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Water Utility Authority

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Technical Memo

To: Kevin Pierard, New Mexico Environment Department, Hazardous Waste Bureau Chief

From: Diane Agnew, Environmental Manager, Albuquerque Bernalillo County Water Utility Authority

CC: Stephanie Stringer (NMED), Mark Kelly (Water Authority)

Date: 11/19/2020

Re: Analysis of Groundwater Monitoring with Passive Diffusion Samplers

Introduction

Groundwater monitoring at the Kirtland Air Force Base (AFB) Bulk Fuels Facility (BFF) project site has been monitored on a quarterly basis since 2001, when the first groundwater monitoring well was installed and sampled. From 2001 until early 2016, the groundwater monitoring wells were sampled using a low-flow sampling technique that consisted of the use of portable and dedicated Bennett pumps. Portable pumps were required for wells in the source area due to issues with corrosion of pumps and pump components if low-flow pumps remained in wells for weeks at a time. The low-flow technique involved the measurement of field parameters (e.g., pH, dissolved oxygen, turbidity, etc.) and purging of three or more well casing volumes in order to ensure samples were representative of the groundwater at the well.

During this timeframe, the list of analytes for samples was consistent across the entire well field, and from quarter-to-quarter, allowing for an understanding of not only the lateral and vertical nature of groundwater contamination, but also the temporal trends. The Quarter 4 (Q4) 2015 quarterly report was the last time monitoring results and maps for the entire groundwater monitoring network were published for all four quarters using the low-flow technique and for the same analytes. Based on groundwater monitoring data collected through Q4 2015, with the caveat that the full extent of the groundwater contamination was not delineated, the ethylene dibromide (EDB) plume length was approximately 6,850 feet (Kirtland AFB, 2018). The thickness estimated by the Air Force for the EDB plume ranged from 40-55 feet (Kirtland AFB, 2018); the full vertical extent of the EDB plume remains a critical data gap at the site.

In 2016, the Air Force and their contractors proposed to the New Mexico Environment Department (NMED) that groundwater sampling methods be transitioned to a passive sampling technique with the deployment of passive diffusion bags in groundwater monitoring wells located north of Ridgecrest Drive. Technical working group (TWG) members considered the request and reviewed the findings of an evaluation study the NMED required Kirtland AFB to complete prior to approval of the use of passive diffusion bags (PDBs). The evaluation study was required to address two crucial areas: 1) the comparability of data collected from PDBs with the historic Bennett pump data for a given well; and 2) the potential vertical variability of analytes in a well column and the potential for the passive sampling technique to “miss” zones of higher concentration. Additionally, the TWG and NMED expressed concern over the deployment of the PDBs in wells that historically had light non-aqueous phase liquid (LNAPL). The result of the verification test was that the NMED approved Kirtland AFB to deploy PDBs in a select number of wells but did not approve expansion of the sampling technique to the entire groundwater monitoring well network.

Concurrent with the request to deploy PDBs, the Air Force also made changes to the quarterly groundwater monitoring program, calling for optimization of the groundwater monitoring program. The changes included a change in frequency of sampling, and the analytes reported for a given well in a given quarter. The only quarter where all groundwater monitoring wells site-wide are sampled for the complete list of volatile organic compounds (VOCs), EDB, metals, anions, and alkalinity is in the fourth quarter of the year. For example, in Q2 2020, "water table" well KAFB-106001 was sampled for EDB, metals, anions, and alkalinity; whereas "water table" well KAFB-106002 was sampled for BTEX (benzene, toluene, ethylbenzene, and xylenes), EDB, metals, anions, alkalinity, and field parameters. It is not clear how this may affect plume concentration contours. Additionally, 96 of the 162 groundwater monitoring wells are not sampled in Q1 and Q3 of the year. This means that for half of the year, 59 percent of the network is not sampled. Further, when the 96 wells are sampled, they are not sampled for a uniform set of compounds. The variability in frequency and analytes from quarter-to-quarter results in uncertainty and limits the ability to look at plume-wide trends.

A compounding and potentially complicating factor in the deployment of PDBs at the BFF project site is the rising groundwater table. Because of the Water Authority's addition of surface water to meet demand, as well as its conservation efforts, groundwater levels have steadily been rising in the aquifer at a rate of as much as three feet per year in some areas. The result is that the groundwater conditions at the site are dynamic; and the groundwater monitoring well network has a limited ability to monitor for and track the extent and migration of groundwater contamination. The passive sampling technique is by nature a static approach to monitoring groundwater quality; and therefore, the use of this technology may limit the ability for evaluating concentration trends at the site under non-equilibrium conditions.

This technical memo summarizes the findings of the Water Authority's continuous review of groundwater monitoring data reported in the Kirtland AFB quarterly monitoring reports for the site. Our analysis went into the history of deployment of PDBs at the site with the expansion of the sampling technique beyond wells approved by NMED on February 28, 2018; as well as how the deployment of this passive technique may be impacting concentration trends, and the understanding of the nature and extent of groundwater contamination at the site.

Rising Water Table and Submerging Wells

The Air Force presents the decreasing concentration trends for EDB as evidence of the successful performance of the groundwater pump and treat interim measure. In the case of benzene, by contrast, the Air Force is using the decreasing concentration trends as evidence that benzene is degrading over time. The Air Force does not acknowledge the effect of the rising water table on groundwater concentrations for either of the contaminants in wells that become submerged. Generally, the EDB at the site travels with groundwater; so, as the water table rises the EDB plume would likely also rise. Additionally, at the BFF site the highest concentrations of EDB have occurred at the water table. A well that is unable to sample at the water table will also be unable to measure EDB concentrations at the water table.

Analysis of contaminant concentrations in groundwater monitoring wells that are screened across the water table, as compared to adjacent water table wells with submerged screens, reveals evidence that the submergence of wells is the more likely explanation for the change in contaminant concentrations. For example, analysis of the replacement water table well, KAFB-106S1, compared to the adjacent, older and submerged well, KAFB-106076, shows the new water table well (KAFB-106S1) has detected contaminant concentrations at or even above historic maximum concentrations from KAFB-106076 (Figures 1a and 1b). There are additional instances where the contaminant concentrations exceed historic maximums in the newly-installed water table wells adjacent to submerged wells used by the Air Force to represent the water table.

The Kirtland AFB BFF quarterly reports include figures that display analytical results for EDB and benzene, including a figure that represents contaminant concentrations at the water table. The figures representing the water table appear to include groundwater monitoring wells with both screens across the water table, and with screens submerged below the water table. Incorporating results from submerged groundwater monitoring wells is an inaccurate representation of the plume at the water table that almost certainly underestimates the concentrations within the plume and the corresponding contours. Additionally, it is not clear which wells are used to generate the plume contours; and inclusion of the wells not used for contouring on the figures misrepresents which wells were used to contour the data.

In addition to the submergence of water table well screens over time, the Water Authority analysis found that the depth of samples also changed and were collected at depths as much as 40 feet below the water table. Table 1 summarizes the wells used to present plume conditions at the water table (Kirtland AFB, 2020); along with the height of the water table above the top of screen, and additionally, the height of the water table above the depth of the sample.

The Air Force presents its groundwater monitoring data based on three reference intervals to represent the vertical extent of groundwater contamination at the site: reference interval (REI) 4857 feet for the "water table" shallow plume, REI 4838 feet for the intermediate plume, and REI 4814 for the deep plume. Figure 2a includes the groundwater monitoring wells from Figure 3-5 from the Q2 2020 quarterly report that are reported as being representative of the water table (REI 4857), and removes wells that are submerged and no longer screened at the water table. Using groundwater elevation data from Q1 2016 through Q4 2019, the average annual water table rise is 3.3 feet (KAFB AFB 2019); Figure 2b illustrates the wells that will remain screened at the water table after applying this rate of change for two years. Table 2 summarizes the number of wells that remain non-submerged, and therefore, representative of plume concentrations at the water table.

Table 2 Summary of Non-Submerged and Submerged Groundwater Monitoring Wells Designated as "Water Table" Wells

Date	Number of Non-submerged "Water Table" Wells	Number of Submerged "Water Table" Wells	Maximum Water Table Height Above Well Screen (feet)	Maximum Water Table Height Above Sample Point (feet)
Q4 2019	28	55	23.1	28.0
Q2 2020	23	60	26.4	40.6
Q4 2021*	21	62	NA	NA

* Number of submerged and non-submerged wells estimated using an average annual water table rise of 2.1 feet.

NA Not applicable

The disparity in detected contaminant concentrations between wells screened at the water table and those with screens submerged are a cause of great concern in the application of analytical results to depict water table plume concentrations. Moreover, the findings of the analysis indicate that caution should be used when relying on concentration trends as a metric for evaluating performance of the pump-and-treat interim measure. Analytical results from wells currently submerged and those that will become submerged, reduce or potentially inhibit the ability to accurately compare analytical results both temporally and spatially, and are likely to fail to detect areas of higher concentrations.

Passive Sampling

The BFF project started evaluating the use of passive samplers including passive diffusion bags and dual membrane samplers to monitor fuel constituent contaminants at the site in 2016. The evaluation period included groundwater monitoring wells at the EDB plume edges, in the source area, and a background location during Q2 and Q4 of 2016. Passive sampling was extended beyond the initial evaluation wells to all downgradient proximal wells in Q2 2017, and nearly all wells north of Ridgecrest Drive by Q4 2017. In the December 20, 2017 Data Gap Monitoring Well Work Plan, a table of 12 wells (KAFB-106240, KAFB-106241, KAFB-106242, KAFB-106243, KAFB-106244, KAFB-106245, KAFB-106041, KAFB-106149-484, KAFB-106151-484, KAFB-106152-484, KAFB-106153-484, and KAFB-106211) was listed for passive monitoring at the site; all other wells were to be sampled by low-flow sampling techniques. The Data Gap Monitoring Well Work Plan, with the 12 listed wells for passive monitoring, was approved in a February 28, 2018 NMED letter. Passive monitoring occurred site-wide at 104 wells out of the 161 groundwater monitoring wells sampled in Q2 2020 (Figure 3). The Water Authority was not able to find any written correspondence from NMED approving passive sampling to occur beyond the approved 12 wells. The expansion of the use of passive monitoring to 104 groundwater monitoring wells is 92 more wells than that which the NMED approved in their February 28, 2018 letter.

During the evaluation period, the Air Force calculated the relative percent difference (RPD) of the results of samples collected using the Bennett pump versus the results from passive samplers. During the evaluation phase for passive sampling in 2016, a maximum RPD of 20% was reported to be acceptable in the Q2 2016 report. A RPD of 35% or less was then determined to be acceptable in the Q4 2016 where data showed RPDs of 35% or less. An acceptable RPD between sampling methods has not been identified or approved by either the February 28, 2018 NMED letter or any other NMED correspondence. The tables included with the Q2 2016 and Q4 2016 quarterly reports do not include the RPDs calculated to show the differences between sampling locations, so it is not clear which wells exceeded the 20% or 35% thresholds. The RPD was last reported in Q4 2016 for the passive sampling evaluation study and in Q2 2017 for the side-by-side passive diffusion bag and dual membrane sampler study. The difference in the sampling method used could result in a data point being above or below project screening levels with the potential to bias the data.

During the initial evaluation of passive diffusion bags, several locations in the source area were used to demonstrate the effectiveness of this method. These sites were reported in the Q4 2016 report to have an RPD of greater than 35%, and therefore, were not deemed appropriate for passive sampling. The Q2 2020 report includes 21 wells in the source area that are sampled using passive samplers rather than low-flow sampling techniques. This represents a change in sampling technique not supported by the large RPD found in the evaluation period and one that goes against the technical recommendations in the December 2014 guidance document *Passive Sampling for Groundwater Monitoring: Technology Status* (Stroo, H.F. et al., 2014).

A July 11, 2020 NMED letter with comments on the Q2 2019 report stated that passive sampling is not appropriate for wells where LNAPL was previously detected. LNAPL was detected in KAFB-106005 in Q3 2016 and has historically been detected in nearby groundwater monitoring wells KAFB-106009 (135 feet north-northeast); KAFB-106059 (360 feet southwest); and KAFB-106079 (360 feet east-northeast). In Q2 2020, KAFB-106005 was sampled using a passive sampler; no LNAPL was present in the well in Q2 2020. The recently installed KAFB-106S4-446 well (30 feet north-northwest of KAFB-106005) was also monitored passively in Q2 2020. Further, KAFB-106079 was passively sampled in Q2 2020.

Although no LNAPL was present in Q2 2020, KAFB-106079 is a source area well having frequent LNAPL detections in the project history including a recent LNAPL detection in Q2 2019. Figure 4 shows wells that were passively sampled in 2020 and wells with historical LNAPL detections. LNAPL detections in source area wells have increased over the last year according to the quarterly reports. The Water Authority has been unable to ascertain the protocol the Air Force is using to determine which wells with historical LNAPL detections are appropriate for passive sampling. Additionally, it is unclear why source area wells in the immediate vicinity of a well with LNAPL detected or previously detected are being passively sampled. It is critical to understand how the Air Force is applying passive sampling to wells in the source area so data collected can be utilized appropriately for decision making about remediation of contamination in the source area.

It remains unclear the depth that passive samplers are being placed in each well; multiple samplers are used each quarter in a given well to sample the different analyte groups (e.g., EDB, volatile organic compounds, etc.) and the string stretches across the length of the well screen. The Quality Assurance Project Plan (QAPjP) for the Bulk Fuels Facility Groundwater Treatment System and Groundwater Monitoring (Revision 3) states the midpoint of the uppermost passive diffusion bag will be set to two feet below the top of the screened interval if the well is submerged.

It is also unclear where certain water quality constituents are monitored within the well because the location on the passive diffusion sample string changes from quarter to quarter. Appendix E-1 from the Q4 2016 (Kirtland AFB, 2017b) report showed graphics with passive diffusion bags meant for organics analyses placed around the midpoint of the screened interval for a well, whether submerged or not. Field monitoring sheets attached to the QAPjP from December 20, 2017, showed sampling schematics for passive sampler strings with organics analyses placed at the top of the string. The variation in placement of the passive samplers inside the well begs the question whether the data are comparable from quarter to quarter for wells with passive sampling. Additionally, placement of the passive samplers in a submerged well screen is an important consideration for both the comparability of data from quarter-to-quarter, as well as the depth interval the results are being used to represent.

Passive samplers placed in submerged wells are not accurately capturing water quality conditions at the water table. In Q2 2020, 56 of the 83 wells with passive diffusion bags were screened at the water table (reference interval 4857 feet) and 33 of those 56 wells (59%) were submerged, meaning that the passive diffusion bags were set to a depth below the water table and are, therefore, not representative of aquifer chemistry at the water table. Contamination contours for the shallow reference interval (4857 feet) determined with passive samples taken from submerged wells may not be an accurate representation of contamination at the Bulk Fuels Facility spill.

Additionally, wells sampled with passive samplers do not have field parameters measured during the sampling event; this means that field conditions for the plume are determined by only 57 wells where low-flow sampling is still utilized by the 161 groundwater wells in the monitoring network sampled in Q2 2020. All 57 wells with field parameters in the Q2 2020 monitoring event were located south of Ridgecrest Drive. Source area wells monitored with passive samplers may not accurately represent contaminant concentrations, and therefore, may influence understanding of plume extent and concentrations.

Lateral and Vertical Extent of Groundwater Contamination

Groundwater concentration contour maps included in the Kirtland AFB quarterly reports for the BFF project continue to exclude all detected concentrations of analytes. For example, Figure 3-5 of the Q2 2020 quarterly report contours concentration data to the maximum contaminant level (MCL) of 0.05 micrograms per liter (ug/L) for EDB but does not address the five detections of EDB that are less than the MCL. Additionally, there was a detection of EDB above the MCL at KAFB-106041, with a detected concentration 0.054 ug/L, that was not included in the plume contours. All detections, including those below the MCL, are important for the understanding of plume migration and concentration trends. Additionally, it is the Water Authority’s continued position that the groundwater must be fully remediated to non-detect concentrations; and no concentration of fuel constituents is acceptable in our customers’ drinking water source.

Summary and Recommendations

The Water Authority’s analysis of groundwater monitoring techniques and data at the Kirtland AFB BFF site found several issues that the Air Force should address before the start of corrective measures evaluation, in order to ensure the proper selection and design of a remedy(ies) to address groundwater contamination:

- The continued submergence of wells screened across the water table results in a reduction of wells that can be considered representative of plume concentrations at the water table.
- The REIs reported by the Air Force have not been adjusted in the past four years despite a nearly eight-feet increase in groundwater levels. As a result, the REI assigned to represent the deepest portion of groundwater contamination is likely biased low, and therefore, not a definitive indicator of the depth of contamination.
- The Air Force is currently using passive sampling at 102 wells despite having NMED approval for only 12 wells. This means that 90 wells are currently sampled with an unapproved sampling methodology. Additionally, there is not an NMED approved RPD that can guide the deployment of this sampling approach.
- The transition from low-flow sampling techniques to the passive sampling has further reduced the ability to accurately determine water table plume concentrations. There are two categories of wells where this limitation occurs:
    1. Non-submerged "water table" wells where the passive sampler is placed below the zone of highest EDB concentrations; and
    2. Submerged "water table" wells where the passive sampler is not only below the water table, but also at a depth lower than depth placement prior to well submergence.
- Concentration trends in wells that have become submerged over time and/or changed to passive sampler techniques cannot be directly attributed to the success of the groundwater pump-and-treat interim measure.
- The comparability of low-flow sampling results to passive sampling results is not supported by the high RPDs (greater than 35%).
- Passive samplers are being deployed in wells that currently or historically have had LNAPL measured, a change that goes against the recommendations of technical guidance for the sampling technique.
- The switch to passive samplers has resulted in a loss of field parameter data, reducing the ability to analyze key groundwater conditions such as redox.

The estimated EDB plume thickness presented by the Air Force is 40-55 feet (Kirtland AFB, 2017). In the Water Authority's analysis, samples from some wells are from depths as much as 40 feet below the water table. The net result is that the samples may have low to non-detect concentrations for EDB because they are sampling from below the plume. Therefore, it can appear that the groundwater concentrations are decreasing, and the effectiveness of the pump and treat system can be overstated. It is crucial that the Air Force collect representative data to use in the evaluation of groundwater concentration trends and the performance evaluations of the treatment system.

The Water Authority's analysis presented in this memo does not explore the fact that not all of the monitoring wells are analyzed for the complete analyte list for fuel contaminants or that the entire well network is not sampled every quarter. Further complicating the picture of groundwater conditions is the fact that not all wells are sampled for the same analytes within a given quarter. The Water Authority recommends a separate analysis into the variability of sampling suites within a given quarter, and from quarter-to-quarter.

Understanding the extent of groundwater contamination at the BFF site is critical for the evaluation, selection, and design of the final remedy for groundwater contamination. It is also crucial that the Air Force accurately represent data for the site and avoid making decisive statements about the effectiveness of pump and treat unless they have addressed the potential influence of factors, such as the rising water table on measured plume concentrations. Incorporating results from submerged groundwater monitoring wells is an inaccurate representation of the plume at the water table that almost certainly underestimates the concentrations within the plume and the corresponding contours. A failure to adequately constrain the extent of contamination has the potential for contaminants, such as EDB, to continue to migrate and pose a risk to nearby water supply wells.

References

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