DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 377TH AIR BASE WING (AFMC)

Colonel Tom D. Miller
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB, NM 87117-5000

Mr. John Kieling, Manager
RCRA Permits Management Program
Hazardous Waste Bureau (HWB)
New Mexico Environment Department (NMED)
2905 Rodeo Park Road
Santa Fe, New Mexico 87505

Dear Mr. Kieling

Kirtland Air Force Base (KAFB) submitted a revised Site Investigation (SI) Work Plan for EOD Hill CG-570 to your office on 30 May 2013, titled "Site Investigation Work Plan EOD Hill April 2013". This revised work plan addressed comments in a Notice of Disapproval received from your office on October 28, 2010. One of the comments required continuous cores to be retrieved from all installed monitoring wells. This comment was addressed in the 30 May 2013 SI work plan submittal. Subsequent to the 30 May 2013 work plan submittal, a fence to fence performance based remediation contract was awarded to complete the activities outlined in the SI work plan for EOD hill CG-570. The contractor has recently met with multiple well drilling companies on site to discuss drilling methodology and the logistics of obtaining oriented cores from each of the wells. The paragraphs below discuss this in more detail. The purpose of this letter is to propose an alternative to orientated continuous cores using diamond drilling prior to the New Mexico Environmental Department (NMED) reviewing and commenting on the April 2013 SI work plan.

The following paragraphs evaluate options for drilling, coring, and logging to obtain information about water-bearing joints, fractures, and faults in a limestone formation for the EOD Hill Site Investigation Project. The recent *Site Investigation Work Plan, EOD Hill (April 2013)* includes specifications for the drilling, sample collection, and construction of five, 4-inch diameter PVC monitoring wells completed to approximately 250 feet in depth.

For monitoring wells installed along the base of EOD Hill, the drilling method would include setting temporary or cemented surface casing in the alluvium and drilling with an air-rotary drill until water is encountered, then coring an approximately 4-inch diameter hole approximately 30 feet to total depth.

The New Mexico Environmental Department (NMED) specifically requested oriented core "....or another technology employed in lieu of obtaining oriented core, so that three-dimensional orientation of the geologic and lithologic structures encountered in the boreholes can be accurately determined." (comment No. 4 second NOD Draft Site Investigation Work Plan EOD Hill; dated October 24, 2010). There are two options for collecting the requested information to determine fracture orientation: oriented core and borehole geophysics. Below is a discussion of each method and recommendations for obtaining the information required by NMED.

Option 1 Reflex ACT to achieve oriented core: The Reflex ACT system provides the ability to mark the bottom of the core, all other orientation data is measured, calculated, and recorded by hand. This system requires an angled borehole so the tool can sense the bottom wall of the borehole to provide the orientation. However, the angle can be as small as 2 degrees from vertical. Although the depths to be drilled are not very deep, there is the potential for boreholes to deviate from the original azimuth and inclination. To properly assign fracture orientation, the data would need to be corrected, by hand, for deviation as measured using a borehole alignment survey tool. Reflex ACT offers survey tools that run inside of drill pipe. Surveys conducted inside drill pipe can vary due to pipe flexion resulting in alignment differing from the actual borehole. Surveys conducted in the open hole would likely be more accurate but would require a separate mobilization of the geophysical logger.

Obtaining oriented cores substantially increases the cost of the project. Coring requires two-pass drilling for a pilot/core hole, then a reaming for geophysics and well construction. Rough cost estimates are $40/ft for drilling with air, $75/ft for coring, plus an additional $25/ft for oriented coring, not including alignment surveys. An alignment survey would need to be conducted before the hole was reamed. Hand measuring the fractures and processing the measurements with the alignment data, would be labor intensive and could potentially introduce errors. The advantage of having physical cores is that it allows visible inspection of fracture filling.

Drilling with polymer mud for oriented cores would also hamper borehole videos and geophysical logging by obscuring the borehole wall. This could be overcome by coring, reaming, and then conducting these surveys on a fresh borehole wall after airlift pumping to clear the hole.

Option 2 Borehole Geophysics: Borehole geophysics can provide information on fracture orientation. Geophysics could be conducted after coring and reaming or following a single-pass drilling with air without introducing fluids or drilling mud. After drilling, the borehole would be air-lift pumped until the water cleared. An optical televiewer would be used in the unsaturated part of the hole and in the saturated interval if the fluids were clear. If the saturated interval was muddy, an acoustic televiewer would be used to image the fractures using sound. Both logs provide borehole deviation and corrected orientation of the fractures in a digital format and graphic representations without requiring additional interpretation. The data are ready to be used in stereo nets, rose diagrams or other forms of fracture analysis.

The acoustic televiewer can have trouble distinguishing between calcite filled and open fractures, but the data can be cross correlated with other logs to help interpret the results. Sonic velocity can also provide fracture location and orientation data, and possibly help determine the

occurrence of physical water in a confined aquifer. Caliper logs, E-logs and temperature and fluid resistivity logs would all contribute to the interpretation. Neutron logging would help interpret open water-filled fractures versus sealed fractures. If water is clear, a video log should be run to provide higher resolution images of specific fractures identified on the geophysical logs. Ultimately, the best way to locate transmissive fractures would be to conduct packer tests after reviewing the geophysical data.

Recommendation

We recommend drilling the wells with the single-pass air-rotary methodology and using geophysical logging outlined in Option 2 to obtain fracture density and orientation data instead of using oriented core methodology based on the following:

- The increased cost per foot required for orientated cores and corresponding increased costs for field time;
- Undesirable introduction of fluids during drilling and potential for formation permeability damage when using oriented core methodology;
- Costs required for alignment surveys; measuring, correcting, and processing individual fracture data for oriented cores versus the digital output available from geophysics methods.

Upon review and concurrence from NMED, Section 3.0 of the SI Work Plan, Data Collection Design and Procedures, will be revised with the approved methods. We would appreciate receiving a reply regarding this matter by 15 July 2014, as the contractor is standing by to mobilize to begin monitoring well installation.

Please contact Mr. Cole Crosgrove at (505) 853-3098 or at cole.crosgrove@kirtland.af.mil if you have any questions.

Sincerely

TOM D. MILLER, Colonel, USAF
Commander

cc:
NMED (Mr. Tom Blaine, Environmental Health Division Director)
AFCEC/CZRX(Mr. Oyelowo)
NMED-HWB (Mr. Moats)
NMED-HWB (Mr. McDonald)
EPA Region 6 (Ms. King))
Central New Mexico Community College Montoya Campus
File