debris:** Ensure test bed is cleared of any debris before next test. Only debris of a non-hazardous nature may be disposed of in the Kirtland AFB C&D Landfill. ***Proponent must maintain documentation that waste is non-hazardous, and provide to the Solid Waste/Recycling Program Manager upon request.***
	Restoration Program – POC: Chief of Env. Restoration: Mr. Wayne Bitner @ 853-3484
R1	Due to the potential for encountering Unexploded Ordnance (UXO), any fieldwork south of Hardin Blvd requires workers to complete UXO Awareness training. ***The 377 MSG/CED EOD Group can provide this short training. They can be contacted at 846-2229.***
R2	Impacts to Environmental Restoration Sites are possible. ***Please contact Restoration Program POC before doing any work.***
	Water Quality Program – POC's: Ms. Andria Cuevas @ 846-2522 and Ms. Rebecca Clines @ 846-2306
WQ 1	**Wastewater – Septic Tanks/Leach Fields:** When feasible, new construction and remodels should connect to the sanitary sewer system. If a new septic system is the only viable option, the septic tank and leach field must meet the requirements of the NMED Liquid Waste Bureau and be registered with the state. Consult the NMED Liquid Waste requirements concerning removal and/or demolition of a septic tank (20.6.2 NMAC, http://www.nmcpr.state.nm.us/nmac/_titles.htm). ***Coordination/Consultation with Water Quality Program POCs required.***
WQ 2	**Water Discharge Activities - Municipal Separate Storm Sewer System (MS4) applies:** The MS4 permit requires all activities, regardless of size, to implement best management practices (BMPs) to ensure that storm water pollutants are contained to the maximum extent practical and do not enter the storm drainage system (http://water.epa.gov/polwaste/npdes/swbmp). Examples of activities include: power washing of surfaces, minor construction, laydown yards, or any activities draining to a storm drain, etc. Additionally, all non-storm water discharges must be approved by the Water Quality Program **prior to discharge**; all other non-storm water discharges are **prohibited**. ***Coordination/Consultation with Water Quality Program POCs required.*** *NOTE: If any ground disturbance other than what is identified in the initial project is to occur, then you MUST re-coordinate with the Water Quality Program personnel prior to commencing work.*

	Water Quality Program – POC's: Ms. Andria Cuevas @ 846-2522 and Ms. Rebecca Clines @ 846-2306
WQ 3	**Land Disturbance Equal to or Greater than 43,560sqft (1 acre) – Construction General Permit (CGP) applies:** CGP applies to any individual project or series of projects/common development plans that cumulatively disturb one (1) acre. Contractors **must** develop a Storm Water Pollution Prevention Plan (SWP3), a draft Notice of Intent (NOI), and a detailed site map for approval by the Water Quality Program at least four (4) weeks prior to the contractor's submission of the approved NOI to the Environmental Protection Agency (EPA). Contractors **must** submit NOIs at least fourteen (14) calendar days prior to commencing ground disturbance (**Note**: 6 weeks total required). Ground disturbance **cannot** begin for fourteen (14) calendar days after EPA acknowledges receipt of the NOI (http://cfpub.epa.gov/npdes/stormwater/cgpenoi.cfm), or unless EPA delays or denies authorization. BMPs complying with the permit conditions **must** be in place before any ground disturbance commences. *Upon project completion,* Contractor **must** achieve final stabilization, in accordance with Part 2.2.2 and Part 9.4.1 of the CGP, prior to submitting a Notice of Termination (NOT) to the EPA and NMED. Contractor **must** comply with the NMED Surface Water Quality conditions specified in Part 9.4 of the CGP (20.6.4 NMAC, http://www.nmcpr.state.nm.us/nmac/_titles.htm). ***Coordination/Consultation with Water Quality Program POCs required.***
WQ 4	**Facilities/Renovations with New Footprints Greater Than 5,000 gross sq ft - EISA, Section 438 applies:** The project footprint consists of all horizontal hard surfaces and disturbed areas, including both building area and pavements. The Energy Independence Security Act (EISA) requirements do not apply to internal renovations, maintenance, or resurfacing of existing pavements. Projects **must** conform to Air Force Sustainable Design and Development (SDD) guidance dated 2 June 2011 and the Unified Facilities Criteria (UFC-2-210-10). **Note: use of retention ponds is strictly prohibited**. Contractor **must** populate and validate the approved EISA spreadsheet prior to land disturbance. EISA estimated cost, written as a separate line-item of estimated cost, and final implementation cost **must** be documented in the DD 1391. ***Coordination with Water Quality Program POCs required.***
WQ 5	**Wastewater – Oil Water Separators, Grease and Sand Traps:** Equipment should only be installed at locations with an identified need and no feasible alternative. Design features and processes should be substantially reviewed prior to installation of equipment (include in DD 1391 if required). ***Coordination/Consultation with Water Quality Program POCs required.***
WQ 6	**Wastewater – Port-a-Potties:** For all projects/events, the contractor must anchor port-a-potties to prevent toppling of the unit. All projects and events that will utilize gray (hand wash station) and black water (port-a-potties) systems must ensure that the contents are disposed of in accordance with local, state and federal laws. ***Coordination/Consultation with Water Quality Program POCs required.***
WQ 7	**Wastewater – Fire Suppression System Discharge:** Discharges from fire suppression systems utilizing chemical suppressants must be contained at the facility. Discharges of chemical suppressants to the environment or the sanitary sewer system are **prohibited**. ***Coordination with Water Quality POCs required.***
WQ 8	**Section 404 Permit:** Any activities in or near the Tijeras or Coyote Arroyos may require a Section 404 Permit. ***Consultation with Water Quality POCs required.***
	Tank Program – POC: Mr. Dustin Akins @846-0226
T1	**Transformers:** ***Please forward*** the make, model, transformer ID, location/building, and oil capacity (in gallons) for each new/replacement transformer being installed ***to Tank Program POC***.
T2	**Tanks – Above Ground Tanks (ASTs), Underground Tanks (USTs) and Generators:** ***Please forward*** the make, model, ID number, location/building, and storage capacity (in gallons) for all new and/or replacement oil storage tanks (including POLs, grease, fuels and generators) over 55 gals to ***Tank Program POC.*** All units over 55 gals must have secondary containment in case of spills/leaks. All USTs and tanks over 1,320 gals must be registered with the state.
	Natural Resources Program – POC: Ms. Erin Riley @ 846-0226
NR 1	**Demolition of Buildings/Structures**: ***Contact Natural Resource POC*** to schedule a survey for bats, snakes, and nesting birds prior to demolition.
NR 2	**Removal/Trimming of Tree(s)**: ***Contact Natural Resource POC*** to schedule a survey for bird nests prior to removal/trimming tree(s).
NR 3	**Outdoor Activities (Including Exterior Building/Structure Renovations)**: ***Contact Natural Resource POC*** to schedule a survey for bird nests/animal issues prior to beginning work.
NR 4	**Replacement of Existing or Installation of New Power Poles:** Poles may need to be retrofitted to prevent bird electrocution. ***Contact Natural Resource Program POC*** to have the poles evaluated.
NR 5	**Trenching:** Potential exists for reptiles/amphibians/small mammals dropping into trenching projects and becoming trapped. Trenches require ramps at no more than 45 degrees so that trapped animals may exit the trench. ***Contact Natural Resource POC*** with questions.
	Cultural Resources Program – POC: Ms. Erin Riley @ 846-0226
CR 1	Building/Structure is Historic; proposed work may indirectly impact historic properties (Area of Potential Effect). ***Please contact Cultural Resource POC before doing any work.***
CR 2	Impacts to Cultural Sites are possible. ***Please contact Cultural Resource POC before doing any work.***
CR 3	**Inadvertent Discovery of Buried Cultural Resources or Native American Human Remains and Objects:** If cultural resources are encountered inadvertently during an undertaking, work in the immediate vicinity shall be halted, the immediate vicinity of the resources shall be secured, and the Cultural Resource Program POC, shall be notified. The following procedures shall be followed: • An in situ evaluation of the resources shall be made by a qualified archaeologist. Based on recommendations from the archaeologist, decisions regarding the treatment of the resources shall be made in consultation with the Cultural Resources Manager (CRM) and the State Historic Preservation Officer (SHPO). • If the resources cannot be evaluated without further archaeological or historic work, the CRM shall be notified and a data recovery program or historic research shall be prepared in consultation with the SHPO. • Based on the results of the data recovery program or historic research, the resources shall be evaluated for eligibility to the National Register in consultation with the CRM and the New Mexico SHPO.

	MISCELLANEOUS
M1	**Ground Disturbance:** AF Form 103 required.
M2	**Project Requires Siting:** Contact Base Siting Office at 853-3747.
M3	**Tree Removal:** Personal use is not allowed. Please remove stumps and ensure trunks are no longer than 5 feet and/or 30 inches in diameter, if being taken to the Kirtland AFB Landfill for mulching. ***Coordination with Landfill Personnel required – Please call 846-5994 for further guidance.***
M4	**Disposal of Construction &Demolition (C&D) Waste at Kirtland C&D Landfill**: In order to gain access to the site, contractors must obtain a KAFB C&D Landfill Pass specific to each contract held for work on KAFB (multiple contracts = multiple passes). Note that a landfill pass establishes eligibility to use the facility; it does not guarantee disposal. Passes are issued Monday – Friday, 0730-1200. ***To obtain a Pass, contractors must bring all of the following items to the Landfill office:*** a) copy of the valid contract issued by a U.S. Government Contracting Agency for work to be accomplished on KAFB that requires use of the KAFB C&D Landfill; b) original, current vehicle registration(s); c) valid proof of insurance; and d) subcontractor appointment letter or contract (if applicable), showing subcontractor's performance period. Contractor's signature to obtain a Pass indicates that contractor will control the waste stream such that only C&D generated on KAFB is disposed at the C&D Landfill (no municipal solid waste, no hazardous waste, no special waste, no off-base waste, etc.), and that contractor assumes full responsibility for proper disposal of any waste that may be rejected at the gate.
M5	**Activities on DOE Permitted Property:** DOE is responsible for adhering to all environmental laws and obtaining all applicable permits prior to commencing work. This includes conducting biological and cultural surveys as applicable. ***Please contact the DOE Environmental Office for further guidance.***
M6	**Environmental Management System (EMS) Awareness:** Kirtland AFB has a conforming EMS. All personnel, to include contractors, need to be aware of the Environmental Commitment Statement found on the Kirtland AFB public website - http://www.kirtland.af.mil/shared/media/document/AFD-140123-056.pdf. Contract work shall be consistent with the relevant policy and objectives identified in the Kirtland AFB EMS applicable to the contract. The Contractor shall ensure that employees are aware of environmental impacts and will mitigate those impacts by practicing pollution prevention techniques. ***Please contact the Kirtland AFB EMS Program Manager, Ms. Lori Crump @ 846-8781, with any questions.***
M7	**Spectrum Management Office (SMO):** All organizations on Kirtland AFB (includes incoming or TDY units and construction companies) that have radios (including walkie talkies), radars, sounders or a device that transmits radio frequencies must have a radio frequency license issued from the National Telecommunications and Information Administration (NTIA) or the Federal Communications Commission (FCC) prior to operation on the Installation. ***Organizations should contact the SMO to ensure that their devices are properly licensed prior to use, or, to request radio frequency assistance from the Installation Spectrum Managers. The SMO can be reached at (505) 853-3769/7426 or via email at 377ABW.SMO@us.af.mil.***
M8	DD1354 is required to capitalize improvements. ***Please submit document upon completion of project to the Real Property Office.***

Note: Listed requirements are subject to change for compliance with statutory/regulatory changes.

SEG

377 ABW SAFETY
DIG PERMIT REQUIREMENTS

REVIEWED BY JON K. LAYMAN ON 1 APRIL 2016

This is just a highlight of some of the requirements found in CFR 1926 Subpart P & AFI 91-203

Contractor Operations: Site supervisor in charge of a trenching operation needs to comply with all of the provisions found in OSHA Standard 29CFR 1926 Subpart P.

DoD Operations: Site supervisor in charge of a trenching operation needs to comply with all of the provisions found in OSHA Standard 29CFR 1926 Subpart P and AFI 91-203 Chapter 25.

- The walls and faces of excavations and trenches over five (5) feet in depth, where workers may be exposed to danger of a cave-in, shall be guarded by a shoring system, sloping and benching system or some other equivalent means. 29 CFR 1926, Subpart P & AFI 91-203.25.8
- Shoring is not required in excavations that are less than 5 feet in depth provided an examination of the ground by a competent person determines that there is no indication of a potential cave-in. 29 CFR 1926.652(a)(1)(ii) & AFI 91-203 25.8
    - Competent person means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.29 CFR 1926.650(b) & AFI91-203 Attachment 1 under Terms
- Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.29 CFR 1926.651(j)(2) & AFI 91-203 25.8.1
- A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet or more in depth so as to require no more than 25 feet of lateral travel for employees. 29 CFR 1926.651(c)(2) & AFI 91-203 25.8.2
- Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated. 29 CFR 1926-651(k)(1) & AFI 91-203 25.8.3
- Personnel, cones or other devices will be positioned to warn motorists in advance of the construction site(s). 29 CFR 1926.201(a)(1) [Flagmen], 29 CFR 1926.200(g)(1) & AFI 91-203 25.9
- Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.29 CFR 1926.651 (d) & AFI 91-203 25.9

ALB[illegible]UERQUE ENVIRONMENTAL HEALTH DEPARTMENT - AIR QUALITY PROGRAM
PHYSICAL ADDRESS - ON[illegible]IVIC PLAZA NW, 3RD FLOOR, ROOM 3047, AL[illegible]UERQUE, NEW MEXICO 87102
MAILING ADDRESS - P.O. BOX 1293, ALBUQUERQUE, NEW MEXICO 87103
(505) 768 - 1972 (VOICE) 1-800-659-8331 (NEW MEXICO RELAY) (505) 768 - 1977 (FAX)

APPLICATION FOR A FUGITIVE DUST CONTROL PROGRAMMATIC PERMIT IN BERNALILLO COUNTY

ALBUQUERQUE - BERNALILLO COUNTY AIR QUALITY CONTROL BOARD REGULATION 20.11.20 NMAC
(ROUTINE MAINTENANCE/ACTIVE OPERATIONS PERMIT FOR SURFACE DISTURBANCE)

DIVISION RECEIPT STAMP BELOW THIS LINE

RECEIVED
ENVIRONMENTAL HEALTH
10 PM 2:53

EFFECTIVE DATE OF THIS APPLICATION FORM: 10/14

SUBMITTAL DATE/TIME 11/10/14

RECEIVED BY Flor Varos.

PERMIT # 6957- P

A PROGRAMMATIC PERMIT (PERMIT) IS A FUGITIVE DUST CONTROL PERMIT, VALID FOR UP TO FIVE YEARS, ISSUED TO A PERMITTEE THAT PERFORMS ROUTINE MAINTENANCE OR ROUTINE ACTIVE OPERATIONS ON LAND OR AT FACILITIES OF ¾ OF AN ACRE OR MORE, WHICH DOES NOT INCLUDE FULL DEPTH RECONSTRUCTION OF A ROADWAY OR SUBSTANTIAL REMOVAL AND REPLACEMENT OF A MANMADE FACILITY.

PART A. - BUSINESS, AGENCY, OR PROPERTY OWNER

(CLEARLY PRINT OR TYPE)

1. BUSINESS/AGENCY NAME: KIRTLAND AIR FORCE BASE BULK FUELS FACILITY

AND/OR

2. PROPERTY OWNERS NAME

PART B. - FACILITY INFORMATION AND GENERAL ACTIVITIES

(CLEARLY PRINT OR TYPE)

IF THE PERMITTEE WISHES TO INCLUDE MULTIPLE FACILITY (SITE) LOCATIONS UNDER THE SAME PERMIT, SUBMIT THE REQUIRED INFORMATION REQUESTED FOR EACH INDIVIDUAL SITE BY SUBMITTING ADDITIONAL COPIES OF PAGES 1 & 2 AS NECESSARY.

SUBMIT AS AN ATTACHMENT TO THIS APPLICATION AN (8 ½" X 11" OR 11" X 17") SITE MAP FOR EACH FACILITY LOCATION

1. FUGITIVE DUST FACILITY (SITE) LOCATION: KIRTLAND AIR FORCE BASE BULK FUELS FACILITY
2. STREET ADDRESS OF FACILITY (if available)
3. MAJOR CROSS STREETS OR INTERSECTION NEARBY FACILITY: Gibson Blvd. SE and Truman St. SE
4. TOTAL ACRES OF THIS FACILITY 564 TSK 8/5/16 ~~2,000~~ ACRES
5. TOTAL ACRES OF THIS FACILITY SUBJECT TO ROUTINE MAINTENANCE/ACTIVE OPERATIONS 18.5 TSK 8/5/16 ~~11~~ ACRES
6. TOTAL MILES OF ROADS/EASEMENTS FOR THIS FACILITY SUBJECT TO ROUTINE MAINTENANCE/ACTIVE OPERATIONS NA
7. TOTAL MILES OF ROADS/EASEMENTS FOR THIS FACILITY CONVERTED TO ACRES NA
8. PROVIDE A DESCRIPTION OF THIS FACILITY'S OPERATION(S): INSTALLATION OF WELLS, WATER TREATMENT SYSTEM, SOIL VAPOR EXTRACTION SYSTEM FOR FUEL CONTAMINATION CHARACTERIZATION AND REMEDIATION AT SWMUs ST-106 AND SS-111.
9. DESCRIBE THE TYPE OF ACTIVITIES AT THIS FACILITY THAT MAY GENERATE FUGITIVE DUST: SURFACE DISTURBANCE DURING WELL INSTALLATION AND CONSTRUCTION ACTIVITIES.

ENTERED

A	B	C	D	E
SOURCE CLASSIFICATION (SEE DEFINITIONS AT THE BOTTOM OF THIS TABLE)	ACRES ROUNDED TO NEAREST WHOLE NUMBER TO BE CONTROLLED AT EACH SOURCE CLASSIFICATION FROM COLUMN A (CONVERT MILES TO ACRES)	EMISSION CONTROL FACTOR MULTIPLIER (20.11.2.15 G. NMAC FEES REGULATION)	GENERAL DESCRIPTION OF THE REASONABLY AVAILABLE CONTROL MEASURE(S) CURRENTLY IN PLACE OR TO BE USED TO MAINTAIN THE ACREAGE AT EACH SOURCE CLASSIFICATION CLAIMED IN COLUMN A (SEE PART E LIST ON PAGE 3) (EXAMPLE: TRAFFIC, WINDBREAKS, ETC.)	TOTAL FEE PER CLASSIFICATION [COLUMN B TIMES (X) COLUMN C]
LOW IMPACT [redacted]		.1		
MODERATE IMPACT [redacted]	~~41~~ 19 TSK 8/5/16	.5	WATERING, TRAFFIC, LANDSCAPING (WET SUPPRESSION, ENFORCED SPEED LIMITS AND TRAFFIC CALMING, RESEEDING; SEE D-1)	~~20.5~~ 9.5 TSK 8/5/16
HIGH IMPACT [redacted]		.9		
MULTIPLY THE SUM OF COLUMN (E) BY $135.00			$135.00 x	~~20.5~~ 9.5 TSK 8/5/16
			ANTICIPATED PERMIT FEE DUE	~~$2767.5~~ TSK $1,282.5 8/5/16

ABBREVIATED DEFINITONS OF SOURCE CLASSIFICATIONS

NO IMPACT MEANS ACTIVE AND INACTIVE SURFACE AREAS THAT PRODUCE VIRTUALLY NO FUGITIVE DUST. SUCH LAND SURFACES ARE EXEMPT FROM THE FUGITIVE DUST CONTROL REGULATION OR REQUIREMENTS TO PAY FEES

LOW IMPACT MEANS ACTIVE AND INACTIVE SURFACE AREAS THAT ARE APPROXIMATELY 90% CONTROLLED

MODERATE IMPACT MEANS ACTIVE AND INACTIVE SURFACE AREAS THAT ARE APPROXIMATELY 50% CONTROLLED

HIGH IMPACT MEANS ACTIVE AND INACTIVE SURFACE AREAS THAT ARE APPROXIMATELY 10% CONTROLLED

UPON RECEIPT OF YOUR APPLICATION, THE DEPARTMENT WILL REVIEW AND VERIFY THE INFORMATION SUBMITTED. ONCE THE DEPARTMENT HAS DETERMINED THAT THE APPLICATION IS COMPLETE, THE DEPARTMENT WILL SIGN THE APPLICATION AND RETURN A COMPLETED COPY TO YOU AS YOUR PERMIT. SUBSEQUENTLY, AN INVOICE WILL BE SENT TO YOU FOR INITIAL PAYMENT OF THE PERMIT FEE. EACH YEAR THEREAFTER, THE DEPARTMENT WILL ALSO SEND AN INVOICE FOR THE ANNUAL FEES DUE. THE APPLICATION MAY BE SENT BY MAIL TO THE ADDRESS THAT APPEARS AT THE TOP OF PAGE 1 OF THIS FORM OR IT MAY BE HAND DELIVERED TO THE SAME ADDRESS BETWEEN THE HOURS OF 8:00AM - 4:30PM MONDAY THROUGH FRIDAY.

PART D. – FUGITIVE DUST CONTROL PLAN

(CLEARLY PRINT OR TYPE)

THE "PERMITTEE" IS REQUIRED TO COMPLY WITH A FUGITIVE DUST CONTROL PLAN (PLAN) THAT DETAILS THE FUGITIVE DUST CONTROL MEASURES THAT WILL BE USED TO MITIGATE THE RELEASE OF FUGITIVE DUST FROM ROUTINE ACTIVE OPERATIONS AND MAINTENANCE. IF YOU ARE NOT SUBMITTING, AS AN ATTACHMENT TO THIS APPLICATION, AN ALTERNATIVE PLAN THEN YOU MUST COMPLETE PART D1 - D2 BELOW TO COMPLETE YOUR FUGITIVE DUST CONTROL PLAN.

1. SUMMARIZE IN DETAIL HOW THE REASONABLY AVAILABLE CONTROL MEASURES CURRENTLY IN PLACE, OR THAT YOU HAVE SELECTED IN COLUMN D OF THE PART C TABLE ABOVE WILL BE USED TO LIMIT OR PREVENT THE RELEASE OF FUGITIVE DUST FROM ROUTINE ACTIVE OPERATIONS AND/OR MAINTENANCE AT THIS FACILITY. (FOR EXAMPLE CREDIT CAN BE TAKEN FOR: EXISTING TREES OR SHRUBBERY, ALONG AT LEAST 50% OF THE PERIMETER OF THE FACILITY, AS A WINDBREAK; OR SALVAGED VEHICLES, MATERIALS, OR EQUIPMENT AT A SALVAGE YARD THAT FORM AN EFFECTIVE WINDBREAK; OR EXISTING FENCING THAT PREVENTS VEHICLE ACCESS TO PROPERTY AS A TRAFFIC CONTROL). DESCRIBE THE HEIGHT, LENGTH, LOCATIONS, TYPES, AMOUNTS, ETC. FOR ALL METHODS TO BE USED AS CONTROL MEASURES. AS A GENERAL RULE, THE DEPARTMENT WILL ALLOW CREDIT FOR WINDBREAKS FOR A LATERAL DISTANCE EQUAL TO 10 TIMES THE HEIGHT OF THE WINDBREAK. THEREFORE, A 6 FOOT HIGH WINDREAK WILL BE CREDITED WITH REDUCING DUST EMISSIONS FOR A DISTANCE OF 60 FEET FROM THE FENCE.

Watering – using wet suppression will help reduce the amount of dust that will become air bound from activities at site. The wet suppression will be used as needed; if wind speeds pick up, more water will be added to the affected areas. During a high wind event the activities will be stopped.
Traffic – traffic controls, including decreased speed limits with appropriate enforcement; other traffic calming methods, vehicle access restrictions and controls; road closures or barricades; and off road vehicle access controls and closures will reduce the amount of dust generated. Also, using properly secured tarps or cargo covering that covers the entire surface area of the load will prevent leakage from the truck bed, sideboards, tailgate, or bottom dump gate will decrease dust. The active areas will be fenced which will reduce traffic during construction and maintenance operations.
Landscaping - reseeding using native grasses as specified in 20.11.20.24 NMAC for areas where the pipeline trench affects the soil

Department Review by________________ **Required Initials of Permittee** MA

PART E. - REASONABLY AVAILABLE CONTROL MEASURES

THE "PERMITTEE" SHALL INCLUDE IN THE PERMIT APPLICATION ONE OR MORE OF THE APPLICABLE REASONABLY AVAILABLE CONTROL TYPE MEASURES LISTED BELOW (ABBREVIATED LIST), OR ONE OR MORE OTHER (ALTERNATIVE) FUGITIVE DUST CONTROL MEASURES, INCLUDING MEASURES TAKEN TO COMPLY WITH ANY OTHER STATUTE OR REGULATION THAT WOULD ALSO EFFECTIVELY CONTROL FUGITIVE DUST DURING ROUTINE ACTIVE OPERATIONS AND MAINTENANCE AND INACTIVE OPERATIONS. FOR A MORE COMPLETE LIST OF CONTROL TYPE MEASURES YOU CAN REFER TO SECTION 23 OF PART 20.11.20 NMAC – FUGITIVE DUST CONTROL.

IF THE "PERMITTEE" CHOOSES TO SUBMIT AS AN ATTACHMENT TO THIS APPLICATION AN ALTERNATIVE FUGITIVE DUST CONTROL PLAN (PLAN) IN LIEU OF USING ANY OF THE REASONABLY AVAILABLE CONTROL MEASURES GIVEN IN PART E BELOW OR FROM SECTION 23 OF PART 20.11.20 NMAC – FUGITIVE DUST CONTROL, THE ALTERNATIVE PLAN (SUCH AS A STORM WATER POLLUTION PREVENTION PLAN) MUST INCLUDE DETAILED INFORMATION THAT ADDRESSES: 1) THE REASONABLY AVAILABLE CONTROL MEASURES TO MITIGATE THE RELEASE OF FUGITIVE DUST FROM ROUTINE ACTIVE OPERATIONS AND MAINTENANCE; AND 2) ACTION(S) TO BE TAKEN TO MITIGATE PROPERTY DAMAGE (SEE PART D OF THIS APPLICATION). IF SUBMITTING AN ALTERNATIVE PLAN YOU STILL MUST COMPLETE PARTS A, B, C, F, AND G OF THIS APPLICATION.

USE THE ONE WORD UNDERLINED HEADINGS BELOW WHEN FILLING IN THE CONTROL MEASURES IN COLUMN D OF THE PART C TABLE ON PAGE 2. THESE MEASURES CAN REDUCE THE RELEASE OF FUGITIVE DUST FROM YOUR FACILITY OR REDUCE THE AMOUNT OF ACREAGE/MILES REQUIRING CONTROL IF APPLIED AS PERMANENT STABILIZATION (FOR EXAMPLE: MAINTAINED PAVEMENT).

PAVING

- paving using well-maintained recycled asphalt, asphaltic concrete, concrete, or petroleum products legal for such use;
- using paved or gravel entry/exit aprons with devices, such as steel grates, capable of knocking mud and bulk material off vehicle tires;
- surfacing with gravel or other mulch material of a size and density sufficient to prevent surface material from becoming airborne

WATERING

- using wet suppression;
- watering the site at the beginning and/or end of each day sufficient to stabilize the area;
- using dust suppressants applied in amounts, rates, and maintained as recommended by the manufacturer (submit manufacturer's data with application)

WINDBREAKS

- installing upwind windbreaks, including fabric fences with the bottom of the fence sufficiently anchored to the ground to prevent material from blowing underneath the fence; all windbreaks and fabric fences should be maintained in an upright and functional condition at all times; all accumulated material on the windward side of the windbreak should be periodically removed to prevent failure of the windbreak;
- installing permanent perimeter and interior walls;
- For Salvage Yards - using salvaged vehicles arranged in rows with minimum spacing between vehicles;
- For Construction or Storage Yards – using construction materials, equipment, trailers, buildings or structures to create a windbreak;
- Using dense hedges, shrubbery or trees;
- Using sand fences, board rail fences, or similar fences that have openings on approximately 50% of the surface;
- Natural barriers

TRAFFIC

- using traffic controls, including decreased speed limits with appropriate enforcement; other traffic calming methods, vehicle access restrictions and controls; road closures or barricades; and off-road vehicle access controls and closures;
- cleaning up spillage and track out as necessary to prevent particulates from being pulverized and entrained into the atmosphere;
- performing regularly scheduled vacuum street cleaning or wet sweeping;
- using properly secured tarps or cargo covering that covers the entire surface area of the load;
- installing fencing to limit vehicle access to property

LANDSCAPING

- reseeding using native grasses as specified in 20.11.20.24 NMAC – native grass seeding and mulch specifications;
- xeriscaping;
- mulching and crimping of straw or hay as specified in Section 20.11.20.24 NMAC;
- conventional landscaping techniques

IT IS REQUIRED DURING A HIGH WIND EVENT THAT ALL FUGITIVE DUST SOURCES CEASE ALL ACTIVE OPERATIONS THAT ARE CAPABLE OF PRODUCING FUGITIVE DUST. A HIGH WIND EVENT IS A CONDITION ANNOUNCED BY THE DEPARTMENT OF WIND SPEEDS OF APPROXIMATELY 30 MILES PER HOUR OR GREATER THAT, WHEN ACCOMPANIED BY DRY SOIL CONDITIONS, IS LIKELY TO RESULT IN WIDESPREAD REDUCED VISIBILITY DUE TO BLOWING FUGITIVE DUST AND MAY RESULT IN ELEVATED PARTICULATE LEVELS THAT MAY CONTRIBUTE TO AN

EXCEEDANCE OR VIOLATION OF AMBIENT AIR QUALITY STANDARDS.

PART F. – SIGNATURE AUTHORITY OF PERMITTEE

THIS APPLICATION SHALL INCLUDE A FUGITIVE DUST CONTROL PLAN THAT MAY UTILIZE REASONABLY AVAILABLE CONTROL MEASURES TO MITIGATE FUGITIVE DUST TO MEET THE OBJECTIVES OF PART 20.11.20 NMAC – FUGITIVE DUST CONTROL.

BY SIGNING BELOW, THE APPLICANT CERTIFIES THAT THE INFORMATION PROVIDED IN THIS APPLICATION FOR A FUGITIVE DUST CONTROL PROGRAMMATIC PERMIT IS TRUE, ACCURATE AND COMPLETE, AND THE APPLICANT AGREES TO BE THE "PERMITTEE".

A "PERMITTEE" IS A PERSON, OWNER OR OPERATOR AND ALL LEGAL HEIRS, SUCCESSORS, AND ASSIGNS WHO HAS APPLIED FOR AND OBTAINED A FUGITIVE DUST CONTROL PERMIT APPROVED BY THE DEPARTMENT. THE "PERMITTEE" AGREES TO TAKE ALL ACTIONS REQUIRED BY THE FUGITIVE DUST CONTROL PERMIT ISSUED BY THE DEPARTMENT TO PREVENT A VIOLATION OF 20.11.20 NMAC – FUGITIVE DUST CONTROL, INCLUDING STOPPING ACTIVE OPERATIONS, IF NECESSARY. THE "PERMITTEE" IS RESPONSIBLE FOR COMPLYING WITH THE FUGITIVE DUST CONTROL PERMIT, THE FUGITIVE DUST CONTROL PLAN, AND ALL REQUIREMENTS OF PART 20.11.20 NMAC - FUGITIVE DUST CONTROL. FAILURE TO COMPLY SHALL BE A VIOLATION OF PART 20.11.20 NMAC – FUGITIVE DUST CONTROL.

THE PERMITTEE SIGNATURE BOX MUST BE COMPLETED

[ONE SET OF SIGNATURE PAGES IS ADEQUATE FOR MULTIPLE FACILITY (SITE) LOCATIONS TO BE PERMITTED UNDER THE SAME PERMITTEE AND OWNER]

CB&I FEDERAL SERVICES
IF A BUSINESS, PRINT PERMITTEE'S BUSINESS NAME

(COMPLETE ALL APPLICABLE INFORMATION)

Mike Amdurer
PRINT NAME OF INDIVIDUAL SIGNING FOR PERMITTEE

Project Manager
PRINT TITLE OF INDIVIDUAL SIGNING FOR PERMITTEE

Michael Amd
SIGNATURE OF PERMITTEE

MA
INITIALS OF PERMITTEE

DATE SUBMITTED

2400 Louisiana Blvd. NE Suite 300
MAILING ADDRESS OF PERMITTEE

Albuquerque
CITY

New Mexico
STATE

87110 TSK 8/5/16
ZIP CODE

505-262-8906 ~~303-486-2503~~
PHONE NUMBER OF PERMITTEE

505-967-9521 ~~303-513-1155~~
CELL PHONE OF PERMITTEE

N/A
PAGER NUMBER OF PERMITTEE

505-262-8855
FAX NUMBER OF PERMITTEE

TSK 8/5/16

Tara.Kunkel@CBIFederalServices.com ~~MIKE.AMDURER@CBIFEDERALSERVICES.COM~~
EMAIL ADDRESS OF PERMITTEE

Designee: Tara Kunkel

THE PERMITTEE SHALL MAKE THE PERMIT AVAILABLE AND EXPLAIN THE REQUIREMENTS OF THE PERMIT TO APPROPRIATE EMPLOYEES, AGENTS, CONTRACTORS, AND ANY OTHER PERSON INVOLVED IN ACTIVE OPERATIONS OR MAINTENANCE AT THIS FACILITY TO ASSIST IN MAINTAINING COMPLIANCE WITH PART 20.11.20 – FUGITIVE DUST CONTROL.
THE PERMITTEE IS RESPONSIBLE FOR MAINTAINING CONTROL MEASURES THAT PREVENT OR ABATE UNREASONABLE INTERFERENCE WITH PUBLIC WELFARE, VISIBILITY AND THE REASONABLE USE OF PROPERTY.

THE APPLICANT SIGNING ABOVE AND APPLYING TO BE THE "PERMITTEE", MAY DESIGNATE AN ADDITIONAL PERSON(S) [INCLUDES AN ENTITY(IES)] TO BE A RESPONSIBLE PERSON AS DEFINED IN 20.11.20.7DD NMAC (DEFINITIONS), IF THE PERSON(S) AGREES IN WRITING TO BE A RESPONSIBLE PERSON.

BEFORE DEPARTMENT REVIEW AND ISSUANCE OF A FUGITIVE DUST CONTROL PROGRAMMATIC PERMIT, IF THE PERMITTEE WISHES TO DESIGNATE A PERSON(S) AS A RESPONSIBLE PERSON(S) FOR COMPLYING WITH ALL OR SPECIFIC ELEMENTS OF THE FUGITIVE DUST CONTROL PERMIT, THE FUGITIVE DUST CONTROL PLAN, AND PART 20.11.20 NMAC.- FUGITIVE DUST CONTROL, THEN THE PERMITTEE MAY REQUEST AN ADDITIONAL RESPONSIBLE PERSON SIGNATURE FORM, WHICH MAY BE ADDED TO THE FUGITIVE DUST CONTROL PERMIT APPLICATION. THE RESPONSIBLE PERSON SIGNATURE FORM MUST INCLUDE ALL APPLICABLE INFORMATION CONCERNING THE DESIGNATED RESPONSIBLE PERSON(S). AFTER THE ISSUANCE OF THE PERMIT, THE DEPARTMENT MAY APPROVE IN WRITING AN AMENDMENT TO THE PERMIT TO ADD OR

Department Review by

Required Initials of Permittee MA

CHANGE A DESIGNATED RESPONSIBLE PERSON(S).

PART G. – FACILITY OWNER INFORMATION (COMPLETE THE OWNER INFORMATION BELOW ONLY IF DIFFERENT THAN THE PERSON WHO HAS SIGNED AS THE PERMITTEE IN SECTION **F.**

However, READ ALL THE INFORMATION BELOW, EVEN IF NOT SIGNING THE FACILITY OWNER INFORMATION BOX. THE PERMITTEE MUST INITIAL THE BOTTOM RIGHT CORNER OF ALL 5 PAGES TO ENSURE THAT ALL THE APPLICATION INFORMATION PROVIDED HAS BEEN REVIEWED.

IF THE PERMITTEE FAILS TO COMPLY WITH THE PROVISIONS OF 20.11.20 NMAC – FUGITIVE DUST CONTROL, THE OWNER, IF DIFFERENT FROM THE PERMITTEE, SHALL BE RESPONSIBLE FOR COMPLYING WITH THE PERMIT. IF THE PERMITTEE FAILS TO TAKE ALL REQUIRED ACTIONS TO PREVENT A VIOLATION OF 20.11.20 NMAC – FUGITIVE DUST CONTROL, THE OWNER SHALL BE RESPONSIBLE TO TAKE ALL ACTIONS REQUIRED TO PREVENT OR SATISFACTORILY RESOLVE A VIOLATION OF 20.11.20 NMAC – FUGITIVE DUST CONTROL, INCLUDING STOPPING ALL ACTIVE OPERATIONS, IF NECESSARY. TO MITIGATE FUGITIVE DUST, ALL INACTIVE DISTURBED SURFACE AREAS MUST BE STABILIZED AND MAINTAINED IN STABLE CONDITION BY THE OWNER, PERMITTEE OR PERSON RESPONSIBLE FOR MAINTENANCE OF THE FACILITY. FAILURE TO COMPLY SHALL BE A VIOLATION OF 20.11.20 NMAC – FUGITIVE DUST CONTROL.

FACILITY OWNER INFORMATION (COMPLETE ALL APPLICABLE INFORMATION)

UNITED STATES AIR FORCE, KIRTLAND AIR FORCE BASE
IF A BUSINESS, PRINT FACILITY OWNER'S BUSINESS NAME

Tom D. Miller, Colonel, USAF
PRINT NAME OF INDIVIDUAL SIGNING FOR FACILITY OWNER

Installation Commander
PRINT TITLE OF INDIVIDUAL SIGNING FOR FACILITY OWNER

Tom D Miller
SIGNATURE OF FACILITY OWNER

TDM
INITIALS OF FACILITY OWNER

3 Nov 14
DATE SIGNED

2050 Wyoming Blvd SE
MAILING ADDRESS OF FACILITY OWNER

Kirtland AFB
CITY

NM
STATE

87117
ZIP CODE

(505)846-8546
PHONE OF FACILITY OWNER

N/A
CELL OF FACILITY OWNER

N/A
PAGER OF FACILITY OWNER

(505)853-6970
FAX OF FACILITY OWNER

JOHN.PIKE@US.AF.MIL
EMAIL ADDRESS OF FACILITY OWNER

THE **GENERAL PROVISIONS** OF 20.11.20 NMAC – FUGITIVE DUST CONTROL - STATES THAT IT SHALL BE A VIOLATION OF 20.11.20 NMAC TO ALLOW FUGITIVE DUST, TRACK-OUT, OR TRANSPORTED MATERIAL FROM ANY ACTIVE OPERATION, OPEN STORAGE PILE, STOCKPILE, PAVED OR UNPAVED ROADWAY, DISTURBED SURFACE AREA, OR INACTIVE DISTURBED SURFACE AREA TO CROSS OR BE CARRIED BEYOND THE PROPERTY LINE, RIGHT-OF-WAY, EASEMENT OR ANY OTHER AREA UNDER CONTROL OF THE PERSON GENERATING OR ALLOWING THE FUGITIVE DUST IF THE FUGITIVE DUST MAY:

1) WITH REASONABLE PROBABILITY INJURE HUMAN HEALTH OR ANIMAL OR PLANT LIFE;

2) UNREASONABLY INTERFERE WITH THE PUBLIC WELFARE, VISIBILITY OR THE REASONABLE USE OF PROPERTY;

3) BE VISIBLE FOR A TOTAL OF 15 MINUTES OR MORE DURING ANY CONSECUTIVE ONE HOUR OBSERVATION PERIOD USING THE VISIBLE FUGITIVE DUST DETECTION METHOD IN 20.11.20.26 (VISUAL DETERMINATION OF FUGITIVE DUST EMISSIONS VIOLATIONS) OR AN EQUIVALENT METHOD APPROVED IN WRITING BY THE DEPARTMENT.

PURSUANT TO THE AIR QUALITY CONTROL ACT, CHAPTER 74, ARTICLE 2 NEW MEXICO STATUTES ANNOTATED 1978, AS AMENDED; THE ALBUQUERQUE JOINT AIR QUALITY CONTROL BOARD ORDINANCE, 9-5-1-1 ROA 1994; THE BERNALILLO COUNTY JOINT AIR QUALITY CONTROL BOARD ORDINANCE, BERNALILLO COUNTY ORDINANCE 94-5, AND THE ALBUQUERQUE/BERNALILLO COUNTY AIR QUALITY CONTROL BOARD (A/BCAQCB) REGULATION TITLE 20, CHAPTER 11, PART 20, NEW MEXICO ADMINISTRATIVE CODE (NMAC), (20.11.20 NMAC) - FUGITIVE DUST CONTROL, AND UPON AUTHORIZED SIGNATURES BELOW, THIS APPLICATION TOGETHER WITH ASSOCIATED DRAWINGS, PLANS, APPENDED DOCUMENTS, OTHER DATA, AND ANY CONDITIONS ATTACHED TO THE PERMIT BY THE DEPARTMENT, WILL BECOME THE FUGITIVE DUST CONTROL PROGRAMMATIC PERMIT.

AREA BELOW FOR DEPARTMENT USE.

DOES THE DEPARTMENT APPROVAL BELOW INCLUDE APPROVAL FOR ANY BULK MATERIAL STOCKPILES TO EXCEED 15 FEET ______ YES __X__ NO

IF YES, MAXIMUM HEIGHT ALLOWED __________ FEET

APPLICATION REVIEWED BY:	DEEMED COMPLETE DATE	PERMIT ISSUED BY:	ISSUE DATE	EXPIRATION DATE
AIR QUALITY PROGRAM	11 / 14 /20 14	AIR QUALITY PROGRAM	11 / 14 /20 14	11 / 14 /20 19

Table 1. Fugitive Dust Permit Acre Calculations

TK 8/5/2016

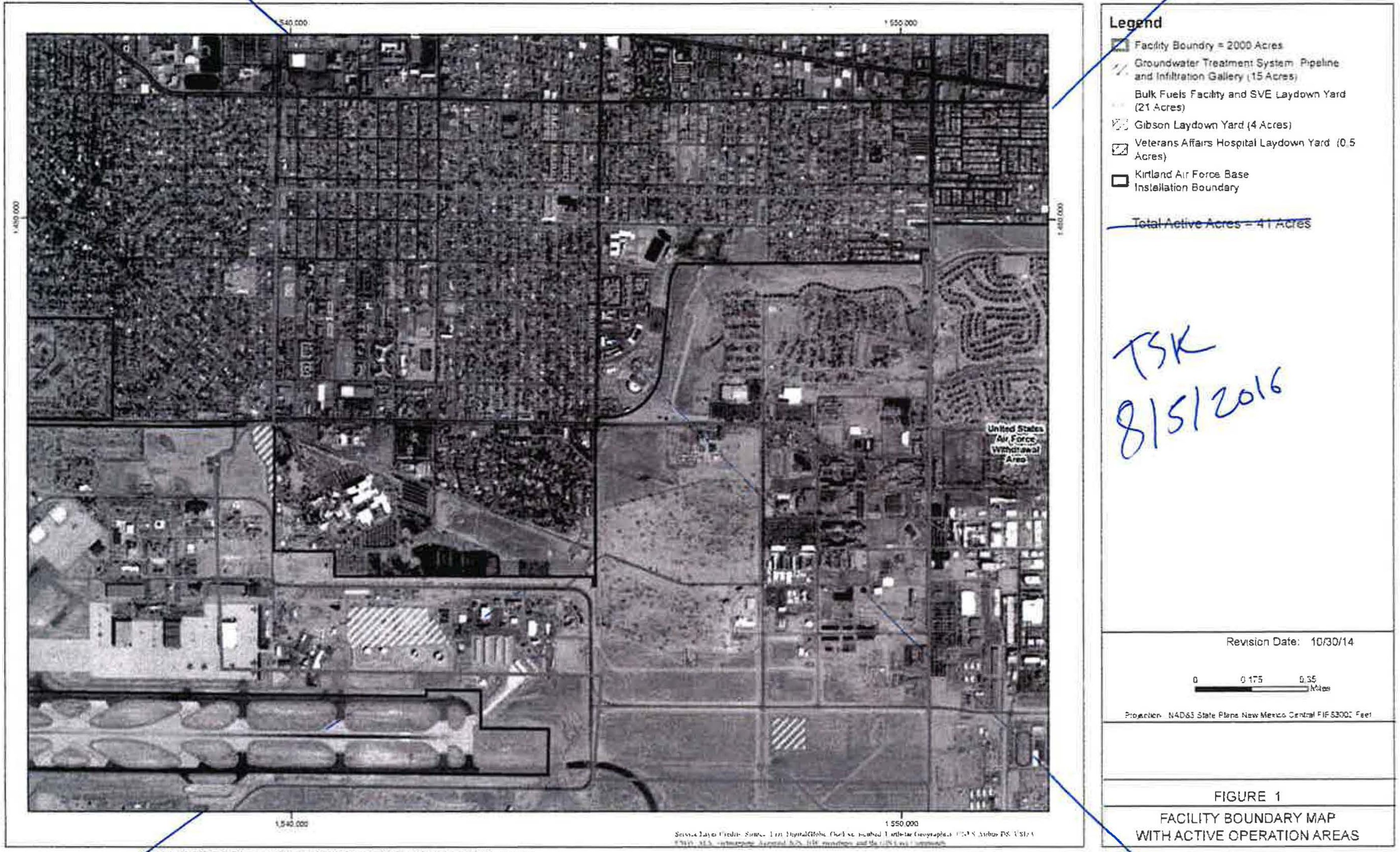
	length (feet)	width (feet)	square feet	additonal 30% for surrounding area	conversion from feet to acres	acres
Gibson Laydown yard	315	400	126000	not necessary	2.30E-05	2.9
Gibson Laydown yard (additional)	500	75	37500	not necessary	2.30E-05	0.9
Soil Vapor Wells Laydown yard and the Bulk Fuels Facility	600	1525	915000	not necessary	2.30E-05	21.0
Groundwater Treatment Pipeline	8350	40	334000	not necessary	2.30E-05	7.7
Groundwater Infiltration Gallery	500	500	250000	325000	2.30E-05	7.5
Groundwater Treatment System	100	100	10000	13000	2.30E-05	0.3
Veteran Affairs Hospital Laydown yard	150	150	22500	not necessary	2.30E-05	0.5
TOTAL						41

please see new Table 1
with new and adjusted
areas shown.

Table 1. Fugitive Dust Permit Acre Calculations

	length (feet)	width (feet)	square feet	additional 30% for surrounding area?	conversion from feet to acres	acres
Soil Vapor Wells Laydown yard and the Bulk Fuels Facility	600	1210	726000	not necessary	2.30E-05	16.7
Veteran Affairs Hospital Laydown yard	150	150	22500	not necessary	2.30E-05	0.5
EDB Biorecirculation Pilot Test Area	290	200	58000	not necessary	2.30E-05	1.3
TOTAL						**18.5**

Please see new Figure 1
with new and adjusted areas.



TSK
8/5/2016

FIGURE 1
FACILITY BOUNDARY MAP
WITH ACTIVE OPERATION AREAS

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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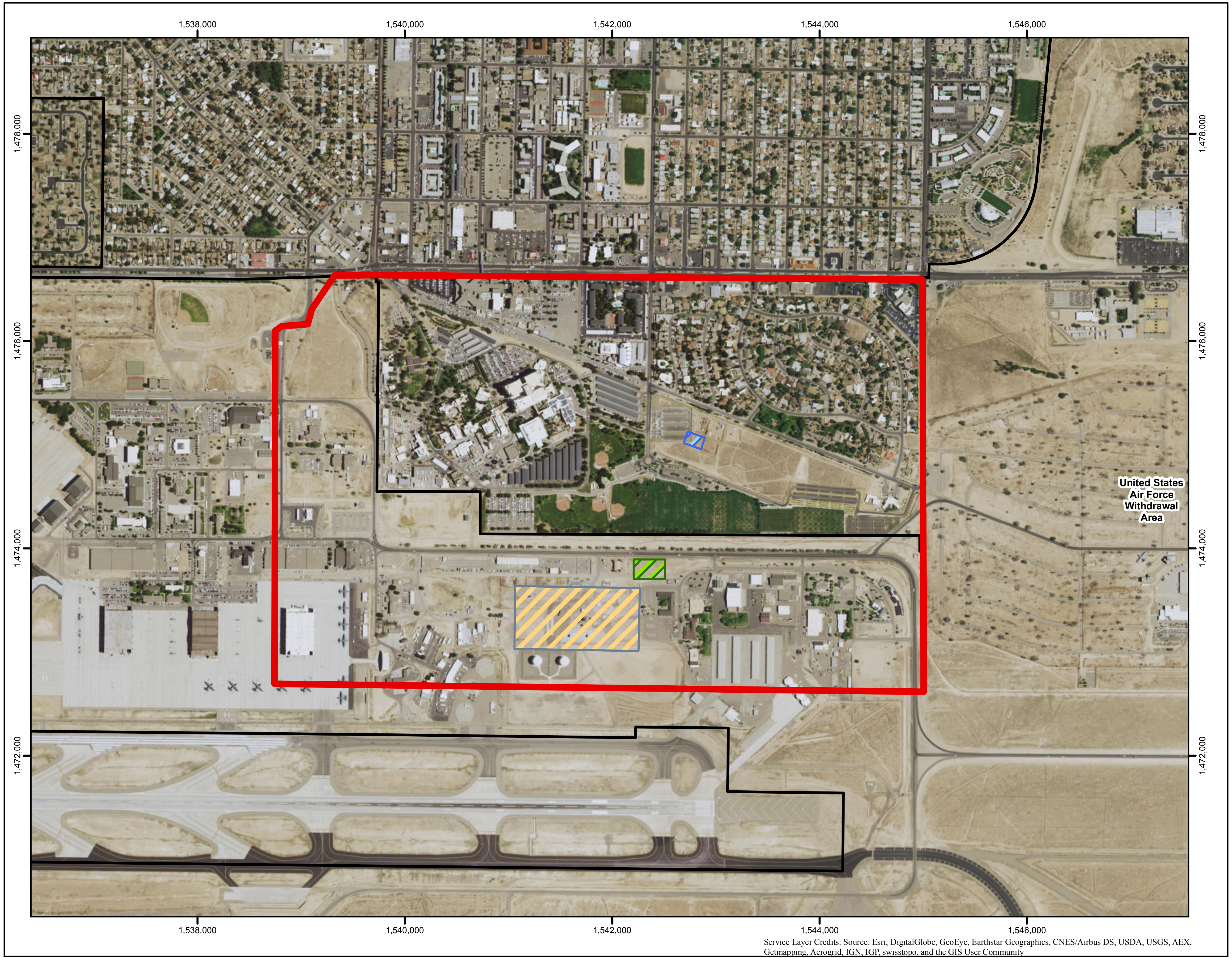

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Legend

- 🟥 Facility Boundary = 564 Acres
- ▨ Bulk Fuels Facility and SVE Laydown Yard (16.7 Acres)
- ▨ Veterans Affairs Hospital Laydown Yard (0.5 Acres)
- ▨ EDB Biorecirculation Pilot Test Area (1.3 Acres)
- ☐ Kirtland Air Force Base Installation Boundary

Total Active Acres = 18.5 Acres

N

Revision Date: 08/04/16

0 500 1,000 Feet

1 in = 1,000 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

FIGURE 1

FACILITY BOUNDARY MAP
WITH ACTIVE OPERATION AREAS

Siting

BASE CIVIL ENGINEER WORK REQUEST

(See Reverse for Instructions)

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average .3 hours per response including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to the Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project 0704-0188, Washington DC 20503. Please DO NOT RETURN your form to either of these addresses. Send your completed form to HQ AFESC/DEMG.

SECTION I - TO BE COMPLETED BY REQUESTER

1. FROM *(Organization)*: CB&I Federal Services LLC

2. OFFICE SYMBOL:

3. DATE OF REQUEST: 08/03/2016

4. WORK REQUEST NO. *(For BCE Use)*: 51659

5. NAME AND PHONE NO. OF REQUESTER: Tara Kunkel, 505-262-8906

6. REQUIRED COMPLETION DATE: 08/31/16

7. BUILDING, FACILITY OR STREET ADDRESS WHERE WORK IS TO BE ACCOMPLISHED: empty lot on Randolph Rd, west of Air National Guard

00000

8. DESCRIPTION OF WORK TO BE ACCOMPLISHED *(Include Sketch or Plan, when appropriate)*

A biorecirculation system has been designed to treat fuel related contamination near the Bulk Fuels Facility. CB&I respectfully requests the use of this area (please see Figure) for storage of a conex box that will house the recirculation system (shown in red) and to establish a less than 90-day RCRA hazardous waste storage area (labeled on Figure) as needed for storing groundwater associated with the extensive sampling required to monitor the success of this system. The conex box and less than 90-day area will remain at this site and in operation for approximately 18 months. The construction fence shown on the attached Figure is temporary and will only be required during active construction, approximately 6 weeks. To power this system, CB&I needs to tie-in to the existing electrical line that runs through the site (See Figure, electrical shown as a thin red line passing through the work site from east to west). CB&I will run new subsurface electrical lines to the conex box that will house the system and from the system to the extraction and injection wells that will be installed (see Figure for locations or proposed wells and utilities). OUT of cycle siting REQUEST

9. BRIEF JUSTIFICATION FOR WORK TO BE ACCOMPLISHED *(Not required for maintenance and repair)*

The EDB bio-enhanced recirculation interim remedy pilot study is being implemented on Kirtland AFB as part of the effort to address groundwater contamination associated with the fuel leaks at the Bulk Fuels Facility. This interim remedy will help inform the selection of a final remedy to treat the aquifer contamination associated with the Bulk Fuels Facility.

received 8/4/16

ORIGINAL 332

10. DONATED RESOURCES

☐ FUNDS ☐ LABOR ☐ MATERIAL ☒ CONTRACT BY REQUESTER ☐ NONE

11. NAME OF REQUESTER: Tara S Kunkel

12. GRADE OF REQUESTER: Deputy Project Manager

13. SIGNATURE OF REQUESTER *(See Reverse of Form*

14. COORDINATION

JC 11 Aug 16
377 ABW/SEG

Moore 11 Aug 16
377 MSG/CEIE
ENVIRONMENTAL MANAGEMENT

G. Giannini
377 MSG/CEOAP
11 Aug 2016

377 MSG/SCXP
11 Aug 2016

4 Aug 2016
377 MSG/CEFT

SECTION II - FOR BASE CIVIL ENGINEER USE

15. WORK ORDER *(Place an "X" in the appropriate box.)*

☐ IN-SERVICE ☐ SELF-HELP ☐ CONTRACT ☐ SABER

16. DIRECT SCHEDULED WORK *(Place an "X" in the appropriate box.)*

☐ EMERGENCY ☐ URGENT ☐ ROUTINE ☐ SELF-HELP ☐ W/C

17. SELF-HELP *(Place an "X" in the appropriate box.)*

☐ BRIEFING REQUIRED ☐ ADEQUATE COORDINATION ☐ INSPECTION REQUIRED

SECTION III - COMPLETE ONLY IF WORK IS TO BE ACCOMPLISHED BY WORK ORDER

18. WORK CLASS:

19. PRIORITY:

20. ESTIMATED HOURS:

21. ESTIMATED FUNDED COST:

22. ESTIMATED TOTAL COST:

☒ 23. THERE IS NO NEED FOR AN ENVIRONMENTAL ASSESSMENT (AFR 19-2) Exempt from NEPA

☐ 24. A WRITTEN ASSESSMENT IS BEING/HAS BEEN PROCESSED

☐ 25. APPROVED

☐ 26. DISAPPROVED

27. REMARKS:

SECTION IV - APPROVING AUTHORITY

28. NAME AND GRADE *(Please Type or Print)*:

29. SIGNATURE:

30. DATE:

AF IMT 332, 19910101, V4

PREVIOUS EDITION IS OBSOLETE

MASTER FILE COPY

CONTINUATION SHEET
AF FM 332. 2014 06 18

27. REMARKS

DATE	ORGANIZATION	PRINT NAME	INITIALS
8/11/16	377 MSG/CETE ENVIRONMENTAL MANAGEMENT	Michelle Bare	mb

Following section(s) on attached Environmental Requirements Checklist apply. AQ3, HW1, HM1, SW3, WQ2/WQ3, NR5, CR3, M1, M4, M6

DATE	ORGANIZATION	PRINT NAME	INITIALS
11aug2016	377 MSG/CEIAP-RP	Geneva Giannini	GG

1354 will be required

DATE	ORGANIZATION	PRINT NAME	INITIALS
24 August 2016	377 MSG/CENPP	Cheslea Farrell	CF

Siting will be approved via 332 approval.

DATE	ORGANIZATION	PRINT NAME	INITIALS

Work Order No: 51659
RCS No:
Dig Permit No:
MHMV No:

Kirtland AFB Checklist of Environmental Requirements for Proposed Project

	Air Quality Program – POC: Ms. Andria Cuevas @ 846-2522 or via e-mail: kirtlandairquality@us.af.mil
AQ 1	**Asbestos:** Due to the age of the building, asbestos-containing material (ACM) may be present. NO RENOVATION/DEMOLITION SHALL BEGIN PRIOR TO CE APPROVAL OF AF FORM 332 AND ASBESTOS SAMPLING, AS REQUIRED. If suspected ACM is encountered and will be disturbed, then asbestos abatement of the area to be renovated must be completed prior to starting the proposed work on the building. ***NOTE:*** NESHAP Notification to the AEHD in accordance with 20.11.20.22 NMAC is required for ACM disturbance. Additional guidance and forms can be found at the City of Albuquerque's website: http://www.cabq.gov/airquality/documents/AsbestosDemoRenoNoticationInstructionsandForm_2015.xls
AQ 2	**Lead Based Paint:** Due to the age of the building, LBP may be present; files are available for review. Contact Air Quality Program personnel to coordinate access to files. If suspected LBP is encountered and will be disturbed, LBP sampling should be performed by the contractor with abatement as necessary prior to commencing the proposed work on the building. ***Coordination/Consultation with Air Quality Program POC required.***
[✓ AQ 3]	**Ground Disturbance:** • If the total ground disturbance is ***greater than or equal to ¾ acre***, then a Fugitive Dust Permit will be required. ***Fugitive Dust Permits must be submitted to the Air Quality Program for review***, and 377 ABW/CC signature, five (5) weeks prior to the anticipated start date of soil disturbance. ***NOTE:*** AEHD AQD requires all Fugitive Dust Permits be submitted to their office 10 business days prior to anticipated start date of soil disturbance and will require a site inspection prior to issuing the permit. • If the total ground disturbance is ***less than ¾ of an acre***, then a fugitive dust permit is not required; however, the contractor must still comply with the following general provisions from 20.11.20.12 NMAC: "Each person shall use reasonably available control measures or any other effective control measure during active operations or on inactive disturbed surface areas, as necessary to prevent the release of fugitive dust, whether or not the person is required by 20.11.20 NMAC to obtain a fugitive dust control permit. It shall be a violation of 20.11.20 NMAC to allow fugitive dust, track out, or transported material from any active operation, open storage pile, stockpile, paved or unpaved roadway, disturbed surface area, or inactive disturbed surface area to cross or be carried beyond the property line, right-of-way, easement or any other area under control of the person generating or allowing the fugitive dust if the fugitive dust may: (1) with reasonable probability injure human health or animal or plant life; (2) unreasonably interfere with the public welfare, visibility or the reasonable use of property; or (3) be visible for a total of 15 minutes or more during any consecutive one hour observation period using the visible fugitive dust detection method in 20.11.20.26 NMAC or an equivalent method approved in writing by the department. Failure to comply with 20.11.20.12 NMAC, a fugitive dust control permit, plan, term or condition shall be a violation of 20.11.20 NMAC." *NOTE: If any ground disturbance other than what is identified in the initial project is to occur, then you MUST re-coordinate with the Air Quality Program personnel prior to commencing work.*
AQ 4	**Boilers:** Natural gas boilers/hot water heaters of size greater than five (5) million BTU (MMBTU) require Stationary Source Air Permitting. If planning to install a boiler fueled by anything other than natural gas, contact Air Quality Program personnel immediately to determine if a permit is needed. If an air permit is required, the permit must be issued prior to purchase of the boiler(s) and can take up to seven (7) months to accomplish. The Air Quality Program is required to track boilers of all sizes/fuel types to comply with the basewide air permit (Title V Operating Permit). ***Coordination/Consultation with Air Quality Program POC required.***
AQ 5	**Refrigerant:** Ensure all equipment containing refrigerant and all HVAC technicians comply with the requirements in 40 CFR Part 82. If you hire an outside contractor, other than Chenega, you must: 1) maintain all invoices and work orders for work on refrigeration equipment for a minimum of 3 years; and 2) maintain an inventory of refrigeration equipment to include: make, model, serial number, refrigerant type, and total refrigerant charge in pounds.
AQ 6	**Generators:** All emergency generators are required to have a 20.11.41 NMAC construction permit from the Albuquerque Environmental Health Department (AEHD) Air Quality Division (AQD). The permit must be in place prior to "commencing construction", which means prior to purchasing the unit (20.11.41.7.C NMAC). It may take as long as 7 months from the initiation of the permit application preparation process to receive a permit from the AEHD AQD. The project is expected to pay for the cost of preparing the permit application and the associated AEHD AQD permit fees. The organization must plan to pay annual emission fee assessed by the AEHD AQD. Contact Air Quality Program personnel to discuss the timeline for the project. AFCEC approval of generator sizing and design is required prior to permitting. ***Coordination/Consultation with Air Quality Program POC required.***
AQ 7	**Building Renovation/Demolition:** If the building to be renovated/demolished is more than 75,000 cubic feet of space then a Fugitive Dust Permit will be required prior to renovation/demolition (***refer to AQ3 – first bulleted item***). An asbestos notification form must be submitted for all building renovation/demolition activities, even if no regulated ACM is present in the building or structure (***refer to AQ1***).
AQ 8	**Air Quality Permitting for New Sources:** An air quality permit from the AEHD AQD may be required for the proposed equipment prior to construction. ***Coordination with the Air Quality POC is required*** to ensure the appropriate measures are taken in the event the source must obtain an air quality permit. It may take as long as 7 months from the initiation of the permit application preparation process to receive a permit from AEHD AQD. The project is expected to pay for the cost of preparing the permit application and the associated AEHD air quality permit fees. The organization must also plan to pay emission fees for the permitted source on an annual basis.
AQ 9	**Permitting and/or Reporting Requirements Exist for Activity:** Activities require Open Burn/Open Detonation permitting through the City of Albuquerque OR there is requirement to report munition items expended during event. ***Prior Coordination with the Air Quality POC is required.***

effective: 25 April 2016
by Martha E. Garcia

	Hazardous Waste Program – POCs: Ms. Rebecca Clines and Ms. Katrina Wheelock @ 846-8003 or via e-mail: kirtlandhazwaste@us.af.mil
HW 1	**Contracted Construction Projects:** All wastes generated must be characterized by the contractor. Any wastes characterized as Universal (lamps, batteries, etc.) or Hazardous must be properly disposed of by the contractor in accordance with (IAW) all federal and state regulations. Transformers, capacitors, and ballasts being removed/replaced must also be characterized and disposed of by the contractor IAW all federal, state, and local regulations. ***Ensure Scope of Work (SOW) and contract funding accurately account for these requirements.***
HW 2	**Self-Help / In-House Projects:** Any Universal (lamps, batteries, etc.) or Hazardous wastes generated must be properly characterized and disposed of IAW all federal and state regulations. Transformers, capacitors, and ballasts being removed/replaced must be characterized and disposed of in accordance with (IAW) all federal, state, and local regulations. Characterization may require fluid sampling. ***Contact the Hazardous Waste program prior to project start for guidance.*** Once project is complete, ***contact Hazardous Waste POCs for proper management of unused/unwanted materials (paints, sealants, etc.).***
HW 3	**TDYs:** Kirtland AFB manages the following items as hazardous waste: used oil, oily rags, rags contaminated with solvent, batteries, paint, sealants, etc. These items must be disposed of IAW federal, state, and local regulations. ***Contact 377 MSG/CEIE Hazardous Waste Program POCs 4 weeks prior to your TDY.***
HW 4	**New/Updated Mission Requirements:** Proposed new/updated activities may introduce or alter a waste stream. ***Contact the Hazardous Waste program to ensure wastes are properly characterized.***
	Hazardous Materials Program – POC: Program Manager: Ms. Lori Crump @ 846-8781 Program Support: Mr. Rickey Spence @ 846-2509 or via e-mail: 377msg@ s.af.mil
HM 1	Any hazardous materials used in the proposed project needs to be identified either by authorizing the material(s) under a shop in EESOH-MIS or by filling out, submitting, and following the guidelines in the short term contractor Memo and worksheet. Please turn in the worksheet, inventory list, and manufacture specific SDS(s) to the 377th MSG/CEIEC Hazardous Material program office or email to 377 MSG/CEIEC Hazardous Materials mail box. ***Please contact Hazardous Materials POCs for Memo and worksheet.***
HM 2	Any hazardous materials used in the proposed deployment need to be identified by filling out, submitting, and following guidelines in the deployment memo and worksheet. Please turn in the worksheet, inventory list, and manufacturer specific SDS(s) to the 377 MSG/CEIEC Hazardous Material program office or email to the 377 MSG/CEIEC Hazardous Materials mail box. ***Please contact Hazardous Materials POCs for Memo and worksheet.***
	Solid Waste/Recycling – POC: Program Manager: Ms. Katrina Wheelock @ 853-2486
SW 1	**Reporting:** Document weight/volume of all waste disposed, recycled, or salvaged off-base. Submit documentation to 377msg.ceanc.12@us.af.mil. ***Contact the Solid Waste/Recycling Program Manager for guidance.***
SW 2	**Furniture/Equipment Disposal:** ***Coordinate with DRMO (853-2269 or 846-6396)*** to establish whether furniture/equipment needs to be turned in. ***Contact your Unit Equipment Manager*** to remove equipment from supply/asset inventories prior to turning in or disposing If disposal is authorized by DRMO and a roll-off is required, submit request on an AF Form 332.
SW 3	**Minor Construction/Demolition:** If using Kirtland AFB C&D Landfill for disposal, segregate scrap metal and corrugated cardboard for recycling at the landfill's recycling area. If a dumpster/roll-off is needed for recycling larger amounts of scrap metal or cardboard, submit request on an AF Form 332.
SW 4	**Major Construction/Demolition:** Ensure that Section 01 74 19 (Construction Waste Management, updated 06/2012) is included in project specifications.
SW 5	**Explosive Testing Debris:** Ensure test bed is cleared of any debris before next test. Only debris of a non-hazardous nature may be disposed of in the Kirtland AFB C&D Landfill. ***Proponent must maintain documentation that waste is non-hazardous, and provide to the Solid Waste/Recycling Program Manager upon request.***
	Restoration Program – POC: Chief of Env. Restoration: Mr. Wayne Bitner @ 853-3484
R1	Due to the potential for encountering Unexploded Ordnance (UXO), any fieldwork south of Hardin Blvd requires workers to complete UXO Awareness training. ***The 377 MSG/CED EOD Group can provide this short training. They can be contacted at 846-2229.***
R2	Impacts to Environmental Restoration Sites are possible. ***Please contact Restoration Program POC before doing any work.***
	Water Quality Program – POC's: Ms. Andria Cuevas @ 846-2522 and Ms. Rebecca Clines @ 846-2306
WQ 1	**Wastewater – Septic Tanks/Leach Fields:** When feasible, new construction and remodels should connect to the sanitary sewer system. If a new septic system is the only viable option, the septic tank and leach field must meet the requirements of the NMED Liquid Waste Bureau and be registered with the state. Consult the NMED Liquid Waste requirements concerning removal and/or demolition of a septic tank (20.6.2 NMAC http www nmcpr sta e nm us/nmac/ titles h n) ***Coordination/Consultation with Water Quality Program POCs required.***
WQ 2	**Water Discharge Activities - Municipal Separate Storm Sewer System (MS4) applies:** The MS4 permit requires all activities, regardless of size, to implement best management practices (BMPs) to ensure that storm water pollutants are contained to the maximum extent practical and do not enter the storm drainage system (http water epa gov/polwas e/ pdes/s o). Examples of activities include: power washing of surfaces, minor construction, laydown yards or any activities draining to a storm drain, etc Additionally, all non-storm water discharges must be approved by the Water Quality Program **prior to discharge**, all other non-storm water discharges are **prohibited**. ***Coordination/Consultation with Water Quality Program POCs required.*** *NOTE: If any ground disturbance other than what is identified in the initial project is to occur, then you must coordinate with the Water Quality Program personnel prior to commencing work.*

2

effective: 25 April 2016
by Martha E. Garcia

	***Water Quality Program** – POC's: Ms. Andria Cuevas @ 846-2522 and Ms. Rebecca Clines @ 846-2306*
WQ 3	**Land Disturbance Equal to or Greater than 43,560sqft (1 acre) – Construction General Permit (CGP) applies:** CGP applies to any individual project or series of projects/common development plans that cumulatively disturb one (1) acre. Contractors **must** develop a Storm Water Pollution Prevention Plan (SWP3), a draft Notice of Intent (NOI), and a detailed site map for approval by the Water Quality Program at least four (4) weeks prior to the contractor's submission of the approved NOI to the Environmental Protection Agency (EPA). Contractors **must** submit NOIs at least fourteen (14) calendar days prior to commencing ground disturbance (**Note**: 6 weeks total required). Ground disturbance **cannot** begin for fourteen (14) calendar days after EPA acknowledges receipt of the NOI (http://cfpub.epa.gov/npdes/stormwater/cgpenoi.cfm), or unless EPA delays or denies authorization. BMPs complying with the permit conditions **must** be in place before any ground disturbance commences *Upon project completion,* Contractor **must** achieve final stabilization, in accordance with Part 2.2.2 and Part 9.4.1 of the CGP, prior to submitting a Notice of Termination (NOT) to the EPA and NMED. Contractor **must** comply with the NMED Surface Water Quality conditions specified in Part 9.4 of the CGP (20.6.4 NMAC, http://www.nmcpr.state.nm.us/nmac/_titles.htm). ***Coordination/Consultation with Water Quality Program POCs required.***
WQ 4	**Facilities/Renovations with New Footprints Greater Than 5,000 gross sq ft - EISA, Section 438 applies:** The project footprint consists of all horizontal hard surfaces and disturbed areas, including both building area and pavements. The Energy Independence Security Act (EISA) requirements do not apply to internal renovations, maintenance, or resurfacing of existing pavements. Projects **must** conform to Air Force Sustainable Design and Development (SDD) guidance dated 2 June 2011 and the Unified Facilities Criteria (UFC-2-210-10). **Note: use of retention ponds is strictly prohibited.** Contractor **must** populate and validate the approved EISA spreadsheet prior to land disturbance. EISA estimated cost, written as a separate line-item of estimated cost, and final implementation cost **must** be documented in the DD 1391. ***Coordination with Water Quality Program POCs required.***
WQ 5	**Wastewater – Oil Water Separators, Grease and Sand Traps:** Equipment should only be installed at locations with an identified need and no feasible alternative. Design features and processes should be substantially reviewed prior to installation of equipment (include in DD 1391 if required). ***Coordination/Consultation with Water Quality Program POCs required.***
WQ 6	**Wastewater – Port-a-Potties:** For all projects/events, the contractor must anchor port-a-potties to prevent toppling of the unit. All projects and events that will utilize gray (hand wash station) and black water (port-a-potties) systems must ensure that the contents are disposed of in accordance with local, state and federal laws ***Coordination/Consultation with Water Quality Program POCs required.***
WQ 7	**Wastewater – Fire Suppression System Discharge:** Discharges from fire suppression systems utilizing chemical suppressants must be contained at the facility. Discharges of chemical suppressants to the environment or the sanitary sewer system are **prohibited** ***Coordination with Water Quality POCs required.***
WQ 8	**Section 404 Permit:** Any activities in or near the Tijeras or Coyote Arroyos may require a Section 404 Permit. ***Consultation with Water Quality POCs required.***
	***Tank Program** – POC: Mr. Dustin Akins @846-0226*
T1	**Transformers:** ***Please forward*** the make, model, transformer ID, location/building, and oil capacity (in gallons) for each new/replacement transformer being installed ***to Tank Program POC.***
T2	**Tanks – Above Ground Tanks (ASTs), Underground Tanks (USTs) and Generators:** ***Please forward*** the make, model, ID number, location/building, and storage capacity (in gallons) for all new and/or replacement oil storage tanks (including POLs, grease, fuels and generators) over 55 gals to ***Tank Program POC.*** All units over 55 gals must have secondary containment in case of spills/leaks. All USTs and tanks over 1,320 gals must be registered with the state.
	***Natural Resources Program** – POC: Ms. Erin Riley @ 846-0226*
NR 1	**Demolition of Buildings/Structures:** ***Contact Natural Resource POC*** to schedule a survey for bats, snakes, and nesting birds prior to demolition.
NR 2	**Removal/Trimming of Tree(s):** ***Contact Natural Resource POC*** to schedule a survey for bird nests prior to removal/trimming tree(s).
NR 3	**Outdoor Activities (Including Exterior Building/Structure Renovations):** ***Contact Natural Resource POC*** to schedule a survey for bird nests/animal issues prior to beginning work.
NR 4	**Replacement of Existing or Installation of New Power Poles:** Poles may need to be retrofitted to prevent bird electrocution. ***Contact Natural Resource Program POC*** to have the poles evaluated.
NR 5	**Trenching:** Potential exists for reptiles/amphibians/small mammals dropping into trenching projects and becoming trapped. Trenches require ramps at no more than 45 degrees so that trapped animals may exit the trench. ***Contact Natural Resource POC*** with questions.
	***Cultural Resources Program** – POC: Ms. Erin Riley @ 846-0226*
CR 1	Building/Structure is Historic; proposed work may indirectly impact historic properties (Area of Potential Effect). ***Please contact Cultural Resource POC before doing any work.***
CR 2	Impacts to Cultural Sites are possible. ***Please contact Cultural Resource POC before doing any work.***
CR 3	**Inadvertent Discovery of Buried Cultural Resources or Native American Human Remains and Objects:** If cultural resources are encountered inadvertently during an undertaking, work in the immediate vicinity shall be halted, the immediate vicinity of the resources shall be secured, and the Cultural Resource Program POC, shall be notified. The following procedures shall be followed: • An in situ evaluation of the resources shall be made by a qualified archaeologist. Based on recommendations from the archaeologist, decisions regarding the treatment of the resources shall be made in consultation with the Cultural Resources Manager (CRM) and the State Historic Preservation Officer (SHPO). • If the resources cannot be evaluated without further archaeological or historic work, the CRM shall be notified and a data recovery program or historic research shall be prepared in consultation with the SHPO. • Based on the results of the data recovery program or historic research, the resources shall be evaluated for eligibility to the National Register in consultation with the CRM and the New Mexico SHPO.

	MISCELLANEOUS
[✓ M1]	**Ground Disturbance:** AF Form 103 required.
M2	**Project Requires Siting**: Contact Base Siting Office at 853-3747.
M3	**Tree Removal:** Personal use is not allowed. Please remove stumps and ensure trunks are no longer than 5 feet and/or 30 inches in diameter, if being taken to the Kirtland AFB Landfill for mulching. ***Coordination with Landfill Personnel required – Please call 846-5994 for further guidance.***
[✓ M4]	**Disposal of Construction &Demolition (C&D) Waste at Kirtland C&D Landfill**: In order to gain access to the site, contractors must obtain a KAFB C&D Landfill Pass specific to each contract held for work on KAFB (multiple contracts = multiple passes). Note that a landfill pass establishes eligibility to use the facility; it does not guarantee disposal. Passes are issued Monday – Friday, 0730-1200. ***To obtain a Pass, contractors must bring all of the following items to the Landfill office:*** a) copy of the valid contract issued by a U.S. Government Contracting Agency for work to be accomplished on KAFB that requires use of the KAFB C&D Landfill; b) original, current vehicle registration(s); c) valid proof of insurance; and d) subcontractor appointment letter or contract (if applicable), showing subcontractor's performance period Contractor's signature to obtain a Pass indicates that contractor will control the waste stream such that only C&D generated on KAFB is disposed at the C&D Landfill (no municipal solid waste, no hazardous waste, no special waste, no off-base waste, etc.), and that contractor assumes full responsibility for proper disposal of any waste that may be rejected at the gate.
M5	**Activities on DOE Permitted Property**: DOE is responsible for adhering to all environmental laws and obtaining all applicable permits prior to commencing work. This includes conducting biological and cultural surveys as applicable. ***Please contact the DOE Environmental Office for further guidance.***
[✓ M6]	**Environmental Management System (EMS) Awareness:** Kirtland AFB has a conforming EMS. All personnel, to include contractors need to be aware of the Environmental Commitment Statement found on the Kirtland AFB public website - http www.kirtland.af.mil/shared media document/AFD-140123-056.pdf. Contract work shall be consistent with the relevant policy and objectives identified in the Kirtland AFB EMS applicable to the contract The Contractor shall ensure that employees are aware of environmental impacts and will mitigate those impacts by practicing pollution prevention techniques. ***Please contact the Kirtland AFB EMS Program Manager, Ms. Lori Crump @ 846-8781, with any questions.***
M7	**Spectrum Management Office (SMO):** All organizations on Kirtland AFB (includes incoming or TDY units and construction companies) that have radios (including walkie talkies), radars, sounders or a device that transmits radio frequencies must have a radio frequency license issued from the National Telecommunications and Information Administration (NTIA) or the Federal Communications Commission (FCC) prior to operation on the Installation. ***Organizations should contact the SMO to ensure that their devices are properly licensed prior to use, or, to request radio frequency assistance from the Installation Spectrum Managers. The SMO can be reached at (505) 853-3769/7426 or via email at 377ABW.SMO@us.af.mil.***
M8	DD1354 is required to capitalize improvements. ***Please submit document upon completion of project to the Real Property Office.***

Note: Listed requirements are subject to change for compliance with statutory/regulatory changes.

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

DISTRICT 1

TOM BLAINE, P.E.
NEW MEXICO STATE ENGINEER

5550 San Antonio Drive, N.E.
Albuquerque, NM 87109 (505) 383-4000

December 7, 2016

File No.: RG-1579

Kirtland Air Force Base
Attn: Wayne Bitner, Chief, Environmental Restoration
AFCEC/Kirtland AFB IST; Bldg 20685
2050 Wyoming Blvd, SE
Kirtland AFB, NM 87117-5270

RE: Permit No. RG-1579 POD316 through POD318

Greetings,

Your copy of the above numbered permit, which has been approved subject to the conditions set forth on the approval page, is enclosed.

Please review the Conditions of Approval for any required submittals. If submittals are not made by the date(s) indicated in the conditions, your rights under this permit are subject to expiration unless a request for an Extension of Time is received in the District Office of the State Engineer by that date, and that Extension of Time is subsequently approved.

Appropriate forms can be downloaded from the OSE website at www.ose.state.nm.us/WR/forms.php or will be mailed to you upon request.

Sincerely,

Christopher Burrus
Water Resource Specialist
Albuquerque, OSE, District 1

C: CB/cb

1-55400
$ 150

File No. RG-1579
POD 316 to POD 318

NEW MEXICO OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO CHANGE AN EXISTING WATER RIGHT
(Non 72-12-1)

(check applicable boxes):

For fees, see State Engineer website: http://www.ose.state.nm.us/

☒ Change Purpose of Use ☒ Groundwater ☐ Surface Water ☒ Change Place of Use ☒ Groundwater ☐ Surface Water	☐ Change Point of Diversion (POD): From: ☐ Groundwater ☐ Surface Water To: ☐ Groundwater ☐ Surface Water	☒ Additional Groundwater Point of Diversion (POD) ☐ Additional Surface Water Point of Diversion (POD)

☐ Temporary Change, NMSA 1978, § 72-12-7(B) Requested Start Date: Requested End Date:
(Not to Exceed 3 ac-ft in One Year)
☐ Water Use Lease, NMSA 1978, §§ 72-6-1 to-7 Requested Start Date: Requested End Date:

1. APPLICANT(S) (Required) Note: water-right owner must be listed as an applicant.

Name: **Kirtland Air Force Base**	Name: **N/A**
Contact or Agent: check here if Agent ☒ **Wayne Bitner**	Contact or Agent: check here if Agent ☐ **N/A**
Mailing Address: **Chief Environmental Restoration 2050 Wyoming Blvd SE**	Mailing Address: **N/A**
City: **Albuquerque**	City:
State: **NM** Zip Code: **87117-5270**	State: Zip Code:
Phone: **N/A** ☐ Home ☐ Cell Phone (Work): **505-853-3484**	Phone: ☐ Home ☐ Cell Phone (Work):
E-mail (optional): **Ludie.Bitner@us..af.mil**	E-mail (optional):

STATE ENGINEERS OFFICE
ALBUQUERQUE, NEW MEXICO
2016 AUG 25 AM 10: 0[illegible]

2. CURRENT OSE FILE INFORMATION (Required)

OSE File No(s): **RG-1579 THROUGH RG-1589**	Priority Date (if known):	Subfile/Cause No. (if applicable):

3. CURRENT PURPOSE OF USE AND AMOUNT OF WATER (Required)

☐ Domestic ☐ Livestock ☐ Irrigation ☐ Municipal ☐ Industrial ☐ Commercial ☒ Other Use (specify): **Pollution Control and Recovery** Describe a specific use If applicable (i.e. sand & gravel washing, dairy etc): **Extraction and injection of groundwater for remediation**	Amount of Water (acre-feet per annum): If more details are needed, type "See Comments" in "Other" field below, and explain in Additional Statements Section. Diversion: **up to 80** Consumptive Use: **None** Other (include units): **See Comments**

FOR OSE INTERNAL USE

Application for Permit, Form wr-06, Rev 9/26/12

File No.: RG-1579	Trn. No.:	Receipt No.:
Trans Description (optional): POD 316 - 318		Sub-Basin:
PCW/LOG Due Date:	PBU Due Date:	

4. COUNTY WHERE WATER RIGHT IS CURRENTLY USED (Required)

Bernalillo

5. ADDITIONAL STATEMENTS CONCERNING THE CURRENT WATER RIGHT

Extraction wells KAFB-106EX1 and KAFB-106EX2 and injection well KAFB-106IN1 will be supplimental to the wells described in Kirtland AFB file No. RG 1579 through RG-1589. The application does not request to increase the allowable groundwater diversion described in RG-1579 through 1589, but seeks to change the purpose of use to pollution control and recovery, and by adding places of use not currently described in water rights RG-1579 through RG-1589. The amount of groundwater removed from the two extraction wells (50 gpm, or 80 acre-feet per year) will be injected into KAFB-106IN1 at a rate of 50 gpm (80 acre-feet per year), so there is no consumptive use.

6. CURRENT or MOVE-FROM POINT(S) OF DIVERSION (POD) (Required)

☐ **Surface POD** **OR** ☒ **Ground Water POD (Well)**

Name of ditch, acequia, or spring:

Stream or water course:

Tributary of:

If application proposes a new point of diversion involving a diversion dam, storage dam, main canal, and/or pipeline, complete Attachment 2. ☐ Check here if Attachment 2 is included in this application packet.

POD Location Required: Coordinate location must be reported in NM State Plane (NAD 83), UTM (NAD 83), or Latitude/Longitude (Lat/Long - WGS84).

District II (Roswell) & District VII (Cimarron) customers, provide a PLSS location in addition to above.

☒ NM State Plane (NAD83) (Feet)
- ☐ NM West Zone
- ☐ NM East Zone
- ☒ NM Central Zone

☐ UTM (NAD83) (Meters)
- ☐Zone 12N
- ☐Zone 13N

☐ Lat/Long (WGS84) (to the nearest 1/10th of second)

POD Number (if known):	X or Easting or Longitude:	Y or Northing or Latitude:	**Provide if known:** **-Public Land Survey System (PLSS)** **(*Quarters or Halves , Section, Township, Range*) OR** **- Hydrographic Survey Map & Tract; OR** **- Lot, Block & Subdivision; OR** **- Land Grant Name**
KAFB-106EX1	**1542418.47**	**1473782.33**	
KAFB-106EX2	**1542254.00**	**1473837.97**	
KAFB-106IN1	**1542331.87**	**1473810.39**	

NOTE: If more PODS need to be described, complete form WR-08 (Attachment 1 – POD Descriptions)

Additional point of diversion descriptions are attached: ☐ **Yes** ☒ **No** **If yes, how many______**

Point of Diversion is on Land Owned by: **Kirtland Air Force Base**

Other description relating point of diversion to common landmarks, streets, or other: **The two extraction wells and one injection well will be located on Kirtland Air Force Base, just south of Randolph Road SE, between Fuels Drive and Air Guard Drive SE.**

FOR OSE INTERNAL USE

File Number: RG-1579 POD 316-318

Trn Number:

7. CURRENT or MOVE-FROM PLACE(S) OF USE (Required)

The land is legally described by (check all that apply):

☒ Public Land Survey System (PLSS) (quarters, section, township, range)
☐ Irrigation or Conservation District Map
☐ Hydrographic Survey Report or Map
☐ Subdivision
☐ Grant

Complete the blocks below for all tracts of land (more than one description can be provided for a tract if available):

PLSS Quarters or Halves, **and/or** Name of Hydrographic Survey, **and/or** Name of Irrigation or Conservation District, **and/or** Name and County of Subdivision **and/or** Grant	PLSS Section **and/or** Map No. **and/or** Lot No.	PLSS Township **and/or** Tract No. (Please list each tract individually) **and/or** Block No.	PLSS Range	Acres	Priority
RG-1579	**36**	**10N**	**3E**		
			Total Acres:		

Other description relating place of use to common landmarks, streets, or other: **Kirtland AFB as described in District Court order: United States District Court, District of New Mexico, State of New Mexico State Engineer vs. Kirtland Air Force, dated November 27, 1973. Court order is included as Attachment 2.**

Place of use is on land owned by (required): **Kirtland Air Force Base**

Are there other sources of water for these lands? No ☒ Yes ☐ describe by OSE file number:

Note: If on Federal or State Land, please provide copy of lease.

FOR OSE INTERNAL USE

File Number: RG-1579 POD 316-318	Trn Number:

8. MOVE-TO PURPOSE OF USE AND AMOUNT OF WATER (Complete this section ONLY if the purpose of use is changing)

☐ Domestic ☐ Livestock ☐ Irrigation
☐ Municipal ☐ Industrial ☐ Commercial
☒ Other Use (specify): **Pollution Control and Recovery**

Describe a specific use If applicable (i.e. sand & gravel washing, dairy etc): **Extraction and injection of GW for remediation**

Amount of Water (acre-feet per annum): If more details are needed, type "See Comments" in "Other" field below, and explain in Additional Statements Section.

Diversion: **up to 80**

Consumptive Use: **None**

Other (include units): **See Comments**

9. MOVE-TO POINT(S) OF DIVERSION (POD) (Complete this section ONLY if adding or replacing a POD)

☐ **Surface POD** OR ☒ **Ground Water POD (Well)**

Name of ditch, acequia, or spring:

Stream or water course: Tributary of:

If application proposes a new point of diversion involving a diversion dam, storage dam, main canal, and/or pipeline, complete Attachment 2. ☐ Check here if Attachment 2 is included in this application packet.

POD Location Required: Coordinate location must be reported in NM State Plane (NAD 83), UTM (NAD 83), or Latitude/Longitude (Lat/Long - WGS84).
District II (Roswell) & District VII (Cimarron) customers, provide a PLSS location in addition to above.

☒ NM State Plane (NAD83) (Feet)
- ☐ NM West Zone
- ☐ NM East Zone
- ☒ NM Central Zone

☐ UTM (NAD83) (Meters)
- ☐Zone 12N
- ☐Zone 13N

☐ Lat/Long (WGS84) (to the nearest 1/10th of second)

POD Number (if known):	X or Easting or Longitude:	Y or Northing or Latitude:	Provide if known: -Public Land Survey System (PLSS) (*Quarters or Halves , Section, Township, Range)* OR - Hydrographic Survey Map & Tract; OR - Lot, Block & Subdivision; OR - Land Grant Name
KAFB-106EX1 POD 316	**1542418.47**	**1473782.33**	
KAFB-106EX2 POD 317	**1542254.00**	**1473837.97**	
KAFB-106IN1 POD 318	**1542331.87**	**1473810.39**	

NOTE: If more PODS need to be described, complete form WR-08 (Attachment 1 – POD Descriptions)
Additional POD descriptions are attached: ☐ Yes ☒ No If yes, how many______

Other description relating point(s) of diversion to common landmarks, streets, or other: **The two extraction wells and one injection well will be located on Kirtland Air Force Base, just south of Randolph Ave SE, between Fuels Drive and Air Guard Drive SE.**

Point of Diversion is on Land Owned by: **Kirtland Air Force Base**

Note: The following information is for wells only. If more than one (1) well needs to be described, provide attachment.

Approximate depth of well (feet): **510.00**

Outside diameter of well casing (inches): **6.00**

Driller Name: **NA**

Driller License Number: **NA**

FOR OSE INTERNAL USE

File Number: RG-1579 POD 316-318

Trn Number:

If replacing the current well, is the current well to be plugged? ☐ Yes ☐ No ☒ Not Applicable

If No, state for what use it is retained:

FOR OSE INTERNAL USE

File Number: RG-1579 POD 316-318	Trn Number:

10. MOVE-TO PLACE(S) OF USE (Complete this section ONLY if adding or changing a place of use)

List each individually

The land is legally described by (check all that apply):

☒ Public Land Survey System (PLSS) (quarters, section, township, range)
☐ Irrigation or Conservation District Map
☐ Hydrographic Survey Report or Map
☐ Subdivision
☐ Grant

Complete the blocks below for all tracts of land (more than one description can be provided for a tract if available):

PLSS Quarters or Halves, **and/or** Name of Hydrographic Survey, **and/or** Name of Irrigation or Conservation District, **and/or** Name and County of Subdivision **and/or** Grant	PLSS Section **and/or** Map No. **and/or** Lot No.	PLSS Township **and/or** Tract No. (Please list each tract individually) **and/or** Block No.	PLSS Range	Acres	Priority
SW 1/4	**36**	**10N**	**3E**		

Total Acres:

Other description relating place of use to common landmarks, streets, or other: **The two extraction wells and one injection well will be located on Kirtland Air Force Base, just south of Randolph Ave SE, between Fuels Drive and Air Guard Drive SE.**

Place of use is on land owned by (required): **Kirtland Air Force Base**

Are there other sources of water for these lands? No ☒ Yes ☐ describe by OSE file number:

Note: If on Federal or State Land, please provide copy of lease.

FOR OSE INTERNAL USE

File Number: RG-1579 POD 316-318
Trn Number:

11. ADDITIONAL STATEMENTS OR EXPLANATIONS

This application seeks to use wells KAFB-106EX1, KAFB-106EX2, and KAFB-106IN1 for a temporary pilot recirculation system supplemental to the Kirtland AFB water rights (RG-1579 through 1589). The application does not request to increase the allowable groundwater diversion described in RG-1579 through RG-1589, but seeks to change the purpose of use to pollution control and recovery, and by adding places of use not currently described in water rights RG-1579 through RG-1589. The two extraction wells will extract groundwater up to 40 acre feet per year (25 gpm) per well (80 acre feet per year total), and the injection well will recirculate amended groundwater at a rate of up to 50 gpm for approximately one year.

ACKNOWLEDGEMENT

I, We (name of applicant(s)), **Eric H. Froehlich**, COLONEL, USAF, 377 ABW COMMANDER

Print Name(s)

affirm that the foregoing statements are true to the best of (my, our) knowledge and belief.

Applicant Signature

Applicant Signature

ACTION OF THE STATE ENGINEER

This application is:

☒ approved ~~☐ partially approved~~ ~~☐ denied~~

provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare and further subject to the attached conditions of approval.

STATE ENGINEERS OFFICE
ALBUQUERQUE NEW MEXICO
2016 AUG 25 AM 10: 04

Witness my hand and seal this 7 day of December 20 16, for the State Engineer,

Tom Blaine, P.E.
State Engineer, State Engineer

By:
Signature

CHRISTOPHER BURPLUS
Print

Title: Water Resource Specialist
Print

FOR OSE INTERNAL USE

Application for Permit, Form wr-06

File Number: RG-1579 POD316-318	Tm Number:

Page 7 of 7

CONDITIONS OF APPROVAL

1. This application is approved as follows:

Permittee:	Kirtland Air Force Base
Permit No:	RG-1579 POD316 through POD318
Application File Date:	August 25, 2016
Notice for Publication Issued:	September 7, 2016
Affidavit of Publication Filed:	October 6, 2016, The Albuquerque Journal published on September 12, 19, and 26, 2016
Priority:	March 1, 1949 through March 6, 1956
Source:	Groundwater
Point of Diversion:	
RG-1579 POD316:	(KAFB-106EX1) Located at a point where X=1,542,418.47 feet and Y=1,473,782.33 feet, NAD 83, SPCS, Central Zone, on land owned by Kirtland Air Force Base, Bernalillo County, New Mexico.
RG-1579 POD317:	(KAFB-106EX2) Located at a point where X=1,542,254.0 feet and Y=1,473,837.97 feet, NAD 83, SPCS, Central Zone, on land owned by Kirtland Air Force Base, Bernalillo County, New Mexico.
RG-1579 POD318:	(KAFB-106IN1) Located at a point where X=1,542,331.87 feet and Y=1,473,810.39 feet, NAD 83, SPCS, Central Zone, on land owned by Kirtland Air Force Base, Bernalillo County, New Mexico.
Purpose of Use:	Pollution Control and Recovery; Extraction from RG-1579 POD 316 and RG-1579 POD317, and Injection into RG-1579 POD318
Place of Use:	within the SW¼, Section 36, Township 10 North, Range 3 East, New Mexico Principal Meridian, Bernalillo County, New Mexico.

2. The total diversion of water from wells RG-1579 POD316, RG-1579 POD317, and RG-1579 POD318 under this permit shall not exceed 80 acre-feet per annum consumptive use.

3. The new wells shall be drilled by a well driller licensed in the State of New Mexico, and a well record for new wells RG-1579 POD316, RG-1579 POD317, and RG-1579 POD318 shall be filed with the Office of the State Engineer within twenty (20) days of drilling the well.

4. Wells RG-1579 POD316, RG-1579 POD317, and RG-1579 POD318 shall be equipped with a totalizing meter of a type, at location(s) approved by, and installed in a manner acceptable to the State Engineer. Records of the amount of water pumped and injected shall be submitted, in writing, to the District 1 Office of the State Engineer on or before the 10th day of each month. No water shall be diverted from any well unless equipped with a functional totalizing meter. The Permittee shall provide in writing the make, model, serial number, date of installation, initial reading, units, and dates of recalibration of each meter and any replacement meter.

5. The Permittee shall utilize the highest and best technology to ensure conservation of water to the maximum extent practical.

6. This Permit will expire on December 1, 2025.

7. The State Engineer retains jurisdiction over this permit.

8. Pursuant to Section 72-8-1 NMSA, the permittee shall allow the state engineer and his representative's entry upon private property for the performance of their respective duties, including access to the wells for meter readings and water level measurements.

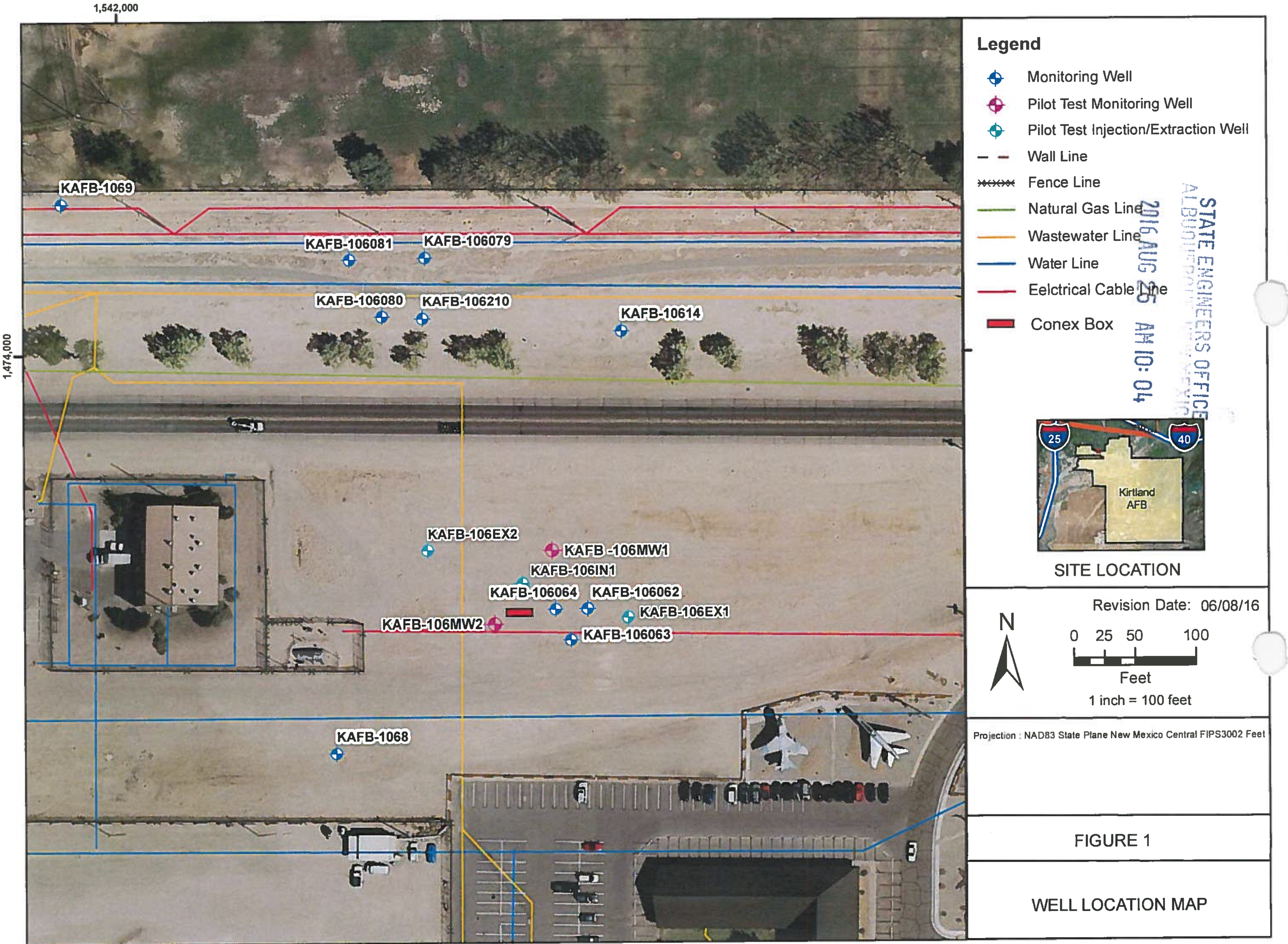
Witness my hand and seal this 7 day of December, A.D., 2016

Tom Blaine, P.E.
NEW MEXICO STATE ENGINEER

By: ____________________

Christopher Burrus
Water Resource Specialist
District I
CB:cb
cc: WRAB

FIGURE 1
PROPOSED WELL LOCATIONS



H:\Kirtland_AFB\GIS_Documents\Project_Maps\ESTCP\KAFB_ESTCP003_location.mxd 06/08/16

ATTACHMENT I
WELL SUMMARY

KIRTLAND AIR FORCE BASE
BULK FUELS FACILITY
WELL SUMMARY
ESTCP Extraction and Injection Wells

Extraction and injection wells will be installed in accordance with the Ethylene Dibromide Recirculation Pilot Test Work Plan (CB&I, 2016). KAFB-106EX1 and KAFB-106EX2 will be used as extraction wells, and KAFB-106IN1 will be used as an injection well for recirculated groundwater and amendment injection. The two extraction wells will be located approximately 90 feet upgradient and downgradient from the single injection well, respectively, and will be used to periodically recirculate groundwater during individual phases of the recirculation pilot test. Groundwater will be extracted from each extraction well at a rate of up to 25 gallons per minute, and injected into KAFB-106IN1 at a rate of up to 50 gallons per minute.

Both the extraction and injection wells will be dilled using Air Rotary Casing Hammer (ARCH) and will be constructed within a 11 ¾ -inch borehole. The wells will be constructed using 6-inch diameter, PVC flush threaded riser pipe and equipped with a 0.040-inch slot stainless steel wire wrap screen with a 5-foot PVC sump (6-inch diameter), and flush threaded bottom cap. For the injection well (KAFB-106IN1), the 20-foot screen will be installed with the top of screen at static groundwater level and extend to 20-feet below static water level (groundwater is approximately 480 feet below ground surface; consequently the screen may extend from 480 to 500 feet below ground surface). To minimize aeration of extracted water, the two extraction wells will be installed with 20-foot screens, the top of which will be located 5 feet below the static groundwater level (groundwater is approximately 480 feet below ground surface; consequently the screen may extend from 485 to 505 feet below ground surface). Following placement of the well screen and riser pipe, filter pack (sand) will be placed adjacent to the well screen followed by a fine sand seal and bentonite chip seal. A cement/bentonite grout will extend from the bentonite chip seal to near ground surface. The bentonite chip seal will be hydrated in lifts using a "clean" water source. Details of well construction are described below.

- The target depth of the well will be re-assessed before drilling using groundwater levels from off-setting wells to project groundwater level at the selected boring location. Currently, depth to static groundwater level is 480-feet below ground surface. If groundwater is encountered during drilling at a shallower depth, then drilling will be stopped temporarily, and the hole will be allowed to equilibrate for approximately 1 hour to determine the water table elevation.

- If the boring is over drilled beyond the bottom of the proposed sump elevation by more than 10 feet, the borehole will be backfilled with filter pack material to an elevation approximately 5 feet below the proposed bottom of sump elevation.

- At the completion drilling and before well construction, a borehole deviation measuring device will be used to log the borehole. The device may be similar to the Reflex EZ-Shot (Single Shot) Deviation Tool or other acceptable device. The results will be used to assess borehole deviation, which is limited to a total of 5 feet or less over the 505 or 510 foot depth of the borehole.

- The wells will be constructed within the borehole using a 5-foot PVC sump and flush threaded cap; flush-threaded stainless steel wire wrap screen with a 0.040-inch slot; and 6-inch PVC riser pipe to the top of the well stick-up (approximately 485 feet). The sump will extend 5 feet below the bottom of the screened interval. Centralizers will be placed just below the screen and just above the screen.

- Once the well string is emplaced inside the driven casing, the 10/20 sand filter pack will be installed in the annular space between the well string and the borehole from the total depth of the bore hole to 10 feet above the top of screen. The filer pack will be emplaced by filling the annulus between the well string and outer driven casing using a treme pipe, then slowly extracting the driven casing, allowing the volume of filter pack to fill the annulus between the well string and the borehole wall. This will be done incrementally in 10-foot lifts, never allowing the screen to be directly exposed to the formation. During this process the screen interval will be gently surged between lifts to insure filter pack placement with no voids.

- A 10-foot hydrated bentonite seal will be emplaced above the sand filter pack, incrementally hydrated with potable water in 1-foot lifts. The seal will be allowed to hydrate for 30 minutes after the last lift is emplaced.

- A high solids (20 wt%) bentonite grout will be emplaced by tremie pipe to within 30 feet of the surface. The bentonite grout will be installed in lifts (approximately 70 feet thick) to prevent collapse of the PVC casing.

- To the ground surface, a cement/bentonite grout mixture will be installed over the high-solids bentonite grout using a tremie pipe. The mixture will consist of 94 pounds of Portland cement to gallons of approved water and 3 percent by weight of sodium bentonite powder.

- The wells will be finished below grade, in a fiberglass well vault approximately 4' by 6' by 4' in size.

As summarized above, both injection and extraction wells will be installed in a similar manner. However, injection well will require the installation of 1.5-inch black steel injection pipe, a Baski flow control valve and associated controls, and a transducer to monitor injection levels. Additionally a 1-inch flush threaded Sch. 40 PVC pipe will be installed to allow access for collection of groundwater level measurements. A sanitary seal will be used to secure the injection pipe, power cable, Baski Valve controls, access drop pipe, and transducer. The injection pipe will extend from the well seal to approximately the mid-point of the screen interval (490 feet bgs); this is where the Baski valve will be set.

The injection pipe will be composed of 60 feet of 1.5 inch fusion bonded epoxy (FBE) coated steel NPT threaded discharge pipe from the valve to above the water table, coupled to 1.5 inch black carbon steel pipe to the surface. Couples will be black carbon steel on the black carbon steel pipe. The injection pipe will be suspended from the surface and centralizers will be used to center and stabilize the tubing during injection. The injection pipe will connect to the Baski flow control valve, below which will be a Grundfos pump. A flow meter and totalizer (volumes will be measured in gallons) will be used measure the injection rate and volume of groundwater entering the injection well.

References

CB&I. 2016. *Ethylene Dibromide Recirculation Pilot Test Work Plan*. Prepared by CB&I Federal Services. Draft. July.

USACE. 2011. *Groundwater Investigation Work Plan, Bulk Fuels Facility (BFF) Spill, Solid Waste Management Units ST-106 and SS-111, Kirtland Air Force Base, Albuquerque, New Mexico*. Prepared by Shaw Environmental & Infrastructure, Inc. for the USACE Albuquerque District under USACE Contract No. W912DY-10-D-0014, Delivery Order 0002. March.

ATTACHMENT 2
KIRTLAND WATER RIGHT

IN THE UNITED STATES DISTRICT COURT

DISTRICT OF NEW MEXICO

73 DEC 3 A 8:26
ALBUQ... N. MEX. ...FFICE

ORIGINAL
FILED IN MY OFFICE
NOV 27 1973
L. G. KANALY
CLERK

STATE OF NEW MEXICO, ex rel,)
S. E. REYNOLDS, State Engineer.)
)
Plaintiff)
)
vs.)
)
JOHN McLUCAS, Secretary of the)
Air Force, THOMAS W. MORGAN,)
Commander, Air Force Special Weapons)
Center, and JAMES B. MYERS, Base)
Commander, Kirtland Air Force Base)
)
Defendants.)

JUDGMENT AND ORDER

THIS MATTER coming on to be heard upon the Stipulation of the parties, and the Court having considered the same and being otherwise fully advised in the premises, finds that the Court has jurisdiction of the parties and the subject matter and that the said Stipulation should be approved and incorporated in the final judgment of this Court.

IT IS THEREFORE ORDERED, ADJUDGED AND DECREED that the Stipulation of the parties is hereby approved and incorporated in this judgment as if set out in full herein.

IT IS FURTHER ORDERED that the defendants, their employees, agents, assigns and successors in interest be and they are hereby permanently enjoined and restrained from any diversion and/or use of water from the Rio Grande Underground Water BAsin in and for Kirtland Air Force BAse except in strict conformity with this final judgment.

HOWARD BRATTON

JUDGE OF THE U. S. DISTRICT COURT

Original;
PLIS
J Gaul

IN THE UNITED STATES DISTRICT COURT

DISTRICT OF NEW MEXICO

73 DEC 3 A 8:

ALBUQUERQUE

ORIGINAL
FILED IN MY OFFICE
NOV 27 1973
L. G. KANALY
CLERK

STATE OF NEW MEXICO, ex rel,
S. E. REYNOLDS, State Engineer.

Plaintiff

vs.

JOHN McLUCAS, Secretary of the
Air Force, THOMAS W. MORGAN,
Commander, Air Force Special Weapons
Center, and JAMES B. MYERS, Base
Commander, Kirtland Air Force Base

Defendants.

STIPULATION

COME NOW the Plaintiff and Defendants herein, by and through their attorneys, and hereby mutually stipulate and agree that final judgment may enter in this cause in the following terms:

1. The United States of America, acting through and by means of the United States Air Force, owns and operates that certain complex of military facilities known as Kirtland Air Force Base within Bernalillo County, New Mexico, which Base includes the former Sandia Base, a Military installation heretofore operated by the United States Army. That area heretofore known as Sandia Base shall be designated in this stipulation as Kirtland East and that area known as Kirtland Air Force Base prior to the merger of the two installations shall be designated as Kirtland West.

2. On November 29, 1956, the Plaintiff, S. E. Reynolds, State Engineer, duly and lawfully declared the Rio Grande Underground Water Basin, an underground reservoir of public waters of the State of New Mexico having reasonably ascertainable boundaries.

3. All of Kirtland East and Kirtland West were, on November 29, 1956, and have continued to the present time to be within the exterior boundaries of the said Rio Grande Underground Water Basin.

4. On November 29, 1956, the United States of America owned within Kirtland East a water supply system consisting of 9 completed and operating wells, together with associated water storage and delivery works, and had prior to that date diverted and used underground waters of the Rio Grande Underground Water Basin by means of each and every of the said 9 wells for the lawful purposes of the said military installation.

5. The said nine wells in the Kirtland East water supply system were duly declared by an authorized representative of the United States of America in the office of the Plaintiff on the 4th day of October, 1957, and have been since that date designated in the files of the State Engineer as wells No. RG-1581 through RG-1589. The respective locations and priorities of the said 9 wells, as declared by the United States of America, are as follows:

RG-1581 NW1/4SE1/4, Sec. 31 T. 10 N., R. 4 E. March 1, 1949
RG-1582 NW1/4NW1/4, Sec. 1 T. 9 N., R. 3 E. August, 1949
RG-1583 NW1/4SW1/4, Sec. 30, T. 10 N., R. 4 E. August, 1949
RG-1584 NE1/4SW1/4, Sec. 6, T. 9 N., R. 4 E. August, 1949
RG-1585 NE1/4SW1/4, Sec. 29, T. 10 N., R. 4 E. July, 1952
RG-1586 SW1/4SE1/4, Sec. 32, T. 10 N., R. 4 E. July, 1952
RG-1587 NW1/4NW1/4, Sec. 6, T. 9 N., R. 4 E. Feb., 1955
RG-1588 SW1/4SW1/4, Sec. 5, T. 9 N., R. 4 E. Feb., 1955
RG-1589 SW1/4SW1/4, Sec. 15, T. 9 N., R. 4 E. Feb., 1949

6. Between November 1, 1958, and May 27, 1959, the United States of America drilled or caused to be drilled, in the NW1/4NE1/4 of Sec. 20, T. 9 N., R. 4 E., an additional water well which was thereafter made a part of the water supply system of Kirtland East. This well is designated in the files of the State Engineer as RG-1581 through RG-1589-S. By means of the said well, the United States of America has thereafter continually diverted and beneficially used public underground waters of the Rio Grande Underground Water Basin, as a supplemental point of diversion in and for Kirtland East.

7. In 1972, the United States of America drilled or caused to be drilled an additional water well within Kirtland East in the NW1/4NE1/4 of Sec. 4, T. 9 N., R. 4 E., which well has been completed except for the installation of a pump and has not yet been put to beneficial use, and which is hereby designated RG-1581 through RG-1589-S-2. The said well was drilled for the purpose of serving as a supplemental well for the water supply system of Kirtland East

8. The United States of America owns, under the Constitution and laws of the State of New Mexico, the right to divert the public underground waters of the Rio Grande Underground Water Basin, through and by means of the said eleven wells set forth in paragraphs 5, 6 and 7, in an amount not to exceed an annual quantity of four thousand five hundred (4,500) acre-feet, and to apply the same to beneficial use for the purposes of Kirtland Air Force Base. The priorities of the said eleven wells composing the water supply system of Kirtland East are as set forth

above in paragraphs 5, 6 and 7. The defendants stipulate that the United States Air Force has no right to divert any of the underground waters of the Rio Grande Underground Water Basin, by means of the said 11 wells or otherwise, for the purposes of Kirtland Air Force Base, except as set forth in this Stipulation, provided, however, that the United States shall enjoy the same right as any other appropriator in the State of New Mexico to make application hereafter to the Plaintiff, State Engineer, for permit to drill supplemental well(s) (i.e., make partial or total change in point of diversion or place or purpose of use) or to effect the transfer of valid and existing water rights for the purposes of Kirtland Air Force Base.

9. On November 29, 1956, the United States of America owned a water supply system in and for Kirtland West consisting of two water wells whose respective locations and priorities were declared in the Office of the State Engineer, by a duly authorized representative of the United States on the 4th day of October, 1957, to be as follows:

RG-1579 NW1/4NW1/4, Sec. 35, T. 10 N., R. 3 E., Oct. 9, 1952
RG-1580 SE1/4NW1/4, Sec. 34, T. 10 N., R. 3 E., Mar. 6, 1956

10. In 1969, the United States of America drilled or caused to be drilled an additional well in and for the Kirtland West water supply system, designated in the records of the State Engineer as RG-1579 and RG-1580 Combined-S, which well was thereafter made a part of the Kirtland West water supply system as a supplemental well.

11. The United States of America owns, under the Constitution and laws of the State of New Mexico, the right to divert

the public underground waters of the Rio Grande Underground Water Basin by means of the three wells set out in paragraphs 9 and 10 above in an amount not to exceed an annual quantity of 1,898 acre-feet for the purposes of Kirtland Air Force Base. The defendants stipulate that the United States Air Force has no right to divert or use the underground waters of the Rio Grande Underground Water Basin for the purposes of Kirtland Air Force Base, except as set forth in this Stipulation, by means of the said three wells or otherwise, provided, however, that the United States of America shall enjoy the same right as any other appropriator of public water in the State of New Mexico to make application to the Plaintiff, State Engineer, hereafter for permit to drill and use supplemental well(s) (i.e., make partial or total change in point of diversion or place or purpose of use) or to effect the transfer of existing valid water rights for the purposes of Kirtland Air Force Base.

12. The United States of America also owns the right under the Constitution and laws of the State of New Mexico to divert public underground waters of the Rio Grande Underground Water Basin in an amount not to exceed three acre-feet per year by and from each of the following three domestic wells located and existing within, and for the purposes of Kirtland Air Force Base:

Location	Priorities
RG-1578 SE1/4NW1/4, Sec. 35, T. 9 N., R. 4 E.	1945
RG-1590 SE1/4NW1/4, Sec. 35, T. 9 N., R. 4 E.	1945
RG-1591 NE1/4SE1/4, Sec. 24, T. 9 N., R. 4 E.	1948

13. The defendants stipulate that the United States Air Force will not after the entry of final judgment herein drill

or cause or allow to be drilled any water well(s) within the boundaries of the Rio Grande Underground Water Basin, within and/or for the purposes of Kirtland Air Force Base (including Kirtland East and Kirtland West), except when and to the extent that it will have fully complied with the laws of the State of New Mexico and the Rules and Regulations of the State Engineer in respect to obtaining from the State Engineer permit(s) to drill water wells and/or produce public waters therefrom for any purpose.

14. The defendants stipulate that they will make on behalf of the United States accurate monthly reports to the Plaintiff, State Engineer, of the total metered quantities of underground water diverted by means of any and all of the wells composing the Kirtland East and Kirtland West water supply systems, provided, however, that the United States of America shall not be required to make application for, or obtain permit authorizing the physical combination of the two water supply systems so long as the total annual metered diversion from each system is within the respective limit established in paragraphs 8 and 11. The defendants further agree that they will, within 60 days of the date of entry of final judgment herein, file in the Office of the Plaintiff, State Engineer, on forms to be supplied by the Plaintiff, applications on behalf of the United States seeking the right to divert and use public underground waters of the Rio Grande Underground Water Basin by means of those two certain wells RG-1581 through RG-1589-S-2 and RG-1579 and RG-1580 Combined-S, within the respective limits set forth in paragraphs 8 and 11 above. The State of New Mexico agrees that together

with the terms of judgment entered in this cause pursuant to this Stipulation, the said applications shall be administratively recognized as evidencing the right of the United States to use the said two wells within the terms of this Stipulation and the Order of the Court entered pursuant thereto, without any further requirement for advertisement or hearing.

PAUL L. BLOOM
Special Assistant Attorney General
State of New Mexico

s/ Victor Ortega
United States Attorney

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

Colonel Eric H. Froehlich
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB NM 87117-5000

AUG 24 2016

Office of the State Engineer
c/o Christopher Burrus, Water Rights Division
5550 San Antonio Blvd. NE
Albuquerque NM 87109

Dear Mr. Burrus

Kirtland Air Force Base (AFB) is submitting herein one "Application for Permit to Change an Existing Water Right" for the temporary pilot system extraction wells KAFB-106EX1 and KAFB-106EX2, and injection well KAFB-106IN1. This application seeks to permit the exploratory wells KAFB-106EX1, KAFB-106EX2, and KAFB-106IN1 as supplemental wells to Kirtland AFB water rights RG-1579 through RG-1589 by changing the purpose of use to pollution control and recovery, and by adding places of use not currently described in water rights RG-1579 through RG-1589. The extraction and injection wells will be advanced into the upper 20 to 30 feet of the water table as part of an in-situ bioremediation pilot test at Kirtland AFB Bulk Fuels Facility Solid Waste Management Unit (SWMU) ST-106/SS-111. All wells included in this request are proposed to be advanced on Kirtland AFB property.

STATE ENGINEERS OFFICE
ALBUQUERQUE NEW MEXICO
2016 AUG 25 AM 10: 08

As part of the Environmental Security Technology Certification Program (ESTCP) project, an in-situ pilot test will evaluate the potential use of enhanced EDB degradation using a biostimulation or bioaugmentation recirculation system. The recirculation system will be designed to extract, amend, and reinject groundwater throughout a 150-foot demonstration zone. The components of the recirculation system will include the extraction and injection wells and their equipment, a tracer and amendment delivery system, and the ancillary equipment required to power the recirculation system. The system will be designed to allow anaerobic mixing of multiple amendments and a bioaugmentation culture into extracted groundwater, prior to discharge to the injection well (KAFB-106IN1).

The two extraction wells will be located approximately 90 feet upgradient and downgradient from the single injection well, respectively, and will be used to periodically recirculate groundwater during individual phases of the recirculation pilot test. The extraction wells will be designed to extract groundwater at a rate of up to 25 gallons per minute each (40 acre-feet per year each), and the injection well will recirculate amended groundwater into the aquifer at a rate of up to 50 gallons per minute (80 acre-feet per year). However, the flow may be dictated by the capacity of the wells to either extract groundwater or inject amended groundwater. The extracted, amended, and injected groundwater will have no additional diversion to Kirtland AFB's water rights. The pilot study is estimated to run for approximately 2 years; however, it is possible that Kirtland AFB could operate the system for a longer period of time if the pilot study is successful.

Extraction wells KAFB-106EX1 and KAFB-106EX2, and injection well KAFB-106IN1 will be supplemental to the wells described in Kirtland AFB file number RG-1579 through RG-1589. The application does not request to increase the allowable groundwater diversion described in RG-1579 through RG-1589, but seeks to change the purpose of use to pollution control and recovery and to add a place of use not currently described in RG-1579 through RG-1589. This application seeks to add Kirtland AFB as a place of use to the water rights RG-1579 through RG-1589.

The specific requirements for pollution control and recovery will apply to the extraction (KAFB-106EX1 and KAFB-106EX2) and injection wells (KAFB-106IN1), and are as follows:

- The need for installing the two extraction wells and one injection well is as follows:
    - An in-situ bioremediation pilot test will be conducted to determine and evaluate the potential for enhanced EDB degradation after biostimulation or bioaugmentation with EDB degrading microorganisms using a recirculation system.
- The estimated maximum period of time for completion of the operation:
    - Recirculation will be performed three times during the pilot test; the active pumping timeframe within each stage will last for a period of approximately four weeks. The initial recirculation stage will mix a tracer in groundwater to evaluate subsurface transport and mixing characteristics. The four weeks of active pumping will be followed by approximately four weeks of monitoring. In the second recirculation stage, groundwater will be amended with inorganic nutrients and yeast extract, and reinjected into the aquifer to assess the performance of biostimulation for EDB degradation. This second active pumping stage will be followed by approximately twelve weeks of monitoring. In the third recirculation stage, groundwater will be amended with a bioaugmentation culture and inorganic nutrients and reinjected into the aquifer to assess the performance of bioaugmentation for EDB degradation. This third active pumping stage will be followed by approximately twelve weeks of monitoring. After active recirculation is complete, groundwater will be monitored for approximately 12 weeks.

- The annual diversion amount for each well:
    - Up to 40 acre-feet per year.

- The annual consumptive use for each well:
    - There is no consumptive use. The amount of groundwater removed by the two extraction wells (approximately 80 acre-feet per year) will be amended and reinjected into the aquifer.

- The maximum amount of water to be diverted for the duration of the operation:

  - Groundwater will be extracted from KAFB-106EX1 and KAFB-106EX2 at a rate of up to 25 gallons per minute per well (40 acre-feet per year per well) or a combined total from both wells of up to 50 gpm (80 acre-feet per year).

  - Groundwater extracted from the aquifer will be injected back into the aquifer at a rate of up to 50 gallons per minute (80 acre-feet per year) during this operation.

- The method and place of discharge
  - The groundwater from extraction wells KAFB-106EX1 and KAFB-106EX2, which are located within current SWMU ST-106/SS-111, will be discharged to injection well KAFB-106IN1, which is located between the extraction wells (see attached Figure 1).

- The method of measurement of water produced and discharged:
  - Extracted groundwater will measured through a totalizing flow meter. Injected amended groundwater will also be measured through another totalizing flow meter (both instantaneous and total flow will be logged).

- The source of water to be injected:
  - Injected water will be extracted from two proposed extraction wells (KAFB-106EX1 and KAFB-106EX2) installed as part of the in-situ bioremediation pilot test at SWMU ST-106/SS-111. The extracted water will be amended with inorganic nutrients prior to injection.

- The method of measurement of water injected:
  - The amount of water entering the injection well will be measured using a flow meter (both instantaneous and total flow will be logged).

- The characteristics of the aquifer:
  - The aquifer is primarily comprised of unconsolidated sand and gravel, with some intermixed silt, with an average hydraulic conductivity of 63 feet/day.

- The method of determining the resulting annual consumptive use of water and depletion from any related stream system:
  - Groundwater extracted from KAFB-106EX1 and KAFB-106EX2 are each projected to be extracted at a rate of up to 25 gallons per minute, equivalent to 40 acre-feet per year per well. The groundwater will be metered as it is extracted from the aquifer and pumped to the recirculation system, and will be metered as the amended groundwater is injected into the aquifer well KAFB-106IN1. The volume removed from the extraction wells will be equal to the amount injected into the aquifer; therefore, there is no consumptive use.

- Proof of any permit required from the New Mexico Environment Department:
  - The New Mexico Environment Department – Hazardous Waste Bureau and Ground Water Quality Bureau has determined that a discharge permit will not be required for the short-term in-situ pilot test. If the pilot test is successful, then

Kirtland AFB will work with NMED to identify any permits required if a full-scale system is to be designed and implemented.

- An access agreement if the applicant is not the owner of the land on which the pollution plume control or recovery well is to be located:
    - Kirtland AFB is the landowner.

In addition to the application, this packet contains a summary of the well construction for the extraction and injection wells, the District Court Order dated November 27, 1973, and a figure showing the well locations. The well construction details may be subject to change.

Please contact Mr. L. Wayne Bitner at (505) 853-3484 or at ludie.bitner@us.af.mil or Mr. Scott Clark at (505) 846-9017 or at scott.clark@us.af.mil if you have any questions.

Sincerely

ERIC H. FROEHLICH, Colonel, USAF
Commander

Attachment:
WR07 Application for Permit to Drill Wells with No Consumptive Use of Water

cc:
AFCEC/CZ (Bodour, Bitner, Clark)
USACE-Omaha District Office (Ellender)
USACE-ABQ District Office (Simpler, Phaneuf)
Public Info Repository, Administrative Record/Information Repository (AR/IR) and File

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

DISTRICT 1

TOM BLAINE, P.E.
NEW MEXICO STATE ENGINEER

5550 San Antonio Drive, N.E.
Albuquerque, NM 87109 (505) 383-4000

August 15, 2016

File No.: RG-1579

Kirtland Air Force Base
c/o Wayne Bitner, Chief Environmental Restoration
AFCEC/Kirtland AFB IST; Bldg 20685
2050 Wyoming Blvd, SE
Kirtland AFB, NM 87117

RE: MONITORING WELL PERMIT RG-1579 (POD316, POD317, and POD318)

Greetings,

Enclosed is your copy of Permit No.: RG-1579 POD316, POD317, and POD318 to drill exploratory wells with no consumptive use, has been approved in accordance with the attached Conditions of Approval.

Sincerely,

Christopher Burrus
Water Resource Specialist
Albuquerque, OSE, District 1

CB;cb;
Enclosure as stated
c: WRAB

HCI-55320
$15.00

File No. RG-1579
POD 316 to 318

NEW MEXICO OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO DRILL A WELL WITH NO CONSUMPTIVE USE OF WATER

(check applicable box):

For fees, see State Engineer website: http://www.ose.state.nm.us/

Purpose: ☐ Pollution Control And / Or Recovery ☐ Geo-Thermal

☐ Exploratory Construction Site De-Watering ☒ Other (Describe): **Two groundwater extraction wells and one injection well**

☐

☐ Monitoring Mineral De-Watering

A separate permit will be required to apply water to beneficial use.

☐ Temporary Request - Requested Start Date: Requested End Date:

Plugging Plan of Operations Submitted? ☐ Yes ☒ No

---

1. APPLICANT(S)

STATE ENGINEERS OFFICE
ALBUQUERQUE, NEW MEXICO
2016 AUG -8 PM 12: 4

Name: **Kirtland Air Force Base**	Name:
Contact or Agent: check here if Agent ☒ **Wayne Bitner, Chief Environmental Restoration**	Contact or Agent: check here if Agent ☐
Mailing Address: **AFCEC/Kirtland AFB IST; Bldg 20685; 2050 Wyoming Blvd SE**	Mailing Address:
City: **Kirtland AFB**	City:
State: **NM** Zip Code:**87117**	State: Zip Code:
Phone: N/A Home Cell Phone (Work):**505-853-3484**	Phone: Home Cell Phone (Work):
E-mail (optional):**ludie.bitner@us.af.mil**	E-mail (optional):

FOR OSE INTERNAL USE

Application for Permit, Form wr-07, Rev 4/12/12

File Number: RG-~~B~~ 1579	Trn Number:
Trans Description (optional): POD 316 to 318	
Sub-Basin:	
PCW/LOG Due Date:	

2. WELL(S) Describe the well(s) applicable to this application.

Location Required: Coordinate location must be reported in NM State Plane (NAD 83), UTM (NAD 83), or Latitude/Longitude (Lat/Long - WGS84).
District II (Roswell) and District VII (Cimarron) customers, provide a PLSS location in addition to above.

☒ NM State Plane (NAD83) (Feet)
  ☐ NM West Zone
  ☐ NM East Zone
  ☒ NM Central Zone

☐ UTM (NAD83) (Meters)
  ☐ Zone 12N
  ☐ Zone 13N

☐ Lat/Long (WGS84) (to the nearest 1/10th of second)

Well Number (if known):	**X or Easting or Longitude:**	**Y or Northing or Latitude:**	**Provide if known:** **-Public Land Survey System (PLSS) (*Quarters or Halves , Section, Township, Range*) OR** **- Hydrographic Survey Map & Tract; OR** **- Lot, Block & Subdivision; OR** **- Land Grant Name**
KAFB-106EX1 POD 316	1542418.47	1473782.33	
KAFB-106EX2 POD 317	1542254.00	1473837.97	
KAFB-106IN1 POD 318	1542331.87	1473810.39	

NOTE: If more well locations need to be described, complete form WR-08 (Attachment 1 – POD Descriptions)
Additional well descriptions are attached: ☐ **Yes** ☒ **No** **If yes, how many**______

Other description relating well to common landmarks, streets, or other: **See attached Figure 1**

Well is on land owned by: **Kirtland Air Force Base**

Well Information: NOTE: If more than one (1) well needs to be described, provide attachment. Attached? ☒ **Yes** ☐ **No**
If yes, how many **3 wells**

Approximate depth of well (feet):See attachment	Outside diameter of well casing (inches): 6"
Driller Name: TBD	Driller License Number: TBD

3. ADDITIONAL STATEMENTS OR EXPLANATIONS

Please see attachments for well locations and installation details. Extraction wells KAFB-106EX1 and KAFB-106EX2, and the injection well KAFB-106IN1 will be advanced into the upper 20 to 30 feet of the water table as part of an in-situ bioremediation pilot test. The two extraction wells will be located approximately 90 feet upgradient and downgradient from the single injection well, respectively, and will be used to periodically recirculate groundwater during individual phases of the recirculation pilot test.

FOR OSE INTERNAL USE

File Number: RG- 1579	Trn Number:

POD 316 to 318

4. SPECIFIC REQUIREMENTS: The applicant must include the following, as applicable to each well type. Please check the appropriate boxes, to indicate the information has been included and/or attached to this application:

Exploratory:
- ☐ Include a description of any proposed pump test, if applicable.

Monitoring:
- ☐ Include the reason for the monitoring well, and,
- ☐ The duration of the planned monitoring.

Pollution Control and/or Recovery:
- ☐ Include a plan for pollution control/recovery, that includes the following:
- ☐ A description of the need for the pollution control or recovery operation.
- ☐ The estimated maximum period of time for completion of the operation.
- ☐ The annual diversion amount.
- ☐ The annual consumptive use amount.
- ☐ The maximum amount of water to be diverted and injected for the duration of the operation.
- ☐ The method and place of discharge.
- ☐ The method of measurement of water produced and discharged.
- ☐ The source of water to be injected.
- ☐ The method of measurement of water injected.
- ☐ The characteristics of the aquifer.
- ☐ The method of determining the resulting annual consumptive use of water and depletion from any related stream system.
- ☐ Proof of any permit required from the New Mexico Environment Department.
- ☐ An access agreement if the applicant is not the owner of the land on which the pollution plume control or recovery well is to be located.

Construction De-Watering:
- ☐ Include a description of the proposed dewatering operation,
- ☐ The estimated duration of the operation,
- ☐ The maximum amount of water to be diverted,
- ☐ A description of the need for the dewatering operation, and,
- ☐ A description of how the diverted water will be disposed of.

Geo-Thermal:
- ☐ Include a description of the geothermal heat exchange project,
- ☐ The amount of water to be diverted and re-injected for the project,
- ☐ The time frame for constructing the geothermal heat exchange project, and,
- ☐ The duration of the project.
- ☐ Preliminary surveys, design data, and additional information shall be included to provide all essential facts relating to the request.

Mine De-Watering:
- ☐ Include a plan for pollution control/recovery, that includes the following:
- ☐ A description of the need for mine dewatering.
- ☐ The estimated maximum period of time for completion of the operation.
- ☐ The source(s) of the water to be diverted.
- ☐ The geohydrologic characteristics of the aquifer(s).
- ☐ The maximum amount of water to be diverted per annum.
- ☐ The maximum amount of water to be diverted for the duration of the operation.
- ☐ The quality of the water.
- ☐ The method of measurement of water diverted.
- ☐ The recharge of water to the aquifer.
- ☐ Description of the estimated area of hydrologic effect of the project.
- ☐ The method and place of discharge.
- ☐ An estimation of the effects on surface water rights and underground water rights from the mine dewatering project.
- ☐ A description of the methods employed to estimate effects on surface water rights and underground water rights.
- ☐ Information on existing wells, rivers, springs, and wetlands within the area of hydrologic effect.

ACKNOWLEDGEMENT

I, We (name of applicant(s)), ERIC H. FROEHLICH, COLONEL, USAF, 377 ABW COMMANDER
Print Name(s)

affirm that the foregoing statements are true to the best of (my, our) knowledge and belief.

Applicant Signature

Applicant Signature

ACTION OF THE STATE ENGINEER

This application is:

☑ approved ~~☐ partially approved~~ ~~☐ denied~~

provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare and further subject to the attached conditions of approval.

Witness my hand and seal this 15 day of August 20 16, for the State Engineer,

Tom Blaine, P.E. State Engineer, State Engineer

By: Signature

Print: CHRISTOPHER BURRIS

Title: Water Resource Specialist
Print

FOR OSE INTERNAL USE

Application for Permit, Form wr-07

File Number: RG-1579	Trn Number:

POD 316 to 318

NEW MEXICO OFFICE OF THE STATE ENGINEER
PERMIT TO DRILL WELL WITH NO CONSUMPTIVE USE
CONDITIONS OF APPROVAL

This application is approved provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare of the state; and further subject to the following conditions of approval:

Permittee:
Kirtland Air Force Base
c/o Wayne Bitner, Chief Environmental Restoration
AFCEC/Kirtland AFB IST; Bldg 20685
2050 Wyoming Blvd, SE
Kirtland AFB, NM 87117

Permit Number: RG-1579

Application File Date: August 8, 2016

Priority: N/A

Source: Groundwater

Points of Diversion: RG-1579 POD316 (KAFB-106EX1) located at a point where X = 1,542,418.47 feet and Y = 1,473,782.33 feet, NMSPCS NAD83, Central Zone within Section 36, Township 10 North, Range 03 East, Bernalillo County, New Mexico.

RG-1579 POD317 (KAFB-106EX2) located at a point where X = 1,542,225.0 feet and Y = 1,473,837.97 feet, NMSPCS NAD83, Central Zone within Section 36, Township 10 North, Range 03 East, Bernalillo County, New Mexico.

RG-1579 POD318 (KAFB-106IN1) located at a point where X = 1,542,331.87 feet and Y = 1,473,810.39 feet, NMSPCS NAD83, Central Zone within Section 36, Township 10 North, Range 03 East, Bernalillo County, New Mexico.

All wells are located on land owned by Kirtland Air Force Base.

Purpose of Use: Exploration

Place of Use: N/A

Amount of Water: N/A

NEW MEXICO OFFICE OF THE STATE ENGINEER
PERMIT TO DRILL WELL WITH NO CONSUMPTIVE USE
CONDITIONS OF APPROVAL

1. No water shall be appropriated and beneficially used under this permit.
2. Wells RG-1579 POD316, POD317, and POD318 shall be drilled and constructed by a driller licensed in the State of New Mexico in accordance with 19.27.4 NMAC.
3. Completed and properly executed Well Records on the form provided by the State Engineer shall be filed within 10 days after the wells are drilled.
4. The Permittee is responsible for obtaining an access agreement.
5. If artesian water is encountered, the Permittee and driller shall comply with Subsection C of 19.27.4.31 NMAC and all rules and regulations pertaining to the drilling and casing of the artesian wells.
6. Wells RG-1579 POD316, POD317, and POD318 shall be plugged upon completion of the permitted use, and a plugging report shall be filed with the State Engineer within 10 days after the wells are plugged.
7. Wells RG-1579 POD316, POD317, and POD318 must be completed within one year of the approval date of this permit.
8. Water shall be used from the well for exploration purposes only, unless and until a permit for a specific use has been issued by the State Engineer.

Witness my hand and seal this 15 day of August 2016

Tom Blaine, P.E.
State Engineer

By: ______________________
Christopher Burrus
Water Resource Specialist
District 1

Page **2** of **2**

File No: RG-1579

FIGURE 1
PROPOSED WELL LOCATIONS

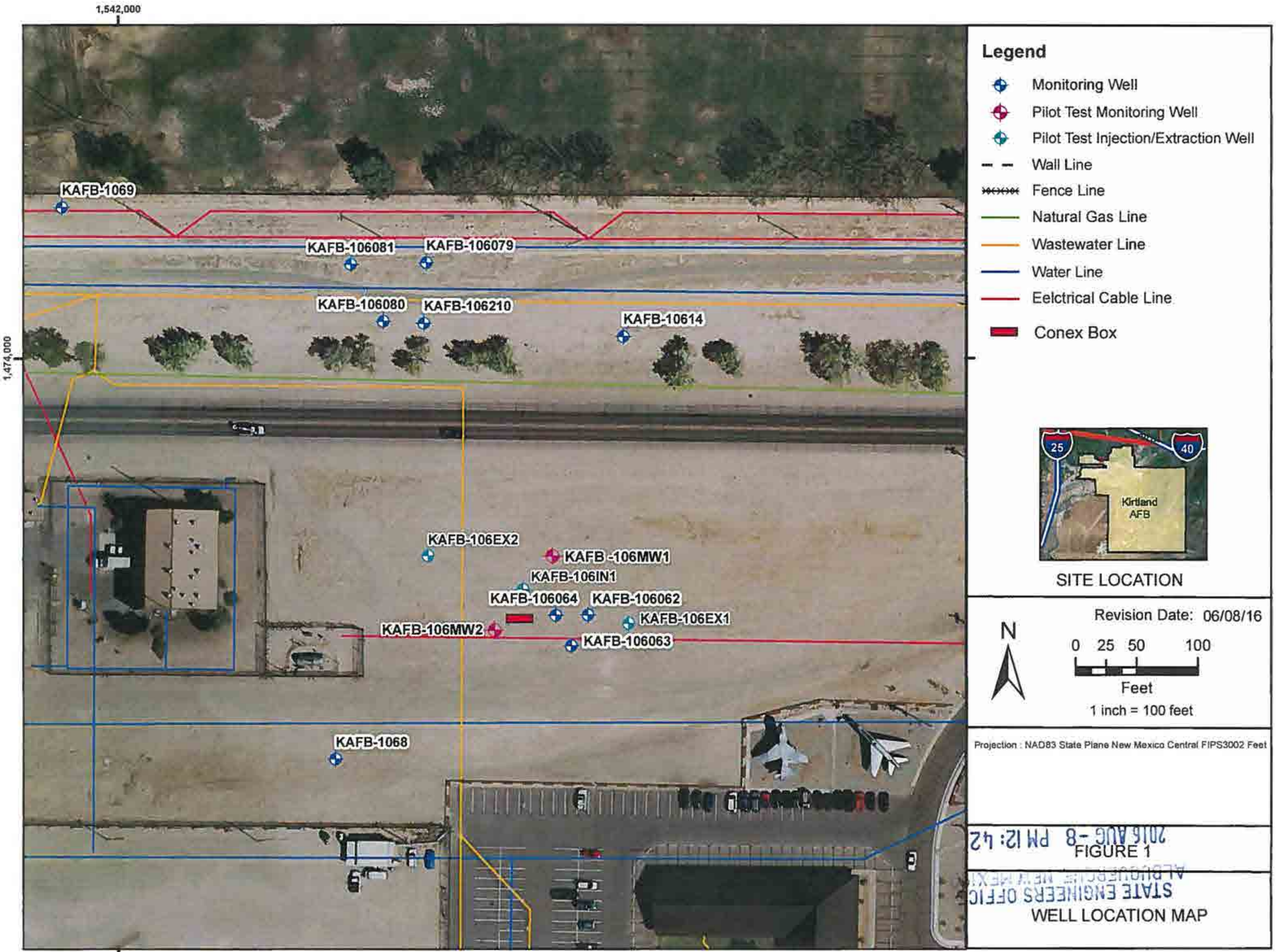


FIGURE 1

WELL LOCATION MAP

H:\Kirtland_AFB\GIS_Documents\Project_Maps\ESTCP\KAFB_ESTCP003_location.mxd 06/08/16

ATTACHMENT I
WELL SUMMARY

KIRTLAND AIR FORCE BASE
BULK FUELS FACILITY
WELL SUMMARY

ESTCP Extraction and Injection Wells

Extraction and injection wells will be installed in accordance with the Ethylene Dibromide Recirculation Pilot Test Work Plan (CB&I, 2016). KAFB-106EX1 and KAFB-106EX2 will be used as extraction wells, and KAFB-106IN1 will be used as an injection well for recirculated groundwater and amendment injection. The two extraction wells will be located approximately 90 feet upgradient and downgradient from the single injection well, respectively, and will be used to periodically recirculate groundwater during individual phases of the recirculation pilot test. Groundwater will be extracted from each extraction well at a rate of up to 25 gallons per minute, and injected into KAFB-106IN1 at a rate of up to 50 gallons per minute.

Both the extraction and injection wells will be dilled using Air Rotary Casing Hammer (ARCH) and will be constructed within a 11 ¾ -inch borehole. The wells will be constructed using 6-inch diameter, PVC flush threaded riser pipe and equipped with a 0.040-inch slot stainless steel wire wrap screen with a 5-foot PVC sump (6-inch diameter), and flush threaded bottom cap. For the injection well (KAFB-106IN1), the 20-foot screen will be installed with the top of screen at static groundwater level and extend to 20-feet below static water level (groundwater is approximately 480 feet below ground surface; consequently the screen may extend from 480 to 500 feet below ground surface). To minimize aeration of extracted water, the two extraction wells will be installed with 20-foot screens, the top of which will be located 5 feet below the static groundwater level (groundwater is approximately 480 feet below ground surface; consequently the screen may extend from 485 to 505 feet below ground surface). Following placement of the well screen and riser pipe, filter pack (sand) will be placed adjacent to the well screen followed by a fine sand seal and bentonite chip seal. A cement/bentonite grout will extend from the bentonite chip seal to near ground surface. The bentonite chip seal will be hydrated in lifts using a "clean" water source. Details of well construction are described below.

- The target depth of the well will be re-assessed before drilling using groundwater levels from off-setting wells to project groundwater level at the selected boring location. Currently, depth to static groundwater level is 480-feet below ground surface. If groundwater is encountered during drilling at a shallower depth, then drilling will be stopped temporarily, and the hole will be allowed to equilibrate for approximately 1 hour to determine the water table elevation.

- If the boring is over drilled beyond the bottom of the proposed sump elevation by more than 10 feet, the borehole will be backfilled with filter pack material to an elevation approximately 5 feet below the proposed bottom of sump elevation.

- At the completion drilling and before well construction, a borehole deviation measuring device will be used to log the borehole. The device may be similar to the Reflex EZ-Shot (Single Shot) Deviation Tool or other acceptable device. The results will be used to assess borehole deviation, which is limited to a total of 5 feet or less over the 505 or 510 foot depth of the borehole.

- The wells will be constructed within the borehole using a 5-foot PVC sump and flush threaded cap; flush-threaded stainless steel wire wrap screen with a 0.040-inch slot; and 6-inch PVC riser pipe to the top of the well stick-up (approximately 485 feet). The sump will extend 5 feet below the bottom of the screened interval. Centralizers will be placed just below the screen and just above the screen.

- Once the well string is emplaced inside the driven casing, the 10/20 sand filter pack will be installed in the annular space between the well string and the borehole from the total depth of the bore hole to 10 feet above the top of screen. The filer pack will be emplaced by filling the annulus between the well string and outer driven casing using a treme pipe, then slowly extracting the driven casing, allowing the volume of filter pack to fill the annulus between the well string and the borehole wall. This will be done incrementally in 10-foot lifts, never allowing the screen to be directly exposed to the formation. During this process the screen interval will be gently surged between lifts to insure filter pack placement with no voids.

- A 10-foot hydrated bentonite seal will be emplaced above the sand filter pack, incrementally hydrated with potable water in 1-foot lifts. The seal will be allowed to hydrate for 30 minutes after the last lift is emplaced.

- A high solids (20 wt%) bentonite grout will be emplaced by tremie pipe to within 30 feet of the surface. The bentonite grout will be installed in lifts (approximately 70 feet thick) to prevent collapse of the PVC casing.

- To the ground surface, a cement/bentonite grout mixture will be installed over the high-solids bentonite grout using a tremie pipe. The mixture will consist of 94 pounds of Portland cement to 7 gallons of approved water and 3 percent by weight of sodium bentonite powder.

- The wells will be finished below grade, in a fiberglass well vault approximately 4’ by 6’ by 4’ in size.

As summarized above, both injection and extraction wells will be installed in a similar manner. However, injection well will require the installation of 1.5-inch black steel injection pipe, a Baski flow control valve and associated controls, and a transducer to monitor injection levels. Additionally a 1-inch flush threaded Sch. 40 PVC pipe will be installed to allow access for collection of groundwater level measurements. A sanitary seal will be used to secure the injection pipe, power cable, Baski Valve controls, access drop pipe, and transducer. The injection pipe will extend from the well seal to approximately the mid-point of the screen interval (490 feet bgs); this is where the Baski valve will be set.

The injection pipe will be composed of 60 feet of 1.5 inch fusion bonded epoxy (FBE) coated steel NPT threaded discharge pipe from the valve to above the water table, coupled to 1.5 inch black carbon steel pipe to the surface. Couples will be black carbon steel on the black carbon steel pipe. The injection pipe will be suspended from the surface and centralizers will be used to center and stabilize the tubing during injection. The injection pipe will connect to the Baski flow control valve, below which will be a Grundfos pump. A flow meter and totalizer (volumes will be measured in gallons) will be used measure the injection rate and volume of groundwater entering the injection well.

References

CB&I. 2016. *Ethylene Dibromide Recirculation Pilot Test Work Plan.* Prepared by CB&I Federal Services. Draft. July.

USACE. 2011. *Groundwater Investigation Work Plan, Bulk Fuels Facility (BFF) Spill, Solid Waste Management Units ST-106 and SS-111, Kirtland Air Force Base, Albuquerque, New Mexico.* Prepared by Shaw Environmental & Infrastructure, Inc. for the USACE Albuquerque District under USACE Contract No. W912DY-10-D-0014, Delivery Order 0002. March.

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

JUL 2 8 2016

Colonel Eric H. Froehlich
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB NM 87117-5000

STATE ENGINEERS OFFICE
ALBUQUERQUE NEW MEXICO
2016 AUG -8 PM 12:41

Office of the State Engineer
c/o Christopher Burrus, Water Rights Division
5550 San Antonio Blvd. NE
Albuquerque NM 87109

Dear Mr. Burrus

Kirtland Air Force Base (AFB) is submitting herein one "Application for Permit to Drill Wells with No Consumptive Use of Water" for the temporary pilot system extraction wells KAFB-106EX1 and KAFB-106EX2, and injection well KAFB-106IN1. The extraction and injection wells will be advanced into the upper 20 to 30 feet of the water table as part of an in-situ bioremediation pilot test at Kirtland AFB Bulk Fuels Facility Solid Waste· Management Unit (SWMU) ST-106/SS-111. These wells are proposed to be advanced on Kirtland AFB property.

As part of the Environmental Security Technology Certification Program (ESTCP) project, an in-situ pilot test will evaluate the potential use of enhanced EDB degradation using a biostimulation or bioaugmentation recirculation system. The recirculation system will be designed to extract, amend, and reinject groundwater throughout a 150-foot demonstration zone. The components of the recirculation system will include the extraction and injection wells and their equipment, a tracer and amendment delivery system, and ancillary equipment to power the recirculation system. The system will be designed to allow anaerobic mixing of multiple amendments and a bioaugmentation culture into extracted groundwater, prior to discharge to the injection well.

The extraction and injection wells will be constructed using approximately 485 feet of 6 inch diameter polyvinyl chloride (PVC) casing equipped with 20 feet of flush-threaded stainless steel wire wrap screen (0.040 slot) with a 5-foot PVC (6-inch diameter) sump and flush-threaded bottom cap. The top of the screen for the injection well (KAFB-106IN1) will be set at static groundwater level and extend to 20-feet below static water level. The two extraction wells (KAFB-106EX1 and KAFB-106EX2) will be installed with 20-foot screens, with the top of screen set at 5 feet below the static groundwater level. The two extraction wells will be located approximately 90 feet upgradient and downgradient from the single injection well, respectively, and will be used to periodically recirculate groundwater during individual phases of the recirculation pilot test. The extraction wells will be designed to extract groundwater at a rate of up to 25 gallons per minute each, and the injection well will recirculate amended groundwater into the aquifer at a rate of up to 50 gallons per minute. However, the flow may be dictated by the capacity of the wells to either extract groundwater or inject amended groundwater. Discharge piping from the recirculation system will extend down into the water column, ending at approximately the mid-point of the screen interval.

Relevant information describing the use of the two extraction wells (KAFB-106EX1 and KAFB-106EX2) and one injection well (KAFB-106IN1) are as follows:

- The need for installing the two extraction wells and one injection well is as follows:
    - An in-situ bioremediation pilot test will be conducted to determine and evaluate the potential for enhanced EDB degradation after biostimulation or bioaugmentation with EDB degrading microorganisms using a recirculation system.

- The estimated maximum period of time for completion of the operation:
    - Recirculation will be performed three times during the pilot test; the active pumping timeframe within each stage will last for a period of approximately four weeks. The initial recirculation stage will mix a tracer in groundwater to evaluate subsurface transport and mixing characteristics. The four weeks of active pumping will be followed by approximately four weeks of monitoring. In the second recirculation stage, groundwater will be amended with inorganic nutrients and yeast extract, and reinjected into the aquifer to assess the performance of biostimulation for EDB degradation. This second active pumping stage will be followed by approximately twelve weeks of monitoring. In the third recirculation stage, groundwater will be amended with a bioaugmentation culture and inorganic nutrients and reinjected into the aquifer to assess the performance of bioaugmentation for EDB degradation. This third active pumping stage will be followed by approximately twelve weeks of monitoring. After active recirculation is complete, groundwater will be monitored for approximately 12 weeks.

- The annual diversion amount for each well:
    - Up to 40 acre-feet per year.

- The annual consumptive use for each well:
    - There is no consumptive use. The amount of groundwater removed by the two extraction wells (approximately 80 acre-feet per year) will be amended and reinjected into the aquifer.

- The maximum amount of water to be diverted for the duration of the operation:
    - Groundwater will be extracted from KAFB-106EX1 and KAFB-106EX2 at a rate of up to 25 gallons per minute per well (40 acre-feet per year) or a total of up to 50 gpm (80 acre feet per year).
    - Groundwater extracted from the aquifer will be injected back into the aquifer at a rate of up to 50 gallons per minute during this operation.

- The method and place of discharge:
    - The groundwater from extraction wells KAFB-106EX1 and KAFB-106EX2, which are located within SWMU ST-106/SS-111, will be discharged to injection well KAFB-106IN1, which is located upgradient from the extraction wells (see attached figure).

- The method of measurement of water produced and discharged:
    - Extracted groundwater will measured through a totalizing flow meter. Injected amended groundwater will also be measured through another totalizing flow meter (both instantaneous and total flow will be logged).

- The source of water to be injected:
    - Injected water will be extracted from two proposed extraction wells (KAFB-106EX1 and KAFB-106EX2) installed as part of the in-situ bioremediation pilot test at SWMU ST-I 06/SS-111. The extracted water will be amended with inorganic nutrients prior to injection.

- The method of measurement of water injected:
    - The amount of water entering the injection well will be measured using a flow meter (both instantaneous and total flow will be logged).

- The characteristics of the aquifer:
    - The aquifer is primarily comprised of unconsolidated sand and gravel, with an average hydraulic conductivity of 63 feet/day.

- The method of determining the resulting annual consumptive use of water and depletion from any related stream system:
    - Groundwater extracted from KAFB-106EX1 and KAFB-106EX2 are each projected to be extracted at a rate of up to 25 gallons per minute, equivalent to 40 acre-feet per year per well. The groundwater will be metered as it is extracted from the aquifer and pumped to the recirculation system, and will be metered as the amended groundwater is injected into the aquifer well KAFB-106IN1. The volume removed from the extraction wells will be equal to the amount injected into the aquifer; therefore, there is no consumptive use.

- Proof of any permit required from the New Mexico Environment Department (NMED):
    - The NMED/Hazardous Waste Bureau and Ground Water Quality Bureau has determined that a discharge permit will not be required for the short-term in-situ pilot test. If the pilot test is successful, then Kirtland AFB will work with NMED to identify any permits required if a full-scale system is to be designed and implemented.

- An access agreement if the applicant is not the owner of the land on which the pollution plume control or recovery well is to be located:
    - Kirtland AFB is the landowner.

In addition to the application, this packet contains a summary of the well construction for the extraction and injection wells, and a figure showing the well locations. The well construction details may be subject to change.

Please contact Mr. L. Wayne Bitner at (505) 853-3484 or at ludie.bitner@us.af.mil or Mr. Scott Clark at (505) 846-9017 or at scott.clark@us.af.mil if you have any questions.

Sincerely

ERIC H. FROEHLICH, Colonel, USAF
Commander

Attachment:
WR07 Application for Permit to Drill Wells with No Consumptive Use of Water

cc:
AFCEC/CZ (Bodour, Bitner, Clark), letter only
USACE-Omaha District Office (Ellender), letter only
USACE-ABQ District Office (Simpler, Phaneuf, Dreeland, Sanchez, Salazar), letter only
Public Info Repository, Administrative Record/Information Repository (AR/IR) and File

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

DISTRICT I

TOM BLAINE, P.E.
STATE ENGINEER

5550 San Antonio Dr. NE
Albuquerque, NM 87109-4127
(505) 383-4000

November 17, 2016

File No: RG-1579
Permit No. RG-1579 PODs 325-328

Kirtland Air Force Base
c/o Wayne Bitner, Chief Environmental Restoration
AFCEC/Kirtland AFB IST; Bldg 20685
2050 Wyoming Blvd SE
Kirtland AFB, NM 87117

Greetings:

Your copy of Permit to Drill Monitoring Wells RG-1579 PODs 325-328, which has been approved in accordance with the attached Conditions of Approval, is enclosed.

Sincerely,

Sharon Kindel

Sharon Kindel
Water Resource Master

Enclosures

File No. R6-1579

NEW MEXICO OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO DRILL A WELL WITH NO CONSUMPTIVE USE OF WATER

HC1-55662
$20—

(check applicable box):

For fees, see State Engineer website: http://www.ose.state.nm.us/

Purpose:

☐ Exploratory
☒ Monitoring
☐ Pollution Control And / Or Recovery
☐ Construction Site De-Watering
☐ Mineral De-Watering
☐ Geo-Thermal
☐ Other (Describe):

A separate permit will be required to apply water to beneficial use.

☐ Temporary Request - Requested Start Date: Requested End Date:

Plugging Plan of Operations Submitted? ☐ Yes ☒ No

STATE ENGINEERS OFFICE
ALBUQUERQUE NEW MEXICO
2016 NOV 10 PM 1:59

1. APPLICANT(S)

Name: **Kirtland Air Force Base**	Name:
Contact or Agent: check here if Agent ☒ **Wayne Bitner, Chief Environmental Restoration**	Contact or Agent: check here if Agent ☐
Mailing Address: **AFCEC/Kirtland AFB IST; Bldg 20685; 2050 Wyoming Blvd SE**	Mailing Address:
City: **Kirtland AFB**	City:
State: **NM** Zip Code:**87117**	State: Zip Code:
Phone: N/A Home Cell Phone (Work):**505-853-3484**	Phone: Home Cell Phone (Work):
E-mail (optional):**ludie.bitner@us.af.mil**	E-mail (optional):

FOR OSE INTERNAL USE

Application for Permit, Form wr-07, Rev 4/12/12

File Number: R6-1579	Trn Number: 598815
Trans Description (optional): PODs 325-328	
Sub-Basin: MRG	
PCW/[✓ LOG] Due Date: 12/7/17	

2. WELL(S) Describe the well(s) applicable to this application.

Location Required: Coordinate location must be reported in NM State Plane (NAD 83), UTM (NAD 83), or Latitude/Longitude (Lat/Long - WGS84).
District II (Roswell) and District VII (Cimarron) customers, provide a PLSS location in addition to above.

☒ NM State Plane (NAD83) (Feet)
- ☐ NM West Zone
- ☐ NM East Zone
- ☒ NM Central Zone

☐ UTM (NAD83) (Meters)
- ☐ Zone 12N
- ☐ Zone 13N

☐ Lat/Long (WGS84) (to the nearest 1/10th of second)

Well Number (if known):	X or Easting or Longitude:	Y or Northing or Latitude:	**Provide if known:** -Public Land Survey System (PLSS) (*Quarters or Halves , Section, Township, Range)* OR - Hydrographic Survey Map & Tract; OR - Lot, Block & Subdivision; OR - Land Grant Name
KAFB-106MW1-S	1542329.391	1473729.014	
KAFB-106MW1-I	1542329.391	1473729.014	
KAFB-106MW2-S	1542340.467	1473757.397	
KAFB-106MW2-I	1542340.467	1473757.397	

NOTE: If more well locations need to be described, complete form WR-08 (Attachment 1 – POD Descriptions)
Additional well descriptions are attached: ☐ **Yes** ☒ **No** **If yes, how many________**

Other description relating well to common landmarks, streets, or other: **See attached Figure 1**

Well is on land owned by: **Kirtland Air Force Base**

Well Information: NOTE: If more than one (1) well needs to be described, provide attachment. Attached? ☒ **Yes** ☐ **No**
If yes, how many 4 wells

Approximate depth of well (feet): approximately 535 feet bgs

Outside diameter of well casing (inches): See attachment

Driller Name: TBD

Driller License Number: TBD

3. ADDITIONAL STATEMENTS OR EXPLANATIONS

Please see attachments for well locations and installation details. The four groundwater monitoring wells will be installed within two boreholes utilizing a nested design, with two wells in each borehole. The well locations and design of the groundwater monitoring wells were selected to evaluate EDB biodegradation during the pilot test.

FOR OSE INTERNAL USE

File Number:

Trn Number:

4. SPECIFIC REQUIREMENTS: The applicant must include the following, as applicable to each well type. Please check the appropriate boxes, to indicate the information has been included and/or attached to this application:

Exploratory:
☐ Include a description of any proposed pump test, if applicable.

Monitoring:
☒ Include the reason for the monitoring well, and,
☒ The duration of the planned monitoring.

Pollution Control and/or Recovery:
☐ Include a plan for pollution control/recovery, that includes the following:
☐ A description of the need for the pollution control or recovery operation.
☐ The estimated maximum period of time for completion of the operation.
☐ The annual diversion amount.
☐ The annual consumptive use amount.
☐ The maximum amount of water to be diverted and injected for the duration of the operation.
☐ The method and place of discharge.
☐ The method of measurement of water produced and discharged.
☐ The source of water to be injected.
☐ The method of measurement of water injected.
☐ The characteristics of the aquifer.
☐ The method of determining the resulting annual consumptive use of water and depletion from any related stream system.
☐ Proof of any permit required from the New Mexico Environment Department.
☐ An access agreement if the applicant is not the owner of the land on which the pollution plume control or recovery well is to be located.

Construction De-Watering:
☐ Include a description of the proposed dewatering operation,
☐ The estimated duration of the operation,
☐ The maximum amount of water to be diverted,
☐ A description of the need for the dewatering operation, and,
☐ A description of how the diverted water will be disposed of.

Geo-Thermal:
☐ Include a description of the geothermal heat exchange project,
☐ The amount of water to be diverted and re-injected for the project,
☐ The time frame for constructing the geothermal heat exchange project, and,
☐ The duration of the project.
☐ Preliminary surveys, design data, and additional information shall be included to provide all essential facts relating to the request.

Mine De-Watering:
☐ Include a plan for pollution control/recovery, that includes the following:
☐ A description of the need for mine dewatering.
☐ The estimated maximum period of time for completion of the operation.
☐ The source(s) of the water to be diverted.
☐ The geohydrologic characteristics of the aquifer(s).
☐ The maximum amount of water to be diverted per annum.
☐ The maximum amount of water to be diverted for the duration of the operation.
☐ The quality of the water.
☐ The method of measurement of water diverted.
☐ The recharge of water to the aquifer.
☐ Description of the estimated area of hydrologic effect of the project.
☐ The method and place of discharge.
☐ An estimation of the effects on surface water rights and underground water rights from the mine dewatering project.
☐ A description of the methods employed to estimate effects on surface water rights and underground water rights.
☐ Information on existing wells, rivers, springs, and wetlands within the area of hydrologic effect.

ACKNOWLEDGEMENT

I, We (name of applicant(s)), ERIC H. FROEHLICH, COLONEL, USAF, 377 ABW COMMANDER
Print Name(s)

affirm that the foregoing statements are true to the best of (my, our) knowledge and belief.

Applicant Signature

Applicant Signature

ACTION OF THE STATE ENGINEER

This application is:

☒ approved ☐ partially approved ☐ denied

provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare and further subject to the attached conditions of approval.

Witness my hand and seal this 17th day of November 20 16, for the State Engineer,

Tom Blaine, P.E.
State Engineer, State Engineer

By: Sharon Kindel
Signature

Sharon Kindel
Print

Title: Water Resource Master
Print

FOR OSE INTERNAL USE

Application for Permit, Form wr-07

File Number:	Trn Number:

NEW MEXICO OFFICE OF THE STATE ENGINEER
PERMIT TO DRILL MONITORING WELLS
CONDITIONS OF APPROVAL

This application is approved provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare of the state; and further subject to the following conditions of approval:

Permittee:	Kirtland Air Force Base
Permit Number:	RG-1579 PODs 325-328
Application File Date:	November 10, 2016

Monitoring Wells/Points of Diversion (PODs):

OSE POD No.	KAFB Well No.	NM State Plane (NAD83) NM Central Zone (feet)	
		X	Y
RG-1579 POD325	KAFB-106MW1-S	1542329.4	1473729.0
RG-1579 POD326	KAFB-106MW1-I	1542329.4	1473729.0
RG-1579 POD327	KAFB-106MW2-S	1542340.5	1473757.4
RG-1579 POD328	KAFB-106MW2-I	1542340.5	1473757.4

1. No water shall be appropriated and beneficially used under this permit.

2. Water shall be used from wells for monitoring purposes only unless and until a permit for a specific use has been issued by the State Engineer.

3. The wells shall be drilled and constructed by a driller licensed in the State of New Mexico in accordance with 19.27.4 NMAC.

4. If artesian water is encountered, the Permittee and driller shall comply with Subsection C of 19.27.4.31 NMAC.

5. The wells shall be drilled and completed within one year of issuance of this permit. Well Records for RG-1579 PODs 325-328 shall be filed no later than twenty (20) days after completion of the wells in accordance with Subsection K of 19.27.4.29 NMAC (i.e. due by December 7, 2017).

6. Upon completion of permitted use, the wells shall be plugged under State Engineer-approved Plugging Plans, and Plugging Records shall be filed with the State Engineer within twenty (20) days after the wells are plugged in accordance with Subsection C of 19.27.4.30 NMAC.

Witness my hand and seal this 17th day of November 2016.

Tom Blaine, P.E., State Engineer

By: Sharon Kindel

Sharon Kindel, Water Resource Master

File Number: ____________________
(For OSE Use Only)

NEW MEXICO OFFICE OF THE STATE ENGINEER
TOTALIZING METER REPORT

1. PERMITTEE

*OSE File/Permit Number: RG-1579 POD 316
Name: Kirtland Air Force Base
Work Phone: 505-846-9017
Contact: Scott Clark
Home Phone:
Address: 2050 Wyoming Blvd SE
Cell Phone: 505-385-3679
City: Albuquerque
Fax:
State: NM Zip: 87117 E-mail (optional): scott.clark@us.af.mil

2. LOCATION OF WELL

*OSE Well/POD Number: POD 316
a. (___) 1/4 (___) 1/4 (___) 1/4 Section(s): (______) Township : (_____) Range : (_____) N.M.P.M.
b. ________________________________ Subdivision
c. Latitude: _______ d _______ m _______ s Longitude: _______ d _______ m _______ s
d. Latitude: _______________ (____) Longitude: _______________ (____)
e. East 1542418.47 (m), North 1473782.33 (m), UTM Zone 13, NAD ( ) 27 or (✔) 83

3. PURPOSE OF USE

( ) Domestic ( ) Livestock ( ) Irrigation ( ) Municipal ( ) Commercial ( ) Industrial (✔) Other: Pollution Control and Recovery

4. FLOW METER DATA

*Serial Number: 61608100437
Make: Georg Fischer Signet LLC
Total # of Dials: 8
Model: Signet 2551 Magmeter, 3-2551-P0-42
Multiplier: **X (** 1 **)**
Meter Size: 3.75 inch diameter
Units: ( ) Acre-feet ( ) Barrels ( ) Cubit-feet (✔) Gallons Other: ________
Fixed Numbers (Check one): **0** ( ) or **00** ( ) or **000** ( ) or **none** (✔)

5. METER READING

*Reading Date: 7 / 17 / 2017

*Actual Meter Reading
(All numbers dials and fixed included): **00005185**

6. ADDITIONAL STATEMENTS OR EXPLANATIONS:

Pictures of all three flow meters and the manufacturer calibration reports are included with this report.

*Submitted by: Caitlin LaChance, APTIM
Date: 7 / 26 / 2017

INSTRUCTIONS:

Specific questions should be answered as follows:

(4) -**Serial Number** is printed on top of lid of meter cover, meter body or meter flange
(5) -**Total # of Dials** is the number of dials that move on register
(6) -**Fixed Numbers** is the number of zeroes that do not move on register
-If you have a trouble trying to find the rest of the meter data required under this section, see **Illustration 1**
Please submit readings of **all digits** of register and **date of the reading**
Under comments, give any pertinent information concerning repair of meter, dates out of service, etc.

* **This is a mandatory item** and must be filled in with each meter reading reported. **If a meter has been replaced**, you have to **completely fill** this form and provide this office with **initial reading** and **date of installation** of the new installed meter, and **last reading** of the replaced meter.

Do Not Write Below This Line

File Number: ____________________
Trn Number: ____________________

Form: wr-26


Signet Magmeter
3-2551-P0-42
CODE:159001279
SN:61608100437


+GF+
Signet Magmeter
0.0 GPM
00005185
ENTER

Georg Fischer Signet LLC
Signet 2551 Magmeter

+GF+

Test Certificate

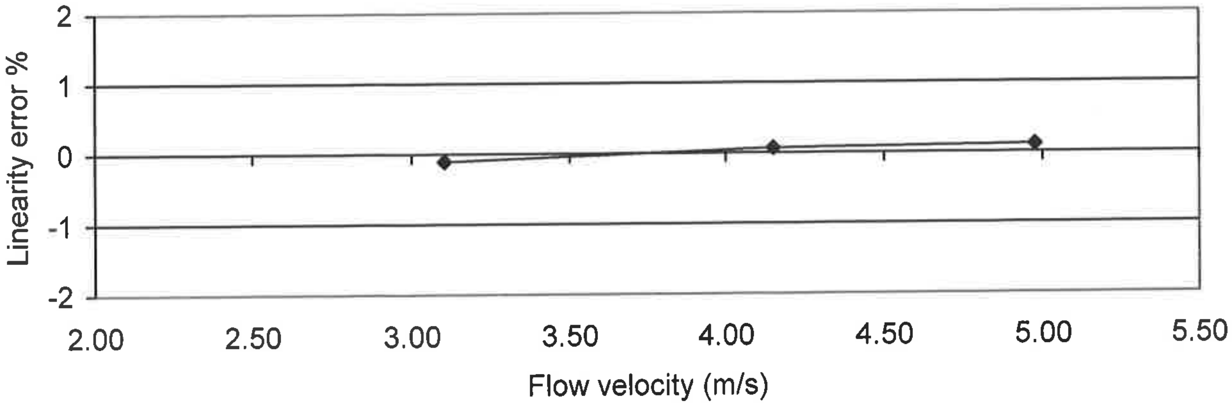
Part Information

Mfr. part #: 3-2551-P0-42
Type: PP/316L SS; mA output
Serial number: 61608100437
Calibration date: August 10, 2016

Test Data

Test media: Water
Pipe type: SYGEF PVDF d50
Pipe fitting: PVDF Tee d50, SFMT015
Output jumper: S³L (applies to 3-2551-XX-X1 only)
Pipe size jumper: Off

Flow Velocity ft/s (m/s)	Flow Velocity ft/s (m/s)	Flow Velocity ft/s (m/s)
Reynolds Number Linearity (% of reading) 10.18 (3.10)	Reynolds Number Linearity (% of reading) 10.18 (3.10)	Reynolds Number Linearity (% of reading) 10.18 (3.10)



Refer to Signet 2551 Magmeter manual (PN 3-2551.090 or 3-2551.090-1) for technical specification.

Georg Fischer Signet LLC certifies that the reference used in the calibration of this product is traceable to NIST (National Institute of Standards and Technology). Improper handling may adversely affect the accuracy.

Georg Fischer Signet LLC products are manufactured under ISO 9001 for Quality and ISO 14001 for Environmental Management.

Georg Fischer Signet LLC
3401 Aero Jet Avenue
El Monte, CA 91731-2882
www.gfsignet.com

File Number: ____________________
(For OSE Use Only)

NEW MEXICO OFFICE OF THE STATE ENGINEER
TOTALIZING METER REPORT

1. PERMITTEE

*OSE File/Permit Number: RG-1579 POD 316
Name: Kirtland Air Force Base
Work Phone: 505-846-9017
Contact: Scott Clark
Home Phone:
Address: 2050 Wyoming Blvd SE
Cell Phone: 505-385-3679
City: Albuquerque
Fax:
State: NM Zip: 87117 E-mail (optional): scott.clark@us.af.mil

2. LOCATION OF WELL

*OSE Well/POD Number: POD 316
a. (___) 1/4 (___) 1/4 (___) 1/4 Section(s): (______) Township: (_____) Range: (_____) N.M.P.M.
b. ______________________ Subdivision
c. Latitude: _______ d _______ m _______ s Longitude: _______ d _______ m _______ s
d. Latitude: ______________ (____) Longitude: ______________ (____)
e. East 1542418.47 (m), North 1473782.33 (m), UTM Zone 13, NAD ☐ 27 or ☑ 83

3. PURPOSE OF USE

☐ Domestic ☐ Livestock ☐ Irrigation ☐ Municipal ☐ Commercial ☐ Industrial ☑ Other: Pollution Control and Recovery

4. FLOW METER DATA

*Serial Number: 61608100437
Make: Georg Fischer Signet LLC
Total # of Dials: 8
Model: Signet 2551 Magmeter, 3-2551-P0-42
Multiplier: **X (** 1 **)**
Meter Size: 3.75 inch diameter
Units: ☐ Acre-feet ☐ Barrels ☐ Cubit-feet ☑ Gallons Other: ________
Fixed Numbers (Check one): **0** ☐ or **00** ☐ or **000** ☐ or **none** ☑

5. METER READING

*Reading Date: 7 / 17 / 2017

*Actual Meter Reading
(All numbers dials and fixed included): **00005185**

6. ADDITIONAL STATEMENTS OR EXPLANATIONS:

Pictures of all three flow meters and the manufacturer calibration reports are included with this report.

*Submitted by: Caitlin LaChance, APTIM
Date: 7 / 26 / 2017

INSTRUCTIONS:

Specific questions should be answered as follows:

(4) -**Serial Number** is printed on top of lid of meter cover, meter body or meter flange
(5) -**Total # of Dials** is the number of dials that move on register
(6) -**Fixed Numbers** is the number of zeroes that do not move on register
-If you have a trouble trying to find the rest of the meter data required under this section, see **Illustration 1**
Please submit readings of **all digits** of register and **date of the reading**
Under comments, give any pertinent information concerning repair of meter, dates out of service, etc.

* **This is a mandatory item** and must be filled in with each meter reading reported. **<u>If a meter has been replaced</u>**, you have to **<u>completely fill</u>** this form and provide this office with **initial reading** and **date of installation** of the new installed meter, and **last reading** of the replaced meter.

Do Not Write Below This Line

File Number: ____________________
Trn Number: ____________________

Form: wr-26

C-82


3-2551-P0-42
CODE:159001279
SN:61608100434
LISTED
3-6050.615/B


+GF+
-0.1 GPM
00005410
Signet Magmeter
ENTER

Georg Fischer Signet LLC
Signet 2551 Magmeter

+GF+

Test Certificate

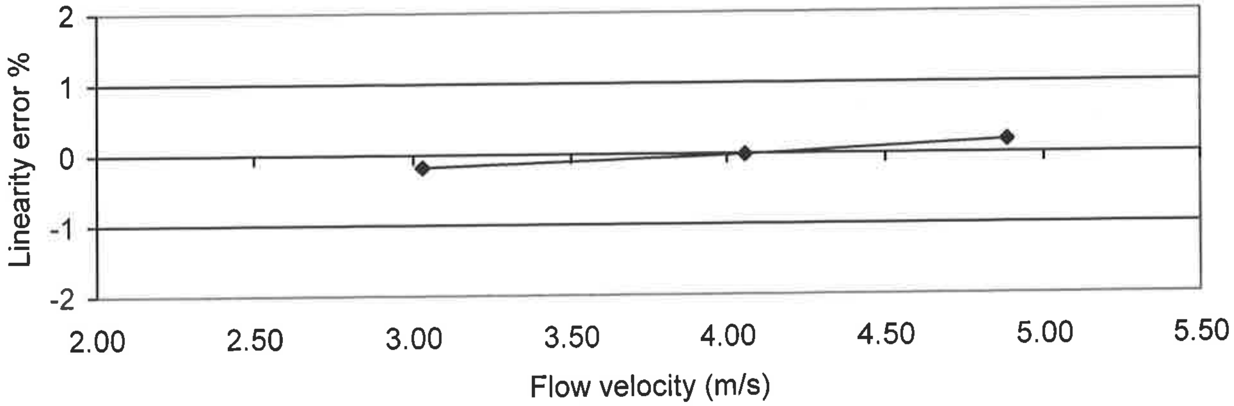
Part Information

Mfr. part #:	3-2551-P0-42
Type:	PP/316L SS; mA output
Serial number:	61608100434
Calibration date:	August 11, 2016

Test Data

Test media:	Water
Pipe type:	SYGEF PVDF d50
Pipe fitting:	PVDF Tee d50, SFMT015
Output jumper:	S³L (applies to 3-2551-XX-X1 only)
Pipe size jumper:	Off

Flow Velocity ft/s (m/s)	Flow Velocity ft/s (m/s)	Flow Velocity ft/s (m/s)
Reynolds Number	Reynolds Number	Reynolds Number
Linearity (% of reading)	Linearity (% of reading)	Linearity (% of reading)
9.94 (3.03)	9.94 (3.03)	9.94 (3.03)



Refer to Signet 2551 Magmeter manual (PN 3-2551.090 or 3-2551.090-1) for technical specification.

Georg Fischer Signet LLC certifies that the reference used in the calibration of this product is traceable to NIST (National Institute of Standards and Technology). Improper handling may adversely affect the accuracy.

Georg Fischer Signet LLC products are manufactured under ISO 9001 for Quality and ISO 14001 for Environmental Management.

Georg Fischer Signet LLC
3401 Aero Jet Avenue
El Monte, CA 91731-2882
www.gfsignet.com

File Number: ____________________
(For OSE Use Only)

NEW MEXICO OFFICE OF THE STATE ENGINEER
TOTALIZING METER REPORT

1. PERMITTEE

*OSE File/Permit Number: RG-1579 POD 316
Name: Kirtland Air Force Base
Work Phone: 505-846-9017
Contact: Scott Clark
Home Phone:
Address: 2050 Wyoming Blvd SE
Cell Phone: 505-385-3679
City: Albuquerque
Fax:
State: NM Zip: 87117 E-mail (optional): scott.clark@us.af.mil

2. LOCATION OF WELL

*OSE Well/POD Number: POD 316
a. (___)1/4 (___)1/4 (___)1/4 Section(s): (______) Township : (_____) Range : (_____) N.M.P.M.
b. ________________ Subdivision
c. Latitude: ______d ______m ______s Longitude: ______d ______m ______s
d. Latitude: ____________ (____) Longitude: ____________ (____)
e. East 1542418.47 (m), North 1473782.33 (m), UTM Zone 13, NAD (__) 27 or (✔) 83

3. PURPOSE OF USE

(_) Domestic (_) Livestock (_) Irrigation (_) Municipal (_) Commercial (_) Industrial (✔) Other: Pollution Control and Recovery

4. FLOW METER DATA

*Serial Number: 61608100437
Make: Georg Fischer Signet LLC
Total # of Dials: 8
Model: Signet 2551 Magmeter, 3-2551-P0-42
Multiplier: X (1)
Meter Size: 3.75 inch diameter
Units: (_) Acre-feet (_) Barrels (_) Cubit-feet (✔) Gallons Other: ________
Fixed Numbers (Check one): **0** ( ) or **00** ( ) or **000** ( ) or **none** (✔)

5. METER READING

*Reading Date: 7 / 17 / 2017

*Actual Meter Reading
(All numbers dials and fixed included): **00005185**

6. ADDITIONAL STATEMENTS OR EXPLANATIONS:

Pictures of all three flow meters and the manufacturer calibration reports are included with this report.

*Submitted by: Caitlin LaChance, APTIM
Date: 7 / 26 / 2017

INSTRUCTIONS:

Specific questions should be answered as follows:

(4) -**Serial Number** is printed on top of lid of meter cover, meter body or meter flange
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Do Not Write Below This Line

File Number: ____________
Trn Number: ____________
C-86
Form: wr-26


+GF+
0.0 GPM
0001782
Signet Magmeter
ENTER

Georg Fischer Signet LLC
Signet 2551 Magmeter

Test Certificate

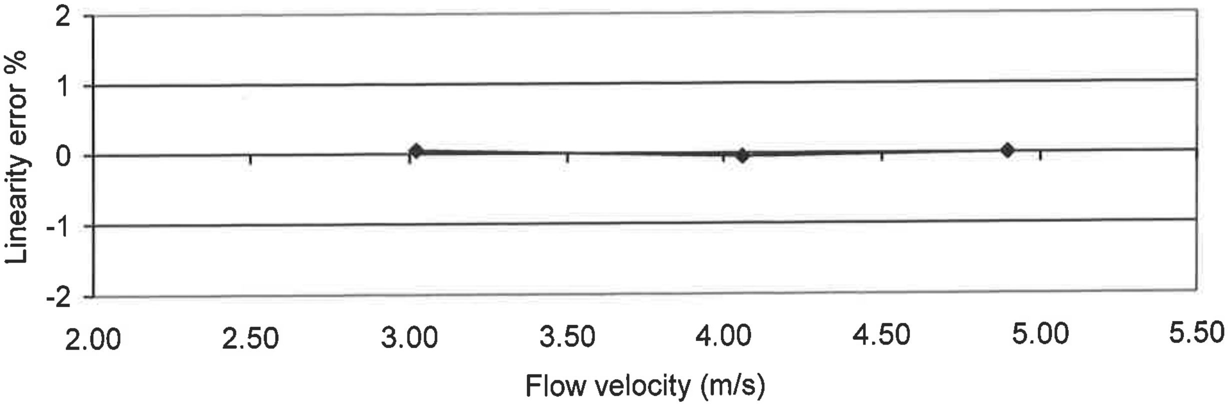
Part Information

Mfr. part #: 3-2551-P0-42
Type: PP/316L SS; mA output
Serial number: 61608120851
Calibration date: August 13, 2016

Test Data

Test media: Water
Pipe type: SYGEF PVDF d50
Pipe fitting: PVDF Tee d50, SFMT015
Output jumper: S³L (applies to 3-2551-XX-X1 only)
Pipe size jumper: Off

Flow Velocity ft/s (m/s)	Flow Velocity ft/s (m/s)	Flow Velocity ft/s (m/s)
Reynolds Number Linearity (% of reading)	Reynolds Number Linearity (% of reading)	Reynolds Number Linearity (% of reading)
9.91 (3.02)	9.91 (3.02)	9.91 (3.02)



Refer to Signet 2551 Magmeter manual (PN 3-2551.090 or 3-2551.090-1) for technical specification.

Georg Fischer Signet LLC certifies that the reference used in the calibration of this product is traceable to NIST (National Institute of Standards and Technology). Improper handling may adversely affect the accuracy.

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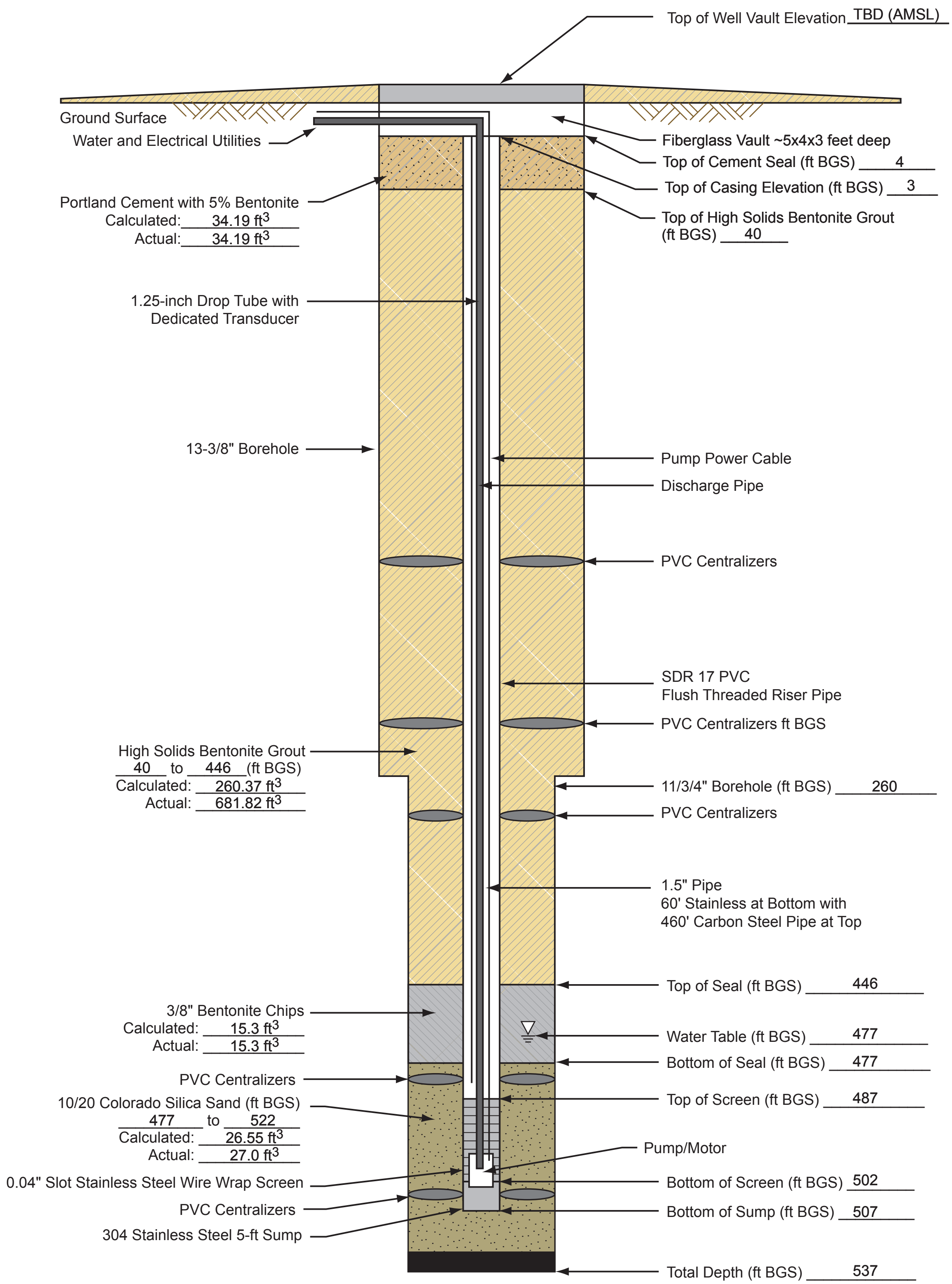
Extraction Well Completion Diagram KAFB-106EX1

Installation Start Date/Time: 3/3/17@1206
Installation End Date/Time: 3/12/17@1625
Completion Date: 4/19/17



Top of Well Vault Elevation TBD (AMSL)

Top of Cement Seal (ft BGS) 4

Top of Casing Elevation (ft BGS) 3

Top of High Solids Bentonite Grout (ft BGS) 40

Portland Cement with 5% Bentonite
Calculated: 34.19 ft^3
Actual: 34.19 ft^3

High Solids Bentonite Grout
40 to 446 (ft BGS)
Calculated: 260.37 ft^3
Actual: 681.82 ft^3

11/3/4" Borehole (ft BGS) 260

Top of Seal (ft BGS) 446

3/8" Bentonite Chips
Calculated: 15.3 ft^3
Actual: 15.3 ft^3

Water Table (ft BGS) 477

Bottom of Seal (ft BGS) 477

Top of Screen (ft BGS) 487

10/20 Colorado Silica Sand (ft BGS)
477 to 522
Calculated: 26.55 ft^3
Actual: 27.0 ft^3

Bottom of Screen (ft BGS) 502

Bottom of Sump (ft BGS) 507

Total Depth (ft BGS) 537

(4,816.90) = *Elevations are NAVD 88 Datum values based on NGS Control Station "Hanger", Elevation = 5,343.43 ft. GPS/RTK methods and GEO1D99 model were used to determine elevations of all surveyed points.*

Not to Scale
BGS = Below Ground Surface

500433_03050100_A7

Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

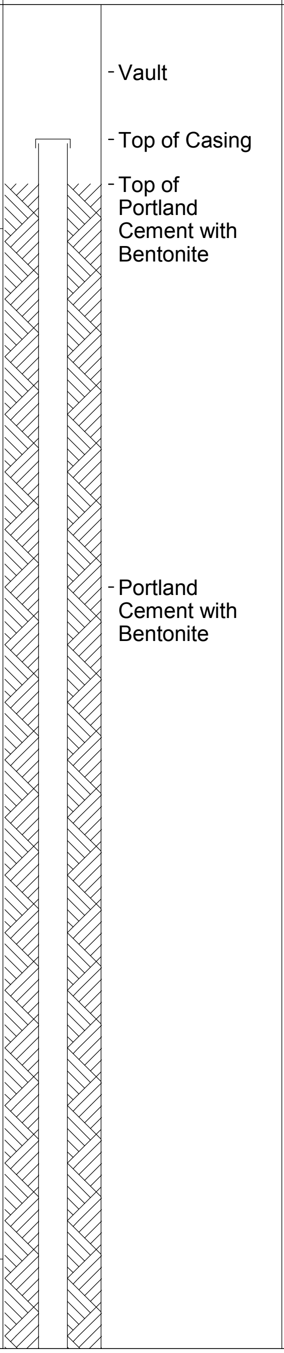
Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Page 1 of 18

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
0					No Lithologic Description.			Borehole was pot holed with air knife to 5 feet bgs. No cuttings returned.
5					SILT with Gravel (ML); brown (7.5YR 4/4); 75% silt; 25% fine gravel to 3/4"; subangular to subrounded; trace sand. Note: gravel is granitic.			Began drilling with 13-3/8 inch casing @ 1206 on 3/3/17. Using under reamer.
10					Same as above (5 ft).			PID = 0.0 ppm @ cyclone and breathing zone (BZ).
15					Gravelly SILT (ML); brown (7.5YR 4/4); 60% silt; 40% coarse gravel to 2"; subangular to subrounded. Note: method of drilling is causing gravel to fracture.	ML		PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ. Kelly down @ 1212, new 20' connection @ 1231.
20								
25					SILT with Gravel (ML); reddish brown (5YR 5/3); 80% silt; 20% gravel; subangular; trace coarse sand. Note: some fractured gravel.			Water added @ cyclone for dust suppression.
30					Lean CLAY with Gravel (CL); reddish brown (5YR 5/3); nonplastic; 80% clay; 20% fine gravel; subangular.	CL		



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

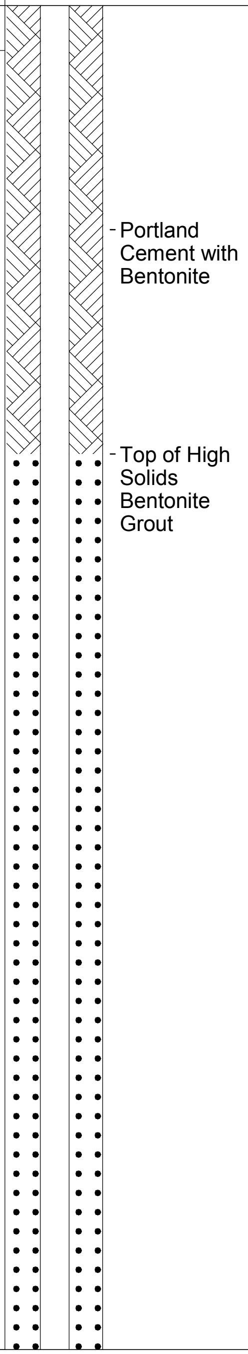
Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
30					Lean CLAY with Gravel (CL); reddish brown (5YR 5/3); nonplastic; 80% clay; 20% fine gravel; subangular.	CL		
					SILT with Sand (ML); light brown (7.5YR 6/4); 85% silt; 15% fine to coarse sand; subangular to subrounded.			PID = 0.0 ppm @ cyclone and BZ.
35					Same as above (31 ft).		Portland Cement with Bentonite	
								Kelly down @ 1242, new 20' connection @ 1253.
40							Top of High Solids Bentonite Grout	Water added at cyclone.
					SILT (ML); light brown (7.5YR 6/3); 90% silt; 10% coarse sand; subangular to subrounded; trace gravel.			
45						ML		
					Same as above (42 ft).			No hammering.
50					Same as above (42 ft); 10% gravel to 1/8"; subangular.			PID = 0.0 ppm @ cyclone and BZ.
55					Same as above (42 ft); 10% gravel to 1/8"; subangular.			
								Kelly down @ 1328; trip out drill rod, add drill collars and 2 stabilizers. New 20' connection @
60								

Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

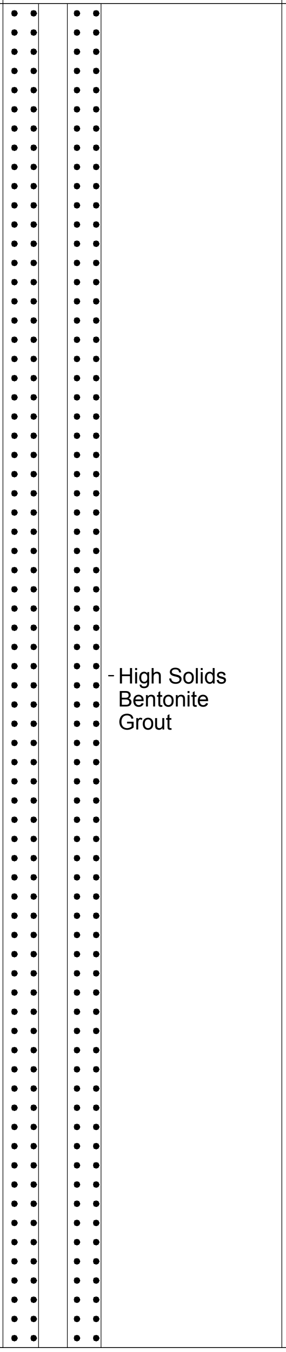
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
60					SILT (ML); brown (7.5YR 5/4); 90% silt; trace clay; 10% fine gravel to 3/4"; subangular.			1433. Hammering.
65					Same as above (60 ft).			PID = 0.0 ppm @ cyclone and BZ.
70					SILT with Sand (ML); light brown (7.5YR 6/4); 75% silt; 20% fine to coarse sand; subangular to subrounded; 5% fine gravel to 3/4"; subangular to subrounded.			
75					Same as above (70 ft).	ML		Hammering. Kelly down @ 1453, new 20' connection @ 1514.
80					Same as above (70 ft).			
85					Same as above (70 ft); 75% silt; 25% fine to coarse sand.			PID = 0.0 ppm @ cyclone and BZ. Water added at cyclone for dust suppression; hammering.
90								



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

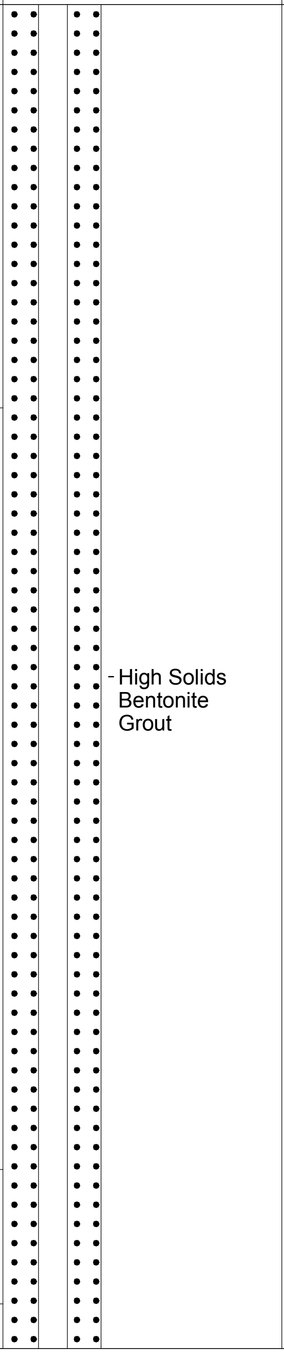
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
90					SILT (ML); reddish brown (5YR 5/3); 90% silt; 5% fine to coarse sand; 5% gravel; subangular to subrounded.	ML		Hammering intermittently.
95					Same as above (90 ft).			Kelly down @ 1528, new 20' connection @ 1537.
100					Silty SAND (SM); brown (7.5YR 5/3); 60% fine sand; subrounded to rounded; trace fine gravel; 40% silt.	SM		Hammering intermittently.
105					Same as above (99 ft).			PID = 0.0 ppm @ cyclone and BZ.
110					Same as above (99 ft); 80% fine to coarse sand; trace gravel; 20% silt.			Hammering intermittently. Water added at cyclone for dust suppression.
115					Same as above (99 ft); 80% fine to coarse sand; trace gravel; 20% silt.			
					Well-graded SAND (SW); pale brown (10YR 6/3); 90% fine to coarse sand; subangular to subrounded; 10% fine gravel to 3/4"; subangular to subrounded; trace silt.	SW		Kelly down @ 1551, new 20' connection @ 1613.
120					Description on next page.	SM		



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

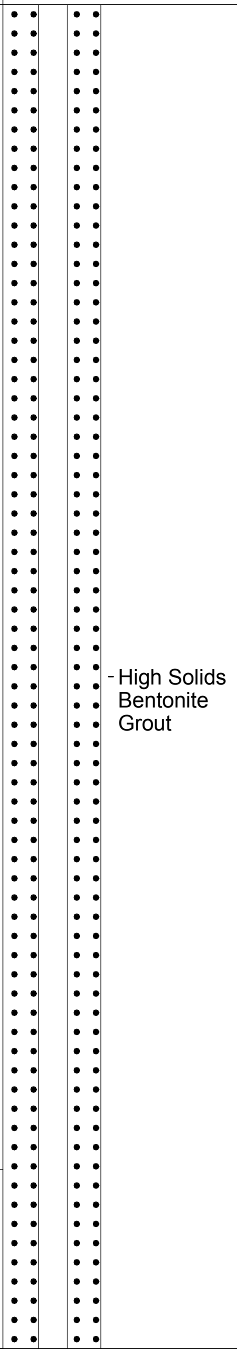
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
120					Silty SAND (SM); light brown (7.5YR 6/4); 70% very fine sand; subrounded; 30% silt.	SM		PID = 0.0 ppm @ cyclone and BZ.
								Hammering intermittently.
125					Same as above (120 ft).			
130					Same as above (120 ft); trace coarse sand; subangular; trace gravel to 1/2"; subrounded.			Water added at cylcone for dust suppression; hammering.
135					Same as above (120 ft); trace coarse sand; subangular; trace gravel to 1/2"; subrounded.		High Solids Bentonite Grout	PID = 0.0 ppm @ cyclone and BZ.
								Kelly down @ 1630, new 20' connection @ 1639.
140					Same as above (120 ft); brown (7.5YR 5/4); 60% fine sand; trace coarse sand; subrounded; 40% silt.			Water added @ cyclone and on hammer for dust suppression.
								Slow drilling; hammering.
145								PID = 0.0 ppm @ cyclone and BZ.
					Lean CLAY with Sand (CL); brown (7.5YR 5/3); very hard; 85% clay; 15% fine sand; trace gravel.	CL		
150								



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

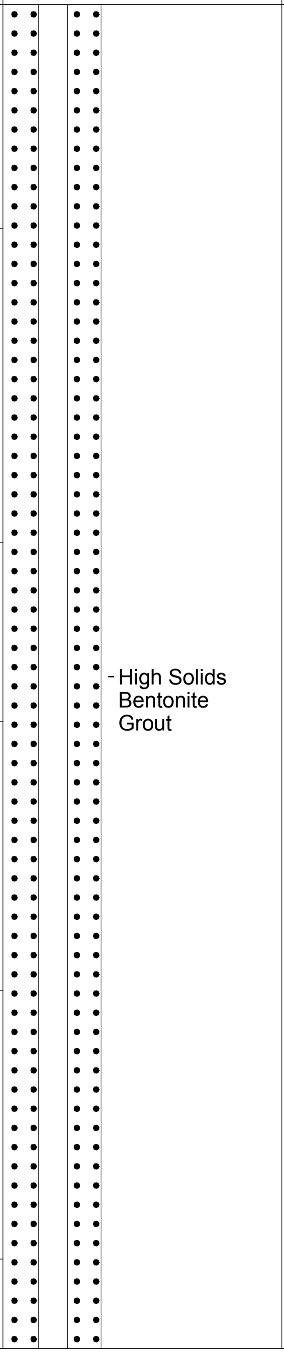
Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
150 155					Lean CLAY with Sand (CL); brown (7.5YR 5/3); very hard; 85% clay; 15% fine sand; trace gravel.	CL		Water added at cylcone and hammer for dust suppression; hammering. PID = 0.0 ppm @ cyclone and BZ.
					SILT (ML); brown (7.5YR 5/4); 90% silt; trace clay; 10% fine sand; subrounded.	ML		Kelly down @ 1710, new 20' connection @ 1718. End of 3/3/17. Resume drilling @ 0747 on 3/4/17. Slow drilling; hammering.
160					SILT with Sand (ML); brown (7.5YR 5/4); 70% silt; 5% clay; 25% fine to coarse sand; subrounded.			
165					Well-graded SAND (SW); brown (7.5YR 5/4); 90% fine to coarse sand; subrounded to rounded; 10% silt.	SW		
170					Silty SAND (SM); brown (7.5YR 4/4); 50% fine to coarse sand; subrounded; 35% silt; 15% clay.	SM		PID = 0.0 ppm @ cyclone and BZ.
175					Well-graded SAND with Silt (SW-SM); light brown (7.5YR 6/4); 90% fine to coarse sand; subrounded; 10% silt; trace clay.	SW-SM		Hammering intermittently. Kelly down @ 0833, new 20' connection @ 0839.
180					Well-graded SAND (SW); light brown (7.5YR 6/4); 100% fine to very coarse sand; subrounded; trace silt.	SW		



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

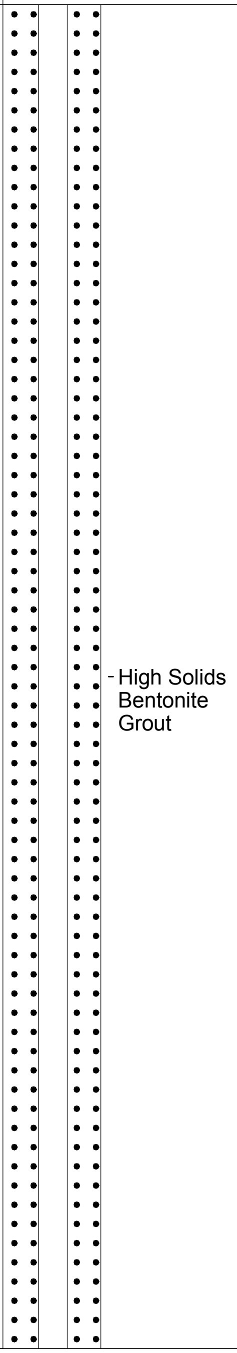
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
180					Well-graded SAND (SW); light brown (7.5YR 6/4); 100% fine to very coarse sand; subangular to subrounded; trace fine gravel; trace silt. Note: sand is granitic minerals.			Some hammering. PID = 0.0 ppm @ cyclone and BZ.
								Hammering.
185								
								Water used at surface for dust suppression while drilling.
					Same as above (180 ft); 90% fine to very coarse sand; 10% gravel to 1/4"; subangular to subrounded.			
190								
								Hammering. PID = 0.0 ppm @ cyclone and BZ.
195					Same as above (180 ft); pale brown (10YR 6/3); 90% fine to very coarse sand; subrounded; 10% fine gravel to 1/8".	SW	High Solids Bentonite Grout	
								Kelly down @ 0929, new 20' connection @ 1036.
200								
					Well-graded SAND with Gravel (SW); pale brown (10YR 6/3); 80% fine to very coarse sand; subrounded; 20% gravel to 3/8"; subrounded.			
								Slow drilling; hammering.
205								
					Same as above (202 ft).			
210								



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
210								
					Well-graded SAND with Gravel (SW); pale brown (10YR 6/3); 80% fine to very coarse sand; subrounded; 20% gravel to 3/8"; subrounded.	SW		PID = 0.0 ppm @ cyclone and BZ.
215								
					Poorly graded GRAVEL (GP); 100% fine gravel to 1/4"; subrounded.	GP		Hammering intermittently.
					Well-graded SAND (SW); pale brown (10YR 10/3); 100% sand; subrounded; trace gravel. Note: sand and gravel are granitic minerals.			Kelly down @ 1108, new 20' connection @ 1116.
220								
					Same as above (216 ft).			
								Very slow drilling; hammering.
225							High Solids Bentonite Grout	
					Same as above (216); 90% sand; 10% fine gravel to 1/4".			
						SW		Hammering continuously.
230								
					Same as above (216); 90% sand; 10% fine gravel to 1/4".			PID = 0.0 ppm @ cyclone and BZ.
235								Water added at cyclone for dust suppression.
					Well-graded SAND with Gravel (SW); pale brown (10YR 10/3); 80% fine to very coarse sand; subrounded; 20% gravel to 1/4". Note: sand and gravel are granitic minerals.			Kelly down @ 1238, new 20' connection @ 1244.
240								

Borehole ID: KAFB-106EX1

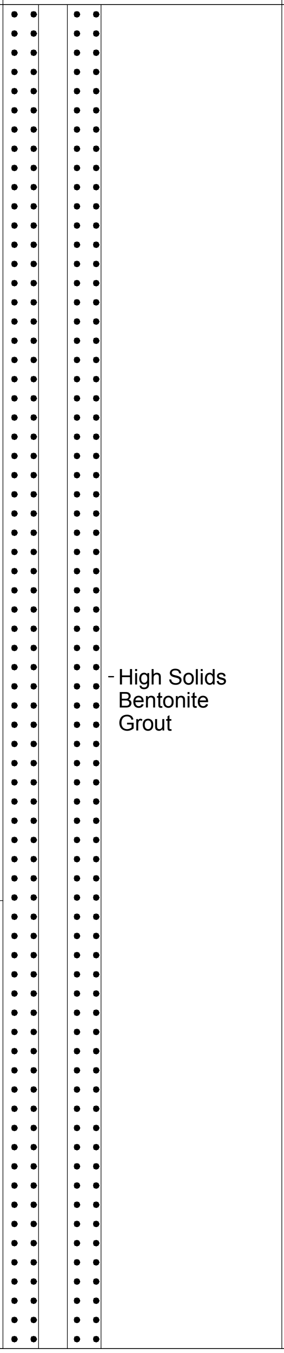
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
240					Well-graded SAND (SW); pale brown (10YR 6/3); 100% fine to coarse sand; trace gravel; subangular to subrounded. Note: gravel is granitic minerals.	SW		Hammering. PID = 0.0 ppm @ cyclone and BZ.
245					Same as above (240 ft).			Hammering almost continuously.
250					Same as above (240 ft); trace gravel to 1/8".			Hammering. PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ.
255					Same as above (240 ft); 90% fine to coarse sand; 10% gravel to 3/8"; subrounded.		High Solids Bentonite Grout	Kelly down @ 1330. Place 5 foot section of 13-3/4" casing @ 1354. Begin tripping in 260 feet of 11-3/4" casing. End of 3/4/17. Resume drilling @ 0805 on 3/5/17.
260					Sandy lean CLAY (CL); yellowish brown (10YR 5/4); dry; 75% clay; 25% fine sand; trace fine gravel to 1/4".	CL		
265					Same as above (260 ft).			No hammering; no water added downhole.
270								

Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

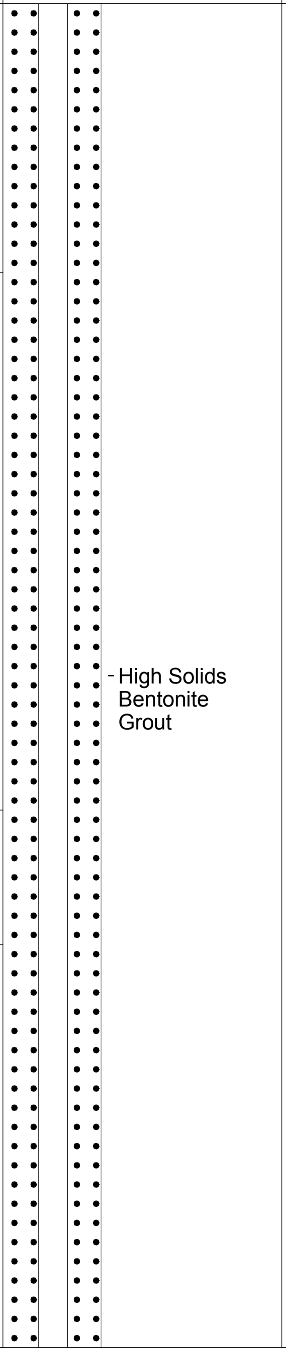
Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Remarks
270				▨	Sandy lean CLAY (CL); yellowish brown (10YR 5/4); dry; 75% clay; 25% fine sand; trace fine gravel to 1/4". Lens of fine to medium sand.	CL	PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ. Hammering intermittently.
275							
				⸬	Poorly graded SAND (SP); light brown (7.5YR 6/4); dry; 85% fine sand; 15% medium to coarse sand.	SP	Kelly down @ 0826, new 20' connection @ 0832.
280							PID = 0.1 ppm @ cyclone and BZ.
					Same as above (276 ft).		
285							Hammering intermittently; no water added downhole.
				‖	SILT (ML); strong brown (7.5YR 5/6); dry; 100% silt; trace fine sand.	ML	
290							
				▨	Clayey SAND (SC); light brown (7.5YR 6/3); 75% fine sand; trace medium and coarse sand; trace fine gravel; 25% clay; low plasticity.	SC	
295							
					Same as above (291 ft); 15% fine gravel to 1/2". Note: gravel is mafics and quartz.		Kelly down @ 0851, new 20' connection @ 0858.
300							

Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

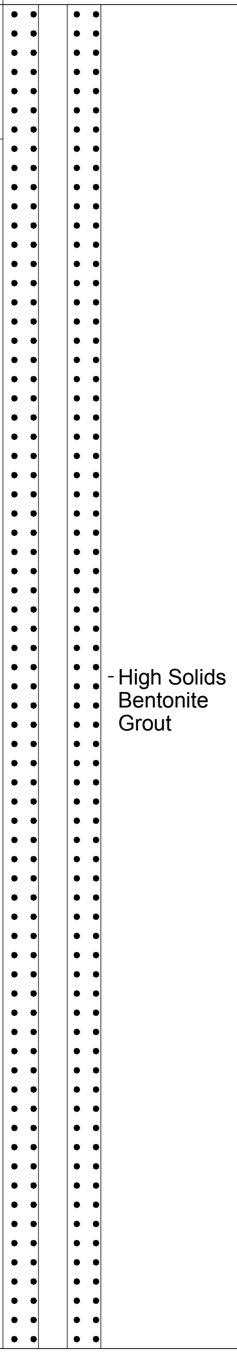
Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
300				▨	Clayey SAND (SC); light brown (7.5YR 6/3); 60% fine sand; trace medium and coarse sand; 15% fine gravel to 1/2"; 25% clay; low plasticity.	SC		PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); dry; 80% fine to coarse sand; 20% fine gravel to 1/2"; subangular to rounded. Note: gravel is mafics and granitic minerals.	SW		Some hammering.
305								
								Hammering; no water added downhole.
310					Same as above (303 ft).			
315					Same as above (303 ft).		High Solids Bentonite Grout	
								Kelly down @ 0922, new 20' connection @ 0929.
320					Same as above (303 ft).			PID = 0.3 ppm @ cyclone and 0.1 ppm @ BZ. Windy.
325					Same as above (303 ft).			Hammering; no water added downhole.
330								



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

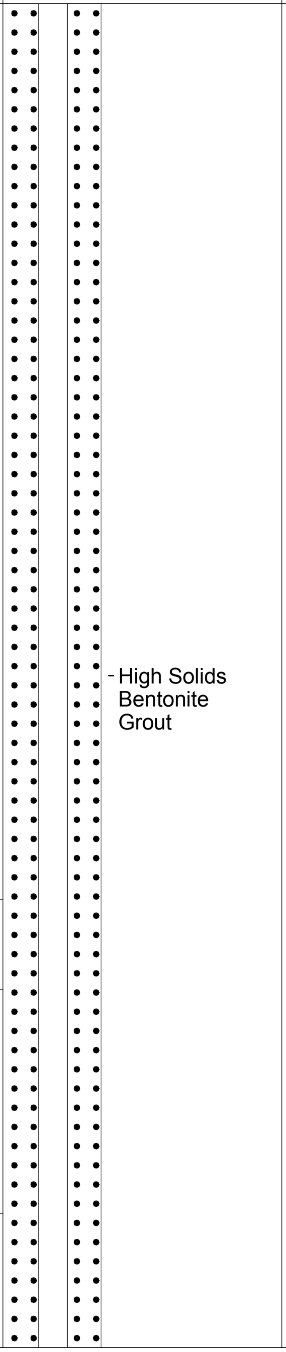
Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 479.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
330					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); dry; 80% fine to coarse sand; 20% fine gravel to 1/8"; subangular to rounded. Note: gravel is mafics and granitic minerals.	SW		PID = 0.3 ppm @ cyclone and 0.2 ppm @ BZ. Hammering; no water added downhole.
335					Same as above (330 ft).			Kelly down @ 0954, new 20' connection @ 1000.
340					Same as above (330 ft).			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
345					Same as above (330 ft).		High Solids Bentonite Grout	
350					Lean CLAY (CL); hard clay lens with sand and gravel.	CL		Very windy, gusts to 32 mph.
					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); dry; 80% fine to coarse sand; 20% fine gravel to 1/8"; subangular to rounded. Note: gravel is mafics and granitic minerals.	SW		
355					Well-graded SAND with Silt and Gravel (SW-SM); reddish yellow (7.5YR 6/6); dry; 60% fine to coarse sand; 30% fine gravel to 3/8"; subangular to rounded.	SW-SM		Kelly down @ 1048. Stop drilling for the day due to high winds. Resume drilling @ 1010 on
360								



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
360					Well-graded SAND with Silt and Gravel (SW-SM); reddish yellow (7.5YR 6/6); dry; 60% fine to coarse sand; 30% fine gravel to 3/8"; subangular to rounded. Note: gravel is fragmented from bit; mafics and granitic minerals.	SW-SM		3/11/17. Had to pull casing back and redrill part of the borehole. PID = 0.1 ppm @ cyclone and BZ.
365					Same as above (360 ft); gravel to 3/4".			Hammering with casing hammer; no water added downhole.
					Well-graded GRAVEL with Silt and Sand (GW-GM); brown (7.5YR 5/4); dry; 60% fine to coarse gravel to 3/4"; angular to rounded; 30% fine to coarse sand; 10% silt. Note: gravel is mafics and granitic minerals.	GW-GM		
370								
					Well-graded SAND with Silt and Gravel (SW-SM); brown (7.5YR 4/3); 70% fine to coarse sand; 20% fine gravel to 1/4"; 10% silt.	SW-SM		Hammering downhole and with casing hammer.
375							High Solids Bentonite Grout	
					Same as above (372 ft).			Kelly down @ 1036, new 20' connection @ 1045.
380								PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
					Same as above (372 ft).			
385								Hammering continuously.
390								

Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

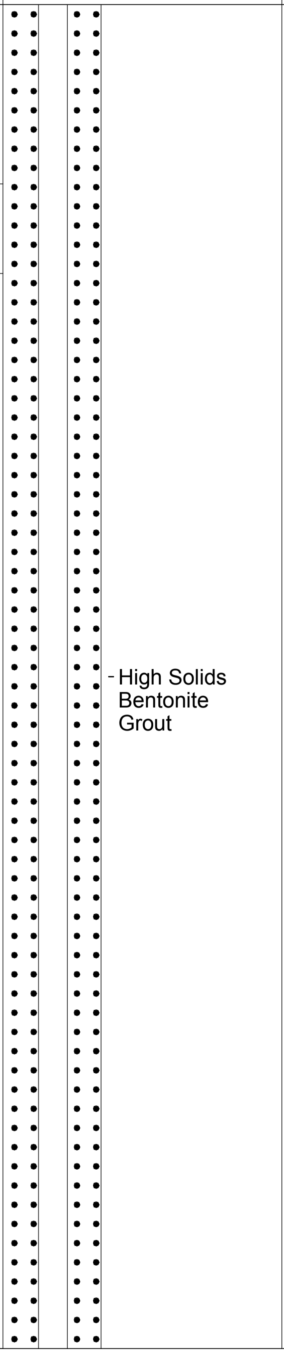
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
390					Well-graded SAND with Silt and Gravel (SW-SM); brown (7.5YR 4/3); 70% fine to coarse sand; 20% fine gravel to 1/4"; 10% silt.	SW		Hammering; no water added downhole.
395					Poorly graded SAND (SP); brown (7.5YR 5/3); dry; 90% medium to coarse sand; trace fine gravel to 1/8"; 10% silt.	SP		
					Well-graded SAND with Gravel (SW); brown (7.5YR 5/4); dry; 70% fine to coarse sand; 30% fine gravel to 1/2"; subangular to rounded; trace silt. Note: gravel is mafics and granitic minerals.			Kelly down @ 1118, new 20' connection @ 1134.
400								PID = 0.1 ppm @ cyclone and BZ.
					Same as above (396 ft).			
405								
					Same as above (396 ft).	SW		
410								
					Same as above (396 ft).			
415								
					Same as above (396 ft).			Kelly down @ 1216, new 20' connection @ 1457. Rig repairs.
420								



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

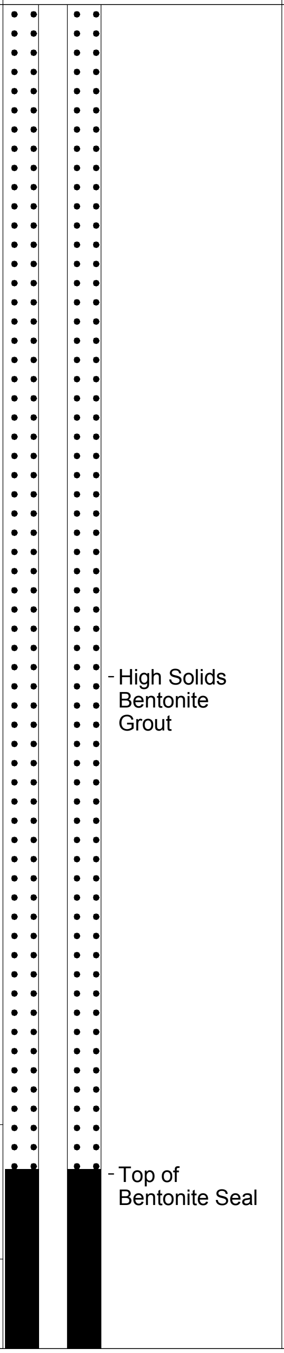
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
420					Well-graded SAND with Gravel (SW); brown (7.5YR 5/4); dry; 70% fine to coarse sand; 30% fine gravel to 1/2"; subangular to rounded; trace silt. Note: gravel is mafics and granitic minerals.	SW		PID = 0.9 ppm @ cyclone and 0.0 ppm @ BZ.
425					Same as above (420 ft).			Hammering continuously with casing hammer. Hammering intermittently with downhole hammer.
430					Same as above (420 ft); light brown (7.5YR 6/4); 80% fine to coarse sand; 15% fine gravel to 1/4"; angular to rounded; 5% silt.			No water added downhole.
435					Same as above (420 ft); light brown (7.5YR 6/4); 80% fine to coarse sand; 15% fine gravel to 1/4"; angular to rounded; 5% silt.			Kelly down @ 1520, new 20' connection. End of 3/11/17. Resume drilling @ 0746 on 3/12/17.
440					Same as above (420 ft); light brown (7.5YR 6/4); 80% fine to coarse sand; 15% fine gravel to 1/4"; angular to rounded; 5% silt.			PID = 0.1 ppm @ cyclone and BZ.
445					SILT (ML); lens.	ML		Hammering; no water added downhole.
					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); dry; 80% fine to coarse sand; 15% fine gravel to 1/2";	SW		
450								



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

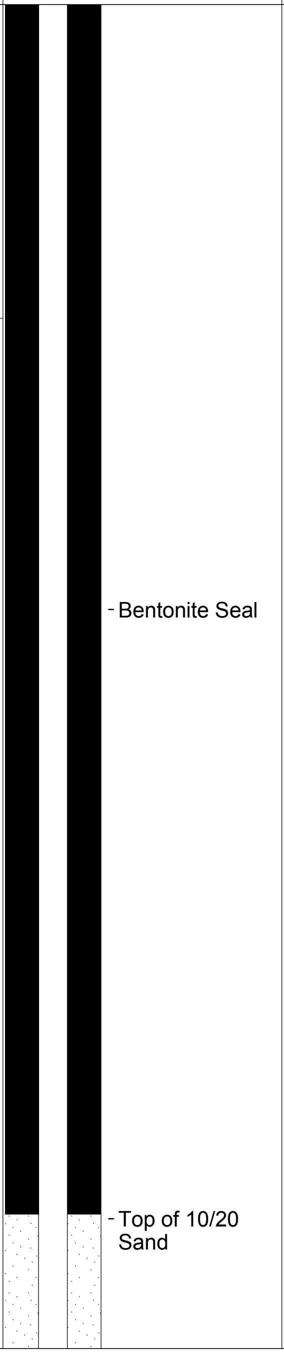
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
∇ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
450					angular to rounded; 5% silt. Note: gravel is mafics and granitic minerals.	SW		
					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); dry; 80% fine to coarse sand; 15% fine gravel to 1/2"; angular to rounded; 5% silt. Note: gravel is mafics and granitic minerals.			Hammering.
455								
					Poorly graded SAND with Silt (SP-SM); yellowish brown (10YR 5/4); dry; 80% fine to medium sand; 10% fine gravel to 1/4"; rounded; 10% silt. Note: gravel is mafics and granitic minerals.	SP-SM		Kelly down @ 0806, new 20' connection @ 0823.
460								PID = 0.1 ppm @ cyclone and BZ.
465			0.2		Same as above (457 ft).		Bentonite Seal	PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
470			1.6		Same as above (457 ft).			PID = 0.1 ppm @ cyclone and BZ.
475			1.5		Same as above (457 ft).			PID = 1.8 ppm @ cyclone and 0.3 ppm @ BZ.
				∇			Top of 10/20 Sand	Kelly down @ 0852, new 20' connection @ 0927. Top of groundwater @ 477 feet bgs.
				▼				
480								



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

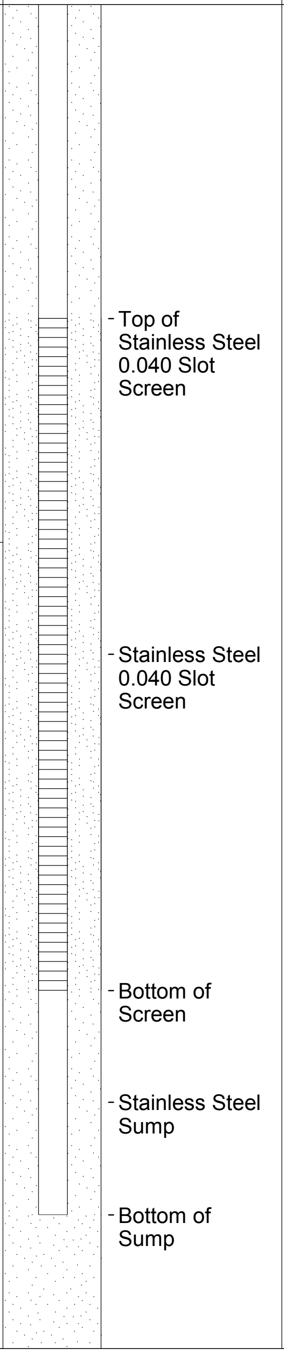
Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
480			12.8		Poorly graded SAND with Silt (SP-SM); yellowish brown (10YR 5/4); wet; 80% fine to medium sand; 10% fine gravel to 1/4"; rounded; 10% silt. Note: gravel is mafics and granitic minerals.	SP-SM		PID = 18.7 ppm @ cyclone and 0.3 ppm @ BZ.
485			37.8		Same as above (480 ft).			PID = 119.8 ppm @ cyclone and 0.5 ppm @ BZ.
490			63.4					PID = 850 ppm @ cyclone and 1.7 ppm @ BZ.
					Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4); wet; 75% fine to coarse sand; 25% fine gravel to 1/2"; subangular to rounded. Note: gravel is mafics and granitic minerals.	SW		Approximately 200 gallons of water added downhole.
495			58.3					PID = 747 ppm @ cyclone and 6.2 ppm @ BZ. Kelly down @ 1020, new 20' connection @ 1039.
500			22.5		Same as above (492 ft).			PID = 31.4 ppm @ cyclone and 1.7 ppm @ BZ.
505			6.8		Same as above (492 ft); poor cuttings returns.			PID = 9.8 ppm @ cyclone and 0.3 ppm @ BZ.
510								Hammering. Approximately 50 gallons of water added



Borehole ID: KAFB-106EX1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/3/2017
Date TD Reached: 3/12/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 479.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards/T. Kunkel

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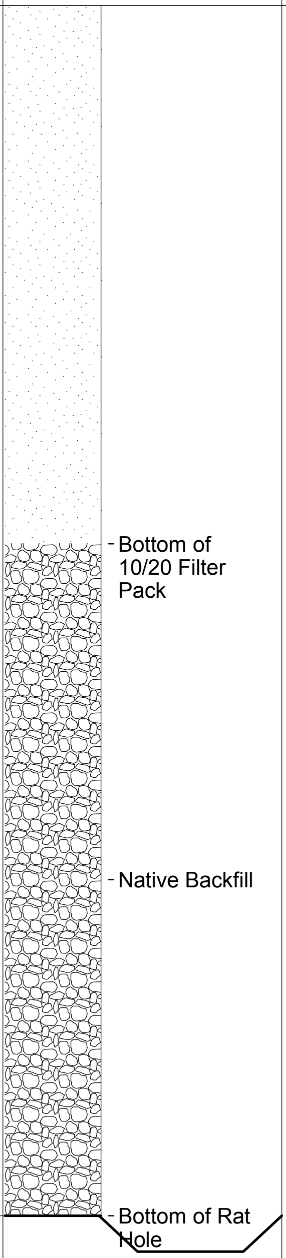
Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
510					Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4); wet; 75% fine to coarse sand; 25% fine gravel to 1/2"; subangular to rounded. Note: poor cuttings returned.			downhole. PID = 4.6 ppm @ cyclone and 0.3 ppm @ BZ.
515								PID = 1.7 ppm @ cyclone and 0.3 ppm @ BZ.
					Same as above (510 ft); gravel to 1".			Kelly down @ 1130, new 20' connection @ 1600.
520			1.9					
					Same as above (510 ft); gravel to 1".	SW		
525			1.4					
					Same as above (510 ft); gravel to 1".			
530			1.6					Approximately 100 gallons of water added downhole.
					Same as above (510 ft); gravel to 1".			Total depth = 537 feet bgs. Reached total depth @ 1625 on 3/12/17.
535			0.9					
540								



Groundwater Extraction Well Development

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KAFB-106EX1

Bailing

Date	Time	Total Volume Bailed (gallons)	Imhoff Cone Measurement (mL sediment per L water)	Comments
4/4/17	0855	0	–	Purging begins
↓	0907	5	10	dark - not a lot of sand - odor present
	0914	15	20	
	0921	20	60	filter pack suspected
	0927	30	34	
	0934	35	33	
	0940	35	–	Empty
	1000	42	9	
	1006	44	22	Water very dark
	1010	50	20	Pump off drum
	1031	55	20	
	1037	60	20	
	1042	65	70	
	1105	70	10	switched to smaller bailer
	1110	74	2	
	1112	76	4	
	1116	80	3	Switening to pumping

Groundwater Extraction Well Development

Page 1 of

Pumping KAFB 106EX1

Date	Time	Rate (gpm)	Depth to Water (ft BGS)	Volume Removed (gallons)	Temp (°C)	pH	EC (mS/cm)	Turbidity (NTU)	Specific Capacity (gpm/ft)	Comments
4/4/17	1520	4	479	NR						Pump On
	1533	4.24	479.6	46	20.4	7.77	0.402	>1000	7	
	1548	4.22	479.6	101	20.5	7.68	0.400	14.2	7	
	1602	4.22	479.6	154	20.5	7.72	0.410	8.32	7	
	1615	4.24	479.6	215	20.6	7.68	0.417	5.63	7	
	1620	NR								Pump off - surge
	1625	NR	478.7	222	NR					Pump on
	1640	4.22	479.6	271	20.6	7.73	0.425	9.86		
	1656	4.24	479.7	340	20.6	7.69	0.430	4.88		Shutting pump off to surge
	1700	NR	4	362.74	NR					
	1710	NR	479	362	NR					Pump back on
	1730		479.7	397	20.8	7.68	0.428	7.31		
4/5/17	0720	4.22	NR		NR					Pump on - clearing ice from lines
	0803	4.22	NR	571	20.4	7.71	0.419	3.81		
	0805									Pump off trip out
	1338	—	479.45	571	NR					Pump on
	1342									Pump off - stopped working
*	16~~15~~28	7.5	off		~~20.6~~	~~7.76~~	~~0.436~~	~~7.48~~	off ~~Pump on~~	
	16~~15~~42	9.5	~~714~~	714	20.6	7.76	0.435	7.48		
	1715	8.5		~~875~~ 876	NR					Pump off
4/6/17	0747	0		884	NR					Pump on
	0763	8.75	NR	931	19.4	8.22	0.426	36.4		
	0823	—		1201	20.0	7.72	0.432	21.9		Pump off - surge
	0833			1201	NR					Pump on

* Total does not include Bailing water

Groundwater Extraction Well Development

Page 2 of ______

Pumping

KAFB-106EX1

Date	Time	Rate (gpm)	Depth to Water (ft BGS)	Volume Removed (gallons)	Temp (°C)	pH	EC (mS/cm)	Turbidity (NTU)	Specific Capacity (gpm/ft)	Comments Pump intake @ 497' bgs
4/7	0808	0	479.3	1201	NR →					Tag ∇ w/ pump in
	0825									Pump on
	0826									off - change wire direction
	0828									Pump on
	0830									Pump off - Blew fuse
	0945									Pump on
	0949	26	482.8	1254	20.2	8.06	0.437	22.1	7.4	
	0959	26	483.2	1654	20.1	8.37	0.448	9.21	6.7	
	1000									Pump off surge
	1010									Pump on
	1017	26	483.05	1810	20.1	8.42	0.456	17.6	7	
	1029			2122	NR →					Pump off - surge
	1037									on
	1045	26	483.25	2,330	20.1	8.14	0.464	22.6		
	1048			2,408	NR →					off - surge
	1058									on
	1102	26	483.2	2,512	20.2	8.24	0.468	32.0	6.7	
	1108	26	483.3	2,668	20.2	8.18	0.467	22.7	6.5	
	1112			2,772						off
	1122	→								on
	1129	26	483.3	2,954	20.2	8.24	0.472	26.8	6.5	
	1130			2,954	NR →					off
	1139			2954						on
	1147	26	483.4	3,136	20.2	8.20	0.475	28.9		
	1148									off
	1231			3,136						on
	1238	26	483.3	3,370	20.2	8.86	0.477	22.9	~~22.9~~	
	1239									off
	1248	26		3,370						on
	1257	26	483.4	3,604	20.2	8.89	0.479	24.6	6.3	off
	1305									on
	1315	26	483.4	3,890	20.2	8.83	0.484	23.9	6.3	
	1316									off
	1327	26		3,890	NR →					on
	1404		4800 →	~~4,670~~						done w/ 30 min pump test

* All ∇ measurements from BTOC

Groundwater Extraction Well Development

Page 3 of ______

Pumping

30 min Pump test KAFB 106EX1

Date	Time	Rate (gpm)	Depth to Water (ft BGS)	Volume Removed (gallons)	Temp (°C)	pH	EC (mS/cm)	Turbidity (NTU)	Specific Capacity (gpm/ft)	Comments
4/7	1332	26	483.85	4020	20.2		0.482	22.8		
↓	1337	26	483.45	4150	20.2		0.479	19.6		
	1342	26	483.54	4280	20.2		0.479	17.2		
	1347	26	483.65	4410	20.2		0.478	10.9		
	1352	26	483.65	4540	20.2		0.480	9.6		
	1357	26	483.7	4670	20.2		0.479	8.4		
	1402	26	483.75	4800	20.2		0.481	7.90		
	1602	26	479.3	4800	NR →					Pump on
	1609	26	483.3	4982	20.2	7.74	0.491	28.1		Pump off
	1619									on
	1627	26	483.35	5190	20.2	7.24	0.500	24.8		off
	1638	–	479.3							on
	1646		483.4	5398	20.2	7.35	0.498	18.0		
	1653		483.5	~~5560~~	20.2	7.20	0.497	11.0		
				5580						
4/8	0758	25								Pump on · Pump test
	0806	20		5,805						
	0900	20		6,885	20.2		0.490	13.7		
	0946	20		7,785	20.3	7.85	0.489	9.25		
	1023	20		8,545	20.3	7.38	0.487	8.48		
	1128	20		9,845	20.2	7.4	0.488	8.26		
	1208	20			20.3	7.4	0.489	7.42		final Readings
	1211			10,705						pump off

Constant Rate Test
Water Levels

Page 1 of 3

Date 4/8/2017

Personnel Crystal Hardee / Chris Scott

Well ID 106EX1

Start Time 0805

Water Level					
Date/Time	Water Level (feet below TOC ~~vault~~)	Drawdown (feet) below TOC	Transducer Depth (feet)	Transducer battery (%)	Comments
0800	479.1	static			
0805					Started pumping 20 GPM
0810	482.8	3.7			
0815	482.9	3.8			
0820	483.0	3.9			
0825	483.1	4			
0830	483.1	4			
0835	483.15	4.05			
0840	483.17	4.07			
0845	483.2	4.1			
0850	483.25	4.15			
0865	483.3	4.2			
0900	483.3	4.2			
0905	483.3	4.2			
0915	483.35	4.25			
0925	483.35	4.25			
0940	483.4	4.3			
0950	483.45	4.35			
1005	483.45	4.35			
1020	483.5	4.4			
1035	483.55	4.45			
1050	483.6	4.5			
1105	483.6	4.5			
1120	483.62	4.52			
1135	483.65	4.65			
1150	483.68	4.58			
1211	483.68	4.58			Pump off

5 ~~10~~ min

.15

* Measurements from below Top of casing - 16" casing stick up

Constant Rate Test
Water Levels

Page 2 of 3

Date 4.8.17

Personnel CHRIS/CRYSTAL

Well ID 106063

Start Time 8:00 AM

Water Level					
Date/Time 4.8.17	Water Level (feet below vault)	Drawdown (feet)	Transducer Depth (feet)	Transducer battery (%)	Comments
8:05	480.40	STATIC Δ	PUMP START @		20 GPM
8:10	480.40				
8:15	480.45				
8:20	480.45				
8:25	480.45				
8:30	480.45				
8:35	480.45				
8:40	480.45				
8:45	480.45				
8:50	480.45				
8:55	480.45				
9:00	480.45				
9:05	480.45				
9:15	480.45				
9:25	480.46				
9:35	480.46				
9:50	480.46				
10:05	480.46				
10:20	480.46				
10:35	480.46				
10:50	480.46				
11:05	480.46				
11:20	480.45				
11:35	480.45				
11:50					
12:05					
12:20					
12:35					
12:50					

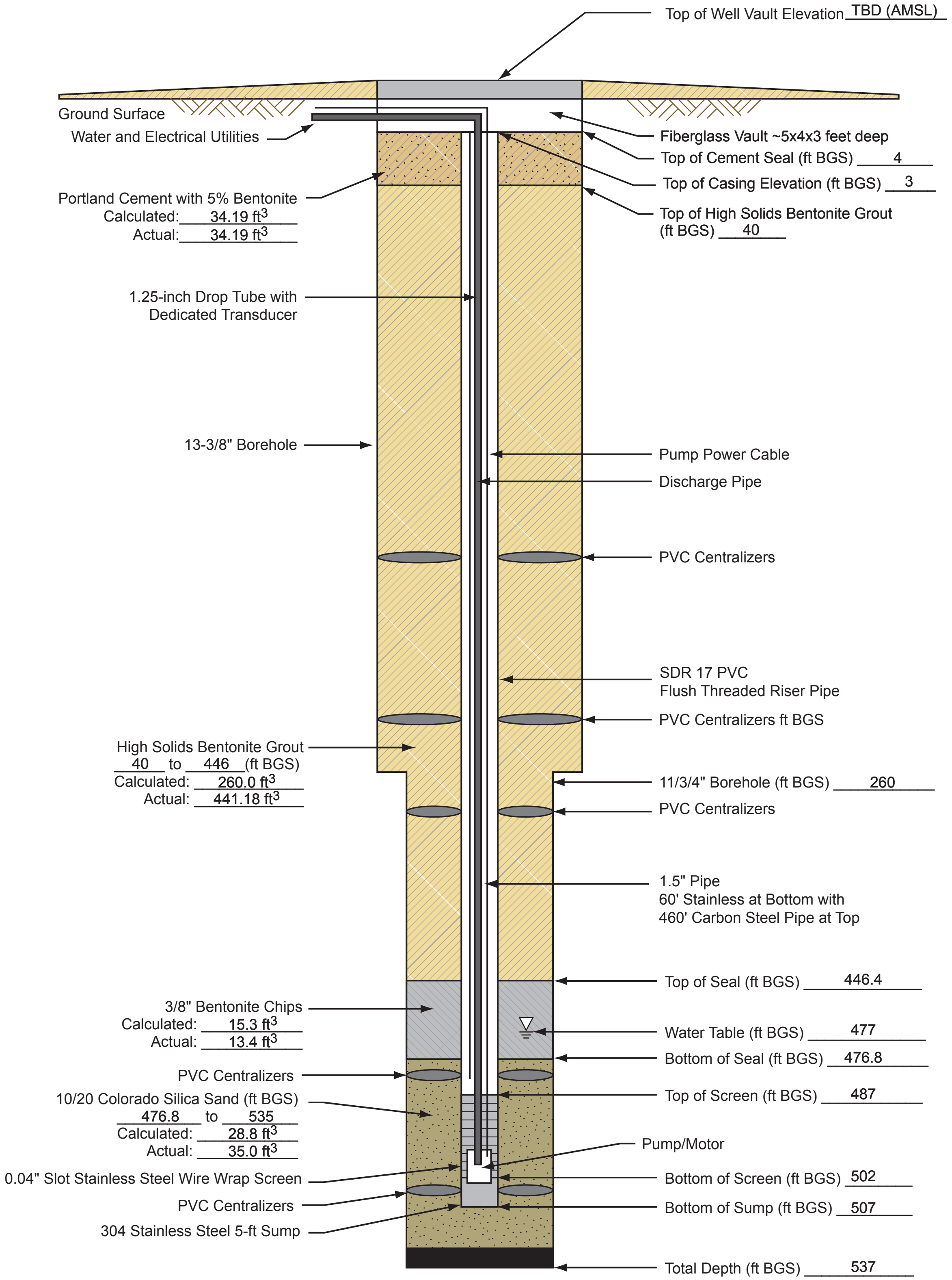
5 MINS

10 MINS

15 MINS

Extraction Well Completion Diagram KAFB-106EX2

Installation Start Date/Time: 2/21/17@1622
Installation End Date/Time: 2/26/17@1628
Completion Date: 4/19/17



(4,816.90) = *Elevations are NAVD 88 Datum values based on NGS Control Station "Hanger", Elevation = 5,343.43 ft. GPS/RTK methods and GEO1D99 model were used to determine elevations of all surveyed points.*

Not to Scale
BGS = Below Ground Surface

Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

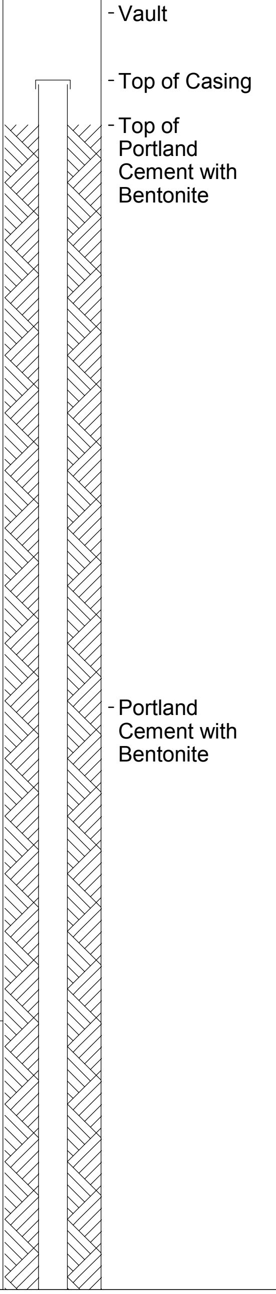
Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Remarks
0					SILT with Gravel (ML); based on water knief.	ML	Borehole was pot holed with air knife to 5 feet bgs. No cuttings returned.
5					SILT with Gravel (ML); yellowish red (5YR 4/6); dry; 80% silt; 20% fine gravel to 1/2"; subangular to rounded; trace coarse sand. Note: gravel is mafics and granitic minerals.		Begin drilling with 13-3/8" drive casing @ 1622 on 2/21/17. Driller is using under reamer on downhole hammer, roller stabilizer, and two drill collars. Cuttings brought to surface will be biased fine.
10					Same as above (5 ft).		
15					Same as above (5 ft); 70% silt; 30% gravel to 1".		
					Gravelly SILT (ML); light reddish brown (5YR 6/4); dry; 60% silt; 30% fine to coarse gravel to 1"; 10% coarse sand; trace medium sand. Note: gravel is mafics and granitic minerals. Large gravel fragments present.		No water added downhole. Kelly down @ 1638, new 20' connection @ 1644.
20							PID = 0.1 ppm @ cyclone and BZ.
25					Sandy lean CLAY (CL); light brown (7.5YR 6/3); slightly moist; 70% clay; 30% fine to coarse sand; trace gravel to 1/4".	CL	No water added.
							Hammering downhole.
30							

Well Diagram



Borehole ID: KAFB-106EX2

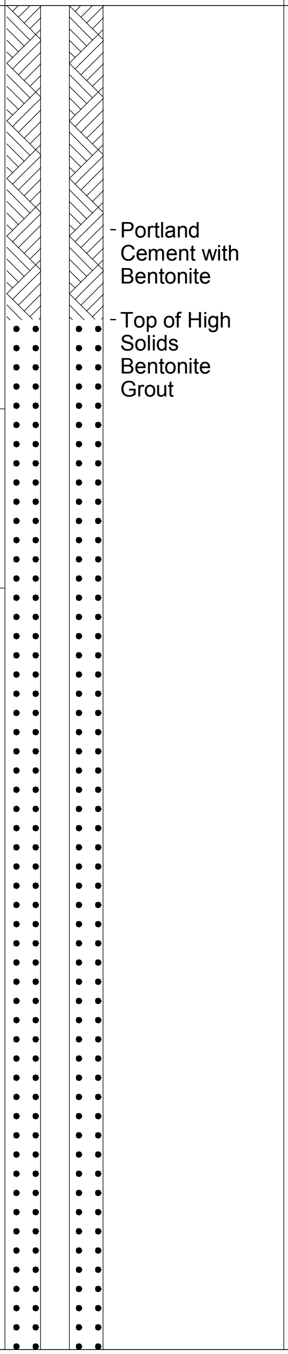
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
30					Gravelly SILT (ML); light reddish brown (5YR 6/4); slightly moist; 60% silt; trace clay; 40% fine gravel to 1/2"; subangular to rounded; trace medium to coarse sand.	ML		Hammering downhole.
35					Same as above (30 ft).			Kelly down @ 1701. End of 2/21/17. Resume drilling @ 0923 on 2/22/17.
40					Fat CLAY with Sand (CH); light brown (7.5YR 6/4); slightly moist; medium plasticity; 75% clay; 25% fine to coarse sand.	CH		PID = 0.0 ppm @ cyclone and BZ.
45					Gravelly SILT (ML); reddish brown (5YR 5/4); dry; 60% silt; 20% fine to medium sand; trace coarse sand; 20% fine gravel to 1/4".	ML		Hammering downhole; no water added downhole.
50					Same as above (43 ft).			PID = 0.0 ppm @ cyclone and BZ.
55					Same as above (43 ft).			Kelly down @ 1008, new 20' connection @ 1052.
60								

BOREHOLE_LOG - CB&I_DRILLING.GDT - 5/9/17 16:28 - Z:\KAFB RAPID\GINT\KAFB_RAPID_11-1-2016.GPJ

Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
60					Sandy SILT (ML); reddish yellow (7.5YR 6/6); dry; 70% silt; 25% fine to coarse sand; 5% fine gravel to 1/4"; angular to rounded.	ML		PID = 0.1 ppm @ cyclone and BZ.
								Hammering downhole and with casing hammer.
65					Same as above (60 ft).			
70					Same as above (60 ft).			PID = 0.1 ppm @ cyclone and BZ.
								No water added downhole.
75					Sandy lean CLAY (CL); yellowish red (5YR 5/6); slightly moist; 70% clay; 25% fine to medium sand; 5% fine gravel to 1/8".	CL	High Solids Bentonite Grout	
								Kelly down @ 1102, new 20' connection @ 1110.
80					Same as above (75 ft).			PID = 0.1 ppm @ cyclone and BZ.
85					Sandy SILT with Gravel (ML); pink (5YR 7/4); 40% silt; 40% fine to medium sand; 20% gravel. Note: gravel is fragmented and coated with silt.	ML		Hammering downhole and with casing hammer.
90								

Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
90					Sandy SILT with Gravel (ML); pink (5YR 7/4); 40% silt; 40% fine to medium sand; 20% gravel. Note: gravel is fragmented and coated with silt.	ML		No water added.
					Sandy lean CLAY (CL); brown (7.5YR 5/4); nonplastic; 70% clay; 30% fine sand; trace gravel fragments. Note: gravel is mafics.	CL		
95								
								Kelly down @ 1140, new 20' connection @ 1253.
					Poorly graded SAND (SP); light brown (7.5YR 6/4); dry; 100% fine sand; trace medium and coarse sand; trace fine gravel to 1/4"; subangular to rounded. Note: gravel is mafics and granitic minerals.			
100								PID = 0.1 ppm @ cyclone and BZ.
105					Same as above (98 ft).		High Solids Bentonite Grout	
						SP		Continuous hammering.
110					Same as above (98 ft).			
								PID = 0.1 ppm @ cyclone and BZ.
115					Same as above (98 ft).			
								Kelly down @ 1305, new 20' connection @ 1418.
					Lean CLAY with Sand (CL); strong brown (7.5YR 5/6); slightly moist; 60% clay; 20% silt; 20% fine sand.	CL		
120								

Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

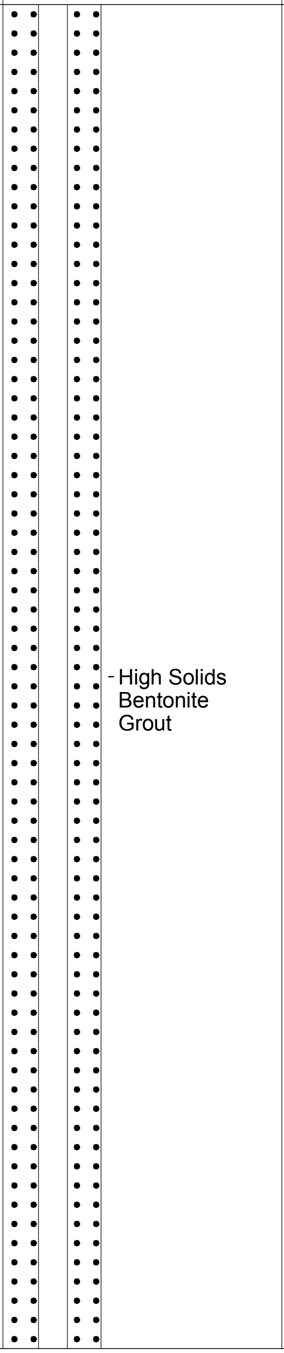
Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
120				▨	Lean CLAY with Sand (CL); strong brown (7.5YR 5/6); slightly moist; 60% clay; 20% silt; 20% fine sand.			PID = 0.1 ppm @ cyclone and BZ.
125				▨	Same as above (120 ft).			Hammering downhole and with casing hammer.
130				▨	Same as above (120 ft).			No water added.
135				▨	Same as above (120 ft).	CL	High Solids Bentonite Grout	
				▨				Kelly down @ 1433, new 20' connection @ 1439.
140				▨	Same as above (120 ft).			PID = 0.1 ppm @ cyclone and BZ.
145				▨	Same as above (120 ft).			Hammering.
150								



Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
∇ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
⊻ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
150					Lean CLAY with Sand (CL); strong brown (7.5YR 5/6); slightly moist; 60% clay; 20% silt; 20% fine sand.	CL		
155								
					Poorly graded SAND (SP); brown (7.5YR 5/3); dry; 95% fine sand; trace medium sand; 5% gravel fragments.	SP		Kelly down @ 1459, new 20' connection @ 1525.
160								PID = 0.1 ppm @ cyclone and BZ.
					Lean CLAY with Sand (CL); reddish yellow (7.5YR 6/6); slightly moist; nonplastic; 80% clay; 20% fine to medium sand.	CL		Added 20 gallons of water downhole to clear clay plug from under reamer.
165							High Solids Bentonite Grout	
					Same as above (163 ft).			
170								
					Sandy SILT (ML); light brown (7.5YR 6/4); dry; 60% silt; 40% fine to coarse sand; trace gravel fragments.	ML		
175								
					Silty SAND (SM); light brown (7.5YR 6/4); dry; 80% fine to coarse sand; 20% silt.	SM		
					Poorly graded SAND (SP); light brown (7.5YR 6/4); dry; 95% fine sand; trace medium and coarse sand; 5% gravel fragments.	SP		Kelly down @ 1636, new 20' connection @ 1649.
180								

Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

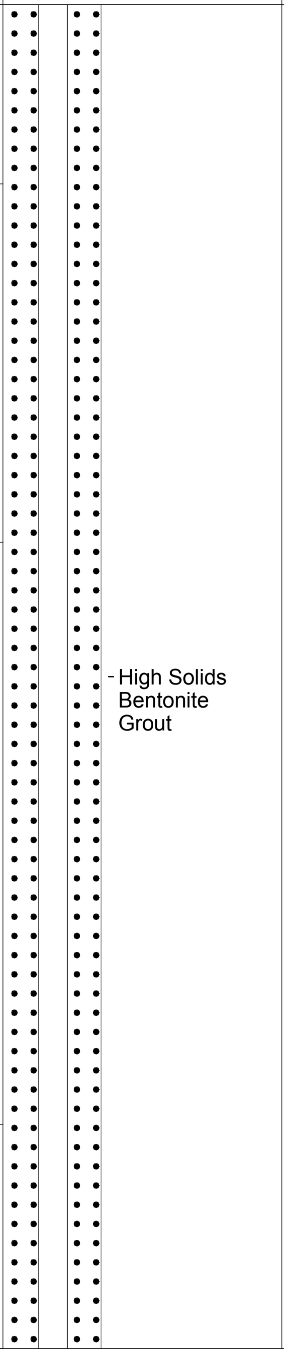
Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
180					Poorly graded SAND (SP); light brown (7.5YR 6/4); dry; 95% fine sand; trace medium and coarse sand; 5% gravel fragments.	SP		PID = 0.1 ppm @ cyclone and BZ.
185					Well-graded SAND (SW); light brown (7.5YR 6/3); dry; 95% fine to coarse sand; trace gravel fragments; 5% silt.	SW		Hammering; slow rate of penetration.
190					Same as above (184 ft).			
					Poorly graded SAND (SP); light brown (7.5YR 6/4); dry; 100% fine sand; trace medium and coarse sand; trace silt.	SP		
195							High Solids Bentonite Grout	
								Kelly down @ 1525. End of 2/22/17. Resume drilling @ 1103 on 2/23/17.
200					Same as above (192 t).			
205								PID = 0.0 ppm @ cyclone and BZ.
					Silty SAND (SM); light brown (7.5YR 6/4); dry; 75% fine sand; trace medium and coarse sand; 25% silt.	SM		Hammering; no water added downhole.
210								



Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
210					Sandy SILT (ML); light brown (7.5YR 6/3); dry; 70% silt; 30% fine to medium sand; trace coarse sand.	ML		Continuous hammering; no water added downhole.
215					Same as above (210 ft).			Kelly down @ 1149, new 20' connection @ 1300.
220					Well-graded SAND with Silt (SW-SM); brown (7.5YR 5/4); dry; 90% fine to coarse sand; 10% silt.	SW-SM		PID = 0.1 ppm @ cyclone and BZ.
					Sandy lean CLAY (CL); brown (7.5YR 5/3); nonplastic; 60% clay; 40% fine to coarse sand; trace gravel fragments.			
225					@ 225 ft: Possible GRAVEL lens.		High Solids Bentonite Grout	@ 225 - 240 ft: almost no drill cuttings returned.
230					Same as above (222 ft).	CL		
235					Same as above (222 ft).			Kelly down @ 1410, new 20' connection @ 1420.
240								

Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

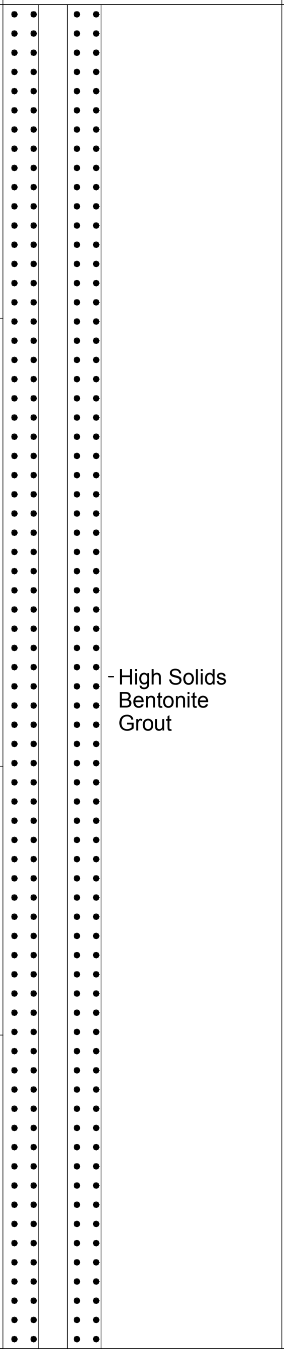
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Remarks
240					Sandy lean CLAY (CL); brown (7.5YR 5/3); nonplastic; 60% clay; 40% fine to coarse sand; trace gravel fragments.	CL	Added approximately 200 gallons of water downhole.
245							
					Silty SAND with Gravel (SM); brown (7.5YR 5/4); 40% fine to coarse sand; 20% gravel fragments; 40% silt. Note: possibly interbedded GRAVEL lens.	SM	Stop drilling @ 1450 on 2/23/17 due to casing hammer failure. Resume drilling @ 0837 on 2/24/17.
250							
					Same as above (247 ft).		Added approximately 40 gallons of water downhole to lift cuttings.
255							
					Silty GRAVEL (GM); 60% gravel fragments; 40% silt.	GM	Kelly down @ 0903, new 5' connection @ 0914. Trip to telescope in 11-3/4" casing. Resume drilling @ 1640. PID = 0.1 ppm @ cyclone and BZ.
260							
					Lean CLAY with Sand (CL); reddish brown (5YR 5/4); low plasticity; 75% clay; 25% fine to medium sand.	CL	
265							
							Poor cuttings returned.
270							

Well Diagram



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Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
270					Lean CLAY with Sand (CL); reddish brown (5YR 5/4); low plasticity; 75% clay; 25% fine to medium sand.	CL		Poor cuttings returned.
275					Same as above (270 ft).			Kelly down @ 1715. End of 2/24/17. Resume drilling @ 0807 on 2/25/17.
280					Same as above (270 ft).			PID = 0.1 ppm @ cyclone and BZ.
285					Well-graded SAND with Gravel (SW); brown (7.5YR 5/4); dry to slightly moist; 85% fine to coarse sand; 15% fine gravel to 1/4". Note: lots of gravel fragments.	SW	High Solids Bentonite Grout	Hammering.
290					Same as above (285 ft).			Poor cuttings returned.
295					Same as above (285 ft).			No water added downhole. Good returns. Kelly down @ 0905, new 20' connection @ 0928.
300								

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Borehole ID: KAFB-106EX2

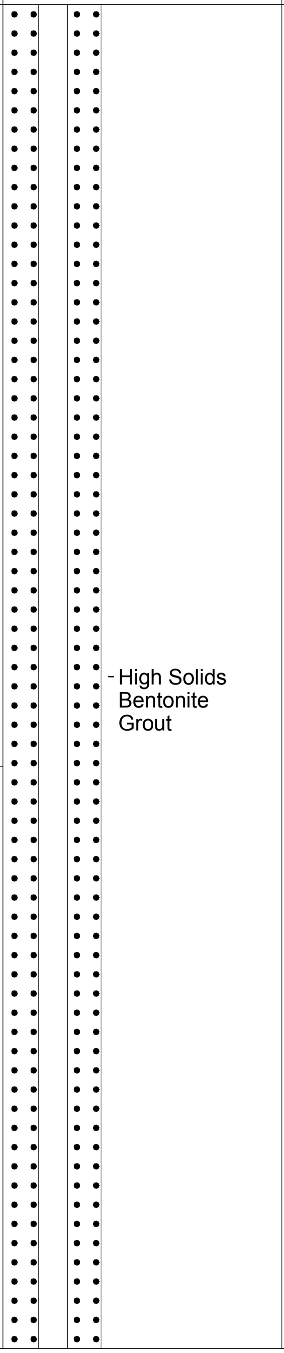
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
300					Well-graded SAND with Gravel (SW); brown (7.5YR 5/4); dry to slightly moist; 85% fine to coarse sand; 15% fine gravel to 1/4". Note: lots of gravel fragments.			PID = 0.1 ppm @ cyclone and BZ. No hammering; no water added downhole.
305					Same as above (300 ft).	SW		
310					Same as above (300 ft).			Hammering downhole only. Add approximately 50 gallons of water to remove clay from hammer and bit.
315					Well-graded SAND with Silt and Gravel (SW-SM); brown (7.5YR 4/4); 70% fine to coarse sand; 20% fine gravel to 1/2"; 10% silt.		High Solids Bentonite Grout	Kelly down @ 1100, change to tricone bit. New 20' connection @ 1414. PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ.
320						SW-SM		
325					Same as above (317 ft).			
330								

Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

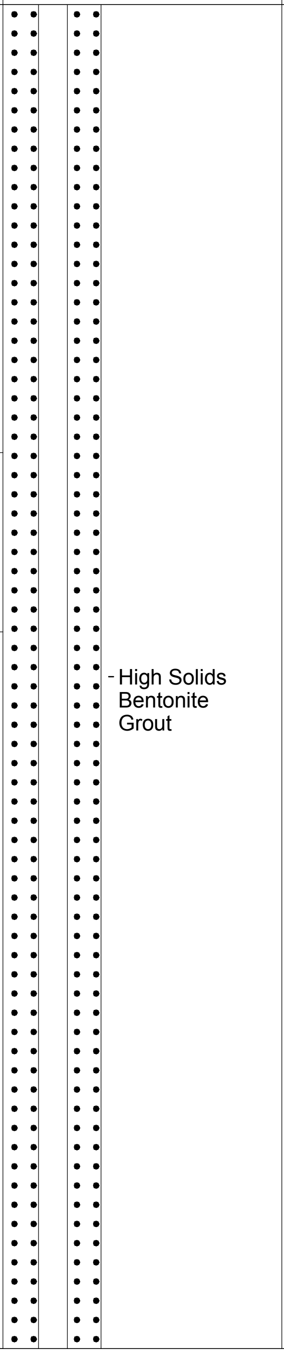
Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
330					Well-graded SAND with Silt and Gravel (SW-SM); brown (7.5YR 4/4); dry to moist; 70% fine to coarse sand; 20% fine gravel to 1/2"; 10% silt.			Slow rate of penetration.
								Hammering; no water added downhole.
335					Same as above (330 ft).	SW-SM		
								Kelly down @ 1543, new 20' connection @ 1611.
340					Poorly graded SAND (SP); pink (7.5YR 7/3); dry; 100% fine sand; trace medium and coarse sand.	SP		PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ.
					Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); dry; 75% fine to coarse sand; 25% fine gravel to 1/2"; trace silt. Note: interbedded SAND (75%) with Silt (10%) and Gravel (15%).			
345								Hammering; no water added downhole.
350					Same as above (344 ft).	SW		
								Rate of penetration increases.
355					Same as above (344 ft).			
								Kelly down @ 1720, new 20' connection @ 1730.
360								

Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

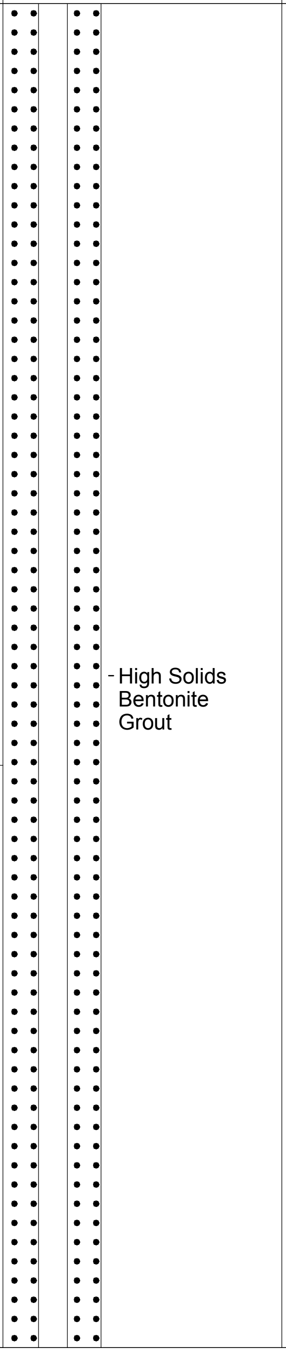
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
360					Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); dry; 75% fine to coarse sand; 25% fine gravel to 1/2"; trace silt. Note: interbedded SAND (75%) with Silt (10%) and Gravel (15%).	SW		PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ. Hammering; no water added downhole.
365					Same as above (360 ft).			
370					Same as above (360 ft).			Good cuttings returned.
375					Well-graded SAND with Silt and Gravel (SW-SM); brown (7.5YR 4/4); 70% fine to coarse sand; 20% fine gravel to 1/2"; 10% silt.	SW-SM		Kelly down @ 1800. End of 2/25/17. Resume drilling @ 0900 on 2/26/17.
380								PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ.
385					Same as above (377 ft).			Hammering. No water added downhole.
390								



Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

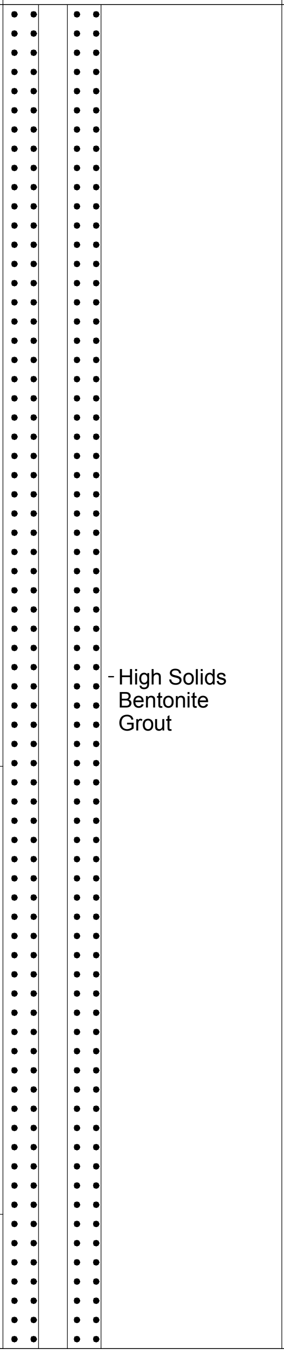
Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
390					Well-graded SAND with Silt and Gravel (SW-SM); brown (7.5YR 4/4); 70% fine to coarse sand; 20% fine gravel to 1/2"; 10% silt.	SW-SM		
395					Same as above (390 ft).			Kelly down @ 0920, new 20' connection @ 0928.
400					Same as above (390 ft).			PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ.
405								
					Poorly graded SAND with Silt (SP-SM); brown (7.5YR 5/3); dry; 90% fine sand; trace medium and coarse sand; 10% silt.	SP-SM		
410								Stop drilling to repair casing hammer.
					Same as above (407 ft).			
415								
					Well-graded SAND with Silt and Gravel (SW-SM); pinkish gray (7.5YR 6/2); dry; 70% fine to coarse sand; 20% gravel to 1/4"; angular to rounded; 10% silt.	SW-SM		Kelly down @ 1047, new 20' connection @ 1128. Conduct rig repairs.
420								

Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

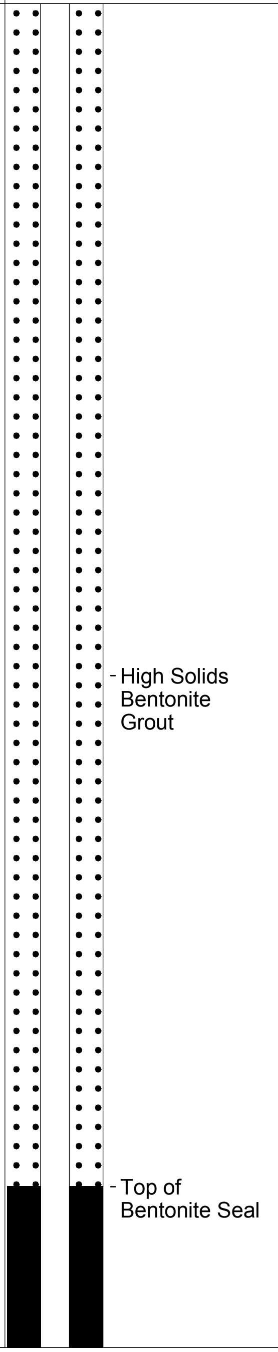
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
420					Well-graded SAND with Silt and Gravel (SW-SM); pinkish gray (7.5YR 6/2); dry; 70% fine to coarse sand; 20% fine gravel to 1/4"; angular to rounded; 10% silt. Note: gravel is mafics and granitic minerals.			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
								Hammering; no water added downhole.
425								
430					Same as above (420 ft).			PID = 0.1 ppm @ cyclone and BZ.
435					Same as above (420 ft).	SW-SM		
								Kelly down @ 1204, new 20' connection @ 1244.
440					Same as above (420 ft).			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
								Hammering; no water added downhole.
445					Same as above (420 ft).			
450								



Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

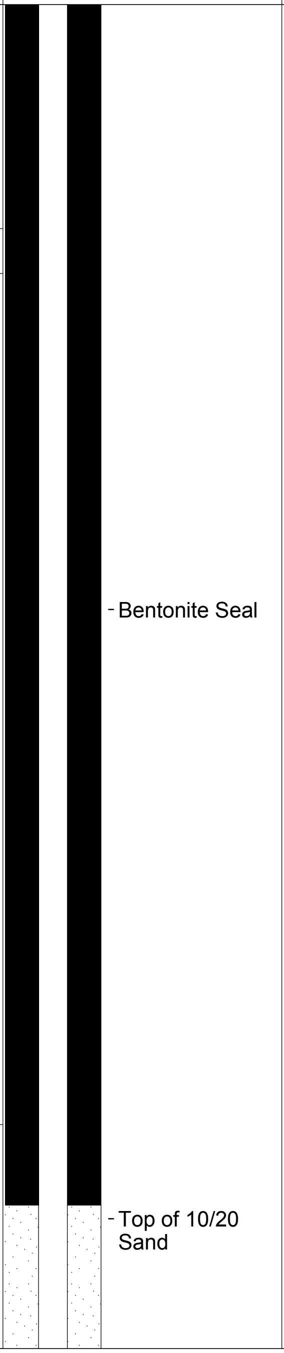
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
450					Well-graded SAND with Silt and Gravel (SW-SM); pinkish gray (7.5YR 6/2); dry; 70% fine to coarse sand; 20% fine gravel to 1/4"; angular to rounded; 10% silt. Note: gravel is mafics and granitic minerals.	SW-SM		Hammering; no water added downhole.
455					Boulders or large cobbles.			
					Silty SAND (SM); light brown (7.5YR 6/3); dry; 75% fine to coarse sand; 5% fine gravel to 1/8"; subrounded to rounded; 20% silt.			Kelly down @ 1326, new 20' connection @ 1350.
460					Same as above (456 ft).			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
465			2.5		Same as above (456 ft). Note: slight fuel odor.	SM		PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
470			2.9		Same as above (456 ft); moist. Note: slight fuel odor.			
475			3.3		Well-graded SAND with Silt (SW-SM); brown (7.5YR 4/3); moist; 90% fine to coarse sand; trace fine gravel to 1/8"; 10% silt. Note: slight fuel odor.	SW-SM		PID = 2.7 ppm @ cyclone and 0.2 ppm @ BZ. Kelly down @ 1420, new 20' connection @ 1429. Top of groundwater @ 477 feet bgs.
480								



Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

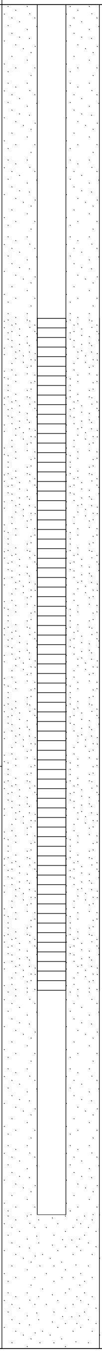
Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
480			3.9		Well-graded SAND with Silt (SW-SM); brown (7.5YR 4/3); wet; 90% fine to coarse sand; trace fine gravel to 1/8"; 10% silt. Note: Fuel odor.	SW-SM		Measurement based on level measured at monitoring well prior to drilling disturbance. PID = 44.7 ppm @ cyclone and 0.1 ppm @ BZ.
485			4.8					
					Same as above (480 ft). Note: strong fuel odor.		Top of Stainless Steel 0.040 Slot Screen	PID = 127.9 ppm @ cyclone and 0.3 ppm @ BZ.
490			19.5					
					Same as above (480 ft). Note: strong fuel odor.			PID = 293.6 ppm @ cyclone and 33.5 ppm @ BZ.
495			111.9				Stainless Steel 0.040 Slot Screen	PID = 227.9 ppm @ cyclone and 28.7 ppm @ BZ.
					Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4); wet; 75% fine to coarse sand; 25% fine gravel to 1/2"; subrounded to rounded; trace silt. Note: gravel is mafics and granitic minerals. Fuel odor.	SW		Kelly down @ 1508, new 20' connection @ 1520.
500			31.2					
							Bottom of Screen	PID = 125.4 ppm @ cyclone and 12.2 ppm @ BZ.
505			7.9		Same as above (497 ft).		Stainless Steel Sump	
							Bottom of Sump	PID = 7.4 ppm @ cyclone and 4.2 ppm @ BZ.
510								



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Borehole ID: KAFB-106EX2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 2/21/2017
Date TD Reached: 2/26/17
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

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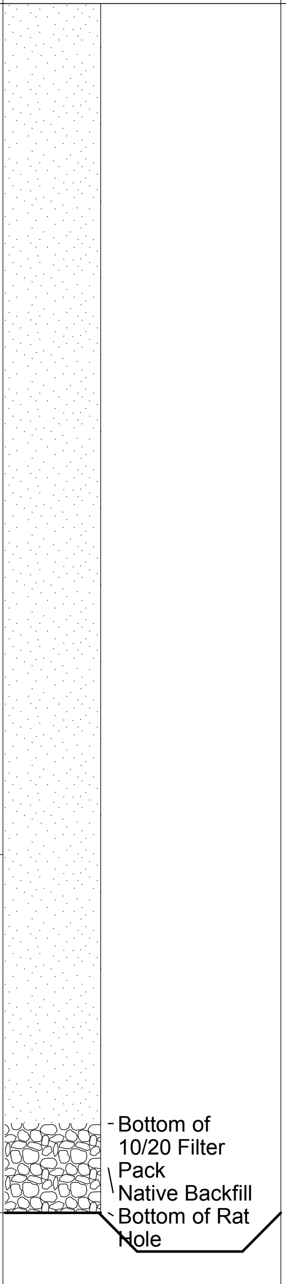
Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
510			3.7		Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4); wet; 75% fine to coarse sand; 25% fine gravel to 1/2"; subrounded to rounded; trace silt. Note: gravel is mafics and granitic minerals. Fuel odor.			PID = 5.6 ppm @ cyclone and 2.8 ppm @ BZ.
515			4.1		Same as above (510 ft).			PID = 2.2 ppm @ cyclone and 2.4 ppm @ BZ. Kelly down @ 1556, new 20' connection @ 1608.
520			4.2		Same as above (510 ft).	SW		PID = 1.9 ppm @ cyclone and 2.2 ppm @ BZ.
525			2.1		Same as above (510 ft).			Poor cuttings returned. PID = 2.1 ppm @ cyclone and 0.8 ppm @ BZ.
530					No cuttings returned.			PID = 3.3 ppm @ cyclone and 1.0 ppm @ BZ.
535								PID = 2.9 ppm @ cyclone and 1.2 ppm @ BZ. Total depth = 537 feet bgs. Reached total depth @ 1628 on 2/26/17.
540								



Groundwater Extraction Well Development

Page 1 of 1

Bailing KAFB 106EX2 Crystal Hardee

Date	Time	Total Volume Bailed (gallons)	Imhoff Cone Measurement (mL sediment per L water)	Comments
4/12/17	1351	5	5	Began Bailing
	1356	10	10	- sand + silt
	1359	15	5	- sand + some filter pack
	1402	20	10	
	1406		5	
	1409		10	
	1417	40	30	- Pulling more sand + filterpack from bottom
	1419		50	
	1422	50	70	- filter pack + silt
	1443		50	
	1454	70	15	
	1512	85	10	
	1516	90	38	
	1525	100	15	
	1540	105	20	
	1549	120	50	switch to smaller bailer
	1558		10	
	1609		5	
	1610	125	.5	
	1630		.5	
	1636		1	
	1641	130	.5	

Groundwater Extraction Well Development

Page 1 of 3

Pumping KAFB106EX2

Date	Time	Rate (gpm)	Depth to Water (ft BGS)	Volume Removed (gallons)	Temp (°C)	pH	EC (mS/cm)	Turbidity (NTU)	Specific Capacity (gpm/ft)	Comments ▽@ 476.35 bTOC
4/13/17	1011	25	~~479.85~~	~~OH~~	~~18.6~~		~~0.698~~			Pump is on
	1013		479.85	50	18.6		0.698			
	1016	25	479.79	125	20.2		0.667	107		
	1021	25	479.85	250					7.14	
	1026	25	479.95	375						
	1031	25	480.0	500						
	1036	25	480.05	625					6.7	
	1041	25	480.1	750						Pump off surging cycles
	1049									Pump on
	1052	25	479.80	800				26.9		
	1054		480.0	850						
	1056		480.05	900				13.6		
	~~1059~~ 1100		480.15	975						off - Surge x2
	1106	Ø	476.4	975						
	1108			975						Pump on
	1111		479.85					23.7		
	1114				20.3		0.752			DO 1.36
	1115		480.05			7				
	1119		480.15	1,225						off - surge
	1131									on
	1134	25	479.9							
	1136	25			20.3	7	0.759	14.2		DO 1.50
	1137	25	480.1							
	1141	25	480.1	1,480	20.4	7	0.758	7.35		DO 1.44
	1142			1,505						Pump off x4
	1300	Ø	476.4	1,505	NR →					static
	1306									Pump test / on
	1311	25.5	479.9		19.3	7.94	0.773	18.3		DO 2.16
	1313		480							
	1316	25.5	480.05	1,760	20.2	7.59	0.769	16.3		
	1321		480.15							
	1324		480.2							
	1326		480.~~42~~ 22		20.2	7.47	0.777	3.56		P.82 ORP - 27
	1330		480.25							
	1332		480.26							
	1334		480.29		20.3	7.48	0.779	2.73		DO 1.58
	1336		480.3	2,525					8.8	Pump off

Groundwater Extraction Well Development

Page 2 of 3

Pumping KAFB 106EX2

Date	Time	Rate (gpm)	Depth to Water (ft BGS)	Volume Removed (gallons)	Temp (°C)	pH	EC (mS/cm)	Turbidity (NTU)	Specific Capacity (gpm/ft)	Comments
4/13/17	1403	25.5	479.9	2525						on
	1407	25.5	480.10		20.3	7.59	0.787	12.0		DO 1.79
	1413			2,780						off
	1422									on
	1424	25.5	480.05		20.7	7.53	0.804	20.2		2.18
↓	1430			3,035						off
1439	~~1449~~									on
1448	~~1445~~	25.5	480.50		20.2	7.46	0.795	4.42		
4/13	1450			3,290						off
	1459	25.5		3,290						on
	1509	25.5	480.35	3,545	20.2	7.45	0.798	4.25		off
	1517									
	1527		480.35		20.2	7.46	0.800	3.82		DO 1.74 ~~[illegible]~~ off
	1535			3,845						on
	545		480.40	3,800	20.2	7.44	0.799	2.71		1.78 DO
	1553		480.45		20.2	7.47	0808	4.17		on 1.92 DO ~~off~~ on
	1604			4,055						off
	1612									on
	1622		480.50	4,310	20.2	7.46	0.806	2.50		off
	1633		~~480.52~~							on
	1643		480.52	4,565	20.2	7.45	0.811	3.66		off
	1705	0	476.45							Pump test
	1706	25.5	480.2							
	1710		480.4							
	1715		480.55							
	1720		480.70							
	1725		480.75							
	1730		480.8							
↓	1735	↓	480.85	5,330						
4/18/17	0727		476.6	5,330	NR →					Morning Static
	0740									Pump on
	0742	25.5	480.45	5.381	19.9	7.60	0.731	12.4		DO 1.28
	0755	NR	NR	5,712.5	NR →					off - surge
	0757	0	475.05		NR →					▽ level
	0806	25.5	NR	5,712.5	NR →					on
	0815	25.5	480.8		20.0	7.40	0.827	3.20		DO 1.41
	0818	25.5		6,018.5						Pump off - Surge
↓	0819	0	476.2	6,018.5	NR →					▽ level mound

Groundwater Extraction Well Development

Page 3 of 3

Pumping

KAFB 106EX2

Date	Time	Rate (gpm)	Depth to Water (ft BGS)	Volume Removed (gallons)	Temp (°C)	pH	EC (mS/cm)	Turbidity (NTU)	Specific Capacity (gpm/ft)	Comments
4/18/17	0828	25.5		6,018.5	NR →					Pump on
	0837	25.5	480.9		20.1	7.37	0.825	2.47	6	
	0839		NR	6,273.5	NR →					off
	0840	0	475.3	6,273.5	NR →					▽ level mound
	0849	25.5		↓	NR →					Pump on
	0858	25.5	480.9		20.1	7.36	0.826	4.10	6	DO 1.56 ORP -3.7
	0900		NR	6,528.5	NR →					off
	0902	0	474.9	↓						▽ level mound
	0916	25.5		6,538.5	NR →					on
	0925	25.5	480.9		20.1	7.41	0.825	2.52	6	DO 1.66
	0926			6,784	NR →					off
	0928	0	475.25	6,784	NR →					▽ level mound
0938 →	~~0935~~ CH	25.5		6,784	NR →					Pump on
	0948	25.5	481	7,039	20.2	7.45	0.825	2.08	5.8	
	0949	0								off ~~▽ level mound~~ CH
	0951	0	475.25	7,039	NR →					▽ level mound
	1000	25.5	NR	7,039	NR →					Pump on
	1009	↓	481		20.2	7.38	0.824	2.26	5.8	DO 1.65
	1010	↓		7,293.5	NR →					Pump off
	1012	0	475.3	7,293.5	NR →					▽ level mound
	1021	25.5		7,293.5	NA →					Pump on
	1029	25.5 →			20.2	7.37	0.823	2.07		DO 1.67
	1031	25.5	481.1	7,548	NR →					Pump off
	1033	0	475.3	7,548	NR →					▽ level mound
	1256	20.5	NR		20.1	7.41	0.825	3.09		} Pump test
	1320	↓	NR		20.2	7.39	0.824	2.76		
	1426	↓	NR		20.2	7.38	0.824	1.89		
	1700	20.5	480.9		20.2	7.39	0.825	1.17		

Constant Rate Test
Water Levels

Page 1 of 2

Date 4/18/17
Personnel Crystal Hardee & Chris Scott

Project Number 500433
Well ID KAFB106EX2
Start Time 1248 @ 20GPM
Stickup Length 16"

Static Water Level (feet BTOC) 476.65
Pump Depth (feet BTOC) 497
Gallons per Minute 20 to 20.5

Dial into 20GPM
start
5 min
10 min
15 min
Recovery

Date/Time 4/18/17	Time Elapsed (minutes)	Water Level (feet BTOC)	Difference from Previous Reading (feet)	Drawdown (feet)	Gallons Purged 7.548 pumping 130 bailing 7,678 total	Comments
1248	0	476.65	Static BTOC		7,678	~starting pump wide open ~25.5 then back off to 20
1245	2	480.40				
1248	0	~~480.1~~			~7,803	~20 GPM @ 1248
1250	8	480.1	3.45	3.45	7,843	
1255	13	480.2	.1	3.55	7,943	
1300	18	480.25	.05	3.6	8,043	
1305	23	480.28	.03	3.63	8,143	
1310	28	480.3	.02	3.65	8,243	
1315	33	480.32	.02	3.~~76~~ 67	8,343	
1325	43	480.37	.05	3.72	8,543	
1335	53	480.39	.02	3.74	8,798	~20.5 GPM
1345	63	480.45	.06	3.8	9,053	
1355	73	480.5	.05	3.85	9,308	
1405	83	480.52	.02	3.87	9,563	
1415	93	480.55	.03	3.9	9,818	
1430	168	480.6	.05	3.95	10,~~200.5~~	10,125.5
1445	123	480.65	.05	4	10,433	
1600	138	480.7	.05	4.05	10,740.5	
1515	153	480.71	.01	4.06	11,048	
1530	168	480.74	.03	4.09	11,355	
1545	183	480.76	.02	4.11		
1600	198	480.79	.03	4.14		
1615	213	480.83	.04	4.18		
1630	228	480.85	.02	4.2		
1645	243	480.~~9~~87	.02	4.22	12,585	
1700	258	480.9	.02	4.25	12,8925	
1702						Pump off, begin recovery
1703		475.15				
1708		476.8				
1714		476.9				

15,750

Constant Rate Test
Water Levels

Page 2 of 2

Date 4/18/17

Personnel Chris Scott & Crystal Hardee

Project Number 500433

Well ID KAFB106MW25 - obs well

Start Time

Stickup Length

Observation well

Static Water Level (feet BTOC) ~~476.~~ 475.9

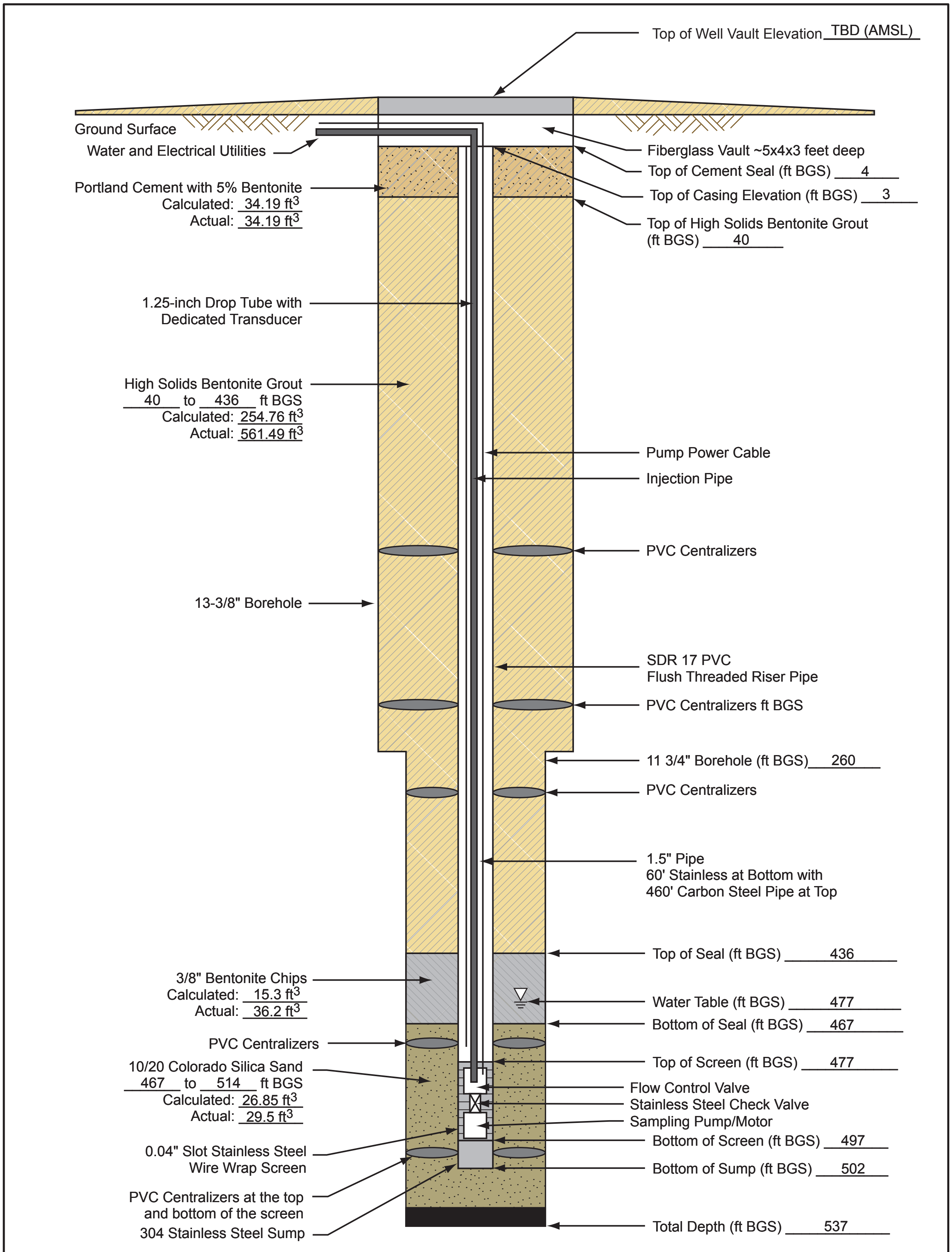
Pump Depth (feet BTOC) — N/A

Gallons per Minute N/A

Date/Time 4/18/17	Time Elapsed (minutes)	Water Level (feet BTOC)	Difference from Previous Reading (feet)	Drawdown (feet)	Gallons Purged	Comments
12:45	0	475.90				STATIC T.O.C.
12:48	0	475.90	0	0	0	START PUMPING
12:58	10	475.90	0	0	0	STEADY BEEP
1:08	20	475.90	0	0	0	STEADY BEEP
1:18	30	475.90	0	0	0	STEADY BEEP
1:30	42	475.90	0	0	0	STEADY BEEP/CLEANED PROBE
1:45	57	475.90	0	0	0	INTERMITTENT BEEP
2:00	72	475.90	0	0	0	" "
2:15	87	475.90	0	0	0	NO INFLUENCE
2:30	102	475.90	0	0	0	" "
2:45	117	475.90	0	0	0	" "
3:15	147	475.90	0	0	0	" "
3:45	170	475.90	0	0	0	NO INFLUENCE
4:00	185	475.90	0	0	0	" "
4:15	200	475.90	0	0	0	NO INFLUENCE
4:30	215					

Injection Well Completion Diagram KAFB-106IN1

Installation Start Date/Time: 3/16/17@0820
Installation End Date/Time: 3/20/17@1500
Completion Date: 4/19/17



(4,816.90) = *Elevations are NAVD 88 Datum values based on NGS Control Station "Hanger", Elevation = 5,343.43 ft. GPS/RTK methods and GEO1D99 model were used to determine elevations of all surveyed points.*

Not to Scale
BGS = Below Ground Surface

500433_03050100_A8

Borehole ID: KAFB-106IN1

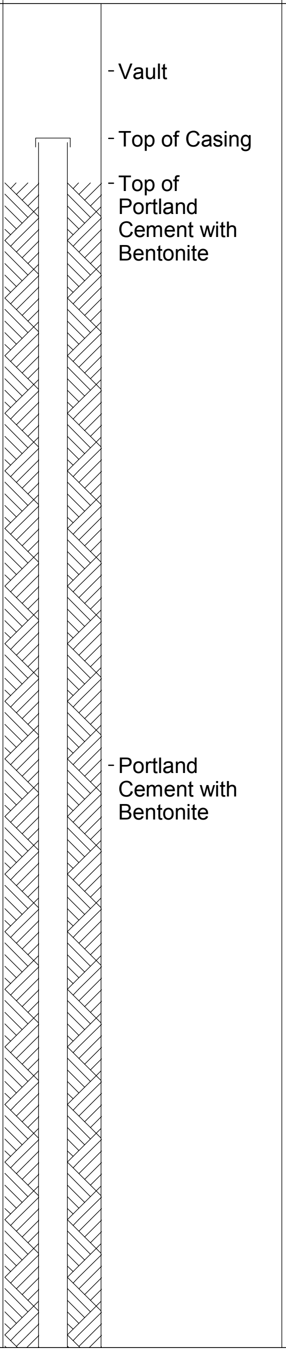
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
0					SILT with Gravel (ML); based on water knife.			Borehole was pot holed with air knife to 5 feet bgs. No cuttings returned.
5					SILT with Gravel (ML); yellowish red (5YR 5/6); dry; 80% silt; 20% fine gravel to 1/2"; subangular to rounded; trace coarse sand. Note: gravel is mafics and granitic minerals; fragmented by downhole hammer.			Begin drilling with 13-3/8" drive casing @ 0820 on 3/16/17. Driller is using underreamer and stabilizer.
10					Same as above (5 ft).			Hammering downhole only. No water added downhole.
15					Same as above (5 ft); gravel to 1".	ML		Kelly down @ 0839, new 20' connection @ 0855.
20					Gravelly SILT (ML); light reddish brown (5YR 6/4); dry; 60% silt; 30% fine to coarse gravel; subangular to rounded; 10% coarse sand. Note: gravel is mafics and granitic minerals.			PID = 0.1 ppm @ breathing zone (BZ) and cyclone.
25					Sandy SILT (ML); yellowish red (5YR 4/6); dry; 70% silt; trace clay; 30% fine to coarse sand; trace fine gravel to 1/8".			Hammering downhole. No water added downhole.
30								

Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

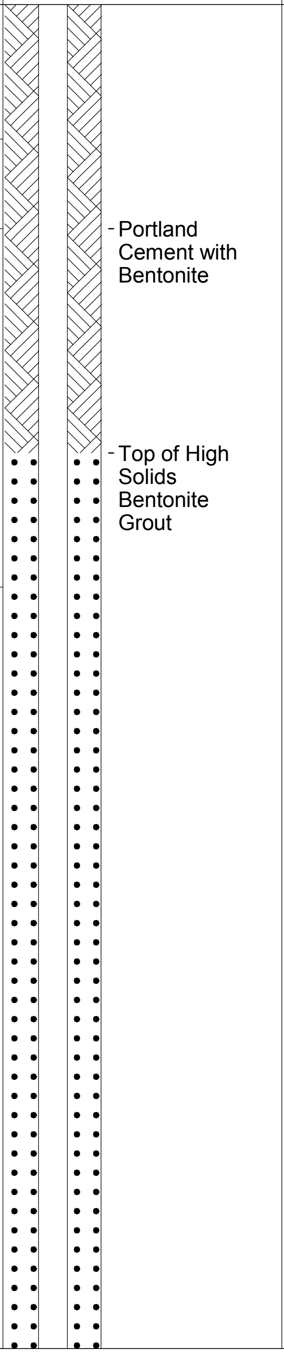
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
30					Sandy SILT (ML); yellowish red (5YR 4/6); dry; 70% silt; trace clay; 30% fine to coarse sand; trace fine gravel to 1/8".	ML		Hammering downhole. No water added downhole.
					Fat CLAY (CL); strong brown (7.5YR 5/8); medium plasticity; 100% clay; trace fine sand.	CH		
35					Gravelly SILT (ML); light reddish brown (5YR 6/4); dry; 60% silt; trace clay; 40% fine gravel to 3/4"; angular to subrounded; trace fine sand.	ML	Portland Cement with Bentonite	Kelly down @ 0925, new 20' connection @ 0937.
40					Same as above (35 ft).		Top of High Solids Bentonite Grout	PID = 0.2 ppm @ BZ and 0.4 ppm @ cyclone.
					Sandy lean CLAY (CL); light brown (7.5YR 6/3); nonplastic; 70% clay; 30% fine sand; trace fine gravel to 1/8".	CL		
45					Gravelly lean CLAY (CL); reddish brown (5YR 5/4); dry; 60% fines; 30% fine gravel to 1/2"; subrounded to rounded; 10% fine sand. Note: majority of the fines observed in cuttings were clay.			Hammering downhole. No water added downhole.
50					Same as above (46 ft).			
55								Kelly down @ 1015, new 20' connection @ 1355.
60								



Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Page 3 of 18

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
60				▨	Gravelly lean CLAY (CL); reddish brown (5YR 5/4); dry; 60% fines; 30% fine gravel to 1/2"; subrounded to rounded; 10% fine sand. Note: majority of the fines observed in cuttings were clay. @ 61 ft: Sandy lean CLAY with Gravel (CL); reddish yellow (7.5YR 4/6); dry; 70% fines; 15% fine to coarse sand; 15% fine gravel to 1/8". Note: majority of the fines observed in cuttings were clay.			PID = 0.1 ppm @ BZ and cyclone. Hammering downhole. No water added downhole.
65				▨				
70				▨	Same as above (61 ft).			
75				▨	Same as above (61 ft).	CL	High Solids Bentonite Grout	Begin hammering with casing hammer. Kelly down @ 1424, new 20' connection @ 1439.
80				▨				PID = 0.1 ppm @ BZ and 0.3 ppm @ cyclone.
				▨	Sandy lean CLAY (CL); yellowish red (5YR 5/6); dry; medium plasticity; 70% clay; 25% fine to medium sand; 5% gravel fragments.			Hammering downhole and with casing hammer. No water added downhole.
85				▨				
90				▨				

Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

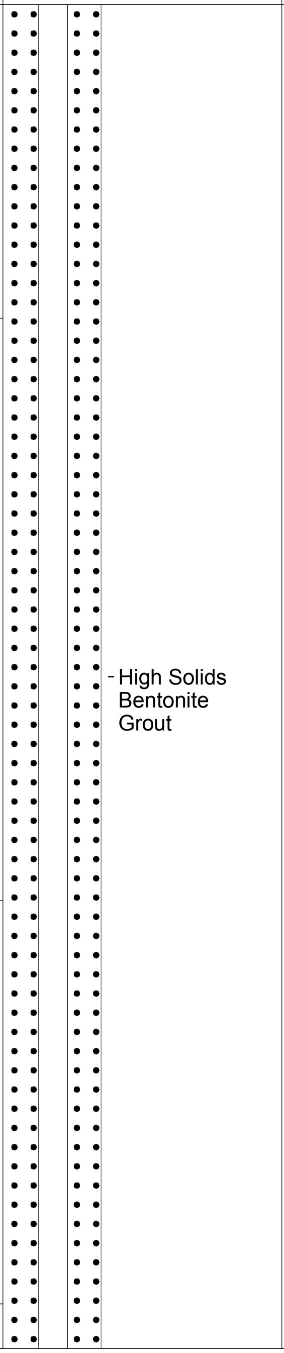
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
90					Sandy lean CLAY (CL); yellowish red (5YR 5/6); dry; medium plasticity; 70% clay; 25% fine to medium sand; 5% gravel fragments.	CL		
					Color change to gray from 93 - 95 ft.			Hammering downhole and with casing hammer. No water added downhole.
95								
					Poorly graded SAND (SP); brown (7.5YR 5/4); dry; 90% fine sand; 10% silt.	SP		Kelly down @ 1520, new 20' connection @ 1530.
100								PID = 0.2 ppm @ BZ and cyclone.
					Same as above (97 ft); trace coarse sand.			
105								Hammering downhole and with casing hammer.
					Same as above (97 ft).			
110					Silty SAND with Gravel (SM); pink (5Y 7/4); dry; 40% fine to coarse sand; 20% gravel fragments; angular; 40% silt.	SM		
								No water added downhole.
115					Same as above (110 ft).			
								Kelly down @ 1553, new 20' connection @ 1640.
120					Description on following page.	CL		



Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
120				▨	Lean CLAY with Sand (CL); light reddish brown (5YR 6/8); dry to slightly moist; 80% clay; 20% fine sand; trace medium and coarse sand.			PID = 0.1 ppm @ BZ and 0.2 ppm @ cyclone. Hammering downhole and with casing hammer.
125				▨	Same as above (120 ft).	CL		
130				▨				
				░	Well-graded SAND with Gravel (SW); reddish gray (5YR 5/2); dry; 80% fine to coarse sand; 20% fine gravel to 1/4"; subrounded to rounded.			No water added downhole.
135				░			High Solids Bentonite Grout	
				░	Same as above (132 ft).	SW		Kelly down @ 1710. End of 3/16/17. Resume drilling @ 0745 on 3/17/17.
140				░				PID = 0.1 ppm @ BZ and 0.2 ppm @ cyclone.
				▨	Sandy lean CLAY (CL); reddish yellow (5YR 6/8); dry to slightly moist; low plasticity; 60% clay; 40% fine sand; trace gravel fragments.			
145				▨				Hammering downhole and with casing hammer. No water added downhole.
				▨	Same as above (142 ft).	CL		
150								

Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

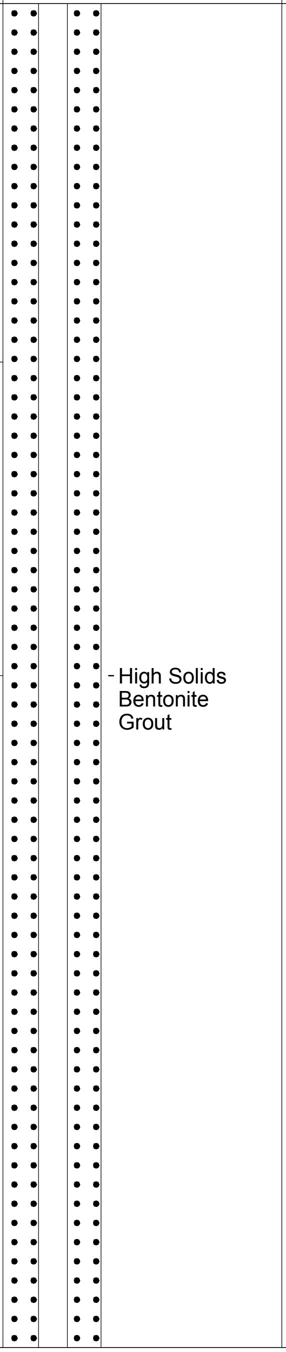
Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Remarks
150				▨	Sandy lean CLAY (CL); reddish yellow (5YR 6/8); dry to slightly moist; low plasticity; 60% clay; 40% fine sand; trace gravel fragments.	CL	Hammering. No water added dowhole or at cyclone.
155				▨	Same as above (150 ft).		Kelly down @ 0819, new 20' connection @ 0829.
					Well-graded SAND (SW); reddish yellow (5YR 6/6); dry; 95% fine to coarse sand; trace gravel fragments; 5% silt.	SW	
160							PID = 0.2 ppm @ BZ and 0.3 ppm @ cyclone.
165					Poorly graded SAND (SP); light brown (7.5YR 6/4); dry; 100% fine sand; trace medium and coarse.	SP	Hammering downhole and with casing hammer.
170					Same as above (165 ft).		
175					Same as above (165 ft).		Kelly down @ 0907, new 20' connection @ 0927.
180							

Well Diagram



Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
180					Poorly graded SAND (SP); light brown (7.5YR 6/4); dry; 100% fine sand; trace medium and coarse.	SP		PID = 0.1 ppm @ BZ and cyclone.
185					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); 85% fine to coarse sand; 15% fine gravel to 1/4"; subrounded to rounded. Note: gravel is mafics and granitic minerals.	SW		No hammering. Suspend drive casing while moving down.
190					Same as above (185 ft).			No water added downhole.
195					Same as above (185 ft).		High Solids Bentonite Grout	Kelly down @ 0952, new 20' connection.
200								PID = 0.1 ppm @ BZ and cyclone.
					Poorly graded SAND (SP); light brown (7.5YR 6/3); dry; 100% medium sand; trace coarse sand.	SP		
205					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); 80% fine to coarse sand; 20% fine gravel to 1/2"; angular to rounded. Note: gravel is mafics and granitic minerals.	SW		Hammering downhole and with casing hammer. No water added downhole.
210								

Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

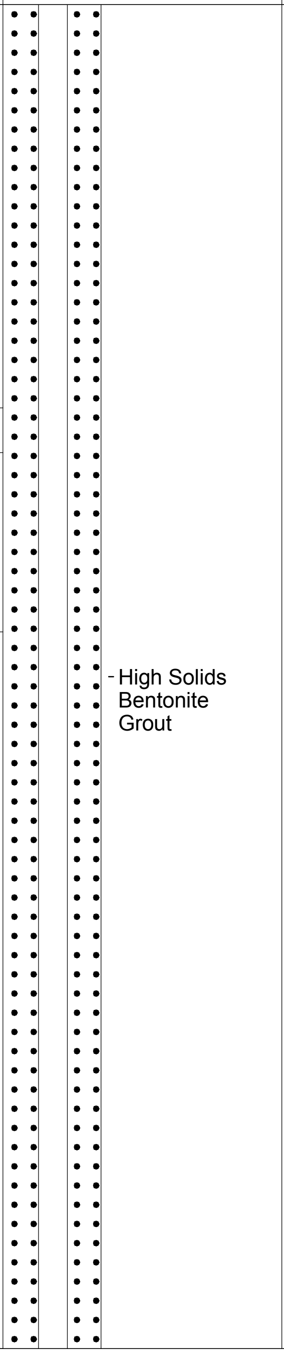
Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
210					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); 80% fine to coarse sand; 20% fine gravel to 1/2"; angular to rounded. Note: gravel is mafics and granitic minerals.			Hammering downhole and with casing hammer.
215					Well-graded SAND (SW); pinkish gray (7.5YR 6/2); dry; 100% fine to coarse sand.	SW		
					Well-graded SAND with Gravel (SW); pinkish gray (7.5YR 6/2); 70% fine to coarse sand; 30% fine gravel to 1/4"; angular to rounded.			Kelly down @ 1026, new 20' connection @ 1034.
220					Lean CLAY with Sand (CL); strong brown (7/5YR 5/6); moist; 80% clay; 20% fine to medium sand.	CL		PID = 0.1 ppm @ BZ and cyclone.
					Well-graded GRAVEL with Sand (GW); dark brown (7.5YR 3/3); 50% fine to coarse gravel to 1-1/4"; angular to rounded; 45% fine to coarse sand; 5% silt. Note: gravel is mafics and granitic minerals.	GW		Driller added approximately 100 gallons of water downhole.
225					Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); 75% fine to coarse sand; 25% fine to coarse gravel to 1"; subangular to rounded; trace silt. Note: gravel is mafics and granitic minerals.		High Solids Bentonite Grout	Hard drilling.
230					Same as above (224 ft).	SW		Hammering.
235					Same as above (224 ft).			Kelly down @ 1138, new 20' connection @ 1245.
240								



Borehole ID: KAFB-106IN1

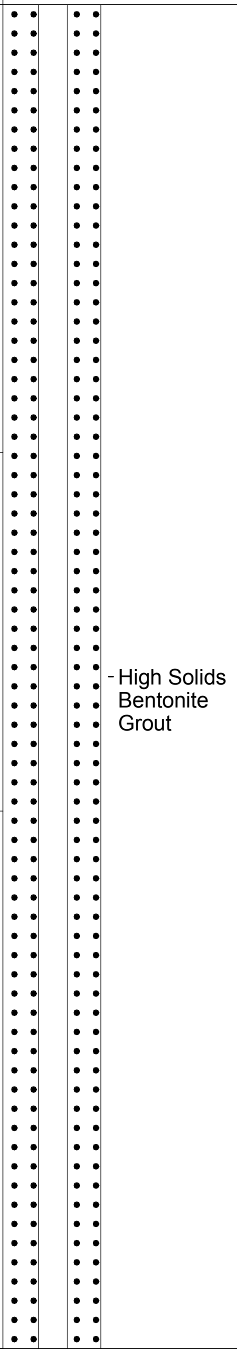
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
240					Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); 75% fine to coarse sand; 25% fine to coarse gravel to 1"; subangular to rounded; trace silt. Note: gravel is mafics and granitic minerals.	SW		Hammering downhole and with casing hammer. No water added downhole.
245					Same as above (240 ft).			
250					Silty SAND with Gravel (SM); brown (7.5YR 5/4); 60% fine to medium sand; 20% fine gravel to 1/2"; subangular to rounded; 20% silt.	SM		
255							High Solids Bentonite Grout	
					Sandy lean CLAY (CL); yellowish brown (10YR 5/4); low plasticity; 70% clay; 25% fine sand; 5% fine gravel to 1/8"; subrounded to rounded.	CL		Kelly down @ 1305, new 5' connection @ 1333. Trip drill sting to run in with 11-3/4" casing. End of 3/17/17. Resume drilling @ 0835 on 3/18/17. PID = 0.1 ppm @ BZ and cyclone.
260								
265					Same as above (258 ft).			
270								Hammering downhole and intermittently with casing hammer.

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Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

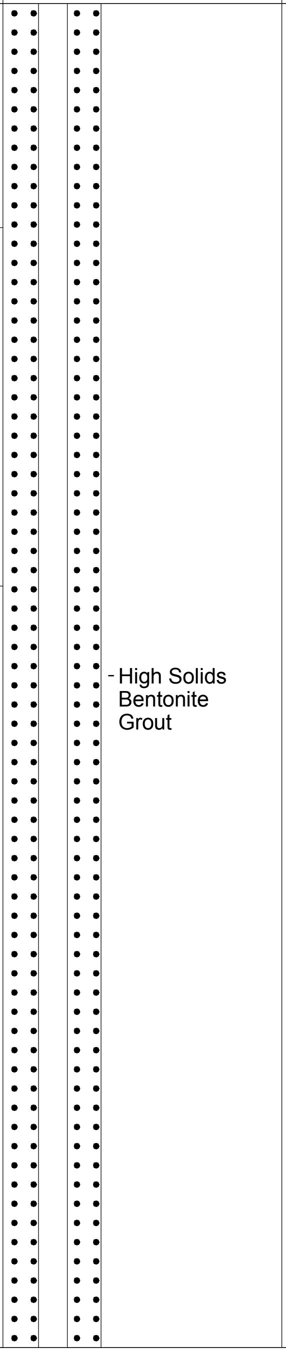
Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
270				▨	Sandy lean CLAY (CL); yellowish brown (10YR 5/4); low plasticity; 70% clay; 25% fine sand; 5% fine gravel to 1/8"; subrounded to rounded.	CL		PID = 0.0 ppm @ BZ and 0.1 ppm @ cyclone. No water added downhole.
275					No cuttings returned. Cyclone plugged and drill bit is stuck. Cuttings appear to be coarse sand with gravel and clay.			Kelly down @ 0800, new 20' connection @ 0910.
280								PID = 0.1 ppm @ BZ and cyclone.
				░	Poorly graded SAND (SP); light brown (7.5YR 6/4); 100% fine sand; trace medium and coarse sand.	SP		Driller added approximately 100 gallons of water dowhole. Resume drilling @ 1310.
285				░				
290				░	Same as above (283 ft).			Hammering downhole.
295				░	Same as above (283 ft).			Kelly down @ 1328, new 20' connection @ 1341.
300								



Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

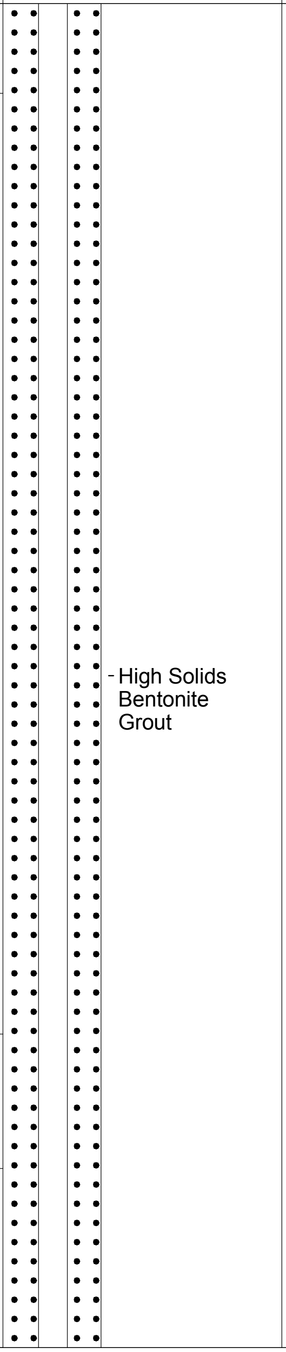
Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
300					Poorly graded SAND (SP); light brown (7.5YR 6/4); 100% fine sand; trace medium and coarse sand.	SP		PID = 0.0 ppm @ BZ and cyclone.
					Well-graded SAND with Gravel (SW); brown (7.5YR 6/4); 80% fine to coarse sand; 20% fine to coarse gravel to 1"; subangular to rounded; trace silt.	SW		
305								Hammering downhole. No water added downhole.
					Same as above (302 ft).			
310								
					Same as above (302 ft).			
315							High Solids Bentonite Grout	
								Kelly down @ 1356, new 20' connection @ 1403.
					Same as above (302 ft).			
320								PID = 0.0 ppm @ BZ and cyclone.
					Sandy lean CLAY (CL); nonplastic; 60% clay; 20% fine to medium sand; 20% fine gravel to 1/4"; angular to rounded.	CL		
325					Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); 70% fine to coarse sand; 30% fine gravel to 1/4"; subrounded to rounded.	SW		No water added downhole.
330								



Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

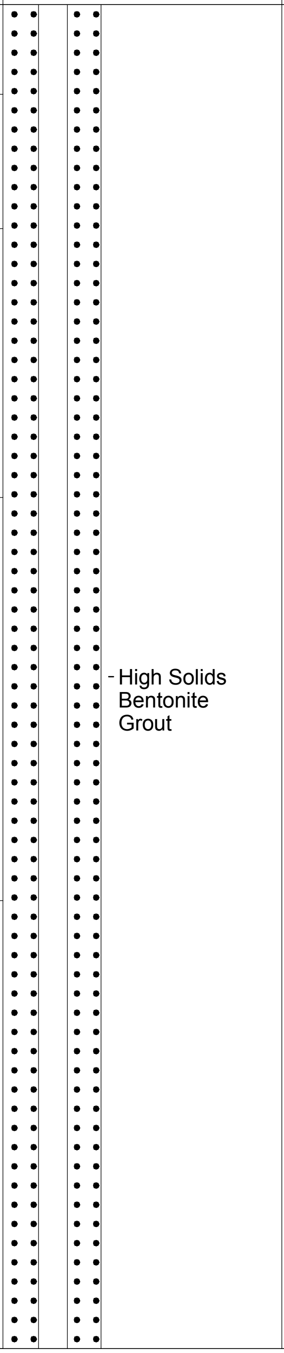
Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
330					Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); 70% fine to coarse sand; 30% fine gravel to 1/4"; subrounded to rounded.	SW		Hammering downhole and with casing hammer. No water added downhole.
					Silty SAND with Gravel (SM); brown (7.5YR 4/2); 50% fine to coarse sand; 25% fine gravel to 1/2"; subrounded to rounded; 25% silt. Note: gravel is mafics and granitic minerals.	SM		
335					Well-graded GRAVEL with Silt and Sand (GW-GM); brown (7/5YR 4/2); 50% fine to coarse gravel to 1"; subangular to rounded; 40% fine to coarse sand; 10% silt. Note: sand and gravel are mafics and granitic minerals.	GW-GM		Kelly down @ 1442, new 20' connection @ 1555. PID = 0.0 ppm @ BZ and 0.1 ppm @ cyclone.
340					Well-graded SAND with Gravel (SW); brown (7.5YR 4/2); 70% fine to coarse sand; 25% fine gravel to 1/2"; subangular to rounded; 5% silt. Note: gravel is mafics and granitic minerals. Same as above (341 ft).	SW	High Solids Bentonite Grout	
345								
350					Poorly graded SAND (SP); brown (7.5YR 5/4); 100% fine sand; trace medium and coarse sand; trace fine gravel to 1/8"; rounded. Note: gravel is granitic minerals. Same as above (350 ft).	SP		No water added downhole. Kelly down @ 1613, new 20' connection @ 1621.
355								
360								

Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
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Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

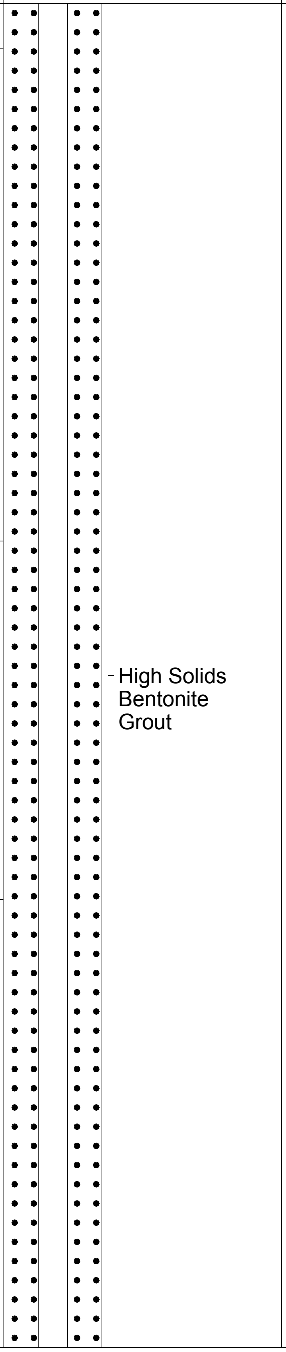
Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
360					Poorly graded SAND (SP); brown (7.5YR 5/4); 100% fine sand; trace medium and coarse sand; trace fine gravel to 1/8"; rounded. Note: gravel is granitic minerals.	SP		PID = 0.0 ppm @ BZ and 0.1 ppm @ cyclone.
					Well-graded SAND (SW); light brown (7.5YR 6/4); dry; 90% fine to coarse sand; 10% fine gravel to 1/4"; subrounded to rounded. Note: gravel is mafics and granitic minerals.	SW		
365								
370								
					Silty GRAVEL with Sand (GM); pinkish gray (7.5YR 6/2); dry; 50% fine gravel to 1/2"; 30% fine to coarse sand; 20% silt. Note: gravel is mafics and granitic minerals.	GM		No water added downhole.
375								
								Kelly down @ 1656, new 20' connection @ 1704.
380					Well-graded SAND with Gravel (SW); brown (7.5YR 5/4); 80% fine to coarse sand; 20% fine gravel to 1/2"; subrounded to rounded. Note: gravel is mafics and granitic minerals.	SW		PID = 0.1 ppm @ BZ and cyclone.
385					Same as above (380 ft).			
								No water added downhole.
390								



Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

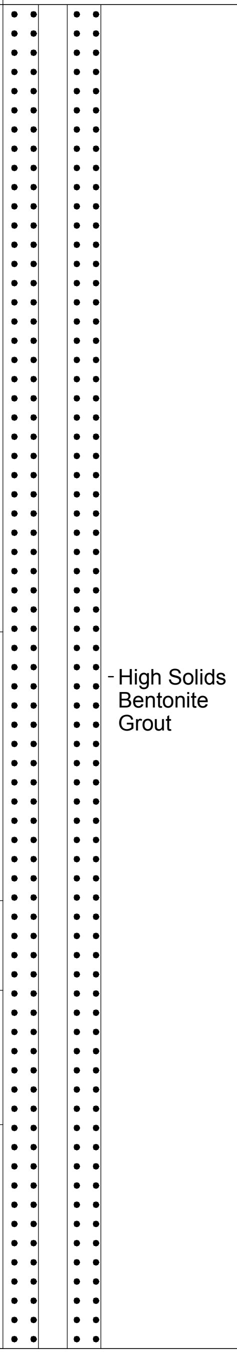
Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
390					Well-graded SAND with Gravel (SW); brown (7.5YR 5/4); 80% fine to coarse sand; 20% fine gravel to 1/2"; subrounded to rounded. Note: gravel is mafics and granitic minerals.	SW		
395					Same as above (390 ft).			No water added downhole.
								Kelly down @ 1730. End of 3/18/17. Resume drilling @ 0810 on 3/19/17.
400					Same as above (390 ft).			PID = 0.1 ppm @ BZ and cyclone.
405					Poorly graded SAND (SP); pale brown (10YR 6/3); 90% fine sand; trace medium sand; 5% fine gravel to 1/4"; rounded; 5% silt. Note: gravel is mafics and granitic minerals.	SP		Hammering with casing hammer. No water added downhole.
410					SILT (ML); strong brown (7.5YR 4/6); 90% silt; 5% fine sand; 5% fine gravel to 1/8".	ML		
					Poorly graded SAND (SP); brown (7.5YR 5/2); 90% fine sand; 5% fine gravel to 1/8"; rounded; 5% silt. Note: gravel is mafics and granitic minerals.	SP		
415					Well-graded SAND (SW); light brown (7.5YR 6/3); dry; 90% fine to coarse sand; 5% fine gravel to 1/4"; 5% silt.	SW		Kelly down @ 0838, new 20' connection @ 0845.
420								

Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

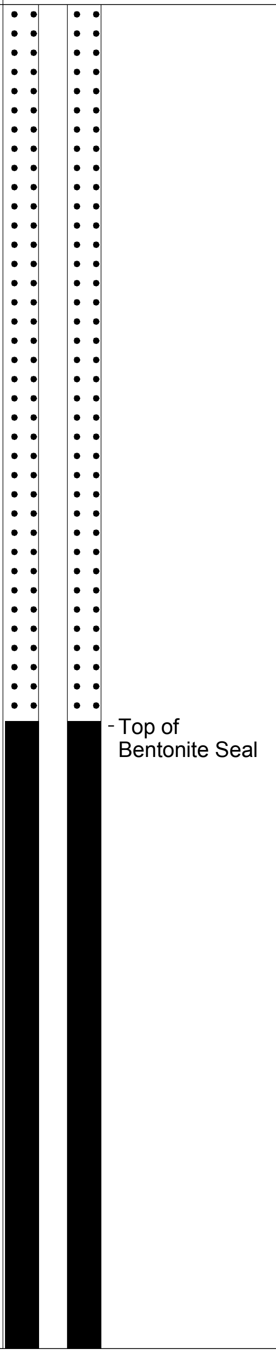
Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
420					Well-graded SAND (SW); light brown (7.5YR 6/3); dry; 90% fine to coarse sand; 5% fine gravel to 1/4"; 5% silt.			PID = 0.1 ppm @ BZ and cyclone.
425								
					Same as above (420 ft).			
430								No water added downhole.
					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); dry; 80% fine to coarse sand; 20% fine gravel to 1/2"; trace silt.			
435						SW		
								Kelly down @ 0914, new 20' connection @ 0925.
					Same as above (432 ft).			
440								PID = 0.2 ppm @ BZ and cyclone.
445					Same as above (432 ft).			
450								



Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

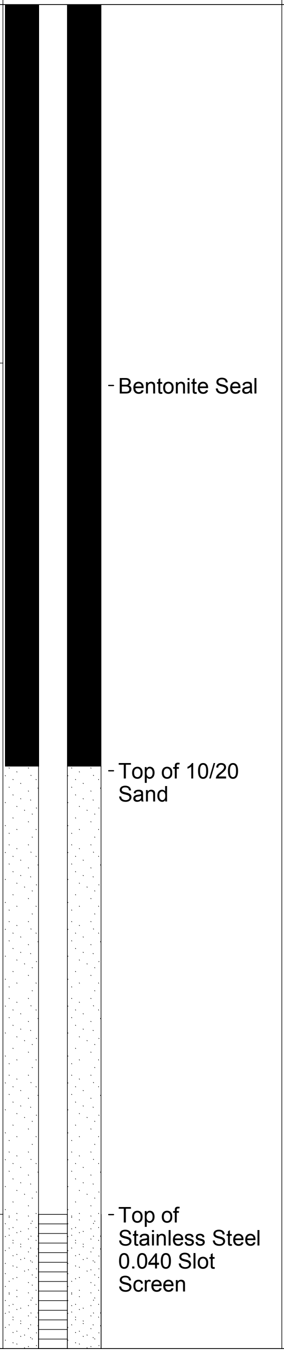
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
450					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); dry; 80% fine to coarse sand; 20% fine gravel to 1/2"; trace silt.	SW		Hammering with casing hammer. No water added downhole.
455					Same as above (450 ft); 70% sand; 30% gravel to 1-1/2".			Kelly down @ 0954, new 20' connection @ 1200.
460					Poorly graded SAND with Silt (SP-SM); yellowish brown (10YR 5/4); dry; 80% fine sand; trace medium sand; 10% fine gravel to 1/4"; rounded; 10% silt. Note: gravel is mafics and quartz.	SP-SM	Bentonite Seal	PID = 0.1 ppm @ BZ and 0.7 ppm @ cyclone. Slight fuel odor.
465			4.5		Same as above (458 ft).		Top of 10/20 Sand	PID = 0.1 ppm @ BZ and 7.5 ppm @ cyclone. Hammering with casing hammer.
470			4.3		Same as above (458 ft).			PID = 0.1 ppm @ BZ and 4.1 ppm @ cyclone.
475			5.8		Same as above (458 ft).			PID = 0.3 ppm @ BZ and 10.2 ppm @ cyclone.
				▼ ▽	Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4); wet; 75% fine to coarse sand; 25% fine gravel to 1"; subangular to rounded.	SW	Top of Stainless Steel 0.040 Slot Screen	Top of groundwater @ 477 feet bgs. Kelly down @ 1252, new 20' connection @ 1300.
480								



Borehole ID: KAFB-106IN1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

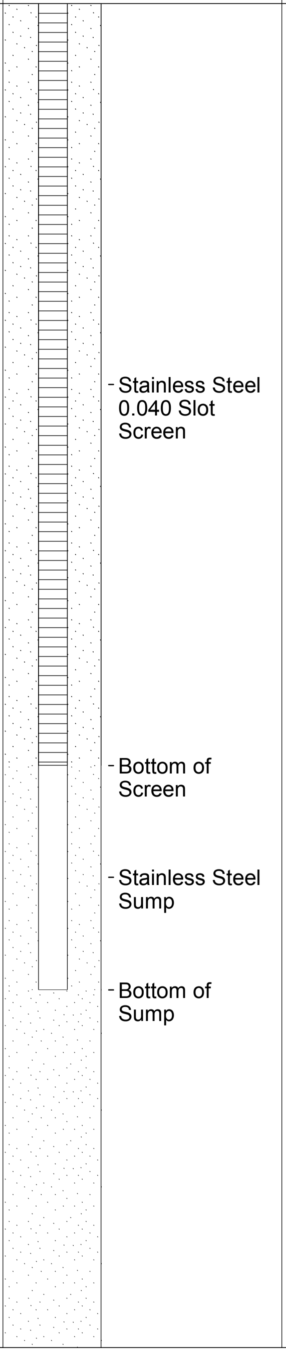
Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
480			12.5		Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4); wet; 75% fine to coarse sand; 25% fine gravel to 1"; subangular to rounded. Note: gravel is mafics and quartz.			PID = 0.2 ppm @ BZ and 11.5 ppm @ cyclone. Hammering. No water added downhole.
485			23.7		Same as above (480 ft).			PID = 0.2 ppm @ BZ and 18.9 ppm @ cyclone.
490			342.3		Same as above (480 ft).		Stainless Steel 0.040 Slot Screen	PID = 1.8 ppm @ BZ and 1,721 ppm @ cyclone.
495			365.7		Same as above (480 ft).	SW	Bottom of Screen	PID = 4.6 ppm @ BZ and 518.6 ppm @ cyclone. Kelly down @ 1344, new 20' connection.
500			95.7		Same as above (480 ft).		Stainless Steel Sump Bottom of Sump	PID = 6.2 ppm @ BZ and 460.8 ppm @ cyclone. Hammering downhole and with casing hammer. No water added downhole.
505			96.3		Same as above (480 ft).			PID = 5.2 ppm @ BZ and 61.9 ppm @ cyclone.
510								

Borehole ID: KAFB-106IN1

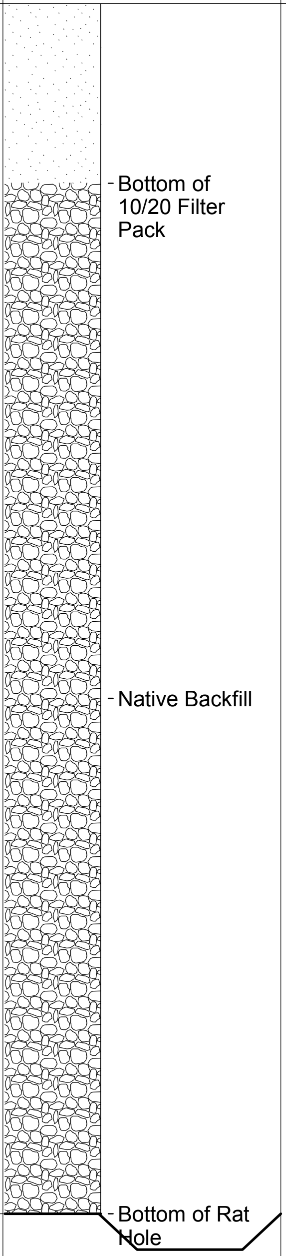
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 3/16/2017
Date TD Reached: 3/20/2017
Date Completed: 4/19/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Vault

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 477.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.60
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
510			43.7		Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4); wet; 75% fine to coarse sand; 25% fine gravel to 1"; subangular to rounded. Note: gravel is mafics and quartz.	SW		PID = 6.0 ppm @ BZ and 54.3 ppm @ cyclone.
515			20.1		Same as above (510 ft).		Bottom of 10/20 Filter Pack	PID = 1.7 ppm @ BZ and 16.8 ppm @ cyclone. Kelly down @ 1415. Added approximately 1,000 gallons of water downhole. End of 3/19/17. Resume drilling @ 1415 on 3/20/17.
520			2.7		Same as above (510 ft).			PID = 0.1 ppm @ BZ and 0.2 ppm @ cyclone.
525			0.7		Same as above (510 ft).		Native Backfill	PID = 0.0 ppm @ BZ and 0.1 ppm @ cyclone.
530			0.7		Same as above (510 ft).			PID = 0.1 ppm @ BZ and 0.3 ppm @ cyclone. PID = 0.1 ppm @ BZ and cyclone.
535			0.2				Bottom of Rat Hole	Kelly down @ 1500. Total depth = 537 feet bgs. Reached total depth on 3/20/17. Added approximately 1,000 gallons of water downhole.
540								

Groundwater Extraction Well Development

Page 1 of 1

Crystal Hardee

Bailing KAFB 106IN1

Date	Time	Total Volume Bailed (gallons)	Imhoff Cone Measurement (mL sediment per L water)	Comments
4/10	0756		35	
	0804		40	
	0811	10	10	
	0815		20	
	0818		20	
	0823	20	3.5	
	0835		8	
	0843		1.5	
	0849		1	
	0852	46	1	Switch to swab
	0915	40	–	start swabbing
	0942	40	-	begin bailing well again
	0946		-	lost most of sand from bailer
	0953		–	- x3 bailer up empty or close to
	0956		~~30~~ 30	- Successful trip
	0958		–	empty - switching bailers
	1006		4	New bailer working great
	1009		3	
	1012	50	5	stepping ~~to~~ pump off Drum
	1049	70	1.5	- switching to Swab
	1135		50	bailing
	1139		40	
	1142		25	
	1146		15	
	1148		30	
	1150		20	
	1154	80	1	
	1206		2	
	1205	95	1	~~Bailing/swabbing complete~~
	1245	97	1	Bailing/swabbing complete

Groundwater Extraction Well Development

Intake @ 492' bgs

Page 1 of ______

Pumping KAFB-106IN-1 Crystal Hardee

Date	Time	Rate (gpm)	Depth to Water (ft BGS)	Volume Removed (gallons)	Temp (°C)	pH	EC (mS/cm)	Turbidity (NTU)	Specific Capacity (gpm/ft)	Comments DO / Comments
4/10	1536	25.5	477.75	~ 0	19.9		0.507	>1000		~~10.9~~ 1.40
	1556	25.5	483.2	510	20.1		0.558	22.1		
	1606		476.8							surge - pump off
	1615									Pump on
	1619	25.5	4832	862	20.1	7	0.571	16.8		2.68
	1631		476.7	1,168						Pump off
	1639									Pump on
	1650	25.5	483.85	1,678						~~off surge~~
	1700			1,983						off for day
4/11	0720	0	477.85	1,933	NR →					static - pre pump
	0729	25.5								Pump on
	0733	25.5	483.5	2,035	19.9	7.65	0.589	7.9339		2.93
	0747	25.5	484.5	2,392	20.0	8.18	0.590	14.1		3.39
	0749			2,443						off - Surge
	0755	0	477.5	2,443	NR →					
	0759									on
	0806	25.5	484.4	2,596	20.1		0.595	8.61		3.31
	0809									off
	0819	0	478.0	2,596	NR →					
	0821									on
	0825	25.5	485.6	2,698	20.1	±9.00	0.594	7.95		3.82
	0834			2,927.5						off
	0836	0	476.3		NR →					
	0844	25.5								on
	0845		484.1							
	0849	25.5	485.1	3,055	20.0	±9.00	0.603	9.97	3.5	3.68
	0856									off
	0858		476.1							
	0908									on
	0913	25.5	484.9	3,182.5	20.1	7.87	0.603	10.2		3.95
	0918			3,310						off
	0921	0	476.05	3,310	NR →					
	0928	25.5		3,310	NR →					on
	0931		484.8	3,335.5	NR →					
	0935	25.5	485.3	3,437.5	20.1	7	0.603	9.19		3.52
	0940			3,565						off
	0942	0	476.2	3,565	NR →					
										on

Groundwater Extraction Well Development

Page 2 of ______

Pumping KAFB 106IN-1

Date	Time	Rate (gpm)	Depth to Water (ft BGS)	Volume Removed (gallons)	Temp (°C)	pH	EC (mS/cm)	Turbidity (NTU)	Specific Capacity (gpm/ft)	Comments
4/11	1008	- Pump off - letting Recover for test								Mini Pump test
	1040	0	478.0	3565						
	1100	25.5	477.95	3565						Pumping
	1101	25.5	484.4	3590.5						
	1102	25.5	484.6	3616						
	1103	25.5	484.85	3641.5						
	1104	25.5	485	3667						
	1105	25.5	485.2	3692.5						
	1110	25.5	485.8	3820						
	1115	25.5	486	3947.5	20.1	~~20.1~~CH	0.604	4.944.94		4.01
	1120	25.5	486.25	4075						
	1125	25.5	486.45	4202.5						3.69
	1130	25.5	486.6	~~4203~~4330		~~20.1~~CH	~~0.604~~CH	~~4.94~~CH		
	1140	25.5	488.95	4585						
	1150	25.5	487.3	4840						
	1200	25.5	487.6	5095						Pump off
	1249									Pump on surge cycle
	1255	25.5	486.7	5248	20.2	±7.00	0.615	10.5	2.9	1300 Pump off
	1302	0	475.85	5248	NR →					Recovery /mound
	1300									Pump on
	1310	25.5	486.8	5401	20.2	7	0.614	10.0		3.71
	1320			5503						off
	1321	0	475.9	5503 ~~544~~	NR →					Recovery /mound
	1334	25.5		5503	NR →					on
	1339	25.5	486.95	5630.5	20.2		0.614	21.0		3.89
	1344									off
	1346	0	475.8	5758	NR →					Recovery /mound
	1356	25.5								on
	1359	25.5	486.4	5,885.5	20.3	±9.00	0.612	13.5		Pump on
	1406			6,013						off
	1408	0	475.8							Recovery /mound
	1500	0	477.96							
	1513	25.5	484.8	6,013						Pump test
	1514	25.5	485.95	6,038.5						
	1515	25.5	486	6,064						
	1516	↓	486.05	6,089.5						
	1517		486.50	6,115						
↓	1518		486.85	6,140.5						

Groundwater Extraction Well Development

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Pumping

RAFB - 106IN-1

Date	Time	Rate (gpm)	Depth to Water (ft BGS)	Volume Removed (gallons)	Temp (°C)	pH	EC (mS/cm)	Turbidity (NTU)	Specific Capacity (gpm/ft)	Comments
4/11	1523	25.5	487.40	6,268						Pump test
	1528	25.5	487.65	6,293.5						
	1533	25.5	487.82	6,319						
	1537	25.5	488	6,370						
	1543	25.5	488.1	6,497.5						Pumpoff
	1549	0	477.81	6,497.5						
	1550									Pump on
	1551	25.5								water
	1559	25.5	487.7	6,701.5	20.1	±7.00	0.620	7.76		
	1601			6,752.5						off
	1611	-	-	6,752.5	NR →					on
	1615	25.5	487.3	6,854.5	20.2		0.615	10.3		
	1622	0		7,130						off
	1630	0	477.85	7,130	NR →					
	1632	25.5								on
	1633	25.5	486.15	7,155.5	20.5		0.604	14.4		
	1646			7,487						off
	1654	0								on
	1656	25.5	486.9	7538	20.1	±7.00	~~0.6~~ 0.602	16.0		
	1704	0								off
	1705	0	475.75	7538	NR	NR	NR	NR		- Done Surging 4 today
4/12	0709	0	477.75	7538	NR →					static
	~~0715~~ - on + Pumping									Pump test
	~~0716~~									Tagger stuck
	0717	25.5	486.1	7614.5					3	
	0718	25.5	486.4	7640					2.9	
	0719	25.5	486.75	7665.5	20.0	±7	0.626	13.6	2.8	
	0720			487.10	7793				2.7	
	0725		487.91	7,920.5					2.5	
	0730		488.33	8,048					2.4	
	0735		488.35	8,175.5					2.4	
	0740		488.50	8,303	20.0	±7	0.624	11.8	2.3	
	0745		488.70	8,430.5					2.3	
	0750		488.82	8,558	20.0	±7	0.623	9.1	2.3	
4/12	0755	0	477.65	8,558	NR →					
	0800		477.9		NR →					
	0805		477.9		NR →					
	0810		477.85		NR →					

Pump

Recovery

Constant Rate Test
Water Levels

Page 1 of 1

Date 4/22/15
Personnel Crystal

Project Number 500433
Well ID 106IN1
Start Time 4:25
Stickup Length 16 in

Static Water Level (feet BTOC) 477.55
Pump Depth (feet BTOC) 492
Gallons per Minute ~20.04

Intake @ ~492

Date/Time 4/22	Time Elapsed (minutes)	Water Level (feet BTOC)	Difference from Previous Reading (feet)	Drawdown (feet)	Gallons Purged	Comments
4:25	0	477.55				Started @ 28 GPM
4:27	2	483.75		6.2	56	
4:28	3	483.58		6.03	76	
4:33	16	483.95	.37	6.4	176	
4:35	12	484.1	.15	6.55	216	20 GPM
4:40	17	484.55	.45	7	316	
4:45	22	484.65	.10	7.1	416	
4:50	27	484.85	.2	7.3	516	
4:55	32	485.00	.15	7.45	616	
5:00	37	485.15	.15	7.6	716	
5:05	42	485.3	.15	7.75	816	
5:10	47	485.4	.1	7.85	1,016	
5:20	57	485.56	.16	8.01	1,216	
5:30	67	485.7	.14	8.15	1,416	
5:40	77	485.8	.1	8.25	1,616	
5:50	87	485.9	.1	8.35	1,816	
6:00	97	486	.1	8.45	2,016	
6:16	107	486.1	.1	8.55	2,216	
6:20	117	486.2	.1	8.65	2,416	
6:30	127	486.3	.1	8.75	2,616	
6:50	147	486.45	.15	8.9	3,016	Pump off

5 min
10 min

4/22/17

Groundwater Extraction Well Development

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Jetting

106 IN-1

Crystal Hardbee

Date	Time	Depth (ft bgs)	Jetting Rate (gpm)	Pumping Rate (gpm)	Imhoff Cone Measurement (mL sediment per L water)	Comments
4/22/17	0849	478.5	19	22	0	Start Jet/Pump
	0850	479.5			under .5	
	0851	480.5			↓	
	0852	481.5			↓	minimal silt v. fine
	0853	482.5			↓	sand observed in
	0854	483.5			↓	each cone. About
	0855	484.5			↓	2-3 cones per interval
	0856	485.5			↓	
	0857	486.5			↓	
	0858	487.5			↓	
	0859	488.5			↓	
	0900	489.5			↓	
	0901	490.5			↓	
	0902	491.5			↓	
	0903	492.5			↓	
	0904	493.5			↓	
	0905	494.5			↓	→ Jet off, pump running
	0913	495			Pump imhoff under 0.5 ml/L	→ Stop pumping. Evaluate
	0925	495			-Under 0.5 during jet.	→ Jet on, pump running.
	0927	494				
	0928	493			↓	
	0929	492			↓	
	0930	491			↓	
	0931	490			↓	
	0932	489			↓	v. minimal silt and
	0933	488			↓	v. fine sand
	0934	487			↓	
	0935	486			↓	
	0936	485			↓	
	0937	484			↓	
	0938	483			↓	
	0939	482			↓	
	0940	481			↓	
	0941	480			↓	→ Jet off, pump. Drop
	0948	494			Tank / Drum	pump to near bottom of screen to
	1021	~480	35	22	<0.5 / <0.5	pumps shut off pump.
	1024	~483			↓ / ↓	-Jet @ 35 gpm
	1027	~486			↓ / ↓	→ pump to catch up
	1033	~489				→ jet again

Stop jet (0905)

begin bottom up jet (0927)

Stop jet (0941)

Start jet top down 3-ft increments 3 min each (1021)

4/22/17

Groundwater Extraction Well Development

Page 2 of 2

Jetting KAFB-106IN 1

Stop jet

pump off

Date	Time	Depth (ft bgs)	Jetting Rate (gpm)	Pumping Rate (gpm)	Imhoff Cone Measurement (mL sediment per L water)	Comments
4/22/17	1035	~492	35 gpm	22 gpm	<0.5 ml/L	jet/pump
	1038	~495	35 gpm	~22 gpm	~0.2 ml	Imhoff from tank and
	1040	~497	0 gpm	22 gpm	~0.2 ml	drum v. clean.
	1048	~497				pump 22 gpm
						pump off

Groundwater Extraction Well Development

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Jetting 106IN1 4/28/17

top to bottom

Date	Time	Depth (ft bgs)	Jetting Rate (gpm)	Pumping Rate (gpm)	Imhoff Cone Measurement (mL sediment per L water)	Comments
4/28	0816	477.5	20.3	23.0		Pump on, jet on
4/28	0817	478.5	20.3	23.0	0 mL/L	
4/28	0818	479.5	20.3	23.0	0 mL/L	few grains
4/28	0819	480.5	20.3	23.0	0 mL/L	few grains
4/28	0820	481.5	20.3	23.0	~0.1 mL/L	slightly cloudy } Sample port and drum
4/28	0821	482.5	20.3	23.0	0 mL/L	slightly cloudy
4/28	0822	483.5	20.3	23.0	0 mL/L	clear
4/28	0823	484.5	20.3	23.0	0 mL/L	clear, few grains from baker
4/28	0824	485.5	20.3	23.0	0 mL/L	few grains
4/28	0825	486.5	20.3	23.0	0 mL/L	slightly cloudy
4/28	0826	487.5	20.3	23.0	0 mL/L	slightly cloudy
4/28	0827	488.5	20.3	23.0	<0.1 mL/L	few grains
4/28	0828	489.5	20.3	23.0	<0.1 mL/L	few grains, cloudy
4/28	0829	490.5	20.3	23.0	0 mL/L	
4/28	0830	491.5	20.3	23.0	0 mL/L	few grains
4/28	0831	492.5	20.3	23.0	0 mL/L	
4/28	0832	493.5	20.3	23.0	0 mL/L	Rotate jet, start downward
4/28	0833	493.5	20.3	23.0	0.2 mL/L	
4/28	0834	492.5	20.3	23.0	<0.2 mL/L	
4/28	0835	491.5	20.3	23.0	0.4 mL/L	
4/28	0836	490.5	20.3	23.0	~0.2 mL/L	slightly
4/28	0836	489.5	20.3	23.0	0.5-0.6 mL/L	cloudy all
4/28	0837	488.5	20.3	23.0	0.3 mL/L	silt and fine sand
4/28	0838	487.5	20.3	23.0	0.3 mL/L	accumulate
4/28	0839	486.5	20.3	23.0	0.5 mL/L	
4/28	0840	485.5	20.3	23.0	0.5 mL/L	
4/28	0841	484.5	20.3	23.0	0.9 mL/L	
4/28	0842	483.5	20.3	23.0	0.9 mL/L	
4/28	0843	482.5	20.3	23.0	0.6 mL/L	
4/28	0844	481.5	20.3	23.0	0.9 mL/L	
4/28	0845	480.5	20.3	23.0	0.8 mL/L	
4/28	0846	479.5	20.3	23.0	~0.7 mL/L	
4/28	0847	478.5	20.3	23.0	~0.8 mL/L	
4/28	0848	477.5	20.3	23.0	~0.9 mL/L	← Jet off, pump on to
4/28	0910	———		23.0	———	clear casing.
4/28	0928	——— short 23 gpm pump test, No jet, Log on transducer.				
4/28	0951	Put pump near bottom				← pump off. about 8.7 ft drawdown
Next page						

bottom to top

pump off →

pump on →

Groundwater Extraction Well Development

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Jetting 106IN1

bottom to top

top to bottom

bottom to top

Date	Time	Depth (ft bgs)	Jetting Rate (gpm)	Pumping Rate (gpm)	Imhoff Cone Measurement (mL sediment per L water)	Comments
4/28	1021	493.5	19	23	0 mL/L	jet on, pump on
4/28	1022	492.5	19	23	0 mL/L	
4/28	1023	491.5	19	23	0.1 mL/L	
4/28	1024	490.5	19	23	0.1 mL/L	
4/28	1025	489.5	19	23	0.1 mL/L	
4/28	1026	488.5	19	23	0.1 mL/L	
4/28	1027	487.5	19	23	0.1 mL/L	
4/28	1028	486.5	19	23	0.2 mL/L	
4/28	1029	485.5	19	23	0.2 mL/L	
4/28	1030	484.5	19	23	0.5 mL/L	
4/28	1031	483.5	19	23	0.6 mL/L	
4/28	1032	482.5	19	23	0.7 mL/L	
4/28	1033	481.5	19	23	0.8 mL/L	
4/28	1034	480.5	19	23	0.9 mL/L	
4/28	1035	479.5	19	23	0.8 mL/L	
4/28	1036	478.5	19	23	0.9 mL/L	
4/28	1037	479.5	19	23	0.6 mL/L	
4/28	1038	480.5	19	23	0.9 mL/L	
4/28	1039	481.5	19	23	1.1 mL/L	
4/28	1040	482.5	19	23	2 mL/L	
4/28	1041	483.5	19	23	2 mL/L	
4/28	1042	484.5	19	23	1 mL/L	
4/28	1043	485.5	19	23	0.5 mL/L	
4/28	1044	486.5	19	23	0.2 mL/L	
4/28	1045	487.5	19	23	0.2 mL/L	
4/28	1046	488.5	19	23	0.1 mL/L	
4/28	1047	489.5	19	23	0.1 mL/L	
4/28	1048	490.5	19	23	<0.1 mL/L	
4/28	1049	491.5	19	23	<0.1 mL/L	
4/28	1050	492.5	19	23	<0.1 mL/L	
4/28	1051	493.5	19	23	0.2 mL/L	
4/28	1052	492.5	19	23	0.1-0.2 mL/L	
4/28	1053	491.5	19	23	0.2 mL/L	
4/28	1054	490.5	19	23	0.2 mL/L	
4/28	1055	489.5	19	23	0.2 mL/L	
4/28	1056	488.5	19	23	0.2 mL/L	
4/28	1057	487.5	19	23	0.2 mL/L	
4/28	1058	486.5	19	23	0.3 mL/L	

Groundwater Extraction Well Development

Page 3 of 5

Jetting 106IN1

Date	Time	Depth (ft bgs)	Jetting Rate (gpm)	Pumping Rate (gpm)	Imhoff Cone Measurement (mL sediment per L water)	Comments
4/28	1059	485.5	19	23	0.3 mL/L	
4/28	1100	484.5	19	23	0.5 mL/L	
4/28	1101	483.5	19	23	0.4 mL/L	
4/28	1102	482.5	19	23	0.9 mL/L	
4/28	1103	481.5	19	23	1.5 mL/L	
4/28	1104	480.5	19	23	1.5 mL/L	
4/28	1105	479.5	19	23	0.7 mL/L	
4/28	1106	478.5	19	23	0.4 mL/L	
4/28	1107	479.5	19	23	0.4 mL/L	
4/28	1108	480.5	19	23	0.8 mL/L	
4/28	1109	481.5	19	23	2.0 mL/L	
4/28	1110	482.5	19	23	1.2 mL/L	
4/28	1111	483.5	19	23	1.0 mL/L	
4/28	1112	484.5	19	23	0.3 mL/L	
4/28	1113	485.5	19	23	0.3 mL/L	
4/28	1114	486.5	19	23	0.2 mL/L	
4/28	1115	487.5	19	23	0.1 mL/L	
4/28	1116	488.5	19	23	0.1 mL/L	
4/28	1117	489.5	19	23	0.2 mL/L	
4/28	1118	490.5	19	23	0.1 mL/L	
4/28	1119	491.5	19	23	0.2 mL/L	
4/28	1120	492.5	19	23	0.2 mL/L	
4/28	1121	493.5	19	23	0.2 mL/L	
4/28	1125	483	19	23	0.3 mL/L	Move jet up to 487'
4/28	1126	482	19	23	0.3 mL/L	Rotate jet
4/28	1127	481	19	23	0.3 mL/L	
4/28	1128	480	19	23	0.8 mL/L	
4/28	1129	479	19	23	0.5 mL/L	
4/28	1130	478.5	19	23	0.4 mL/L	
4/28	1132	478.5	19	23	0.5 mL/L	
4/28	1133	479.5	19	23	1.5 mL/L	
4/28	1134	480.5	19	23	0.5 mL/L	
4/28	1135	481.5	19	23	0.4 mL/L	
4/28	1136	482.5	19	23	0.2 mL/L	
4/28	1137	483.5	19	23	0.2 mL/L	
4/28	1138	484.5	19	23	0.2 mL/L	
4/28	1139	485.5	19	23	0.2 mL/L	
4/28	1140	486.5	19	23	0.1 mL/L	
4/28	1141	487.5	19	23	0.1 mL/L	

bottom to top

top to bottom

work on top 10 ft

Groundwater Extraction Well Development

Page 4 of 5

Jetting 106IN1

Date	Time	Depth (ft bgs)	Jetting Rate (gpm)	Pumping Rate (gpm)	Imhoff Cone Measurement (mL sediment per L water)	Comments
4/28	1142	486.5	19	23	0.3	
4/28	1143	485.5	19	23	0.3	
4/28	1144	484.5	19	23	0.3	
4/28	1145	483.5	19	23	0.3	
4/28	1146	482.5	19	23	0.4	
4/28	1147	481.5	19	23	0.5	
4/28	1148	480.5	19	23	0.4	
4/28	1149	479.5	19	23	0.3	
4/28	1150	478	19	23	0.4	
4/28	1151	477.5	19	23	0.4 ←	jet off, move
4/28	1152	493.5	—	23	←	pump down and pump
4/28	1220	←		23		to clean casing
4/28	1402	493.5	30	23	0.3	~~turn on~~ extraction — Pump
4/28	1403	492.5	30	23	<0.1	pumps. Drawdown
4/28	1404	491.5	30	23	0.4	test.
4/28	1405	490.5	30	23	0.2	Continue jet/pump.
4/28	1406	489.5	30	23	0.3	
4/28	1407	488.5	30	23	0.2	
4/28	1408	487.5	30	23	0.2	
4/28	1409	486.5	30	23	0.4	
4/28	1410	485.5	30	23	0.4	
4/28	1411	484.5	30	23	0.5	
4/28	1412	483.5	30	23	0.2	
4/28	1413	482.5	30	23	0.6	
4/28	1414	481.5	30	23	1.0	
4/28	1415	480.5	30	23	1.5	
4/28	1416	479.5	30	23	1.2	
4/28	1417	478.5	30	23	1.5	
4/28	1418	477.5	30	23	1.5	Rotate Jet
4/28	1419	478.5	30	23	1.2	
4/28	1420	479.5	30	23	1.0	
4/28	1421	480.5	30	23	0.8	
4/28	1422	481.6	30	23	0.7	
4/28	1423	482.5	30	23	0.5	
4/28	1424	483.5	30	23	0.4	
4/28	1425	484.5	30	23	0.2	
4/28	1426	485.5	30	23	0.2	
4/28	1427	486.5	30	23	0.1	

Jetting bottom to top

CB&I

Jetting
~~Constant Rate Test~~
~~Water Levels~~

Page 5 of 5

Date 4/28/17

Personnel TK, CH

Well ID KAFB-106IN1

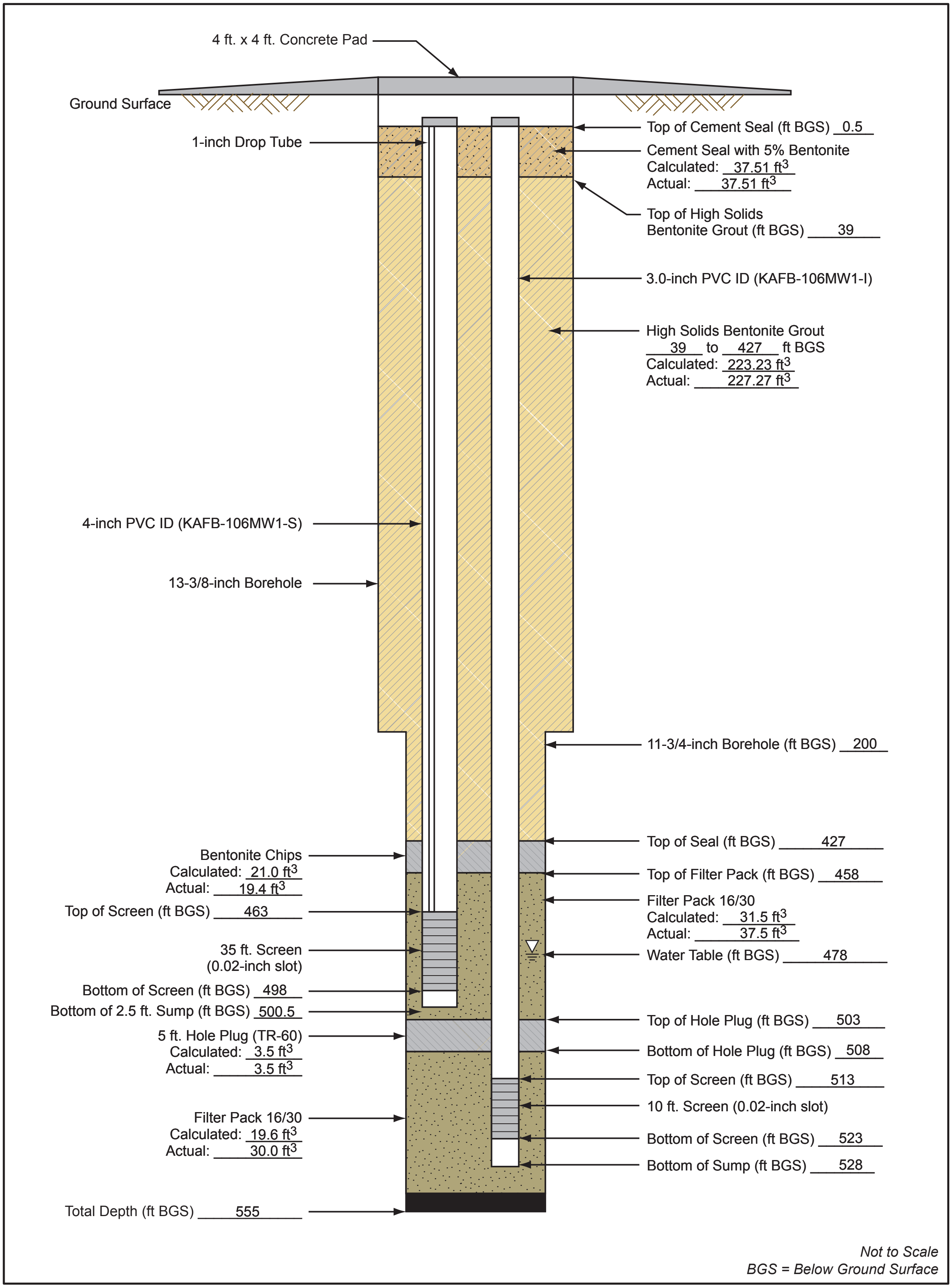
Start Time

~~Water Level~~ Jetting						
Date/Time		~~Water Level (feet below vault)~~ Depth ft bgs	~~Drawdown (feet)~~ Jetting Rate (gpm	~~Transducer Depth (feet)~~ Pumping Rate (gpm)	~~Transducer battery (%)~~ Imho & cone (mL/L)	Comments
4/28	1428	487.5	30	23	0.2	
4/28	1429	488.5	30	23	0.3	
4/28	1430	489.5	30	23	0.3	
4/28	1431	490.5	30	23	0.2	
4/28	1432	491.5	30	23	0.4	
4/28	1433	492.5	30	25	0.2	
4/28	1434	493.5	30	23	0.2	
4/28	1435	492.5	30	23	0.~~4~~	Rotate jet.
4/28	1436	491.5	30	23	0.5	
4/28	1437	490.5	30	23	0.7	
4/28	1438	489.5	30	23	1.0	
4/28	1439	488.5	30	23	1.5	
4/28	1440	487.5	30	23	2.0	
4/28	1441	486.5	30	23	2.3	
4/28	1442	485.5	30	23	2.0	
4/28	1441	484.5	30	23	2.0	
4/28	1442	483.5	30	23	1.9	
4/28	1443	482.5	30	23	~2.5	
4/28	1444	481.5	30	23	~2.7	
4/28	1445	480.5	30	23	2.0	
4/28	1446	479.5	30	23	2.5	
4/28	1447	478.5	30	23	~2.4	
4/28	1448	477.5	30	23	1.2	Rotate jet, from baker
4/28	1449	478.5	30	23	1.6	
4/28	1450	479.5	30	23	~1.5	jet off, pump to
4/28	1451	480.5	30	23	~1.5	clear casing.
4/28	1452	481.5	30	23	1.8	1514 - pump off.
4/28	1453	482.5	30	23	3.5	Const Rate - 1534 start insitu log.
4/28	1454	483.5	30	23	~2.0	- 1536 turn pump on. adjust flow
4/28	1455	484.5	30	23	~2.0	- 1540 pump at 20 gpm (adjusted)
4/28	1456	485.5	30	23	4.5	- 1740 pump off.
4/28	1457	486.5	30	23	3.0	End constant rate
4/28	1458	487.5	30	23	2.5	test.
4/28	1459	488.5	30	23	2.5	
4/28	1500	489.5	30	23	1.5	
4/28	1501	490.5	30	23	1.5	
4/28	1502	491.5	30	23	1.0	
4/28	1503	493	30	23	0.5	

Static was 17.8' under water.

Monitoring Well Completion Diagram KAFB-106MW1

Installation Start Date/Time: 1/8/17@ 0745
Installation End Date/Time: 1/12/17@1638
Completion Date: 3/24/17



Top of Cement Seal (ft BGS) 0.5
Cement Seal with 5% Bentonite
Calculated: 37.51 ft^3
Actual: 37.51 ft^3

Top of High Solids Bentonite Grout (ft BGS) 39

High Solids Bentonite Grout
39 to 427 ft BGS
Calculated: 223.23 ft^3
Actual: 227.27 ft^3

11-3/4-inch Borehole (ft BGS) 200

Top of Seal (ft BGS) 427

Top of Filter Pack (ft BGS) 458

Filter Pack 16/30
Calculated: 31.5 ft^3
Actual: 37.5 ft^3

Water Table (ft BGS) 478

Top of Hole Plug (ft BGS) 503

Bottom of Hole Plug (ft BGS) 508

Top of Screen (ft BGS) 513

Bottom of Screen (ft BGS) 523

Bottom of Sump (ft BGS) 528

Bentonite Chips
Calculated: 21.0 ft^3
Actual: 19.4 ft^3

Top of Screen (ft BGS) 463

35 ft. Screen
(0.02-inch slot)

Bottom of Screen (ft BGS) 498

Bottom of 2.5 ft. Sump (ft BGS) 500.5

5 ft. Hole Plug (TR-60)
Calculated: 3.5 ft^3
Actual: 3.5 ft^3

Filter Pack 16/30
Calculated: 19.6 ft^3
Actual: 30.0 ft^3

Total Depth (ft BGS) 555

Not to Scale
BGS = Below Ground Surface

500433_03050100_A10

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

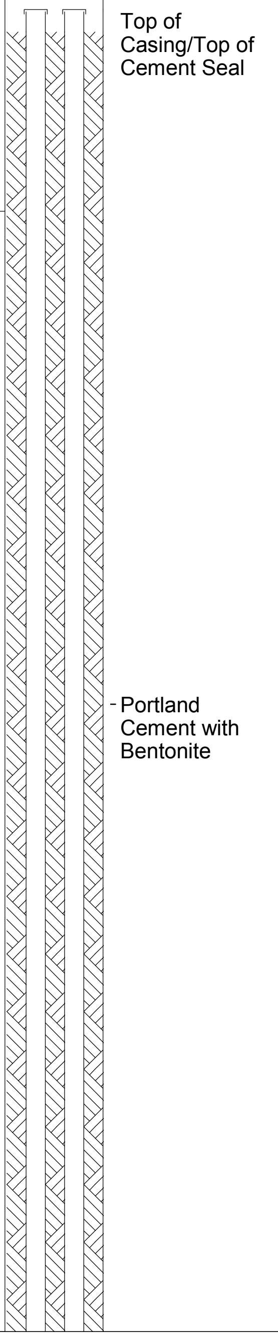
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Page 1 of 19

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
0					No lithologic description.			Location pot-holed with water knife to 5 feet bgs. No cuttings returned.
5					SILT with Gravel (ML); yellowish red (5YR 4/6); dry to slightly moist; 85% silt; 15% fine gravel; subrounded to rounded. Note: gravel is mafic.	ML		Begin drilling with 13 3/8" drive casing on 1/8/17 @ 0745.
10					Same as above (5 ft).			No hammering, no water added.
15					Same as above (5 ft).			Kelly down @ 0750, new 20'connection @ 0755.
20					Same as above (5 ft).			PID = 0.0 ppm @ cyclone and breathing zone (BZ).
25					Gravelly SILT (ML); light reddish brown (5YR 6/4); dry; 60% silt; 40% fine gravel; angular to rounded; trace very fine sand.			No hammering.
30								

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.30
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

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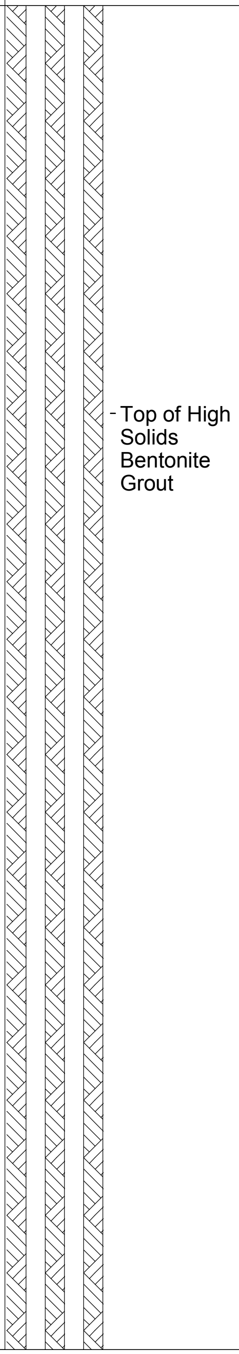
Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
30					Gravelly SILT (ML); light reddish brown (5YR 6/4); dry; 60% silt; 40% fine gravel; angular to rounded; trace very fine sand.			
35					Same as above (30 ft).			
								Kelly down @ 0804, new 20' connection @ 0811.
40							Top of High Solids Bentonite Grout	PID = 0.0 ppm @ cyclone and BZ. Hammering intermittently. No water added.
45					Same as above (30 ft); reddish brown (5YR 5/4); 50% silt; 50% fine to coarse gravel; angular to rounded; trace fine and medium sand. Note: gravel is mafics and quartz.	ML		
50					Same as above (30 ft); reddish brown (5YR 5/4); 50% silt; 50% fine to coarse gravel; angular to rounded; trace fine and medium sand. Note: gravel is mafics and quartz.			
55								
					Same as above (30 ft); reddish brown (5YR 5/4); 50% silt; 50% fine to coarse gravel; angular to rounded; trace fine and medium sand. Note: gravel is mafics			Kelly down @ 0818, new 20' connection @ 0826.
60								



Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

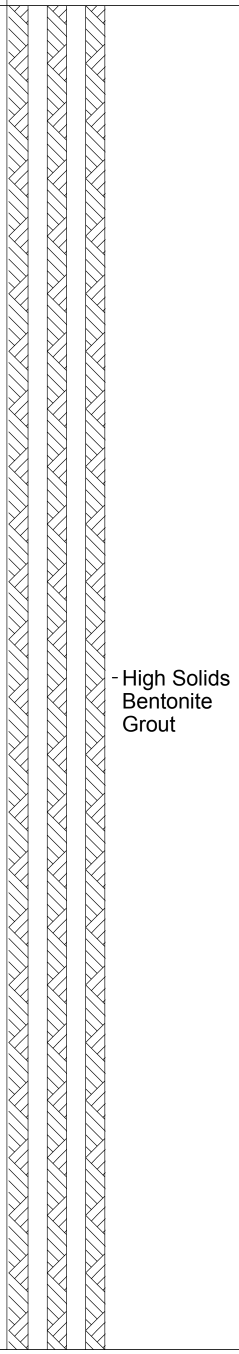
Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Page 3 of 19

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
60					and quartz. Gravelly SILT (ML); reddish brown (5YR 5/4); 50% silt; 50% fine to coarse gravel; angular to rounded; trace fine and medium sand. Note: gravel is mafics and quartz.			PID = 0.0 ppm @ cyclone and BZ.
65					Same as above (60 ft).			
70					SILT with Gravel (ML); yellowish red (5YR 5/6); dry; 80% silt; 20% fine gravel; angular to rounded.			Begin hammering. No water added.
75					Same as above (75 ft).	ML	High Solids Bentonite Grout	Kelly down @ 0831, new 20' connection @ 0837. PID = 0.0 ppm @ cyclone and BZ.
80					Same as above (70 ft).			
85								
90					SILT (ML); light reddish brown (5YR 6/4); dry; 90% silt; 10% fine gravel; rounded; trace fine sand.			Hammering. No water added.



BOREHOLE_LOG - CB&I_DRILLING.GDT - 5/8/17 10:41 - Z:\KAFB RAPID\GINT\KAFB_RAPID_11-1-2016.GPJ

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

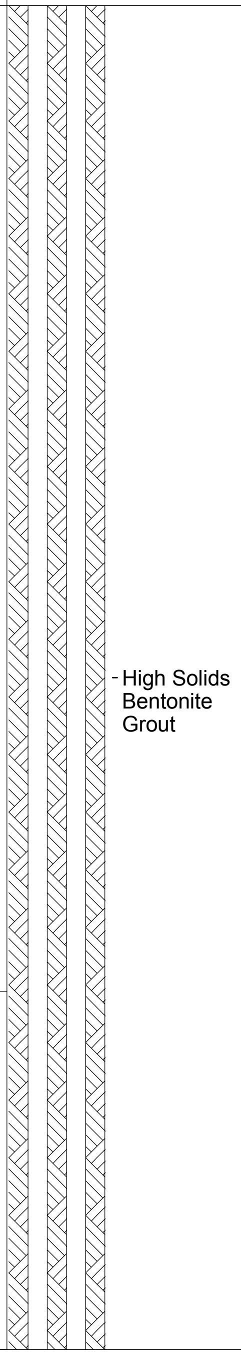
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
90					SILT (ML); light reddish brown (5YR 6/4); dry; 90% silt; 10% fine gravel; rounded; trace fine sand.	ML		Hammering. No water added.
95					Same as above (90 ft).			
								Kelly down @ 0845, new 20' connection @ 0857. PID = 0.0 ppm @ cyclone and BZ.
100					Same as above (90 ft).			
								Hammering. No water added.
105					Same as above (90 ft).		High Solids Bentonite Grout	
110					Same as above (90 ft).			
					Poorly graded SAND with Silt and Gravel (SP-SM); very pale brown (10YR 7/3); dry; 60% fine to medium sand; 30% fine gravel; angular to rounded; 10% silt. Note: gravel is granitic minerals and mafics.	SP-SM		Hammering. No water added.
115								
								Kelly down @ 1416, new 20' connection @ 1423. PID = 0.0 ppm @ cyclone and BZ.
120								



Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

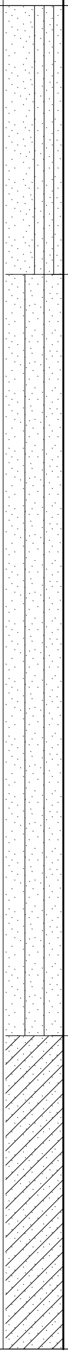
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

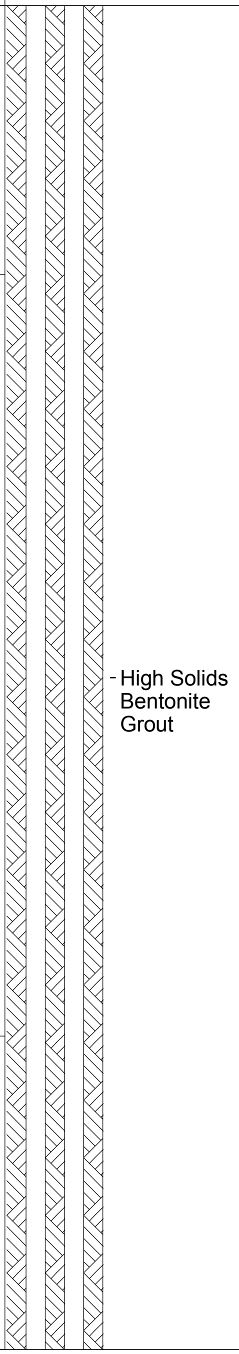
Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
120 125					Poorly graded SAND with Silt and Gravel (SP-SM); very pale brown (10YR 7/3); dry; 60% fine to medium sand; 30% fine gravel; angular to rounded; 10% silt. Note: gravel is granitic minerals and mafics.	SP-SM		
130					Silty SAND (SM); yellowish red (5YR 5/6); 50% fine sand; 10% fine gravel; subrounded to rounded; 40% silt. Note: gravel is granitic minerals and mafics.	SM		Hammering. No water added downhole. Water added at cyclone for dust suppression.
135					Same as above (126 ft).		High Solids Bentonite Grout	
140					Same as above (126 ft).			Kelly down @ 1515, new 20' connection @ 1523. PID = 0.0 ppm at cyclone and BZ.
145 150					Clayey SAND (SC); yellowish red (5YR 5/6); moist; 60% fine sand; trace fine gravel; 40% clay; trace silt.	SC		Hammering. No water added at cyclone or downhole.





Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

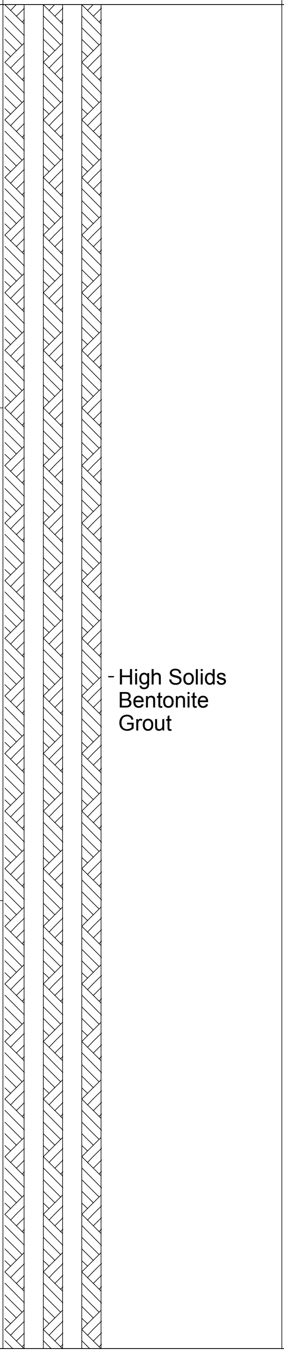
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
⊻ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
150					Clayey SAND (SC); yellowish red (5YR 5/6); moist; 60% fine sand; trace fine gravel; 40% clay; trace silt.			PID = 0.0 ppm @ cyclone and BZ.
155					Same as above (150 ft).	SC		
								Kelly down @ 1535, new 20' connection @ 1548.
160					Well-graded SAND (SW); reddish yellow (7.5YR 6/6); slightly moist; 90% fine to coarse sand; 10% fine gravel.			PID = 0.0 ppm @ cyclone and BZ.
165					Same as above (159 ft).	SW	High Solids Bentonite Grout	Hammering. No water added.
170					Poorly graded SAND (SP); light brown (7.5YR 6/4); slightly moist; 100% fine to medium sand; trace fine gravel.			
175					Same as above (170 ft).	SP		
180								Kelly down @ 1602, new 20' connection @ 1608. PID = 0.0 ppm @ cyclone and BZ.



Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

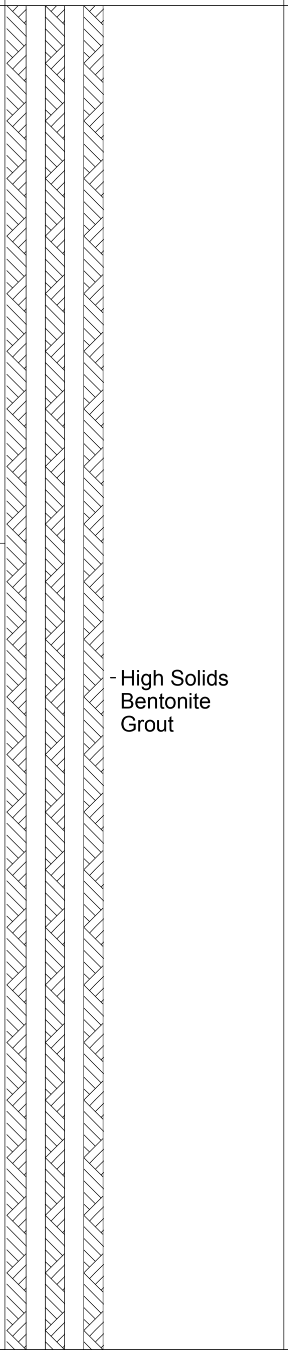
Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
180					Poorly graded SAND (SP); light brown (7.5YR 6/4); slightly moist; 100% fine to medium sand; trace fine gravel.			Hammering. No water added.
185					Same as above (180 ft).	SP		
190					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); moist; 80% fine to coarse sand; 20% fine gravel to 1/2"; angular to rounded. Note: gravel is granitic and mafics.			Hammering. No water added.
195							High Solids Bentonite Grout	Kelly down @ 1627. End drilling with 13 3/8" casing at 200 ft. Begin drilling with 11 3/4" casing @ 1300 on 1/9/17.
200					Well-graded SAND (SW); light brown (7.5YR 6/4); slightly moist; 90% fine to medium sand; trace coarse sand; 10% fine gravel to <1/2"; angular to rounded.	SW		
205					Same as above (200 ft).			No hammering. No water added.
210								

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

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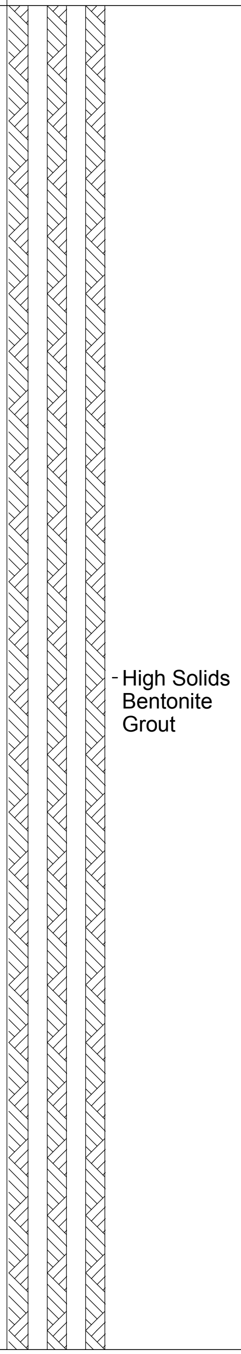


Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
210					Well-graded SAND with Gravel (SW); reddish yellow (7.5YR 6/6); moist; 75% fine to coarse sand; 25% fine gravel to 1"; subrounded to rounded. @ 212 ft: Same as above (210 ft); 70% fine to coarse sand; 30% fine gravel.			No hammering. No water added.
215								Hammering. Kelly down @ 1335, new 20' connection @ 1347.
220					Same as above (210 ft); 70% fine to coarse sand; 30% fine gravel.			End of 1/9/17. Resume drilling @ 1040 on 1/10/17.
225					Same as above (210 ft); brown (7.5YR 5/4); 70% fine to coarse sand; 30% fine gravel to 3/4". Note: gravel is granitic minerals and mafics.	SW	High Solids Bentonite Grout	
230								Hammering. No water added.
235					Same as above (210 ft); brown (7.5YR 5/4); 70% fine to coarse sand; 30% fine gravel to 3/4". Note: gravel is granitic minerals and mafics.			Kelly down @ 1054, new 20' connection @ 1059. PID = 0.1 ppm @ cyclone and BZ.
240								

BOREHOLE_LOG - CB&I_DRILLING.GDT - 5/8/17 10:41 - Z:\KAFB RAPID\GINT\KAFB_RAPID_11-1-2016.GPJ

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
240					Well-graded SAND with Gravel (SW); brown (7.5YR 5/4); moist; 70% fine to coarse sand; 30% fine gravel to 3/4"; subrounded to rounded. Note: gravel is granitic minerals and mafics.	SW		
245					Same as above (240 ft).			Hammering. No water added.
250					Same as above (240 ft); % fine sand increases; fine gravel to 1"; trace silt.			
255							High Solids Bentonite Grout	
					Silty SAND with Gravel (SM); brown (7.5YR 5/3); 60% fine to medium sand; 20% fine gravel to 7/8"; subangular to rounded; 20% silt. Note: gravel is granitic minerals and mafics.	SM		Kelly down @ 1109, new 20' connection @ 1115. PID = 0.1 ppm @ BZ and cyclone.
260								Hammering. Water added at cyclone.
265					Sandy lean CLAY (CL); yellowish brown (10YR 5/4); firm; 65% clay; 30% fine sand; 5% fine gravel to 1/2"; subrounded to rounded. Note: gravel is granitic minerals and mafics.	CL		
270								

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
270					Sandy lean CLAY (CL); yellowish brown (10YR 5/4); firm; 65% clay; 30% fine sand; 5% fine gravel to 1/2"; subrounded to rounded. Note: gravel is granitic minerals and mafics.			Hammering. Water added at cyclone.
275					Same as above (270 ft).			
						CL		Kelly down @ 1130, new 20' connection @ 1136.
280					Same as above (270 ft).			PID = 0.1 ppm @ BZ and 0.0 ppm @ cyclone.
285					Well-graded SAND (SW); light yellowish brown (10YR 6/4); moist; 95% fine to coarse sand; 5% fine gravel to 3/4"; subrounded to rounded. Note: gravel is granitic minerals and mafics.		High Solids Bentonite Grout	Hammering. No water added downhole.
						SW		
290					Same as above (290 ft).			
					Poorly graded SAND (SP); very pale brown (10YR 7/4); slightly moist; 100% fine sand; trace fine gravel to 1/8".			
295						SP		
300								Kelly down @ 1149, new 20' connection @ 1153. PID = 0.0 ppm @ cyclone and 0.1 ppm @ BZ.

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

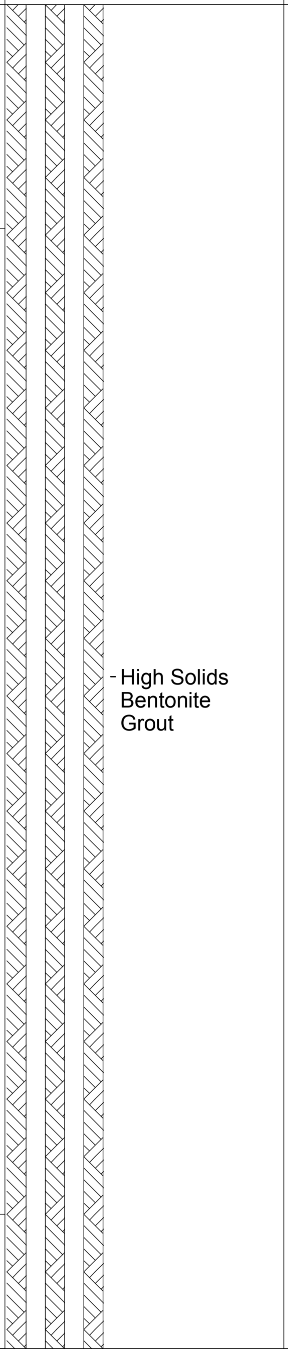
Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
300					Poorly graded SAND (SP); very pale brown (10YR 7/4); slightly moist; 100% fine sand; trace fine gravel to 1/8".	SP		Hammering. No water added downhole.
305					Well-graded SAND (SW); brown (7.5YR 5/4); moist; 100% fine to coarse sand; trace fine gravel to 1/8".	SW		
310					Same as above (305 ft).			
					Well-graded SAND with Gravel (SW); strong brown (7.5YR 5/6); dry to slightly moist; 75% fine to coarse sand; 20% fine gravel to 3/4"; 5% silt.			Hammering. No water added downhole.
315								
								Kelly down @ 1206, new 20' connection @ 1215. PID = 0.1 ppm @ BZ and top of casing, and 0.0 ppm @ cyclone.
320								
					Well-graded SAND (SW); brown (10YR 5/3); dry to slightly moist; 100% fine to coarse sand; trace silt.			
325								
					Well-graded GRAVEL with Sand (GW); yellowish brown (10YR 5/4); 60% fine to coarse gravel to 1.25"; 40% fine to coarse sand.	GW		Hammering. No water added downhole; added at cyclone.
330								

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

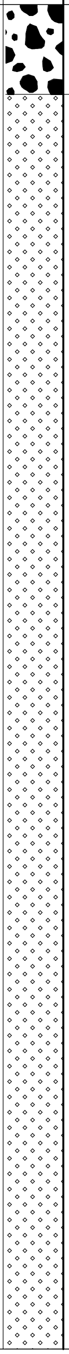
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

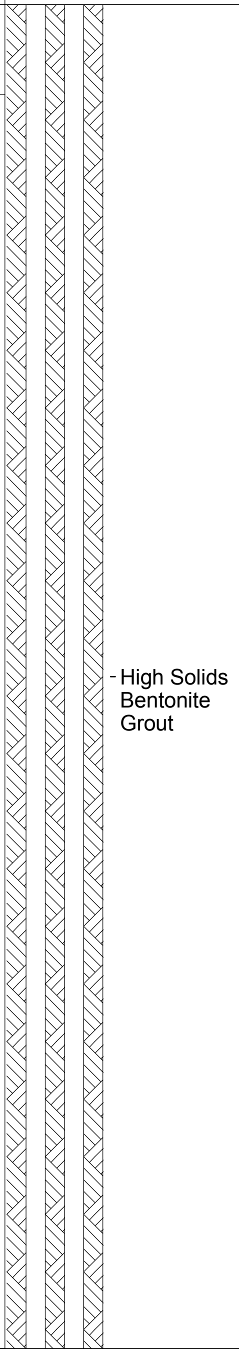
Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
330					Well-graded GRAVEL with Sand (GW); slightly moist; yellowish brown (10YR 5/4); 60% fine to coarse gravel to 1.35"; 40% fine to coarse sand.	GW		Hammering. No water added downhole.
					Well-graded SAND (SW); brown (10YR 5/4); slightly moist; 95% fine to coarse sand; 5% fine gravel to 1/4"; trace silt.			
335					Same as above (332 ft).			Kelly down @ 1323, new 20' connection @ 1330. PID = 0.0 ppm @ BZ, cyclone, and casing top.
340					Same as above (332 ft).			
345						SW	High Solids Bentonite Grout	
					Well-graded SAND with Gravel (SW); yellowish brown (10YR 5/6); 75% fine to coarse sand; 25% fine gravel to 3/4"; subrounded to rounded. Note: gravel is granitic minerals and mafics.			Rig repair @ 1350, resume drilling @ 1540.
350								Hammering. No water added downhole; added at cyclone.
355					Same as above (348 ft.)			Kelly down @ 1550, new 20' connection @ 1555. PID = 0.0 ppm @ BZ, cyclone, and casing top.
360								





Borehole ID: KAFB-106MW1

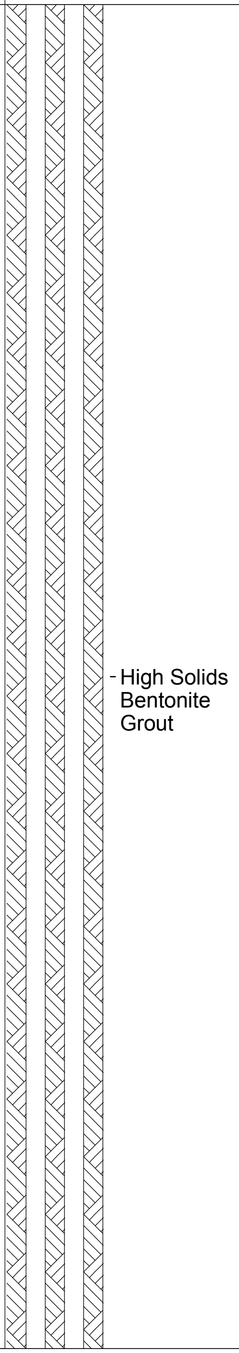
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
360					Well-graded SAND with Gravel (SW); yellowish brown (10YR 5/6); 75% fine to coarse sand; 25% fine gravel to 3/4"; subrounded to rounded. Note: gravel is granitic minerals and mafics.			Hammering. No water added downhole.
365					Same as above (360 ft).			
370					Same as above (360 ft).			
375					Same as above (360 ft).	SW	High Solids Bentonite Grout	Kelly down @ 1623, new 20' connection @ 1630. PID = 0.1 ppm @ BZ and 0.0 ppm @ cyclone and casing top.
380					Same as above (360 ft).			
385					Same as above (360 ft).			Hammering. No water added downhole.
390								

BOREHOLE_LOG - CB&I_DRILLING.GDT - 5/8/17 10:41 - Z:\KAFB RAPID\GINT\KAFB_RAPID_11-1-2016.GPJ

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

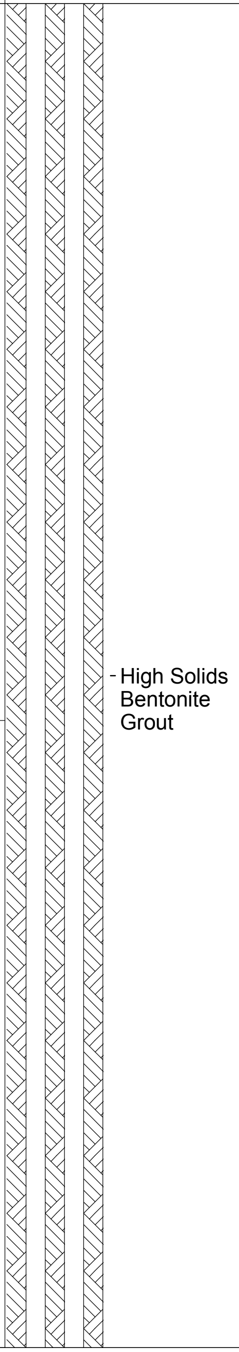
Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.30
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
390					Well-graded SAND with Gravel (SW); yellowish brown (10YR 5/6); 75% fine to coarse sand; 25% fine gravel to 3/4"; subrounded to rounded. Note: gravel is granitic minerals and mafics.	SW		Hammering. No water added downhole.
395					Same as above (390 ft).			Kelly down @ 1700, new 20' connection.
400					Same as above (390 ft)			End of 1/10/17. Resume drilling @ 0738 on 1/11/17.
405							High Solids Bentonite Grout	
					Poorly graded SAND (SP); pale brown (10YR 6/3); dry to slightly moist; 100% fine sand; trace medium sand; trace silt.	SP		Hammering. No water added downhole
410					Same as above (406 ft).			
415					Same as above (406 ft).			Kelly down @ 0757, new 20' connection @ 0802. PID = 0.1 ppm @ BZ and 0.0 ppm @ cyclone.
420								



Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
420					Poorly graded SAND (SP); pale brown (10YR 6/4); dry to slightly moist; 100% fine sand; trace medium sand; trace silt.	SP		
					Well-graded SAND (SW); yellowish brown (10YR 5/4); dry; 90% fine to coarse sand; 10% fine gravel to 1/2"; trace silt.	SW		Hammering. No water added downhole.
							High Solids Bentonite Grout	
425								
					Same as above (421 ft).			Stop drilling for rig repair @ 0815. Resume drilling @ 1315.
							Top of Bentonite Seal	
430								
					Same as above (421 ft); grayish brown (10YR 5/2); 5% fine gravel to 1/4"; 5% silt.			
435								
								Kelly down @ 1330, new 20' connection @1400. PID = 0.1 ppm @ BZ and 0.0 ppm @ cyclone.
440								
					Well-graded SAND with Gravel (SW); brownish yellow (10YR 6/6); dry; 80% fine to coarse sand; 20% fine gravel to 3/4"; trace silt. Note: gravel is granitic minerals and mafics.			Hammering. No water added downhole.
445								
								Stop drilling for rig repair @ 1420. Resume drilling @ 1425.
450								

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

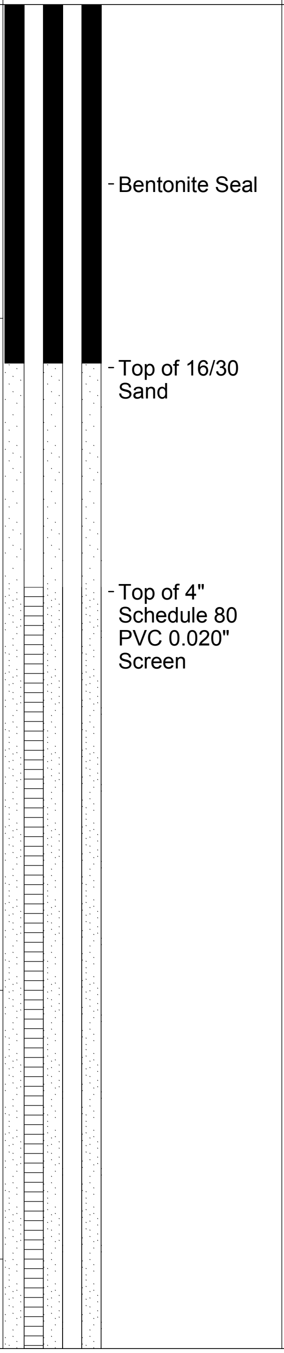
Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
450					Well-graded SAND (SW); strong brown (7.5YR 5/6); dry; 100% fine to coarse sand; trace silt.	SW		Hammering. No water added downhole.
455					Same as above (450 ft).			
					Poorly graded SAND (SP); dark yellowish brown (10YR 4/6); 90% fine sand; trace medium sand; 5% fine gravel to 3/4"; subrounded to rounded; 5% silt.	SP		Water added at cyclone. Kelly down @ 1440. Pull back 100' casing due to sand locking. End of 1/11/17. Resume drilling @ 1036 on 1/12/17.
460								
465			0.0					PID = 0.0 ppm @ BZ and cyclone.
					Poorly graded SAND with Silt (SP); yellowish brown (10YR 5/4); 80% fine to medium sand; 10% fine gravel to 1/2"; rounded; 10% silt.			Hammering. No water added downhole.
470			0.8					
					Well-graded SAND with Gravel (SW); yellowish brown (10YR 5/6); moist; 75% fine to coarse sand; 25% fine gravel to 3/4"; rounded; trace silt. Note: gravel is granitic minerals and mafics.	SW		Slight fuel odor @ 473 feet. Hammering. Rate of casing penetration slowing.
475			1.2					
				▼				
			8.4	▽	Poorly graded SAND (SP); description on next page.	SP		Kelly down @ 1115, new 20' connection @ 1120. PID = 0.0 ppm @ BZ and 3.7 ppm @ cyclone.
480								

Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

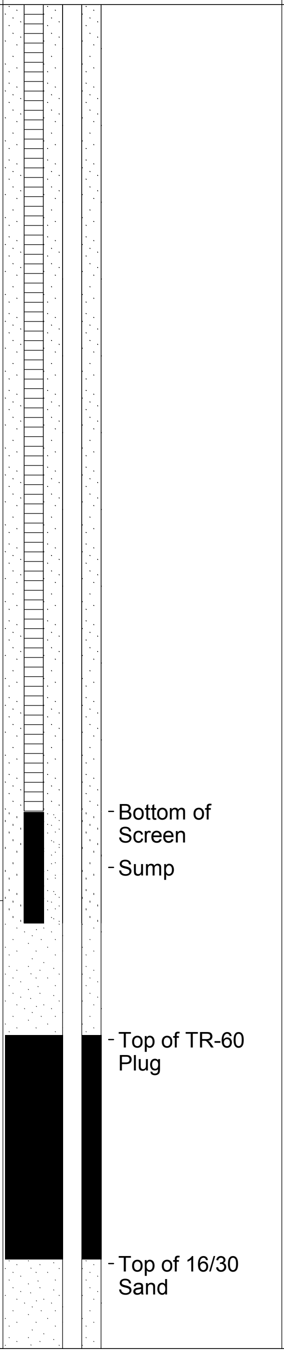
Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.30
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
480					Poorly graded SAND (SP); strong brown (7.5YR 5/6); wet; 90% fine sand; trace medium sand; 10% fine gravel to 1/2"; trace silt. Note: fuel odor.	SP		Hammering, slow drilling.
			1.5					
485					Same as above (480 ft).			
								PID = 3.8 ppm @ cyclone and 0.0 ppm @ BZ.
			9.1					
490					Same as above (480 ft).			PID = 23.4 ppm @ cyclone.
			11.1					PID = 90.1 ppm @ cyclone.
			347.7					PID = 392.5 ppm @ cyclone.
495					Same as above (480 ft).			
			111.3					Kelly down @ 1215, new 20' connection @ 1315.
500					Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4); wet; 80% fine to coarse sand; 20% fine gravel to 1"; subrounded to rounded. Note: gravel is granitic minerals and mafics.	SW		PID = 9.5 ppm @ BZ and 36.5 ppm @ top of casing.
			62.1					PID = 54.3 ppm @ cyclone and 2.7 ppm @ BZ.
505					Same as above (500 ft).			Hammering, slow drilling. PID = 54.7 ppm @ cyclone and 2.1 ppm @ BZ.
			57.2					
510								



Borehole ID: KAFB-106MW1

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

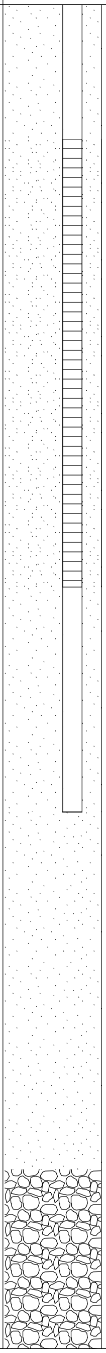
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.30

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
510					Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4); wet; 80% fine to coarse sand; 20% fine gravel to 1"; subrounded to rounded. Note: gravel is granitic minerals and mafics. @ 512 ft: Same as above (510 ft); yellowish brown (10YR 5/6); 60% fine to coarse sand; 40% fine to coarse gravel to 1.25".			
			31.3					Hammering. No water added.
							Top of 3" Schedule 80 PVC 0.020" Screen	
515								
			2.4					Kelly down @ 1423, new 20' connection @ 1429. PID = 1.7 ppm @ top of casing and 0.2 ppm @ BZ.
520					Same as above (510 ft); yellowish brown (10YR 5/6); 60% fine to coarse sand; 40% fine to coarse gravel to 1.25".			
			1.7					Hammering. PID = 0.8 ppm @ cyclone. No water added.
							Bottom of Screen	
525					Same as above (510 ft); yellowish brown (10YR 5/6); 60% fine to coarse sand; 40% fine to coarse gravel to 1.25".	SW	Sump	
			1.6					PID = 0.5 ppm @ cyclone.
							Bottom of Sump	
530								
			1.4					PID = 0.1 ppm @ cyclone.
								Hammering, slow drilling.
535					Well-graded SAND (SW); dark yellowish brown (10YR 4/6); wet; 90% fine to coarse sand; 10% fine gravel to 3/4"; rounded. Note: gravel is granitic minerals and mafics.		Bottom of 16/30 Filter Pack	
			0.7				Native Backfill	Kelly down @ 1530, new 20' connection @ 1535. PID = 0.2 ppm @ cyclone, 0.3 ppm @ top
540								



Borehole ID: KAFB-106MW1

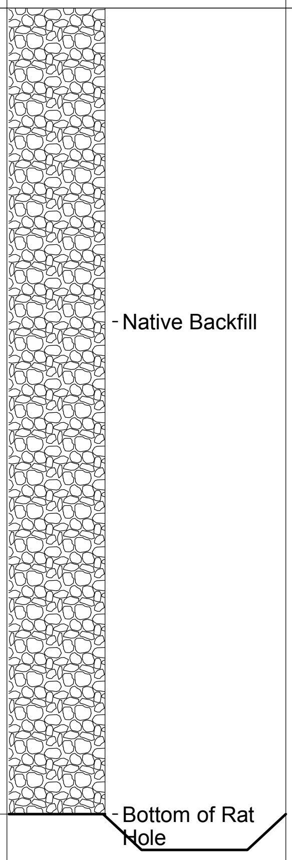
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/8/2017
Date TD Reached: 1/12/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
⊻ After Drilling: 476.30
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
540			1.0		Well-graded SAND (SW); dark yellowish brown (10YR 4/6); wet; 90% fine to coarse sand; 10% fine gravel to 3/4"; rounded. Note: gravel is granitic minerals and mafics.	SW	Native Backfill	of casing, and 0.1 ppm @ BZ. PID = 0.4 ppm @ cyclone and 0.1 ppm @ BZ.
545			0.4		Same as above (540 ft).			PID = 0.3 ppm @ cyclone and 0.1 ppm @ BZ.
550			0.3		Same as above (540 ft).			Hammering, slow drilling. PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
555			0.2				Bottom of Rat Hole	PID = 0.1 ppm @ cyclone and BZ. Total Depth = 558 feet bgs. Reached total depth @ 1638 on 1/12/17.
560								
565								
570								

Well Development Record

Project Name: RAPID ESTCP
Location: KAFB
Personnel: Crystal Hardee + Chris Scott
Date: 3/26/17

Well/Piez. No.: KAFB-106MW1-S
Date Installed:
Csg. Diameter (I.D.): 4"
Total Depth (ft. BGL): 500.5

X Bailing
X Pumping
X Original Development
☐ Redevelopment
☐ Other

Development Date: 3/~~36~~ 26 CAD /17 - 3/28/17
Depth to Water Before Developing Well (ft. BGL): 475.7

Vol. (V) Purge Factor Volume to Purge

Height of Water Column: 25 feet = gal. * 1 =

$V=(B * r_c^2 * L_c * 7.48)+(B * (r_w^2 - r_c^2) * L_s * Ø_s * 7.48)+(H_2O$ added during drilling/installation) = 36 gallons

Depth Purging From: 500-463, 3/27
Time Purging Begins: 1605
Weather: Sunny warm 3/26 Raining 3/28
Screened Interval (ft BGL): 463-498
Equipment Nos.: pH Meter: 106407 EC Meter: 106407 Turbidity Meter: 6203

Equipment Decontaminated Prior to Development: Y X N
Describe: Steam Cleaned
Collected Sample of Water Added to Well: Y N X
Describe: N/A
Comment:

Date	Time	Water Level (ft. Below TOC)	Volume Removed (gal.)	Temp.°C	pH	EC (ms/cm)	Turbidity N.T.U.	Comments
3/36	1605	475.7	0	NR	NR	NR	NR	Begin bailing - strong odor
	1726	NR	45	NR	NR	NR	NR	done bailing for day
3/27	0735	NR	45	NR	—	—	→	begin bailing 3/27
↓	0835	NR	90	NR	—	—	→	continue bailing - still removing sand
↓	0866	NR	95	NR	—	—	→	switching to swab
↓	0920	NR	95	NR	—	—	→	switching to bailer
↓	1024	NR	140	NR	—	—	→	bailing
↓	1230	NR	185	NR	—	—	→	stop for lunch

Notes:
- Water Levels - Reported to the nearest 0.01 foot
- pH - Reading rounded to 0.1 pH units
- Water temperature - Reported to nearest 0.1C
- Turbidity report in NTV nearest whole #

GPM = Gallons Per Minute

Where:
B=3.14
$Ø_s$= porosity of the sand pack
r_c= radius of the well casing and screen in feet
L_c= length of water column inside the casing and screen in feet
r_w= radius of the well bore in feet
L_s= length of saturated portion of the sand pack in feet
7.48 gallons/cubic foot= conversion from cubic feet to gallons

CB&I

Well Development Record

Project: KAFB ESTCP

Project Number: 500433

Date: 3/28/17

Time Start:

Well No: KAFB-106MW1-S

Samplers: Crystal Hardee

Checked By:

Time Finish:

Field Chemistry (cont'd)

first Reading

~3.8 gpm

3.31gpm

Date	Time	Water Level (ft. Below TOC)	Volume Removed (gal.)	Temp.°C	pH	EC (ms/cm)	Turbidity N.T.U.	Comments
3/27	1300	NR	185	NR →				begin to swab - ↑sand content
	1439	NR	230	NR →				
	1713	NR	240	NR →				Pump tripped in - Ready for AM
3/28	0740	NR	240	NR →				
	0746	NR	240	17.6	8.15	0.608	24.4	Pump intake @ 493' - pump on
	0756	NR	276	19.3	7.48	0.623	7.66	
	0807	NR	312	19.0	7.45	0.617	2.52	
	0817	NR	348	18.8	7.44	0.627	1.92	
	0827	NR	384	18.9	7.46	0.623	1.7	
	0836		414	19.0	7.5	0.625	1.42	Pump off
	0848	NR	414	NR →				pump on
	0858	NR	450	19.7	7.33	0.647	3.99	
	0908	NR	486	19.8	7.41	0.648	245	
	0920	NR	522	19.4	7.41	0.640	1.26	Development done
							T.Ch	

Was well sampled after development? YES NO X

Sample Method: N/A

Sample Name: N/A

Analyses: N/A

* switched back to bailing @ 1340

Well Development Record

Project Name: RAPID ESTCP
Location: KAFB
Personnel Crystal Hardee + Chris Scott
Date: 3/25/17 - 3/26/17

Well/Piez. No.: KAFB-106MW1I
Date Installed: 1/19/17
Csg. Diameter (I.D.): 3"
Total Depth (ft. BGL): 528

X Bailing
X Pumping
X Original Development
☐ Redevelopment
☐ Other

Development Date: 3/25/17 - ~~X~~ 3/26/17
Depth to Water Before Developing Well (ft. BGL): 475.7' below top of casing

Vol. (V) Purge Factor Volume to Purge

Height of Water Column: ~~70.4~~ 52.3' feet = gal. * 1 =

V=(B * r_c^2 * L_c * 7.48)+(B * (r_w^2 - r_c^2) * L_s * $Ø_s$ * 7.48)+(H_2O added during drilling/installation) =70.4+ gallons

Depth Purging From: 528 - 515
Time Purging Begins: 1224
Weather: warm, slight breeze
Screened Interval (ft BGL): 513 - 523
Equipment Nos.: **pH Meter:** 106407 **EC Meter:** 106407 **Turbidity Meter:** 0203

Equipment Decontaminated Prior to Development: Y X N
Describe: Steam Cleaned
Collected Sample of Water Added to Well: Y N X
Describe: N/A
Comment:

Date	Time	Water Level (ft. Below TOC)	Volume Removed (gal.)	Temp.°C	pH	EC (ms/cm)	Turbidity N.T.U.	Comments
3/25	1224	475.7	0	NR	NR	NR	NR	begin bailing - well silty + cloudy
↓	1330	NR	15	NR	→			switch to surging - switched to 15' ss bailer
	1405	NR	15	NR	→			start swabbing
	1450	NR	15	NR	→			start bailing
	1700	NR	40	NR	→			prepare for pumping tomorrow
3/26	1120		40	NR	→			start pump Intake @ 515
	1140		60	20.6	7.83	.402	>1000	water is clear
	1155		97.5	21.0	7.89	.400	13.8	

pump @ 2.5 GPM

Notes:
* Water Levels - Reported to the nearest 0.01 foot
* pH - Reading rounded to 0.1 pH units
* Water temperature - Reported to nearest 0.1C
* Turbidity report in NTV nearest whole #
GPM = Gallons Per Minute

Where:
B=3.14
$Ø_s$= porosity of the sand pack
r_c= radius of the well casing and screen in feet
L_c= length of water column inside the casing and screen in feet
r_w= radius of the well bore in feet
L_s= length of saturated portion of the sand pack in feet
7.48 gallons/cubic foot= conversion from cubic feet to gallons

Well Development Record

Project: KAFB ESTCP

Project Number: 500433

Date: 3/26/17

Time Start:

Well No: KAFB-106MW1-I

Samplers: Crystal Handel

Checked By:

Time Finish:

Field Chemistry (cont'd)

Date	Time	Water Level (ft. Below TOC)	Volume Removed (gal.)	Temp.°C	pH	EC (ms/cm)	Turbidity N.T.U.	Comments
	1210	NR	135	21.0	7.74	0.393	4.26	
	1215		146	NR ⟶				Shut pump off - surge
	1225		146	NR ⟶				~2.76 gpm
	1240		187.4	21.8	7.85	0.396	76.1	
	1250		215	21.1	7.77	0.401	17.4	
	1262		225	NR ⟶				surge
	1311		253	21.7	7.77	0.403	45.7	~2.8 / 3.0 gpm
	1315		267	21.6	7.77	0.402	39.8	surge
	1325		284	21.5	7.76	0.404	35.8	
	1340		322	21.4	7.77	0.403	32.9	
	1345		336	21.8	7.78	0.400	17.7	
	1350		350	21.3	7.80	0.398	15.9	
	1355		385	20.8	7.80	0.399	8.84	
	1400		435	20.9	7.81	0.399	5.29	
	1415	↓	~470	21.0	7.80	0.400	4.09	Development complete

Was well sampled after development? YES ______ NO X

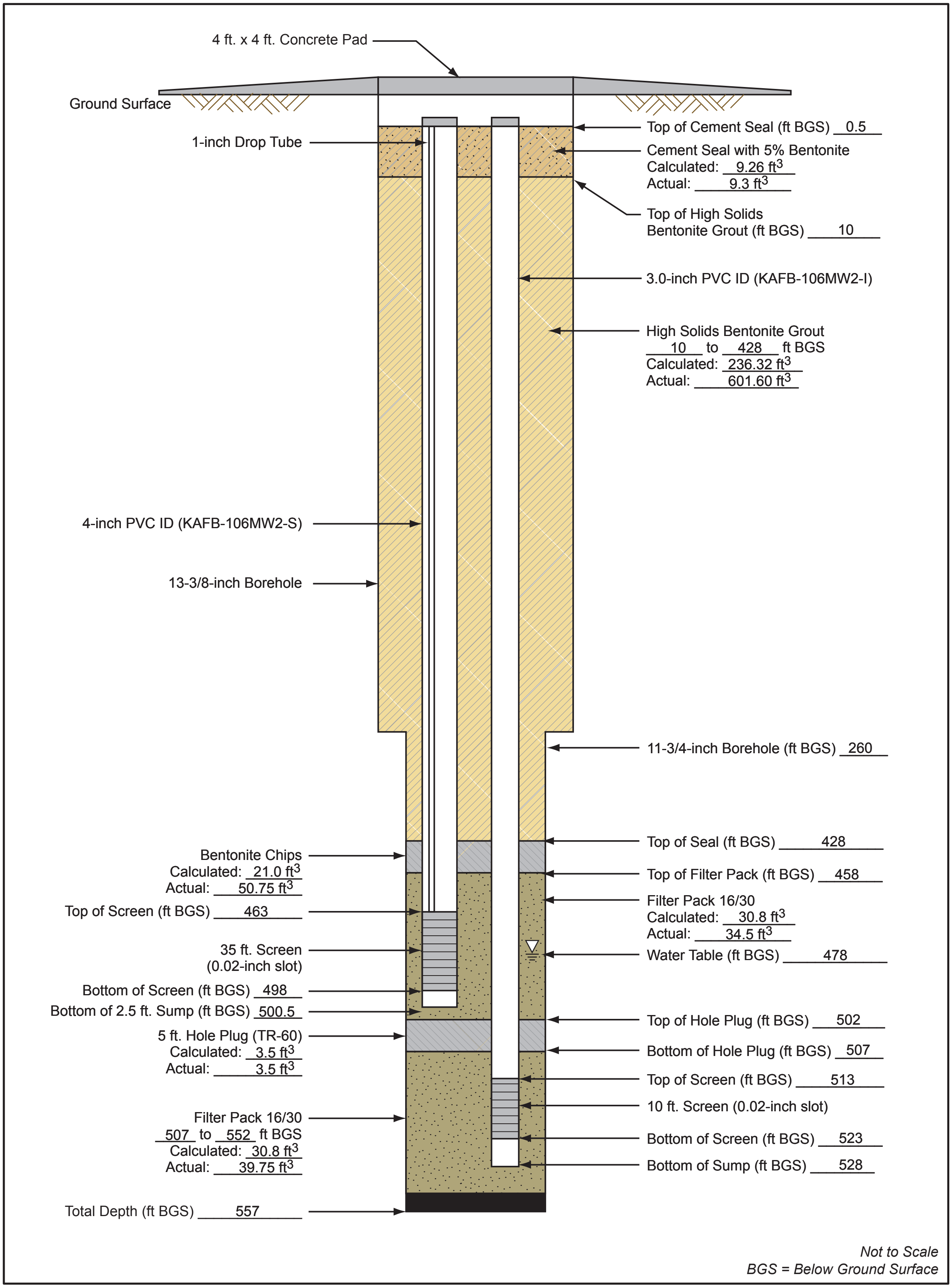
Sample Method: N/A

Sample Name: N/A

Analyses: N/A

Monitoring Well Completion Diagram KAFB-106MW2

Installation Start Date/Time: 1/31/17@1420
Installation End Date/Time: 2/16/17@1140
Completion Date: 3/24/17



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Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

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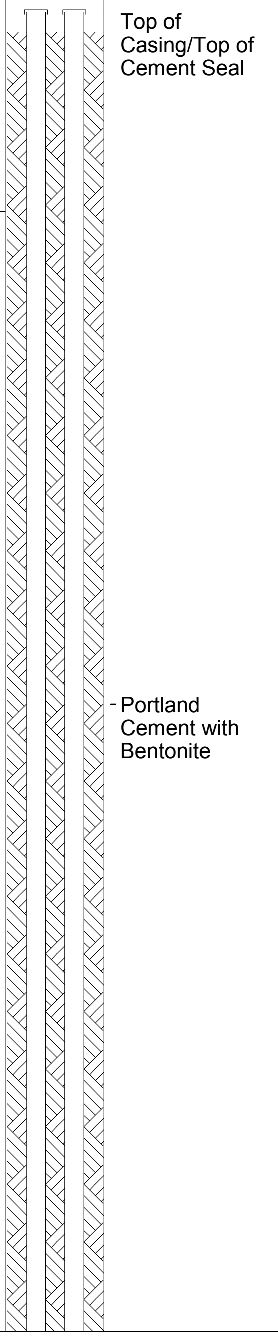


Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
0					No Lithologic Description.			Borehole was pot holed with water knife to 5 feet bgs. No cuttings returned.
5					SILT with Gravel (ML); yellowish red (5YR 4/6); dry; 80% silt; 20% fine gravel to 3/4"; subangular to rounded; trace coarse sand. Note: gravel is mafics and granitic minerals.	ML		Begin drilling with 13-3/8 casing @ 1420 on 1/31/17. Driller is using drill rod assembly with roller stabilizer and 2 drill collars.
10					Same as above (5 ft).			No hammering. No water added downhole.
15					Same as above (5 ft); gravel to 1.25".			
					Gravelly SILT (ML); light reddish brown (5YR 6/4); dry; 60% silt; 30% fine to coarse gravel to 1.5"; angular to subrounded; 10% coarse sand; angular to rounded. Note: rock fragments to 1/4"; angular.			Kelly down @ 1433, new 20' connected @ 1445.
20								PID = 0.0 ppm @ breathing zone (BZ) and cyclone.
					Sandy SILT (ML); yellowish red (5YR 4/6); dry; 70% silt; trace clay; 30% fine to coarse sand. Note: greater percentage of coarse sand present.			
25								No hammering. No water added downhole.
30					Gravelly SILT (ML); light reddish brown (5YR 6/4); dry; 60% silt; trace clay; 40% fine gravel to 3/4"; angular to			Intermittent hammering.

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

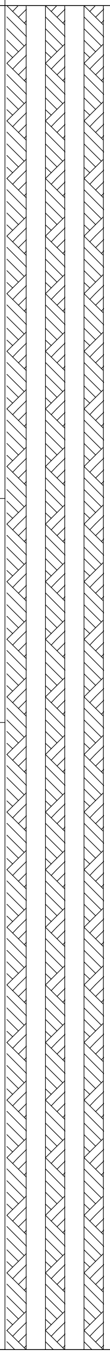
Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
30					subrounded; trace medium to coarse sand.			
					Gravelly SILT (ML); light reddish brown (5YR 6/4); dry; 60% silt; trace clay; 40% fine gravel to 3/4"; angular to subrounded; trace medium to coarse sand.			
35					Same as above (30 ft).	ML		Some hammering. Kelly down @ 1508, new 20' connection @ 1625.
40							Top of High Solids Bentonite Grout	
					Sandy lean CLAY (CL); light brown (7.5YR 6/3); 70% clay; 30% fine sand; trace fine gravel to 1/4"; angular. Note: gravel is coated with clay.	CL		PID = 0.0 ppm @ BZ and cyclone.
45								Hammering. No water added downhole.
					Gravelly SILT (ML); reddish brown (5YR 5/4); dry; 60% silt; trace clay; 40% fine gravel to 1/4"; rounded; trace fine sand. Note: gravel is coated with clay.			
50					Same as above (46 ft).	ML		
55					Same as above (46 ft).			Kelly down @ 1700. End of 1/31/17. Resume drilling @ 1424 on 2/2/17 with a button bit and
60					Description on next page.			

Borehole ID: KAFB-106MW2

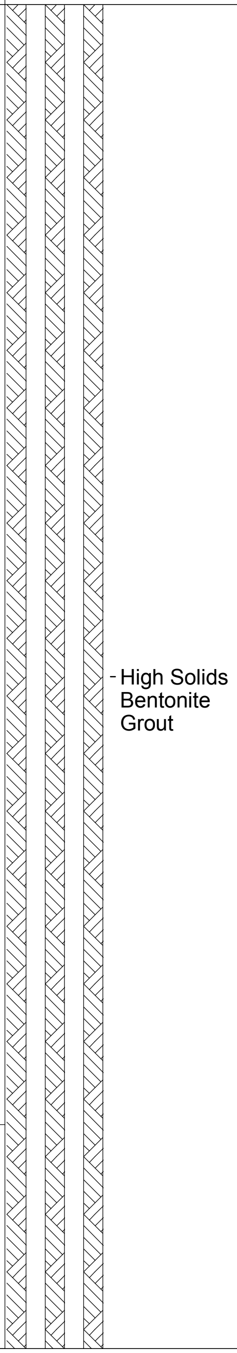
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
60					SILT with Sand (ML); reddish yellow (7.5YR 6/6); dry; 75% silt; trace clay; 25% fine to coarse sand; angular to rounded. Note: fragmented gravels.			downhole hammer. Cuttings biased fine with current drill assembly.
65					Same as above (60 ft).			PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ.
70					Same as above (60 ft).	ML		Downhole hammering. No water added downhole.
75					Same as above (60 ft).			Kelly down @ 1436, new 20' connection @ 1445.
80					Same as above (60 ft).			PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ. Downhole hammering. No water added downhole.
85					Sandy lean CLAY (CL); yellowish red (5YR 5/6); dry to slightly moist; 70% clay; 25% fine to medium sand; 5% gravel fragments.	CL		Hammering downhole and with casing hammer.
90								

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
90				▨	Sandy lean CLAY (CL); yellowish red (5YR 5/6); dry to slightly moist; 70% clay; 25% fine to medium sand; 5% gravel fragments.	CL		Hammering downhole. No water added downhole.
95				▨	Same as above (90 ft).			Kelly down @ 1524, new 20' connection. End of 2/2/17. Resume drilling @ 0735 on 2/3/17.
100				▨	Same as above (90 ft).			PID = 0.2 ppm @ cyclone and 0.0 ppm @ BZ.
105				▨	Same as above (90 ft).		High Solids Bentonite Grout	
110				▥	Sandy SILT with Gravel (ML); pink (5YR 7/4); dry; 40% silt and clay; 40% fine to medium sand; 20% gravel fragments; angular.	ML		
115				▥	Same as above (110 ft).			
120				▨	Lean CLAY with Sand (CL); light reddish brown (5YR 6/4); dry to slightly moist; 80% clay; 20% fine to medium sand.	CL		Kelly down @ 0757, new 20' connection @ 0910. PID = 0.3 ppm @ cyclone and 0.1 ppm @ BZ.

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
120					Lean CLAY with Sand (CL); light reddish brown (5YR 6/4); dry to slightly moist; 80% clay; 20% fine to medium sand. Note: gravel fragments.			Hammering downhole and with casing hammer. No water added downhole.
125					Same as above (120 ft).	CL		
130					Same as above (120 ft).			
					Well-graded SAND with Gravel (SW); reddish brown (5YR 5/3); dry; 80% fine to coarse sand; 20% gravel fragments; angular.			Continuous hammering.
135							High Solids Bentonite Grout	
					Same as above (132 ft).	SW		Kelly down @ 0946, new 20' connection @ 1000.
140								
					Sandy lean CLAY (CL); reddish yellow (5YR 6/8); slightly moist; low plasticity; 60% clay; 40% fine sand. Note: gravel fragments.			Continuous hammering.
145								
					Same as above (141 ft).	CL		
150								

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

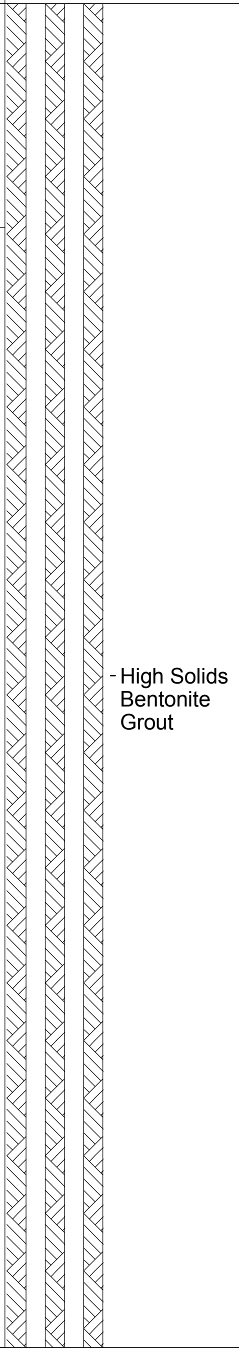
Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Remarks
150				▨	Sandy lean CLAY (CL); reddish yellow (5YR 6/8); slightly moist; low plasticity; 60% clay; 40% fine sand. Note: gravel fragments.	CL	
155				⁘	Well-graded SAND (SW); reddish yellow (5YR 6/6); dry; 95% fine to coarse sand; 5% silt. Note: gravel fragments present and higher percentage of fine sand.	SW	Kelly down @ 1023. Trip out drill rod to conduct repairs. End of 2/3/17. Resume drilling @ 0817 on 2/4/17.
160				⁘	Same as above (155 ft).		Stop drilling @ 0840 due to rig repairs. Resume drilling @ 0944 on 2/7/17.
165				⁘	Same as above (155 ft); light brown (7.5YR 6/4); dry to slightly moist; 100% fine to coarse sand.		
170				⁘	Same as above (155 ft); light brown (7.5YR 6/4); dry to slightly moist; 100% fine to coarse sand.		Hammering downhole and with casing hammer. No water added downhole.
175				⁘	Same as above (155 ft); light brown (7.5YR 6/4); dry to slightly moist; 100% fine to coarse sand.		Kelly down @ 0954, new 20' connection.
180							

Well Diagram



Borehole ID: KAFB-106MW2

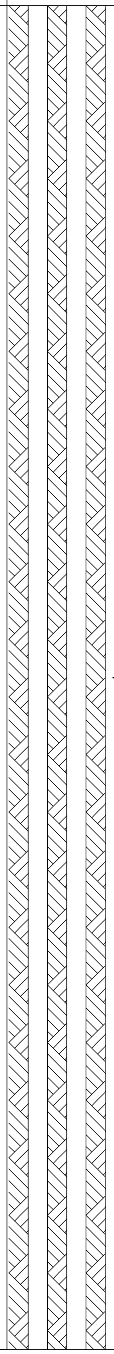
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
180					Well-graded SAND (SW); light brown (7.5YR 6/4); dry to slightly moist; 100% fine to coarse sand.			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ. Hydraulic head failure, replace drill rig. Resume drilling @ 0812 on 2/9/17.
185					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); moist; 85% fine to coarse sand; 15% fine gravel to 1/4"; subrounded to rounded. Note: gravel is mafics and quartz.			Continuous hammering. No water added downhole.
190					Same as above (185 ft).			
195					Same as above (185 ft).	SW		
								Kelly down @ 0830, new 20' conneciton @ 0838.
200								PID = 0.1 ppm @ cyclone and BZ.
					Same as above (185 ft); gravel to 3/4".			Continuous hammering.
205								
					Same as above (185 ft); gravel to 3/4".			
210								

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

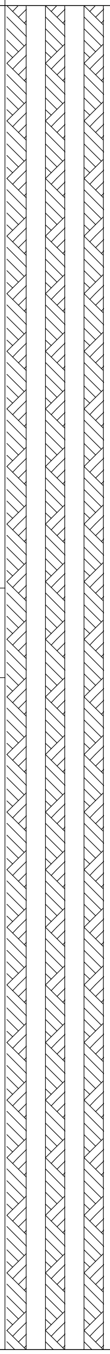
Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
210					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); moist; 85% fine to coarse sand; 15% fine gravel to 3/4"; subrounded to rounded. Note: gravel is mafics and quartz.	SW		Continuous hammering.
215					Same as above (210 ft); 80% fine to coarse sand; 20% gravel to 3/4"; angular to rounded.			Kelly down @ 0856, new 20' connection @ 0912.
220								PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
					Well-graded GRAVEL with Sand (GW); dark brown (7.5YR 3/3); 50% fine to caorse gravel to 1"; angular to rounded; 45% fine to coarse sand; 5% silt. Note: gravel is mafics and quartz.	GW		
225					Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); 75% fine to coarse sand; 25% fine to coarse gravel to 1"; subangular to rounded; trace fines. Note: gravel is mafics and granitic minerals.	SW	High Solids Bentonite Grout	
230								Hammering. No water added downhole.
235					Same as above (225 ft).			Kelly down @ 0946, new 20' connection @ 0952.
240								

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

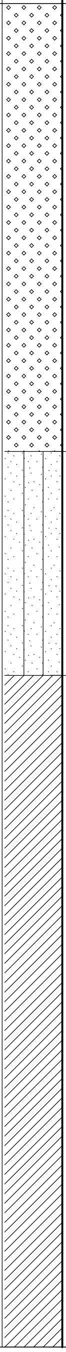
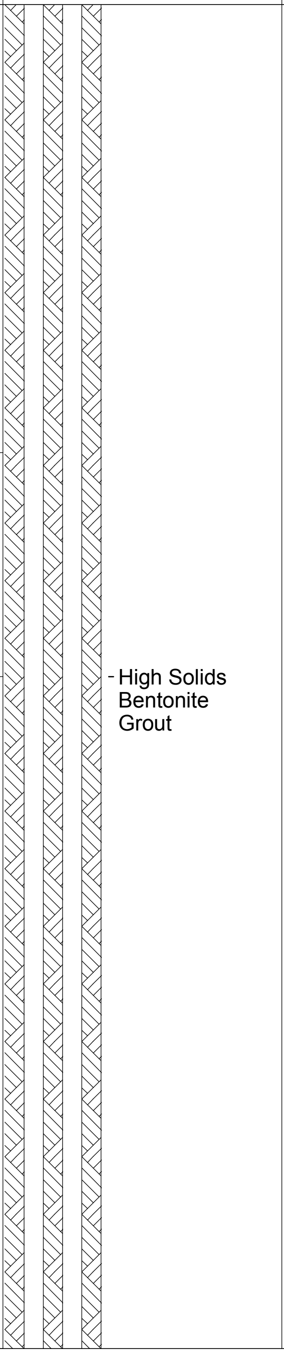
Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
240					Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); 75% fine to coarse sand; 25% fine to coarse gravel to 1"; subangular to rounded; trace fines. Note: gravel is mafics and granitic minerals. @ 241 ft: gravel is more rounded.	SW		PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ. Hammering. Bit in drive shoe.
245								
250					Silty SAND with Gravel (SM); brown (7.5YR 5/3); 60% fine to medium sand; 20% fine gravel to 1/2"; subrounded to rounded; 20% silt.	SM		Hammering.
255					Sandy lean CLAY (CL); yellowish brown (10YR 5/4); low plasticity; 70% clay; 30% fine sand; trace fine gravel to 1/8"; rounded.	CL		Kelly down @ 1038, new 5' connection @ 1047. Water added at cyclone for dust suppression. Trip out drill bit to survey borehole and trip in 11-3/4" casing. End of 2/9/17. Resume drilling @ 1042 on 2/14/17. PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ. Driller using rod assembly with under reaming bit and downhole hammer.
260					Same as above (255 ft).			
265					Same as above (255 ft).			
270								

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

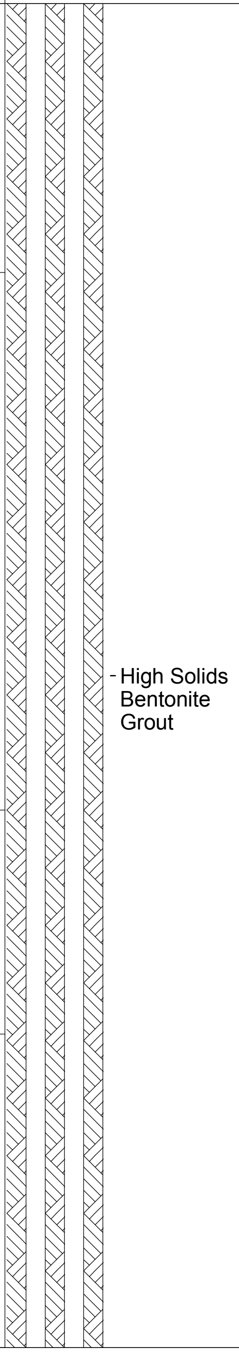
Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Remarks
270				▨	Sandy lean CLAY (CL); yellowish brown (10YR 5/4); low plasticity; 70% clay; 30% fine sand; trace fine gravel to 1/8"; rounded.	CL	Hammering downhole. No water added downhole.
275				▨			
				░	Poorly graded SAND (SP); light brown (7.5YR 6/4); 100% fine sand; trace medium and coarse sand; trace fine gravel.	SP	Kelly down @ 1053, new 20' connection @ 1400. Water added @ cyclone.
280				░			PID = 0.1 ppm @ cyclone and BZ.
				░	Same as above (276 ft).		
285				░			Hammering downhole.
				▨	Clayey SAND with Gravel (SC); brown (7.5YR 5/4); 60% fine to medium sand; trace coarse sand; 15% fine gravel to 1/4"; subrounded to rounded; 25% clay. Note: clay is slightly plastic.	SC	
290				▨			Intermittent hammering of casing.
				⁘	Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); 80% fine to coarse sand; 20% gravel fragments.	SW	
295				⁘			Kelly down @ 1415, new 20' connection @ 1421.
300				⁘			

Well Diagram



Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

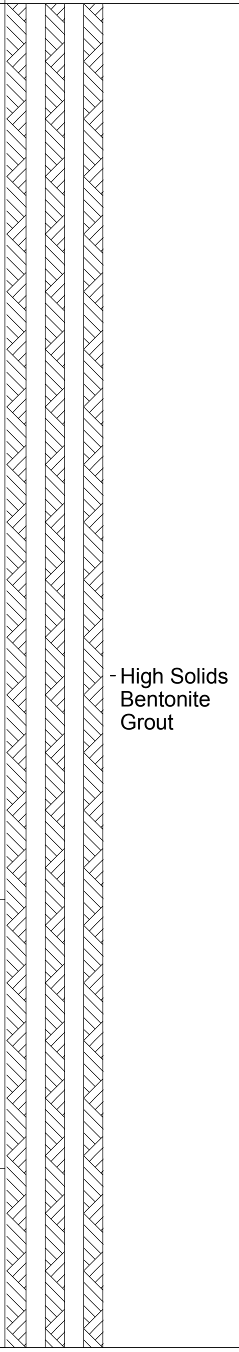
Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
300				⁘	Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); 80% fine to coarse sand; 20% gravel fragments.	SW		PID = 0.1 ppm @ cyclone and BZ. Hammering downhole and with casing hammer. No water added downhole.
305				⁘	Same as above (300 ft).			
310				⁘	Same as above (300 ft).			
315				⁘	Same as above (300 ft).			Kelly down @ 1438, new 20' connection @ 1443.
320				▨	Sandy lean CLAY with Gravel (CL); brown (10YR 4/3); 70% clay; 15% fine to medium sand; trace coarse sand; 15% fine gravel to 1/8"; subrounded to rounded.	CL		PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ. Hammering downhole and with casing hammer.
325				⁘	Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); 70% fine to coarse sand; 30% fine gravel to 1/8". Note: gravel fragments to 1/2".	SW		
330								

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
330					Well-graded SAND with Gravel (SW); brown (7.5YR 4/4); 70% fine to coarse sand; 30% fine gravel to 1/8". Note: gravel fragments to 1/2".	SW		
								Hammering downhole and with casing hammer.
335					Same as above (330 ft).			
								Kelly down @ 1516, new 20' connection @ 1523.
340					Same as above (330 ft).			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
345							High Solids Bentonite Grout	
					SILT (ML); light brown (7.5YR 6/4); 90% silt; 5% fine sand; 5% fine gravel to 1/4".	ML		
								No downhole hammering; using casing hammer intermittently.
350								
					Same as above (347 ft).			
355								
					Same as above (347 ft).			Kelly down @ 1535. End of 2/14/17. Resume drilling @ 0934 on 2/15/17.
360								

BOREHOLE_LOG - CB&I_DRILLING.GDT - 5/9/17 16:32 - Z:\KAFB RAPID\GINT\KAFB_RAPID_11-1-2016.GPJ

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
360					SILT (ML); light brown (7.5YR 6/4); 90% silt; 5% fine sand; 5% fine gravel to 1/4".	ML		Hammering downhole and with casing hammer. No water added downhole.
365					Well-graded SAND (SW); light brown (7.5YR 6/4); 90% fine to coarse sand; 10% fine gravel to 1/4"; trace silt. Note: gravel is mafics and quartz. Gravel fragments present.	SW		
370					Same as above (363 ft).			Coarse gravel @ 370 to 373 feet bgs.
375					Well-graded GRAVEL with Silt and Sand (GW-GM); pinkish gray (7.5YR 6/2); dry; 60% fine gravel to 1/4"; 30% fine to coarse sand; 10% silt. Note: gravel is mafics and quartz. Gravel fragments present.	GW-GM	High Solids Bentonite Grout	Kelly down @ 1020, new 20' connection @ 1127.
380					Same as above (375 ft).			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
385					Well-graded SAND (SW); brown (7.5YR 5/4); 100% fine to coarse sand.	SW		Hammering downhole and with casing hammer.
390								

Borehole ID: KAFB-106MW2

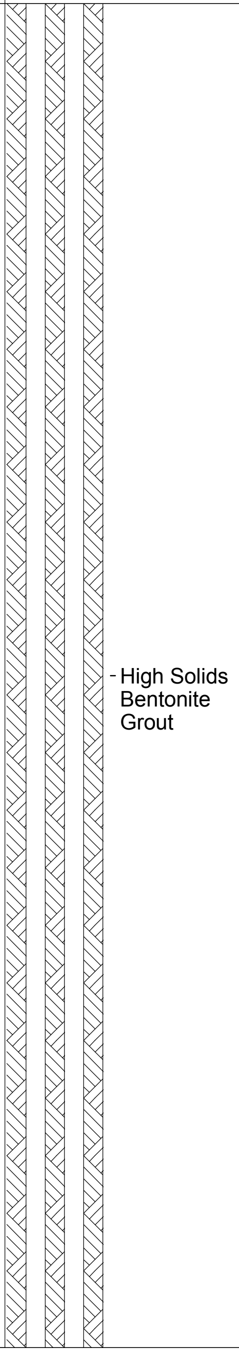
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▽ After Drilling: 476.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
390					Well-graded SAND (SW); brown (7.5YR 5/4); 100% fine to coarse sand.			Water added @ cyclone for dust suppression.
395					Well-graded SAND with Gravel (SW); brown (7.5YR 5/4); 70% fine to coarse sand; 30% fine gravel to 1/2"; subrounded to rounded; trace silt. Note: gravel fragments present.			Kelly down @ 1213, new 20' connection @ 1300.
400					Same as above (394 ft).			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
405					Same as above (394 ft).	SW		
410					Well-graded SAND (SW); light brown (7.5YR 6/3); dry; 90% fine to coarse sand; 5% fine gravel to 1/8"; 5% silt. Note: gravel fragments present.			Hammering downhole and with casing hammer. No water added downhole.
415					Same as above (408 ft).			Kelly down @ 1326, new 20' connection @ 1336.
420								

BOREHOLE_LOG - CB&I_DRILLING.GDT - 5/9/17 16:32 - Z:\KAFB RAPID\GINT\KAFB_RAPID_11-1-2016.GPJ

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

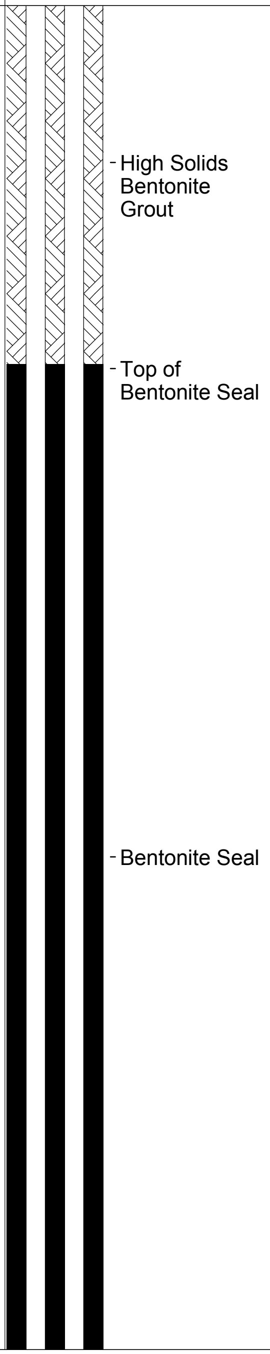
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
420					Well-graded SAND (SW); light brown (7.5YR 6/3); dry; 90% fine to coarse sand; 5% fine gravel to 1/8"; 5% silt. Note: gravel fragments present.			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
425					Same as above (420 ft).			Hammering downhole and with casing hammer. No water added downhole.
430					Same as above (420 ft).			
435					Same as above (420 ft).	SW		Kelly down @ 1406, new 20' connection @ 1601.
440					Same as above (420 ft).			PID = 0.2 ppm @ cyclone and 0.1 ppm @ BZ.
445					Same as above (420 ft).			Hammering downhole and with casing hammer.
450								



Borehole ID: KAFB-106MW2

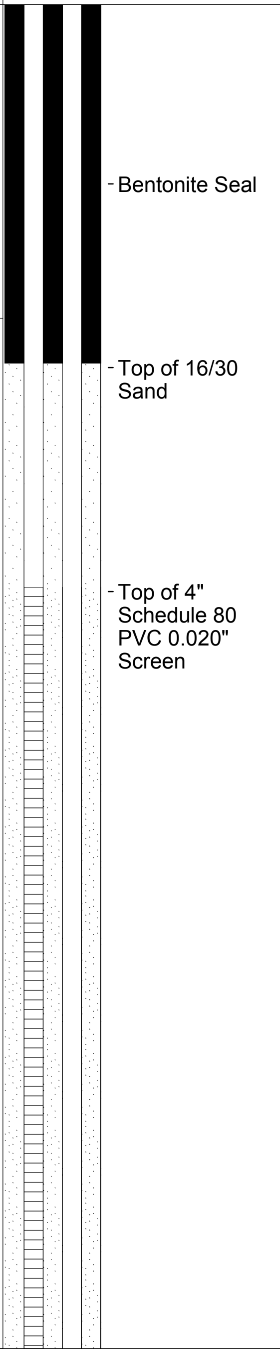
Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
450					Well-graded SAND with Gravel (SW); light brown (7.5YR 6/4); dry; 80% fine to coarse sand; 20% fine gravel to 1/4"; trace silt. Note: gravel fragments present.	SW	Bentonite Seal	
455								
					Poorly graded SAND (SP); yellowish brown (10YR 5/4); dry; 80% fine to medium sand; 10% fine gravel to 1/4"; 10% silt.	SP	Top of 16/30 Sand	Kelly down @ 1650, new 20' connection @ 1700.
460								PID = 0.1 ppm @ cyclone and 0.0 ppm @ BZ.
							Top of 4" Schedule 80 PVC 0.020" Screen	
465			0.7		Same as above (457 ft).			
								Hammering.
470			0.4		Same as above (457 ft); moist.			
					Same as above (457 ft); wet.			Top of saturated cuttings @ 474 feet bgs. Water level is artifically high from drilling.
475			2.0	▼				
				▽	Same as above (457 ft); wet. Note: strong fuel odor.			Kelly down @ 1733. End of 2/15/17. Resume drilling @ 0740 on 2/16/17.
480								

Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

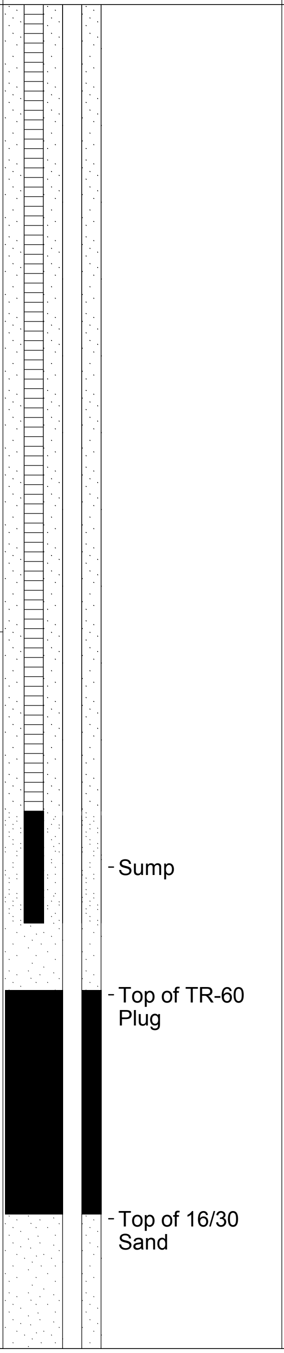
Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00
Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
480					Poorly graded SAND (SP); yellowish brown (10YR 5/4); wet; 80% fine to medium sand; 10% fine gravel to 1/4"; 10% silt.	SP		Static water level @ 478 feet bgs.
485			102.0		Same as above (480 ft).			Hammering downhole and with casing hammer. PID = 1135 ppm @ cyclone and 2.2 ppm @ BZ.
490			377.0		Same as above (480 ft).			Add approximately 25 gallons of clean water downhole to lift cuttings to surface. PID = 924 ppm @ cyclone and 1.8 ppm @ BZ.
495			185.0		Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4/); wet; 75% fine to coarse sand; 25% fine gravel to 1/2"; subangular to rounded. Note: gravel is mafics and quartz. Gravel fragments present.	SW		Kelly down @ 0843, new 20' connection @ 0856.
500			81.2		Same as above (494 ft).			PID = 276 ppm @ cyclone and 4.6 ppm @ BZ. Hammering.
505			21.7		Same as above (494 ft).			PID = 63 ppm @ cyclone and 2.1 ppm @ BZ.
510								



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Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

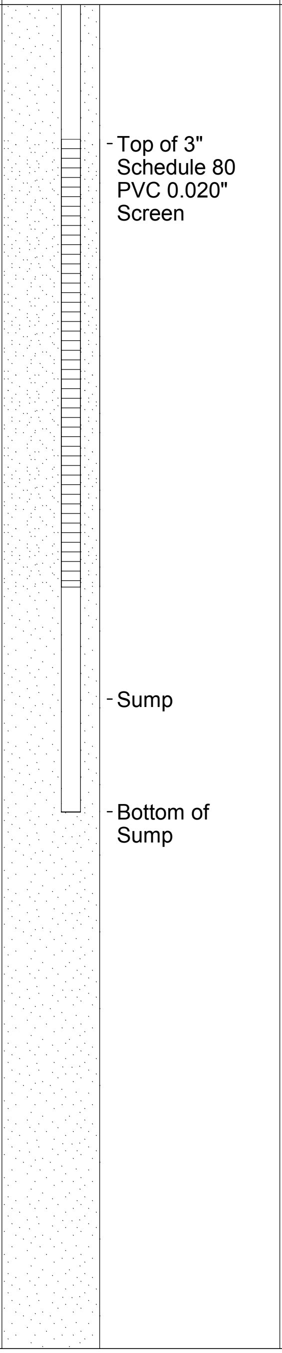
Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
∇ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
⊻ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards

Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
510					Well-graded SAND with Gravel (SW); dark yellowish brown (10YR 4/4/); wet; 75% fine to coarse sand; 25% fine gravel to 1/2"; subangular to rounded. Note: gravel is mafics and quartz. Gravel fragments present.			Poor cuttings return from 510 to 525 feet bgs. Add approximately 100 gallons of clean water downhole to lift cuttings to surface.
515			9.9		Same as above (510 ft).			PID = 21.2 ppm @ cyclone and 1.1 ppm @ BZ. Kelly down @ 0931, new 20' connection @ 0946.
520					Same as above (510 ft).			PID = 8.9 ppm @ cyclone and 1.0 ppm @ BZ.
525					Same as above (510 ft); dark yellowish brown (10YR 4/6); 80% fine to coarse sand; 20% fine gravel to 1/4"; rounded; trace silt.	SW		
530			2.7		Same as above (510 ft); dark yellowish brown (10YR 4/6); 80% fine to coarse sand; 20% fine gravel to 1/4"; rounded; trace silt.			PID = 7.1 ppm @ cyclone and 0.8 ppm @ BZ.
535			1.5		No Lithologic Description; limited cuttings returned. Cuttings appear to be Well-graded SAND (SW) with trace gravel to 1/4".	SW		Kelly down @ 1041, new 20' connection @ 1050.
540								



Borehole ID: KAFB-106MW2

Client: US Army Corps of Engineers
Project Location: KAFB, Albuquerque, NM
Project Name: KAFB RAPID SWMU ST-106/SS-111
Project Number: 500433

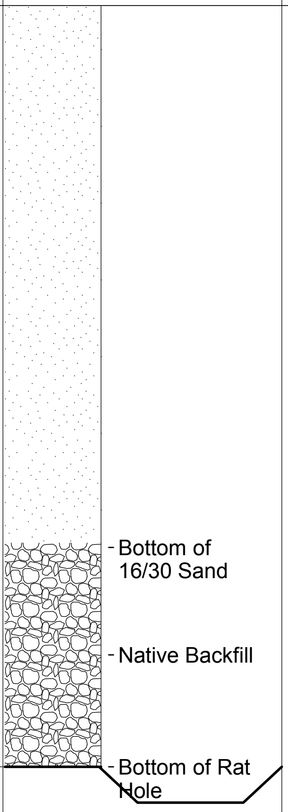
Date Started: 1/31/2017
Date TD Reached: 2/16/2017
Date Completed: 3/24/2017

Ground Elevation AMSL (ft): Not Recorded
Y Coordinate:
X Coordinate:

Hole Diameter Upper (in.): 13-3/8
Hole Diameter Lower (in.): 11-3/4
Surface Completion Type: Flush

Groundwater Levels BGS (ft):
▽ At Time of Drilling: 478.00
▼ At End of Drilling: Not Recorded
▼ After Drilling: 476.00

Drillling Contractor: Cascade Drilling
Drilling Method: Air Rotary Casing Hammer
Logged By: T. Richards



Depth (ft)	Sample Type	Number	Headspace PID	Lithologic Log	Material Description	U.S.C.S.	Well Diagram	Remarks
540					No Lithologic Description; limited cuttings returned. Cuttings appear to be Well-graded SAND (SW) with trace gravel to 1/4".	SW		PID = 1.1 ppm @ cyclone and 0.5 ppm @ BZ. Hammering; very slow drilling.
545					Same as above (540 ft); No lithologic description.			PID = 10.1 ppm @ cyclone and 0.2 ppm @ BZ.
550					Same as above (540 ft); No lithologic description.			
								PID = 0.2 ppm @ cyclone and BZ.
								PID = 0.2 ppm @ cyclone and BZ. Total depth = 557 feet bgs. Reached total depth @ 1140 on 2/16/17.
555								
560								
565								
570								

CB&I

Pg 1 of 1

Well Development Record

Project Name: RAPID ESTCP

Location: KAFB

Personnel: Crystal Hardee & Chris Scott

Date: 3/29/~~8~~17

Well/Piez. No.: KAFB-106MW2-S

Date Installed:

Csg. Diameter (I.D.): 4"

Total Depth (ft. BGL): 500.5

X Bailing

X Pumping

X Original Development

☐ Redevelopment

☐ Other

Development Date: 3/29/17 - 3/30/17

Depth to Water Before Developing Well (ft. BGL): 476

Vol. (V) Purge Factor Volume to Purge

Height of Water Column: 24.3 feet = gal. * 1 =

$V=(B * r_c^2 * L_c * 7.48)+(B * (r_w^2 - r_c^2) * L_s * Ø_s * 7.48)+(H_2O$ added during drilling/installation) = 35 gallons

Depth Purging From: 500.5 - 480

Time Purging Begins: 1405

Weather:

Screened Interval (ft BGL): 463-498

Equipment Nos.: pH Meter: 106407 EC Meter: 106407 Turbidity Meter: 0203

Equipment Decontaminated Prior to Development: Y X N

Describe: Steam Cleaned

Collected Sample of Water Added to Well: Y N X

Describe: N/A

Comment:

Date	Time	Water Level (ft. Below TOC)	Volume Removed (gal.)	Temp.°C	pH	EC (ms/cm)	Turbidity N.T.U.	Comments
3/29	1405	476	0	NR	→	→	→	swab
	1420	NR	0	NR	→	→	→	bail
	1509	~~300~~	30	NR	→	→	→	trip in pump
	1630	NR	30	NR	→	→	→	pipe tripped in
3/30	0730	NR	30	NR	→	→	→	Pump on
	0740	NR	65	20.0	7.52	0.702	21.00	
	0748	NR	100	20.5	7.48	.712	6.52	
	0753	NR	110	NR	→	→	→	Pump off - surge

~3.9 GPM

Notes:
* Water Levels - Reported to the nearest 0.01 foot
* pH - Reading rounded to 0.1 pH units
* Water temperature - Reported to nearest 0.1C
* Turbidity report in NTV nearest whole #
GPM = Gallons Per Minute

Where:
B=3.14
$Ø_s$= porosity of the sand pack
r_c= radius of the well casing and screen in feet
L_c= length of water column inside the casing and screen in feet
r_w= radius of the well bore in feet
L_s= length of saturated portion of the sand pack in feet
7.48 gallons/cubic foot= conversion from cubic feet to gallons

Well Development Record

Project: KAFB ESTCP

Project Number: 500433

Date:

Time Start:

Well No: KAFB 106MW23

Samplers: Crystal Handel

Checked By:

Time Finish:

Field Chemistry (cont'd)

Date	Time	Water Level (ft. Below TOC)	Volume Removed (gal.)	Temp.°C	pH	EC (ms/cm)	Turbidity N.T.U.	Comments
	0800	NR	110	NR	→	→	NR	Pump on
	0808	NR	145	20.9	7.58	.708	131	
	0816	NR	180	20.8	7.54	.710	15.8	
	0824	NR	215	20.4	7.55	.705	9.61	-Pump off -surge
	0833	NR	215	NR	→	→	→	Pump on
	0841	NR	250	20.7	7.6	.706	20.6	
	0849	NR	285	20.4	7.54	0.701	6.48	
	0854	NR	309	NR	→	→	→	Pump off - surge
	0859	NR	309	NR	→	→	→	pump on last cycle
	0909	NR	344	20.8	7.61	0.704	20.8	
	0916	NR	379	20.8	7.54	0.699	10.1	
	0924	NR	414	20.7	7.51	0.697	6.91	
	0932	NR	449	20.3	7.50	0.698	4.74	Development complete

Was well sampled after development? YES ______ NO X ______

Sample Method: N/A

Sample Name: N/A

Analyses: N/A

Pg 1 of 1

Well Development Record

Project Name: RAPID ESTCP

Location: KAFB

Well/Piez. No.: KAFB-106MW2-I

Personnel: Crystal Hardee + Chris Scott

Date Installed: 2/20/17

Date: 3/28/17

Csg. Diameter (I.D.): 3"

Total Depth (ft. BGL): 528

X Bailing

X Pumping

X Original Development

☐ Redevelopment

☐ Other

Development Date: 3/28/17 - 3/29/17

Depth to Water Before Developing Well (ft. BGL): 475.8

Vol. (V) Purge Factor Volume to Purge

Height of Water Column: 52.2 feet = 97.6 gal. * 1 = 97.6

$V=(B * r_c^2 * L_c * 7.48)+(B * (r_w^2 - r_c^2) * L_s * Ø_s * 7.48)+(H_2O \text{ added during drilling/installation}) =$ 97.6 gallons

Depth Purging From: 528-515

Time Purging Begins: 1340

Weather: warm/cloudy - cool in AM

Screened Interval (ft BGL): 513-523

Equipment Nos.: **pH Meter:** 106407 **EC Meter:** 106407 **Turbidity Meter:** 0203

Equipment Decontaminated Prior to Development: Y X N

Describe: Steam Cleaned

Collected Sample of Water Added to Well: Y N X

Describe: N/A

Comment:

Date	Time	Water Level (ft. Below TOC)	Volume Removed (gal.)	Temp.°C	pH	EC (ms/cm)	Turbidity N.T.U.	Comments
3/28	1340	475.8	0	NR →				swab / Bailing
↓	1523	NR	~~46~~8	NR →				bailing
	1625	NR	15	NR →				trip in pump
3/29	0753		15	NR →				Pumping / Pump on
↓	0758	NR	15	X17.2	7.46		>1000	
	0817	NR	95	20.3	7.70	.309	30.9	Pump off-Surging
	0839	NR	95	NR →				Pump on
	0910	NR	192	20.7	7.77	.363	35.1	

pumping @ ~6 to 7 gpm

3.8 gpm

0912 - pump off - surging

Notes:
* Water Levels - Reported to the nearest 0.01 foot
* pH - Reading rounded to 0.1 pH units
* Water temperature - Reported to nearest 0.1C
* Turbidity report in NTV nearest whole #
GPM = Gallons Per Minute

Where:
B=3.14
$Ø_s$= porosity of the sand pack
r_c= radius of the well casing and screen in feet
L_c= length of water column inside the casing and screen in feet
r_w= radius of the well bore in feet
L_s= length of saturated portion of the sand pack in feet
7.48 gallons/cubic foot= conversion from cubic feet to gallons

CBI

Well Development Record

Project: KAFB ESTCP

Project Number: 500433

Date: 3/29/17

Time Start:

Well No: KAFB 106MW2 I

Samplers: Crystal Hardee

Checked By: C. LaChance

Time Finish: 1231

Field Chemistry (cont'd)

Date	Time	Water Level (ft. Below TOC)	Volume Removed (gal.)	Temp.°C	pH	EC (ms/cm)	Turbidity N.T.U.	Comments
3/29/17	0918	NR	192	NR →				Pump on 3.8gpm
	0943	NR	289	20.7	7.71	0.362	22.4	Intake @ 515
	1008	NR	386	20.6	7.77	0.368	12.9	
	1033	NR	486	20.7	7.81	0.372	11.1	
	1058	NR	583	20.4	7.80	0.371	5.43	
	1123	NR	680	20.8	7.84	0.369	6.42	shutting pump off-surge
	1133	NR	680	NR →				surge- pump off
	1138	NR	680	NR →				Pump on
	1206	NR	777	20.8	7.85	0.368	6.83	
	1231	NR	875	20.8	7.88	0.366	4.99	Development complete

Was well sampled after development? YES ______ NO X

Sample Method: N/A

Sample Name: N/A

Analyses: N/A

NEW MEXICO
ENVIRONMENT DEPARTMENT

2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303
Phone (505) 476-6000 Fax (505) 476-6030
www.env.nm.gov

SUSANA MARTINEZ
Governor
JOHN A. SANCHEZ
Lieutenant Governor

BUTCH TONGATE
Cabinet Secretary
J. C. BORREGO
Deputy Secretary

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

April 20, 2017

Colonel Eric. H. Froelich
Base Commander
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB, NM 87117-5606

Lieutenant Colonel Wayne J. Acosta
Civil Engineer Office
377 Civil Engineering Division
2050 Wyoming Blvd SE, Suite 116
Kirtland AFB, NM 87117-5270

RE: BULK FUELS FACILITY EXPANSION OF THE DISSOLVED-PHASE PLUME
GROUNDWATER TREATMENT SYSTEM DESIGN, REVISION 2
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE
EPA ID# NM9570024423, HWB-KAFB-13-MISC

Dear Colonel Froelich and Lt. Colonel Acosta:

The New Mexico Environment Department ("NMED") is in receipt of the Kirtland Air Force Base ("KAFB") report titled *Borehole Abandonment Activities Report, Performed as part of the construction effort for the Ethylene Dibromide In Situ Biodegradation Pilot Test* ("Report"), dated March 8, 2017. The Report addresses abandonment activities relating to a borehole for groundwater monitoring well KAFB-106MW2. The Report also documents revisions to the original borehole abandonment plan due to delivery of an incorrect grout mixture for borehole abandonment.

NMED concurs with the Office of the State Engineer's February 20, 2017 approval of the original borehole abandonment plan. It is noted that the drilling contractor placed pre-mixed material that did not meet the OSE approved specifications down the borehole from 500 feet below ground surface ("bgs") to 87 feet bgs. KAFB is proposing to complete borehole abandonment with 95-97 percent Type I/II Portland cement and 3-5 percent bentonite grout mix from 87 to 2 feet bgs. From 2 feet bgs to the ground surface, KAFB proposes to use native soil from the surface of the site. For the reasons noted herein, the proposed additional borehole abandonment activities are approved.

If you have any questions regarding this letter, please contact Diane Agnew at (505) 222-9555.

Sincerely,

Juan Carlos Borrego
Deputy Secretary
Environment Department

cc: Col. M. Harner, KAFB
K. Lynnes, KAFB
A. Bodour, KAFB-AFCEC
T. Simpler, USACE
M.L. Leonard, AEHD
F. Shean, ABCWUA
L. King, EPA-Region 6 (6PD-N)
J. Kieling, NMED-HWB
D. Agnew, NMED-GWQB
S. Pullen, NMED-GWQB
M. Hunter, NMED-GWQB

File: KAFB 2017 Bulk Fuels Facility Spill

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

Colonel Eric H. Froehlich
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB NM 87117-5000

MAR 0 8 2017

Mr. John Kieling, Bureau Chief
Hazardous Waste Bureau (HWB)
New Mexico Environment Department (NMED)
2905 Rodeo Park Drive East, Building 1
Santa Fe NM 87505-6303

RECEIVED
MAR - 8 2017
NMED
Albuquerque Field Office

Dear Mr. Kieling

Please find attached the Borehole Abandonment Activities Report which addresses abandonment activities performed at the original KAFB-106MW2 borehole location and subsequent activities relating to the abandonment. Abandonment activities were performed at the Kirtland Air Force Base Bulk Fuels Facility site. The Report also includes the original well plugging plan that was submitted and approved by the Office of the State Engineer on 10 February 2017 and the revised plugging plan submitted to the New Mexico Environment Department. This document is being submitted to address the email received from the New Mexico Environment Department on 1 March 2017 regarding borehole abandonment.

Once the proposed abandonment of the remaining 87 feet of the borehole has been approved, abandonment will be completed and a well plugging report will be submitted to the Office of the State Engineer and to the New Mexico Environment Department, if they desire, documenting the deviation from the plugging plan and the actual material that was used during abandonment.

Please contact Mr. Scott Clark at 505-846-9017 or at scott.clark@us.af.mil if you have any questions.

Sincerely

ERIC H. FROEHLICH, Colonel, USAF
Commander

2 Attachments:
1. Original OSE Plugging Plan with Approval with Conditions Letter
2. Revised Plugging Plan from Drilling Subcontractor

cc:
NMED-HWB (Agnew), letter/hard copy
NMED-GWQB (Hunter), letter/hard copy
SAF-IEE (Lynnes), electronic
AFCEC/CZ (Bodour, Clark), electronic
USACE-Omaha District Office (Ellender), electronic
USACE-ABQ District Office (Simpler, Phaneuf), electronic
Public Info Repository, Administrative Record/Information Repository, and File, letter/hard copy

40 CFR 270.11
DOCUMENT CERTIFICATION
MARCH 2017

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.

ERIC H. FROEHLICH, Colonel, USAF
Commander, 377th Air Base Wing

This document has been approved for public release.

KIRTLAND AIR FORCE BASE
377th Air Base Wing Public Affairs

March 8, 2017

Subject: Borehole Abandonment Activities Report,
Performed as part of the construction effort for the Ethylene Dibromide In Situ Biodegradation Pilot Test.
Bulk Fuels Facility, Kirtland Air Force Base, New Mexico

This Borehole Abandonment Activity Report has been prepared by CB&I Federal Services LLC (CB&I) for the U.S. Army Corps of Engineers (USACE), Omaha District, under Contract No. W9128F-12-D-0003, Task Order 0025 to address borehole abandonment at the original KAFB-106MW2 location. The activities described in this Report were performed at the Kirtland Air Force Base (AFB) Bulk Fuels Facility (BFF) site.

The original borehole KAFB-106MW2 was evaluated and determined to have a large vertical deviation after drilling (approximately 85.35 degrees at the bottom of the borehole). The deviation was measured and evaluated while the drive casing was in the borehole prior to any well installation activities. It was determined that the deviation was too great for successful well installation and that the borehole should be abandoned.

No well infrastructure was placed in the original borehole for KAFB-106MW2, and the borehole contained only the 11 ¾ inch drive casing. Depth to water was measured at approximately 475 feet below ground surface (bgs) in the borehole for KAFB-106MW2. This depth was likely slightly elevated compared to site background due to recent drilling activities and the fact that the drive casing extended below the water table, which can cause artificial elevation within the casing.

No future borehole or well abandonment activities, for boreholes or wells that cross the water table, shall be performed without a plan approved by the New Mexico Environment Department and the Office of the State Engineer (OSE) in accordance with Section 6.5.17.10 of the Hazardous Waste Treatment Facility Operating Permit (Environmental Protection Agency identification number NM9570024423) and Section 19.27.4 of the New Mexico Administrative Code.

Completed Borehole Abandonment Activities

Borehole abandonment commenced on January 30, 2017 after verbal communication with the OSE prior to submittal of a plugging plan or approval of that plan.

Several 20-foot sticks of 11 ¾ inch drive casing were removed from the borehole and the native formation was allowed to collapse into the borehole from a depth of 557 feet bgs to approximately 500 feet bgs.

The planned borehole abandonment material was a 1 to 1 ratio by weight of Portland cement and sand slurry containing 6 gallons of water per 94 pound bag of cement (9-sack cement/sand slurry). This material was ordered from a concrete/cement supply company by the drilling subcontractor and premixed off site. Upon delivery of the pre-mixed material in a cement truck, the drilling subcontractor and contractor personnel asked the driver if the correct material had been mixed and delivered. Both parties were told yes by the concrete/cement company. A tremie pipe was placed to 500 feet bgs and was used to pump the material to approximately 450 feet bgs. It was observed that the material seemed dense and difficult to tremie. The narrow tremie pipe was then removed and the material was placed from 450 feet to approximately 87 feet bgs (depth measured after settling) using the drive casing as the tremie pipe. The drive casing was incrementally removed as the cement/sand slurry was placed. The theoretical volume of sealant required for the 11 ¾ inch borehole from a depth of 500 feet was calculated to be approximately 13 cubic yards. The actual volume recorded during grouting activities was 13 cubic yards, bringing the cement/sand slurry up to 87 feet bgs. From the total borehole depth of 557 to 500 feet bgs, native formation backfilled the bottom of the borehole as the drive casing was removed, that volume was approximately 1.6 cubic yards.

Since the theoretical amount of cement/sand slurry did not exceed the actual amount placed down hole and the depth where placement of sealing started was 500 feet bgs, no bridging of material occurred in the borehole.

Later that day, after borehole abandonment had commenced to approximately 87 feet bgs, it was discovered that the material that had been delivered and placed in the borehole was a 2-sack cement/sand slurry (flowable fill material) containing approximately 1 gallon of water per 6.2 pounds of cement. The concrete/cement company had misheard the order placed by the drilling subcontractor and mixed and delivered the wrong material to the site. The material had been difficult to tremie into the borehole due to the high sand content of the mix.

The original borehole plugging plan was submitted to the OSE on February 6, 2017 and reflected the incorrect material placed. The OSE provided approval with modifications on February 10, 2017 stating that the correct material should be placed in accordance with NMAC 19.27.4.30.C.1. The OSE approval and original plugging plan are included as Attachment 1. The drilling subcontractor contacted the OSE on February 14, 2017 and discussed the improper material that was used to backfill and was informed by the OSE to use an approved material for plugging the top 87 feet of the borehole. The plugging plan was then revised to reflect the material that should have been used for abandonment, included as Attachment 2.

After abandonment is complete, a well plugging report will be submitted to the OSE within 20 days after completion of well abandonment activities documenting the deviation from the plugging plan and the actual material that had been placed in the borehole.

Additional Borehole Abandonment Activities that have not been performed

Abandonment of the original borehole KAFB-106MW2 is not complete pending approval of material to be placed from approximately 87 feet bgs to 2 feet bgs. The following mix is proposed for this depth interval: a 95-97% Type I/II Portland cement and 3-5% bentonite grout mix with 6 gallons of water per 94 pounds of cement with an additional 1.5 to 2.5 gallons of water added for the bentonite volume.

The cement slurry discussed above is proposed to be placed via tremie pipe. The theoretical volume used to fill this interval is approximately 3.5 cubic yards (over estimate based on potential loose formation in this zone) providing that the borehole has not accumulated native formation above the sealant that was originally placed to 87 feet bgs.

From a depth of two feet to ground surface, the borehole is proposed to be filled with native soil from the surface of the site. The borehole is located in an undeveloped area of Kirtland AFB and the native soil will be reseeded at the end of construction activities.

Attachment 1

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

DISTRICT 1

TOM BLAINE, P.E.
NEW MEXICO STATE ENGINEER

5550 San Antonio Drive, N.E.
Albuquerque, NM 87109 (505) 383-4000

February 10, 2017

File No.: RG-1579 POD327-328

Kirtland Air Force Base
Attn: Wayne Bitner, Chief, Environmental Restoration
AFCEC/Kirtland AFB IST; Bldg 20685
2050 Wyoming Blvd, SE
Kirtland AFB, NM 87117-5270

Greetings:

Enclosed is the Well Plugging Plans of Operations, which has been approved subject to the Conditions of Approval, attached hereto.

Sincerely,

Christopher Burrus
Water Resource Specialist
Albuquerque, OSE, District 1

Enclosures as stated

c: WRAB

WELL PLUGGING
PLAN OF OPERATIONS

NOTE: A Well Plugging Plan of Operations shall be filed with and accepted by the Office of the State Engineer prior to plugging.

I. FILING FEE:
There is no filing fee for this form.

II. GENERAL / WELL OWNERSHIP:

Existing Office of the State Engineer POD Number (Well Number) for well to be plugged: RG-1579 PODs 327-328

Name of well owner: Kirtland Air Force Base

Mailing address: Chief Environmental Restoration, 377 MSG/CEANR, 2050 Wyoming Blvd. SE

City: Kirtland AFB State: New Mexico Zip code: 87117

Phone number: 505-846-9017 E-mail: scott.clark@us.af.mil

III. WELL DRILLER INFORMATION:

Well Driller contracted to provide plugging services: Cascade Drilling L.P.

New Mexico Well Driller License No.: WD-1210 Expiration Date: 10/31/17

IV. WELL INFORMATION:

Note: A copy of the existing Well Record for the well to be plugged should be attached to this plan.

1) GPS Well Location: Latitude: 35 deg, 3 min, 1.05 sec
Longitude: -106 deg, 34 min, 39.71 sec, NAD 83

2) Reason(s) for plugging well: A gyroscopic borehole tool was used prior to well installation to determine the degree of borehole deviation. During testing, it was determined that the bottom of the borehole was deviated 26.35 feet. The deviation results measured at PODs 327 and 328 (nested monitoring well) are too large for successful well installation. The only infrastructure in the borehole is the 11-3/4-inch overdrive casing, which will be removed during borehole abandonment.

STATE ENGINEER OFFICE
ALBUQUERQUE, NEW MEXICO
2017 FEB -6 PM 8:11

3) Was well used for any type of monitoring program? No If yes, please use section VII of this form to detail what hydrogeologic parameters were monitored. If the well was used to monitor contaminated or poor quality water, authorization from the New Mexico Environment Department may be required prior to plugging.

4) Does the well tap brackish, saline, or otherwise poor quality water? No If yes, provide additional detail, including analytical results and/or laboratory report(s):

5) Static water level: 475 feet below land surface

6) Depth of the well: 557 feet below land surface

7) Inside diameter of innermost casing: 11-3/4 inches.

8) Casing material: Stainless steel overdrive casing. Casing will be removed during abandonment.

9) The well was constructed with:

N/A an open-hole production interval, state the open interval: ____________________

N/A a well screen or perforated pipe, state the screened interval(s): ____________________

10) What annular interval surrounding the artesian casing of this well is cement-grouted? N/A

11) Was the well built with surface casing? No If yes, is the annulus surrounding the surface casing grouted or otherwise sealed? N/A If yes, please describe: ____________________

12) Has all pumping equipment and associated piping been removed from the well? N/A If not, describe remaining equipment and intentions to remove prior to plugging in Section VII of this form.

V. DESCRIPTION OF PLANNED WELL PLUGGING:

Note: If this plan proposes to plug an artesian well in a way other than with cement grout, placed bottom to top with a tremie pipe, a detailed diagram of the well showing proposed final plugged configuration shall be attached, as well as any additional technical information, such as geophysical logs, that are necessary to adequately describe the proposal.

1) Describe the method by which cement grout shall be placed in the well, or describe requested plugging methodology proposed for the well: The 11-3/4-inch casing will be pulled up and native soil will be allowed to backfill the borehole until the top of groundwater is reached (475 feet bgs). A cement-sand slurry will be pumped downhole to approximately 40 feet bgs as the overdrive casing is progressively pulled upward throughout grouting. Upon reaching 40 feet bgs, a bentonite slurry will be pumped in place to approximately 2 feet bgs, and remaining overdrive casing will be removed. Native soil will cover the top 2 feet of the borehole, as it is located in an undeveloped area containing only native vegetation.

2) Will well head be cut-off below land surface after plugging? No; well installation activities were not initiated.

VI. PLUGGING AND SEALING MATERIALS:

Note: The plugging of a well that taps poor quality water may require the use of a specialty cement or specialty sealant

1) For plugging intervals that employ cement grout, complete and attach Table A.

2) For plugging intervals that will employ approved non-cement based sealant(s), complete and attach Table B.

3) Theoretical volume of grout required to plug the well to land surface: 13 cubic yards (2555 gallons)

4) Type of Cement proposed: Portland-based cement-sand slurry

5) Proposed cement grout mix: See Additional Notes gallons of water per 94 pound sack of Portland cement.

6) Will the grout be: X batch-mixed and delivered to the site

_______ mixed on site

7) Grout additives requested, and percent by dry weight relative to cement: ____________________

8) Additional notes and calculations: ~~NMDOT Flowable Fill #2 will be used to abandon well. Mix will include 1 gallon of water per 6.2 pounds of cement~~ CG 2/10/17 Not an approved variant. SEE Conditions of approval for Alternative plugging.

VII. ADDITIONAL INFORMATION: List additional information below, or on separate sheet(s): Well Records for PODs 327 and 328 have not been submitted to the OSE. The deviation was discovered prior to well installation activities. The approved permit to drill a well with no consumptive use is attached.

VIII. SIGNATURE:

I, DAWN A. NICKELL, COLONEL, USAF, 377 ABW VICE COMMANDER, say that I have carefully read the foregoing Well Plugging Plan of Operations and any attachments, which are a part hereof; that I am familiar with the rules and regulations of the State Engineer pertaining to the plugging of wells and will comply with them, and that each and all of the statements in the Well Plugging Plan of Operations and attachments are true to the best of my knowledge and belief.

Dawn A Nickell
Signature of Applicant

FEB 03 2017
Date

2017 FEB -6 PM 8: 11
STATE ENGINEER OFFICE
ALBUQUERQUE, NEW MEXICO

IX. ACTION OF THE STATE ENGINEER:

This Well Plugging Plan of Operations is:

✓ Approved subject to the attached conditions.
____ Not approved for the reasons provided on the attached letter.

Witness my hand and official seal this 10 day of February, 2017

~~Scott A. Verhines, State Engineer~~
Tom Blaine, P.E.
State Engineer

By: ____________________

TABLE A - For plugging intervals that employ cement grout. Start with deepest interval.

	Interval 1 – deepest	Interval 2	Interval 3 – most shallow
			Note: if the well is non-artesian and breaches only one aquifer, use only this column.
Top of proposed interval of grout placement (ft bgl)			40
Bottom of proposed interval of grout placement (ft bgl)			475
Theoretical volume of grout required per interval (gallons)			2555
Proposed cement grout mix gallons of water per 94-lb. sack of Portland cement			Flowable Fill mix will include 1 gallon of water per 6.2 pounds of cement
Mixed on-site or batch-mixed and delivered?			Batch-mixed and delivered
Grout additive 1 requested			
Additive 1 percent by dry weight relative to cement			
Grout additive 2 requested			
Additive 2 percent by dry weight relative to cement			

TABLE B - For plugging intervals that will employ approved non-cement based sealant(s). Start with deepest interval.

	Interval 1 – deepest	Interval 2	Interval 3 – most shallow
			Note: if the well is non-artesian and breaches only one aquifer, use only this column.
Top of proposed interval of sealant placement (ft bgl)			2
Bottom of proposed sealant of grout placement (ft bgl)			40
Theoretical volume of sealant required per interval (gallons)			223
Proposed abandonment sealant (manufacturer and trade name)			Bentonite slurry

1912

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

DISTRICT 1

TOM BLAINE, P.E.
NEW MEXICO STATE ENGINEER

5550 San Antonio Drive, N.E.
Albuquerque, NM 87109 (505) 383-4000

Materials submitted by Kirtland Air Force Base (KAFB) identify one 12-inch Outer Diameter (OD) borehole drilled with an 11.75-inch Inner Diameter (ID) casing to a depth of 557-feet below ground surface (bgs) that deviated from a functional vertical path by 26.35-feet. Depth to water was measured at 475-feet bgs. KAFB request the abandonment of the borehole to re-drill the permitted Point of Diversion (POD) under permit RG-1579 POD327 and POD328. Cascade Drilling L.P., a New Mexico licensed driller (WD-1210), will perform the plugging.

The applicant proposes to plug the borehole using the casing, 12-inch Outer Diameter (OD), as a tremie for the transportation of materials to accomplish the plugging in four (4) distinct intervals as follows:

• Interval 1	475-feet bgs to 557-feet bgs is within the water bearing zone and expected to be filled with flowing native subsurface soil from the saturated area of the borehole during the tremie/casing withdraw,
• Interval 2	40-feet bgs to 475-feet bgs, is expected to be sealed with a cement and sand mixture,
• Interval 3	2-feet bgs to 40-feet bgs, filled with a bentonite slurry, and
• Interval 4	The remaining 2-feet to surface will be filled with clean native soil.

Permittee:
Kirtland Air Force Base
c/o Chief Environmental Restoration
2050 Wyoming Blvd, SE
Kirtland Air Force Base, NM 87117

Approximate coordinates: Latitude: 35° 03' 1.05" N, Longitude: 106° 34' 39.71" W

<u>SPECIFIC PLUGGING CONDITIONS OF APPROVAL FOR WELL (RG-1579 POD327 AND POD328), RIO GRANDE UNDERGROUND BASIN LOCATED IN SECTION 36, TOWNSHIP 10 NORTH, RANGE 3 EAST</u>

1. Water well drilling and well drilling activities, including well plugging, are regulated under 19.27.4 NMAC, which requires any person engaged in the business of well drilling within New Mexico to obtain a Well Driller License issued by the New Mexico Office of the State Engineer (NMOSE). Therefore, the firm of a New Mexico licensed Well Driller shall perform the well plugging.

2. **<u>Measurement of the current static water level in the well prior to initiation of plugging IS REQUIRED</u>, and shall be recorded on line II.7. of the Plugging Record.**

3. Theoretical volume of sealant required for abandonment of the 12-inch OD casing is approximately 5.8752 gallons per vertical foot. The reported depth of 557-feet was obtained from the plugging plan, and the theoretical volume of sealant necessary to plug the well is 3,873 gallons total.

4. **Plugging by use of Type I/II Portland Cement** is authorized as a sealant. Fundamental water demand for Type I/II Portland neat cement grout is 5.2 gallons per 94 lb/sack cement. The American Water Works Association (AWWA) Standard A100-06 allows up to 6.0 gallons water per sack (a less viscous mix), which may be used if necessary to aid placement of the slurry in well. NMAC 19.27.4.30.C.1 specifies **placement of sealant by use of tremie pipe**. When a tremie is used for grout/chip/pellet placement, it shall extend to near the total depth of the borehole/well at the initiation of plugging. The tremie shall be incrementally removed to retain the tremie bottom a limited distance above the top of the rising column of chips or pellets throughout the plugging process. Pumping the chips or pellets down the tremie with fresh water is allowed.

   Alternative plugging by use of Type I/II Portland and Sand Mixture is also authorized. The American Water Works Association (AWWA) Standard A100-06 and NMOSE, allows up to 1 part by weight of sand to 1 part cement with no more than 6 gallons of water per 94 lb sack of cement, may be used if necessary to aid placement of the slurry in well. NMAC 19.27.4.30.C.1 specifies **placement of sealant by use of tremie pipe**. When a tremie is used for grout/chip/pellet placement, it shall extend to near the total depth of the borehole/well at the initiation of plugging. The tremie shall be incrementally removed to retain the tremie bottom a limited distance above the top of the rising column of chips or pellets throughout the plugging process.

5. Should the NMED, or another regulatory agency sharing jurisdiction of the project authorize, or by regulation require a more stringent well plugging procedure than herein acknowledged, the more-stringent procedure should be followed. This, in part, includes provisions regarding pre-authorization to proceed, contaminant remediation, inspection, pulling/perforating of casing, or prohibition of free discharge of any fluid from the borehole during or related to the plugging process.

6. NMOSE witnessing of the plugging will not be required, but shall be facilitated if a NMOSE observer is onsite. NMOSE witnessing may be requested during normal work hours by calling the District 1 NMOSE Office at 505-383-4000, at least 48-hours in advance. NMOSE inspection will occur dependant on personnel availability.

7. A Well Plugging Report itemizing actual abandonment process and materials used shall be filed with the State Engineer (NMOSE, 5550 San Antonio Dr. N.E., Albuquerque, NM 87109), within 20 days after completion of well plugging. Please attach a copy of these plugging conditions.

The NMOSE Well Plugging Plan of Operations is hereby approved with the aforesaid conditions applied.

Witness my hand and seal this 10 day of February, 2017.

Tom Blaine P.E., State Engineer

By: ____________________________________

Christopher Burrus
Water Resource Specialist
District 1
Albuquerque, New Mexico

Attachment 2

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

FEB 22 2017

Colonel Dawn A. Nickell
377 ABW/CV
2000 Wyoming Blvd SE
Kirtland AFB NM 87117-5000

Mr. John Kieling, Bureau Chief
Hazardous Waste Bureau (HWB)
New Mexico Environment Department (NMED)
2905 Rodeo Park Drive East, Building 1
Santa Fe NM 87505-6303

Dear Mr. Kieling

Kirtland Air Force Base is submitting herein one revised "Well Plugging Plan of Operations" for one borehole that would have contained the two nested wells (KAFB-106MW2-S and KAFB-106MW2-I). Kirtland AFB is proposing to plug and abandon the borehole, which had no well infrastructure installed, due to a borehole deviation measurement of 26.35 feet. The deviation measured at the borehole was too large for successful well installation, thus the overdrive casing will be removed and the borehole grouted using a Portland cement-sand slurry.

If you have any questions or concerns, please contact Mr. Scott Clark at (505) 846-9017 or at scott.clark@us.af.mil.

Sincerely,

Dawn A Nickell
DAWN A. NICKELL, Colonel, USAF
Vice Commander

cc:
NMED-RPD (McQuillan), letter/hard copy
NMED-GWQB (Agnew, Pullen, Hunter), letter/hard copy
EPA Region 6 (King, Ellinger), electronic
SAF-IEE (Lynnes), electronic
AFCEC/CZ (Bodour, Clark), electronic
USACE-Omaha District Office (Ellender), electronic
USACE-ABQ District Office (Simpler, Phaneuf), electronic
Public Info Repository, Administrative Record/Information Repository, and File, letter/hard copy

WELL PLUGGING
PLAN OF OPERATIONS

NOTE: A Well Plugging Plan of Operations shall be filed with and accepted by the Office of the State Engineer prior to plugging.

I. FILING FEE: There is no filing fee for this form.

II. GENERAL / WELL OWNERSHIP:

Existing Office of the State Engineer POD Number (Well Number) for well to be plugged: RG-1579 PODs 327-328

Name of well owner: Kirtland Air Force Base

Mailing address: Chief Environmental Restoration. 377 MSG/CEANR, 2050 Wyoming Blvd. SE

City: Kirtland AFB State: New Mexico Zip code: 87117

Phone number: 505-846-9017 E-mail: scott.clark@us.af.mil

III. WELL DRILLER INFORMATION:

Well Driller contracted to provide plugging services: Cascade drilling, L.P.

New Mexico Well Driller License No.: WD-1210 Expiration Date: 10/31/17

IV. WELL INFORMATION:

Note: A copy of the existing Well Record for the well to be plugged should be attached to this plan.

1) GPS Well Location:
Latitude: 35 deg, 3 min, 1.05 sec
Longitude: -106 deg, 34 min, 39.71 sec, NAD 83

2) Reason(s) for plugging well: A gyroscopic survey tool was used prior to well installation to determine the degrees of borehole deviation.During testing it was determined the bottom of the borehole was deviated 26.35 feet. The results measured at PODs 327 and 328 (nested monitoring well) are too large for successful well installation. The only infrastructure in the borehole is the 11 3/4" overdrive casing, which will be removed during borehole abandonment.

3) Was well used for any type of monitoring program or environmental assessment? No If yes, please use section VII of this form to detail what hydrogeologic parameters were monitored. If the well was used to monitor contaminated or poor quality water, authorization from the New Mexico Environment Department may be required prior to plugging.

4) Does the well tap brackish, saline, or otherwise poor quality water? No If yes, provide additional detail, including analytical results and/or laboratory report(s): ______

5) Static water level: 475 feet below land surface / feet above land surface (circle one)

6) Depth of the well: 557 feet

7) Inside diameter of innermost casing: 11 3/4" inches.

8) Casing material: Steel drive casing, casing will be removed during abandonment.

9) The well was constructed with:

NA an open-hole production interval, state the open interval:

NA a well screen or perforated pipe, state the screened interval(s):

10) What annular interval surrounding the artesian casing of this well is cement-grouted? NA

11) Was the well built with surface casing? No If yes, is the annulus surrounding the surface casing grouted or otherwise sealed? NA If yes, please describe:

12) Has all pumping equipment and associated piping been removed from the well? NA If not, describe remaining equipment and intentions to remove prior to plugging in Section VII of this form.

V. DESCRIPTION OF PLANNED WELL PLUGGING:

Note: If this plan proposes to plug an artesian well in a way other than with cement grout, placed bottom to top with a tremie pipe, a detailed diagram of the well showing proposed final plugged configuration shall be attached, as well as any additional technical information, such as geophysical logs, that are necessary to adequately describe the proposal.

1) Describe the method by which cement grout shall be placed in the well, or describe requested plugging methodology proposed for the well: Tremie Pipe will be placed to 500' in the hole and grout (9 sack cement sand slurry) will be pumped until 450' or 25' above the water table. The tremie then removed and grout pumped inside the 11 3/4" drive casing as the casing is removed allowing the grout to displace the casing. This will be completed until aproximately 87' bgs at which time a cement grout will be pumped to 2' bgs. Native soil will be placed to surface.

2) Will well head be cut-off below land surface after plugging? No well installation activities were initiated so no well exists.

VI. PLUGGING AND SEALING MATERIALS:

Note: The plugging of a well that taps poor quality water may require the use of a specialty cement or specialty sealant

1) For plugging intervals that employ cement grout, complete and attach Table A.

2) For plugging intervals that will employ approved non-cement based sealant(s), complete and attach Table B.

3) Theoretical volume of grout required to plug the well to land surface: 13 cubic yards (2,555 gallons)

4) Type of Cement proposed: 9 sack portland cement sand slurry (9 sack of Portland cement per cubic yard)

5) Proposed cement grout mix: 6 (six) gallons of water per 94 pound sack of Portland cement.

6) Will the grout be: X batch-mixed and delivered to the site

_______ mixed on site

7) Grout additives requested, and percent by dry weight relative to cement: Please see attached letter.

8) Additional notes and calculations: No well records for PODs 327 and 328 have been submitted as no well has been installed.

VII. ADDITIONAL INFORMATION:

List additional information below, or on separate sheet(s):

VIII. SIGNATURE:

I, DAWN A. NICKELL, COLONEL, USAF, 377 ABW VICE COMMANDER, say that I have carefully read the foregoing Well Plugging Plan of Operations and any attachments, which are a part hereof; that I am familiar with the rules and regulations of the State Engineer pertaining to the plugging of wells and will comply with them, and that each and all of the statements in the Well Plugging Plan of Operations and attachments are true to the best of my knowledge and belief.

Dawn A Nickell — 22 Feb 17

Signature of Applicant — Date

IX. ACTION OF THE STATE ENGINEER:

This Well Plugging Plan of Operations is:

_______ Approved subject to the attached conditions.
_______ Not approved for the reasons provided on the attached letter.

Witness my hand and official seal this ___________ day of _____________________, ____________

Tom Blaine P.E., New Mexico State Engineer

By: ______________________________

Trn. No

TABLE A - For plugging intervals that employ cement grout. Start with deepest interval.

	Interval 1 – deepest	**Interval 2**	**Interval 3 – most shallow**
			Note: if the well is non-artesian and breaches only one aquifer, use only this column.
Top of proposed interval of grout placement (ft bgl)			
Bottom of proposed interval of grout placement (ft bgl)			
Theoretical volume of grout required per interval (gallons)			
Proposed cement grout mix gallons of water per 94-lb. sack of Portland cement			
Mixed on-site or batch-mixed and delivered?			
Grout additive 1 requested			
Additive 1 percent by dry weight relative to cement			
Grout additive 2 requested			
Additive 2 percent by dry weight relative to cement			

TABLE B - For plugging intervals that will employ approved non-cement based sealant(s). Start with deepest interval.

	Interval 1 – deepest	**Interval 2**	**Interval 3 – most shallow**
			Note: if the well is non-artesian and breaches only one aquifer, use only this column.
Top of proposed interval of sealant placement (ft bgl)			
Bottom of proposed sealant of grout placement (ft bgl)			
Theoretical volume of sealant required per interval (gallons)			
Proposed abandonment sealant (manufacturer and trade name)			

Customer-----------: **Cascade**
Property -----------: **Kirtland AFB**
Hole ID--------------: **106-NW2**
Date ----------------: 1/27/2017
Backsite ------------: 322
Mag Dec -----------: 8.6
Svy Ref Point -----: 330.6
Projected Depth --: N/A

Survey Type ---------: SRG
Latitude ---------------: N/A
Traverse --------------: N/A
Water Contact--------: N/A

<u>Comments</u>
Thank You!

IDS Technician
Jason Farnsworth
775-385-4006

MEAS DEPTH	TRUE VERTICAL DEPTH	TRUE VERTICAL X-SECTION	INCL (HORZ)	DIRECTION	RECTANGULAR COORDINATES		DOGLEG 100/FT	CLOSURE DISTANCE	CLOSURE DIR	TEMP
					N+/S-	E+/W-				(F)
(FEET)	(FEET)	(FEET)	(DEG)	(AZIMUTH)	(FEET)	(FEET)	(DEG)	(FEET)	(DEG)	(DEG)
=======	=======	=======	======	===========	=======	=======	=======	=======	======	=====
0	0.00	0.00	-89.35	114.70	0.00	0.00	0.00	0.00	0.00	44.8
25	25.00	0.26	-89.45	101.60	-0.08	0.25	0.68	0.26	108.70	45.7
50	50.00	0.56	-89.11	83.30	-0.08	0.56	1.63	0.56	98.67	45.7
75	74.99	0.97	-89.00	97.60	-0.09	0.97	1.04	0.97	95.39	46.6
100	99.99	1.47	-88.68	89.90	-0.12	1.47	1.42	1.47	94.64	46.6
125	124.98	2.15	-88.22	92.30	-0.13	2.15	1.86	2.15	93.59	47.5
150	149.97	2.94	-88.18	92.50	-0.17	2.93	0.16	2.94	93.27	46.6
175	174.95	3.76	-88.04	94.20	-0.22	3.75	0.60	3.76	93.29	47.5
200	199.94	4.61	-88.04	97.20	-0.30	4.60	0.41	4.61	93.74	48.3
225	224.92	5.62	-87.32	102.80	-0.48	5.60	3.02	5.62	94.94	50.1
250	249.89	6.84	-86.98	109.20	-0.83	6.79	1.86	6.84	96.97	50.1
275	274.85	8.15	-86.94	107.00	-1.24	8.05	0.49	8.15	98.77	50.1
300	299.81	9.54	-86.59	108.70	-1.68	9.39	1.45	9.54	100.11	51.9
325	324.76	11.10	-86.19	109.00	-2.18	10.88	1.60	11.10	101.35	51.0
350	349.70	12.79	-85.97	110.10	-2.76	12.49	0.93	12.79	102.44	51.9
375	374.64	14.58	-85.76	111.20	-3.39	14.18	0.90	14.58	103.46	51.0
400	399.57	16.45	-85.57	113.10	-4.11	15.93	0.95	16.45	104.45	52.7
425	424.49	18.38	-85.48	113.40	-4.88	17.72	0.37	18.38	105.38	49.2
450	449.41	20.33	-85.47	116.40	-5.71	19.51	0.95	20.33	106.30	52.7
475	474.33	22.30	-85.36	115.30	-6.58	21.31	0.56	22.30	107.15	54.5
500	499.25	24.32	-85.28	114.60	-7.44	23.16	0.39	24.32	107.80	56.2
525	524.17	26.35	-85.35	113.50	-8.27	25.02	0.46	26.35	108.29	57.1