New Mexico Environment Department

2017 Strategic Plan

Kirtland Air Force Base Fuel Leak

Project Collaborators:

New Mexico Environment Department

U.S. Air Force Civil Engineering Center

U.S. Air Force, Kirtland Air Force Base

U.S. Army Corps of Engineers

U.S. Environmental Protection Agency

City of Albuquerque, Environmental Health Department

Albuquerque-Bernalillo County Water Utility Authority

New Mexico Bureau of Geology

U.S. Geological Survey

FINAL

Version 4.0, April 2017

A PARTNERSHIP FOR SUCCESS

A collaborative technical team is solving the complex hydrogeologic and engineering challenges posed by the fuel leak, with support from Albuquerque's neighborhood and citizen's groups.

US Army Corps of Engineers

Sundance Consulting Inc.

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Albuquerque City Council

Christ United Methodist Church

HAWLEY GEOMATTERS

Thomson and Associates

Westside Coalition Neighborhood Association

District 6 Coalition of Neighborhood Associations

A Message from NMED Cabinet Secretary Butch Tongate:

Cleaning up the Kirtland Air Force Base fuel leak continues to be one of our state's top environmental challenges and a top priority for this administration. Although plagued in the early days with a lack of coordination, characterization, and follow-through--since 2010 we have been pulling together with partners, launching a cleanup system that is showing real results. All of this was accomplished while communicating with the public, every step of the way, through meetings, town halls, online stats, and reports such as this one .

A core part of the cleanup at KAFB is the groundwater pump & treat system. This pumping activity pulls contaminated water out of the aquifer, then it travels through pipes to the treatment plant that was designed and built specifically to remove ethylene dibromide (EDB). During the next year or two, more evidence of plume capture as well as decreasing EDB concentrations and shrinkage of the contamination zone are expected.

As described in this Strategic Plan, we have a very ambitious agenda planned for 2017 with the U.S. Air Force. The groundwater treatment system will be expanded, and testing of various new cleanup technologies will be conducted, so that our work is as effective as possible, using the most innovative strategies

The Air Force brought in top tier talent so that we could scale up and apply cleanup techniques that were identified as effective in promising laboratory microcosm studies. These techniques involve a strategy called bioremediation in which microorganisms consume and break down environmental pollutants in order to clean up a polluted site. Albuquerque will become the first location in the world for successful bioremediation of EDB in groundwater at this scale, and lab results indicate a high probability for success in the field.

The information gained from these and other cleanup activities and tests will be described in a forthcoming report that the Air Force will submit to NMED in 2017 for our review and approval. If approved, the report's findings will help to guide continuing cleanup decisions that will bring about the suite of final corrective actions.

NMED is especially pleased that in 2016 several more neighborhood stakeholder groups joined the team of organizations working cooperatively with us, the Air Force, the City of Albuquerque, the U.S. Environmental Protection Agency, and the Albuquerque-Bernalillo County Water Utility Authority as we work together to coordinate and clean up this fuel leak in the safest, most effective manner possible.

Sincerely ,

Butch Tongate

Butch Tongate

Secretary of Environment

Table of Contents

The New Mexico Environment Department (NMED) 2017 update to the Strategic Plan continues our roadmap for aggressively remediating soil and groundwater at the Kirtland Air Force Base (KAFB) fuel site throughout this year. The 2017 Strategic Plan summarizes accomplishments in 2016 and presents data-driven strategies for continued progress of our goal throughout 2017.

One Goal, Three Strategies

GOAL: Protect Albuquerque's aquifer and drinking water supply wells in the area from contamination associated with the Bulk Fuels Facility fuel leak.

STRATEGIES TO ACHIEVE THE GOAL:

1) **Implement a robust site monitoring and wellhead protection program.**
   Compliance monitoring (soil vapor and groundwater) for the Resource Conservation and Recovery Act (RCRA) permit, and monitoring of sentinel wells and water supply wells.

2) **Deploy multiple cleanup technologies, both simultaneously and sequentially, to cleanup soil and groundwater.**
   Continued operation of the groundwater treatment system to collapse the dissolved-phase ethylene dibromide (EDB) plume; launch pilot tests for aerobic and anaerobic in-situ biodegradation of groundwater contamination; and launch bioventing pilot test for remediation of source area soil contamination.

3) **Meet or exceed all requirements for providing public information and involvement.**
   Our continued effort to increase transparency and exceed requirements for public information and involvement.

Details of these strategies are outlined in the following pages.

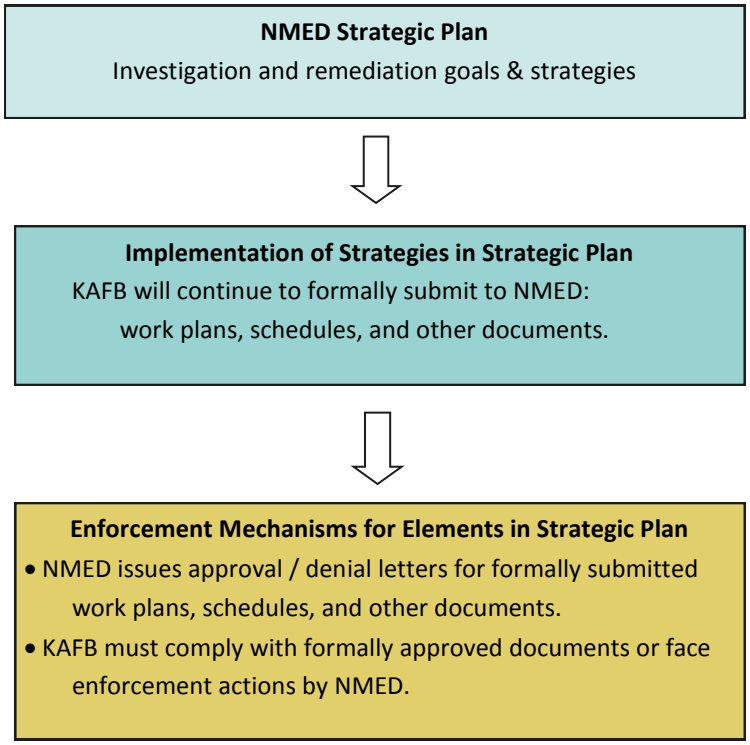
The NMED developed this Strategic Plan to provide a clear vision on how to continue to advance the fuel cleanup during 2017. The Strategic Plan continues to be a guide to the various strategies currently in place, being actively implemented, as well as strategies that have been identified by the technical working groups as viable measures to implement. The strategies discussed in the 2017 Strategic Plan have been revised to better reflect the key initiatives NMED will be driving in the next year to aggressively continue progress on fuel remediation in both the source area and downgradient dissolve-phase EDB plume.

The strategic plan includes the following key sections:

- Projection Accomplishments in 2016
- Introduction
- Regulatory Framework
- General Project Timeline
- Discussion of the three strategies

Appendix A of this 2017 Strategic Plan includes acronyms with their respective definitions as well as a glossary of terms. Appendix B contains links to additional technical information and resources, Appendix C is the risk dashboard and garden fact sheet developed for the BFF site, and Appendix D contains information on the technical working groups.

The NMED Strategic Plan is not an element required by the RCRA process; we developed it as a reference and planning document. It is not an enforceable document under RCRA or any other regulatory authority. The strategies presented in the 2017 update to the Strategic Plan are accomplished by the U.S. Air Force (Air Force) submitting regulatory documents for NMED approval. The following figure shows the relationship between the regulatory framework and the Strategic Plan.



Increasing transparency and public involvement is a primary goal. The NMED values public involvement and comments. This final version of the 2017 Strategic Plan incorporates changes in response to public comments received on the draft posted earlier this year. A draft Strategic Plan for calendar year 2018 will be issued in December 2017.

Project Roles and Responsibilities

Collaborative efforts at the local, state, and federal levels from agencies, contractors, neighborhood associations, legislators, and other interested stakeholders have greatly contributed to the accelerated project work since 2014.

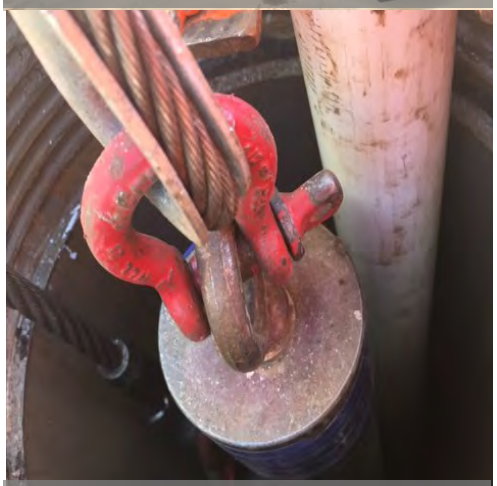
The NMED is the primary regulatory authority for this site's corrective action. Additional regulatory authority is held by the City of Albuquerque Environmental Health Department. The Air Force is the party responsible for conducting the site's corrective action and is actively doing so through the Air Force Civil Engineer Center and a wide variety of expert contractors. Additional information on roles, responsibilities, and project partners is available at the NMED website under About the Project - Project Partners.

In December of 2015, the NMED and Air Force executed a Memorandum of Agreement (MOA) that reimburses NMED for costs associated with oversight of the KAFB Bulk Fuels Facility (BFF) leak site. The MOA allows for reimbursement for up to $250,000 per year for three years in order to fund continuing regulatory activities associated with clean-up of the jet fuel leak. The funding through this agreement will help ease the financial burden associated with providing the dedicated regulatory oversight and review required by a project as complex and extensive as the KAFB BFF fuel leak site.

Project Accomplishments in 2016

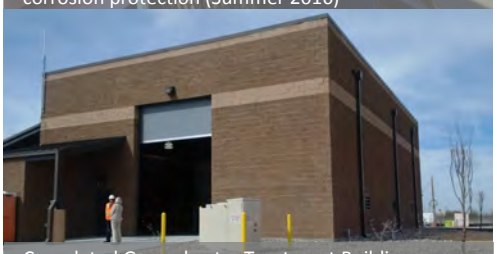
In 2015, NMED and the Air Force closed data gaps in the northeastern extent of the EDB plume, continued progress on collapsing the EDB plume, and conducted laboratory and field studies to identify technologies to remediate the source area. Specifically, the following work was completed on the four strategies outlined in the 2016 Strategic Plan:

Using ARCH drill groundwater monitoring well



Nested wells during construction (Fall 2016)

Installation of anode on extraction well pump for corrosion protection (Summer 2016)



Completed Groundwater Treatment Building (Spring 2016)

Site Monitoring and Wellhead Protection (Strategy 1)

- ✓ Drilled 2 new, nested groundwater monitoring wells to address a remaining data gap at the northwestern extent of the EDB plume.
- ✓ Monthly testing of drinking water wells continued to show no detectable fuel contaminants.
- ✓ Optimization of quarterly sampling for groundwater and soil vapor.
- ✓ Completed a comprehensive surveying of all monitoring wells across KAFB to improve well coordinate survey data accuracy.
- ✓ Conducted a validation study to evaluate the application of passive diffusion samplers in order to optimize sampling costs and waste management.

Source Area Remediation (Strategy 2)

- ✓ Continued the soil vapor rebound and biorespiration testing.
- ✓ Submitted a work plan for an In Situ Bioremediation Pilot Test to evaluate effectiveness of enhanced biodegradation of EDB.

Groundwater Remediation (Strategy 3)

- ✓ Continued extraction and treatment of EDB-impacted groundwater as part of the EDB plume collapse interim measure.
- ✓ Submitted a work plan for the drilling of a 4th extraction well and expansion of the groundwater treatment system (GWTS).
- ✓ Drilled a 4th extraction well for expansion of the EDB plume collapse IM.
- ✓ Expanded the treatment capacity of the GWTS.
- ✓ Treated water used for irrigation at the KAFB Golf Course.
- ✓ Completed a gravity-fed injection pilot test at KAFB-7.
- ✓ Draft Discharge Permit (DP)-1839 posted for public review and comment for gravity-fed injection at KAFB-7 and up to 4 additional injection wells for discharge of treated water.
- ✓ Conducted field and laboratory sampling to troubleshoot fouling issues at the GWTS and extraction well KAFB-106233.

Inside GWTS building with four 20,000 pound GAC tanks.

Public Outreach and Participation (Strategy 4):

- ✓ Creation of an animation of the BFF project site and conceptual model.
- ✓ NMED and KAFB held 3 joint public meetings in April, July, and November.
- ✓ Participation in 12 presentations to Neighborhood Associations, university seminars, and professional societies.
- ✓ Presented site information and data to Highland High School Advance Placement Chemistry and Environmental Science students.
- ✓ Conducted a public field trip in April.
- ✓ Hosted a booth at the International District Fair in September to allow direct access to NMED and Air Force experts.
- ✓ KAFB completed public surveys and interviews to gauge interest in a possible a Restoration Advisory Board.
- ✓ Hosted a technical workshop in November for the public, providing access to NMED and Air Force experts for detailed discussions of data and technical topics.
- ✓ Development of gardening fact sheet and risk dashboard.

Mr. Bitner (Air Force) and participant at the International District Fair (Sept. 2016)

Mr. McQuillan talking with participants at the KAFB Golf Course Main Pond on a public field trip (Apr. 2016)

Introduction

The BFF at KAFB became operational in 1953 and has been used over time for the storage of aviation gasoline (AvGas), jet propellant 4 (JP-4), jet propellant 8 (JP-8), and smaller amounts of diesel fuel and unleaded gasoline. Initially, fuel was delivered to the facility via railroad until deliveries were transition to tanker truck sometime between 1986 and 1991. Fuel was offloaded to the Former Fuel Offloading Rack (FFOR), pumped through underground pipelines to the pump house, and then to large fuel storage tanks at the BFF. The leaks were discovered in 1999 when a BFF worker noticed fuel staining on the ground surface at the FFOR. In order to investigate the leak, pressure testing of the two underground pipelines was performed; both pipelines failed pressure testing. Due to the combination of the variation in gain and loss totals from 1996 to 1999 (the facility was only required to keep records for the preceding three years), the uncertainty in the metering of the original fueling infrastructure, and the uncertainty in the year that the releases began it is not possible to develop an estimate of the total fuel leaked at the BFF site.

The leaked fuel in the ground is referred to as light non-aqueous phase liquid (LNAPL), which includes liquid compounds that are not water, that do not dissolve in water, and are less dense than water. Once in the ground surface, the LNAPL traveled downward due to the force of gravity through approximately 480 feet of vadose zone. The vadose zone is the part of the earth between the ground surface and the water table (also called the unsaturated zone). As the LNAPL moved through the vadose zone, constituents of the LNAPL partitioned into different phases:

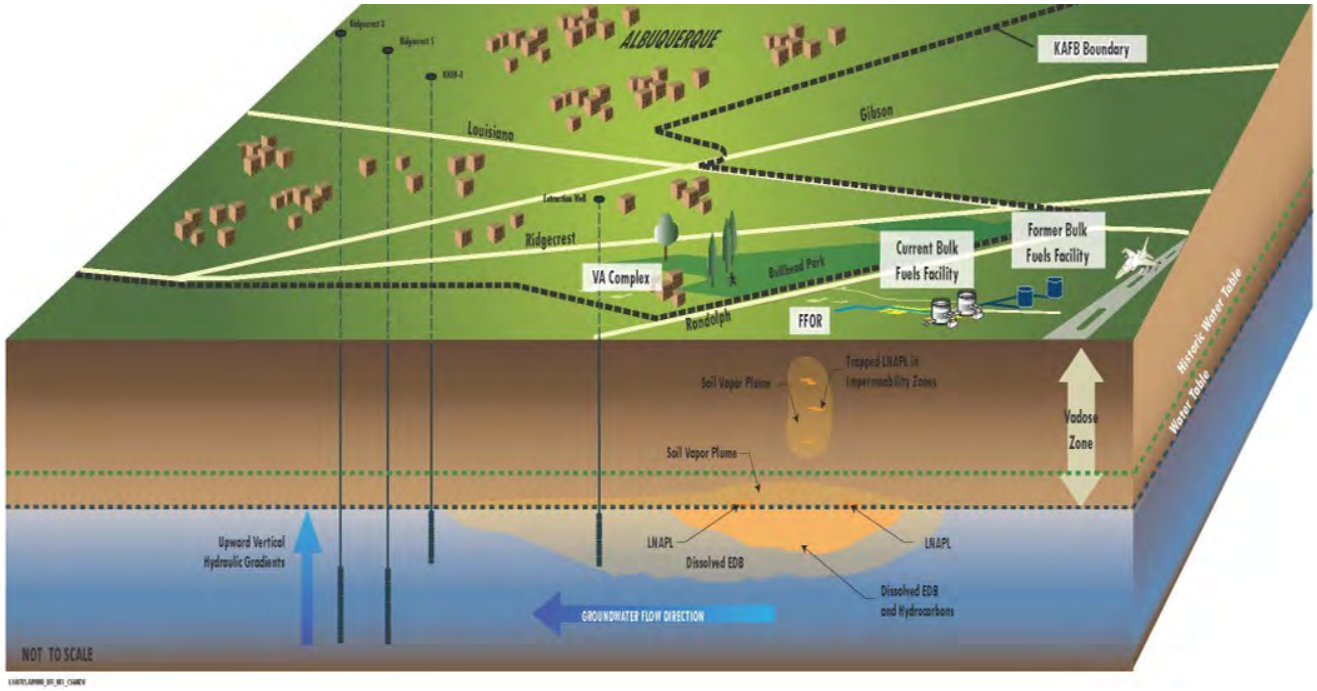
- LNAPL residual fuel;
- Soil vapor (lighter fuel constituents as vapor in soil);
- Adsorbed contaminants (fuel constituents attached to soil particles); and
- Dissolved contaminants (fuel constituents in groundwater).

The leaking LNAPL migrated down to the water table, creating a layer of floating LNAPL that depressed the water table. Constituents in the LNAPL dissolved into groundwater resulting in plumes of groundwater contamination. Due to increased use of groundwater by a growing Albuquerque population, water levels were decreasing when the LNAPL reached the water table. As the water table lowered, the LNAPL continued to travel downward, following the receding water table. In 2009, groundwater conservation efforts were implemented by the Albuquerque Bernalillo County Water Utility Authority (Water Authority) and the water table began to rise. As the water table increased, the LNAPL has become submerged and trapped within the groundwater. This “drowned” LNAPL may still be a source for dissolved EDB and other contaminants into the groundwater though data indicates that the contribution is at equilibrium.

As of the 4th Quarter 2015, the Shallow Zone EDB plume is approximately 6,860 feet long and ranges from 500 to 1,150 feet wide with a maximum EDB concentration of 93 micrograms per liter in the source area. The highest concentrations of benzene and EDB in soil vapor were measured near the FFOR at 840 parts per million volume (ppmv) and 26 ppmv, respectively.

The aquifer contains naturally occurring upward vertical hydraulic gradients. These upward gradients mean that deep groundwater, such as in the zones tapped by drinking water wells, moves upwards into shallower aquifer zones. The upward gradients help to prevent the fuel contamination from moving downward, and offer some protection of the drinking water wells.

Conceptual Diagram of the KAFB Fuel Leak



The conceptual diagram illustrates the nature and extent of fuel-related contamination across the site. Fuel originally floated on the water table but has, over time, become submerged as regional groundwater levels rise. The LNAPL migration path through the subsurface was influenced by the local geology, the properties of the compound and soil, and the height of the water table over time. This conceptual site model continues to be evaluated as data is collected and data gaps are closed.

Benzene and other hydrocarbons are readily biodegraded by native groundwater bacteria. EDB is biodegrading only in the presence of biodegrading hydrocarbons. Once the EDB has migrated beyond the area of hydrocarbon contamination, there is currently no evidence of EDB biodegradation. However, there is stable isotope data that indicates abiotic hydrolysis is occurring, potentially playing a role in the stability of the EDB plume. Understanding the biodegradation of EDB in groundwater is currently an area of interest for technical working groups at this site.

Multiple measures have been implemented in the source area to remove mass of fuel contamination. Almost 5,000 tons of soil contaminated with fuel constituents has been removed through three separate excavation events between 2000 and 2014. Four years of bioslurping significantly reduced the amount of residual LNAPL. Soil vapor extraction (SVE) was initiated in 2003 and vacuumed approximately 570,000 gallons of fuel from soil in the source area. The operation of SVE also facilitated biodegradation of an additional 200,000 gallons of fuel for a total of 770,000 gallons of fuel.

In 2015, an interim measure began operation to address the dissolved-phase EDB groundwater plume. The groundwater pump and treat system was designed to:

- ⇒ Stop migration of EDB towards drinking water wells;
- ⇒ Extract and treat EDB contaminated groundwater; and
- ⇒ Collapse the EDB plume back towards the KAFB boundary.

Beginning in March 2015, a cone of depression was observed in groundwater levels, resulting from the operation of the first three groundwater extraction wells. This cone of depression was the first line of evidence of EDB plume capture and collapse. References for additional technical information are attached in Appendix B.

The NMED has regulatory authority to administer the federal Safe Drinking Water Act (SDWA) program and the RCRA hazardous waste program. In addition to the SWDA and RCRA, site characterization and remediation actions must comply with other applicable laws and regulations such as the NM Water Quality Control Commission (WQCC) Regulations, New Mexico Air Quality Standards, and Office of the State Engineer Regulations. As such, permits are required from NMED, the Office of the State Engineer, and Albuquerque Environmental Health Department depending on the specific planned activity.

Regulatory documents submitted to the NMED by the Air Force are posted to the project websites and are available to the public (Appendix B).

Safe Drinking Water Act

One of NMED's SWDA responsibilities is to require that public water systems supply drinking water to consumers that complies with the United States Environmental Protection Agency (EPA) Primary (human health based) Maximum Contaminant Levels (MCLs).

Resource Conservation and Recovery Act

Site investigation and cleanup activities of the jet fuel leak at KAFB follows a specific regulatory process known as Corrective Action. This process is spelled out in state and federal regulations, as well as in provisions in Part 6 of the KAFB Hazardous Waste Treatment Facility Operating Permit (RCRA permit). The RCRA process will end when cleanup (corrective action complete) is achieved.

Cleanup Levels for BFF

The KAFB RCRA Permit defines the cleanup standards that KAFB is required to use for remediation of soil and groundwater the BFF site. In the case of groundwater, cleanup levels must be the WQCC water quality standards and the EPA MCLs, whichever is the lowest. The table below summarizes the WQCC water quality standard and EPA MCL for the constituents of concern for the BFF project; the ***bold italic*** font denotes the cleanup standard being applied per the permit. This list of COCs is based on groundwater samples with concentrations greater than ether the WQCC water quality standard or EPA MCL. Additionally, soil cleanup must meet the screening levels defined by the NMED in the most current version of Table A-1 in the *NMED Risk Assessment Guidance for Site Investigations and Remediation*.

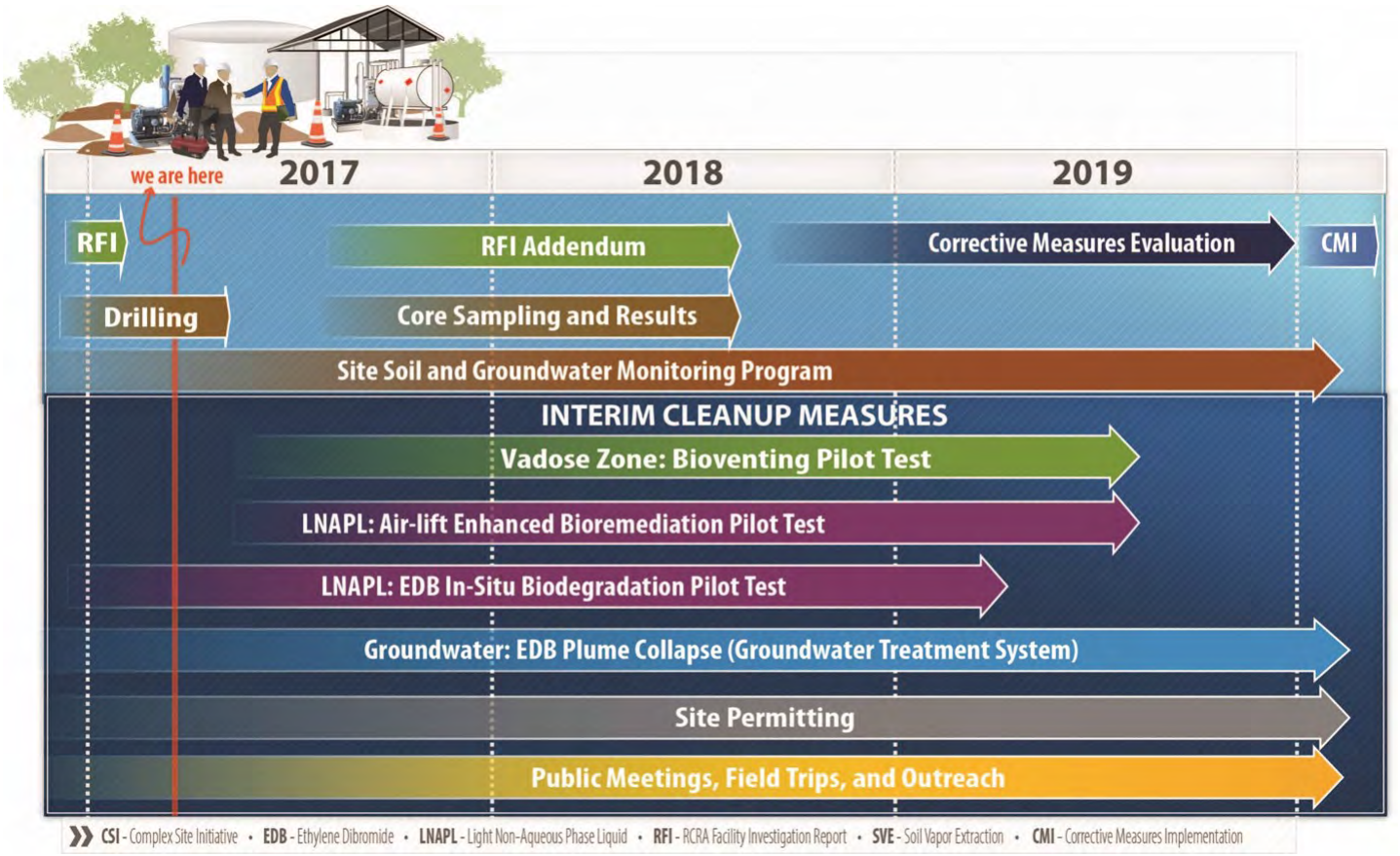
Constituent	Primary MCL* (µg/L)	WQCC Water Quality Standard** (ug/L)
EDB	***0.05***	0.1
Benzene	***5***	10
Toluene	1,000	***750***
Ethylbenzene	***700***	750
Xylenes (total)	10,000	***620***

*EPA MCLs have been adopted by NMED as part of our regulatory authority (https://www.epa.gov/dwstandardsregulations)

**WQCC Water Quality Standards are listed in New Mexico Administrative Code (NMAC) 20.6.2.3103 (http://164.64.110.239/nmac/parts/title20/20.006.0002.htm)

The timeline below highlights the site investigation and interim measure activities planned through 2018.

Project Timeline through 2019



The KAFB RCRA permit provides for using interim measures in order to reduce or prevent migration of hazardous constituents that have, or may result in, an unacceptable human or environmental exposure while long-term corrective action remedies are being evaluated and implemented. Interim measures for the KAFB BFF leak site are focused on two areas: source area (Strategy 2) and groundwater (Strategy 3).

Site assessment and characterization activities are ongoing to address the few remaining data gaps in the EDB plume and source area. A RCRA Facility Investigation (RFI) report was submitted to the NMED on January 31, 2017. A risk assessment is also part of the RFI and will be submitted April 2017. The risk assessment uses the nature and extent of fuel-related contamination to evaluate potential risk to human health and the environment, both on-KAFB and off . An addendum to the RFI Report is expected late-2017 to include additional site characterization data being collected at the two newest data gap groundwater monitoring wells and continuous cores to be collected to further define LNAPL at the site. The RFI report and report addendum will be reviewed by the NMED. After approval by NMED, the data included in the RFI will be used to support the Corrective Measures Evaluation (CME) and the selection of the final corrective action.

In the CME process, performance data collected on interim measures will be critical to helping the Air Force, NMED, other project partners, and the public evaluate the multiple remediation options for consideration as final corrective action for the KAFB BFF fuel leak. The RCRA permit for KAFB requires that the CME process begin with a work plan, submitted within 90 days of notice from the NMED that a CME work plan is required. This step in the corrective action process could begin in 2017.

General timeline of current and expected project activities:

Winter/Spring 2017	*Strategy 1: Site Monitoring and Wellhead Protection* • Submit RFI and risk assessment. • Complete well development and first round of sampling of new data gap groundwater monitoring wells. • Continue monthly sampling of drinking water supply wells. • Continue quarterly sampling of sentinel wells. • Continue periodic sampling of soil vapor and groundwater monitoring wells. • Complete validation study of passive diffusion sampling technology. • Submit work plan for coring to address data gaps in characterization of LNAPL at the site. *Strategy 2: Cleanup Strategies for Soil and Groundwater* • Conduct Complex Site Initiative (CSI) meetings. • Begin field-scale pilot test for an in-situ anaerobic degradation of EDB treatability study. • Complete construction of conveyance lines for the 4th groundwater extraction well; begin operation. • Submit work plan and complete field work to rehabilitate and re-develop extraction well KAFB-106233. • Install sand filters at groundwater treatment building. • Evaluate EDB concentration and groundwater elevation data to evaluate progress of plume capture and collapse. *Strategy 3: Public Participation and Outreach* • Finalize 2017 Strategic Plan, incorporating public comments received. • Host Spring 2017 technical public workshop. • Host Spring Public Meeting and Technical Deep Dive Session. • Continue to present project updates at the invitation of community groups and other organizations.
Summer 2017	*Strategy 1: Site Monitoring and Wellhead Protection* • Continue monthly sampling of drinking water supply wells. • Continue quarterly sampling of sentinel wells. • Continue periodic sampling of soil vapor and groundwater monitoring wells. • Evaluate groundwater monitoring program for further optimization using passive diffusion bag sampling technology. • Mobilize and begin field activities to collect continuous cores for LNAPL data gap. *Strategy 2: Cleanup Strategies for Soil and Groundwater* • Conduct CSI meetings. • Continue field-scale pilot test for an in-situ anaerobic degradation of EDB treatability study. • Bring 4th groundwater extraction well online.

Summer 2017	*Strategy 2: Cleanup Strategies for Soil and Groundwater (continued)* • Continue operation of groundwater treatment system with all four extraction wells in operation. • Continue data evaluation to monitor evidence for progress in plume capture and collapse. • Complete permitting of gravity-fed injection at KAFB-7 and up to 4 additional injection wells for the discharge of treated water. • Complete aquifer testing of four newest extraction wells. • Submit work plan for bioventing pilot test to treat remaining soil contamination. • Submit work plan for air-lift enhanced bioremediation interim measure. • Continue field-scale pilot test for in-situ anaerobic degradation of EDB treatability study. *Strategy 3: Public Participation and Outreach* • Host Summer Public Meeting and Poster Session. • Host Summer Field Trip. • Continue to present project updates at the invitation of community groups and other organizations.
Fall / Winter 2017	*Strategy 1: Site Monitoring and Wellhead Protection* • Continue monthly sampling of drinking water supply wells. • Continue quarterly sampling of sentinel wells. • Continue periodic sampling of soil vapor and groundwater monitoring wells. • Submit RFI Report Addendum *Strategy 2: Cleanup Strategies for Soil and Groundwater* • Conduct CSI meetings to review source area data and pilot test performance • Mobilize and begin construction of bioventing pilot test. • Mobilize and begin construction of air-lift enhanced bioremediation interim measure. • Continue field-scale pilot test for in-situ anaerobic degradation of EDB treatability study. *Strategy 3: Public Participation and Outreach* • Initiate update to the Strategic Plan and post for public comment. • Host Fall Public Meeting and Technical Deep Dive Session. • Continue to present project updates at the invitation of community groups and other organizations.

To track activities and progress during 2016, plan to attend public meetings, sign up for the NMED email list serve (link on website), and check project websites:

New Mexico Environment Department

⇒ www.env.nm.gov/NMED/Issues/KirtlandFuelPlume

Kirtland Air Force Base

⇒ http://www.kirtlandjetfuelremediation.com

STRATEGY 1

Implement a robust soil, groundwater, and wellhead monitoring program.

2017 Strategy

As fuel plume cleanup proceeds, the following plan is being implemented:

⇒ Continue to test for fuel contaminants at drinking water wellheads monthly (current regulatory requirements are for testing every 3 years).

⇒ Continue to test sentinel wells quarterly to provide early detection of any contaminant migration towards the drinking water wells.

⇒ Continue routine monitoring of soil and groundwater in compliance with the RCRA permit.

⇒ Complete monthly sampling at the groundwater treatment system of influent and treated discharge water for compliance with NMED Ground Water Quality Bureau (GWQB) discharge permit.

⇒ Further optimization of groundwater monitoring sampling to implement passive diffusion bag sampling technology.

⇒ The Water Utility Authority is voluntarily sampling its nearby wells for fuel related contaminants on a monthly basis.

⇒ Collect continuous cores within the source area and along the plume edge for analysis. Targeted analyses will include geotechnical, geochemical, and microbiological methods.

In 2016, KAFB drilled and installed two data gap groundwater well nests near the northwestern edge of the dissolved-phase EDB plume in order to complete definition of the horizontal and vertical extent of EDB. These wells will be sampled during 2017 and the data will be evaluated to determine if any data gaps remain.

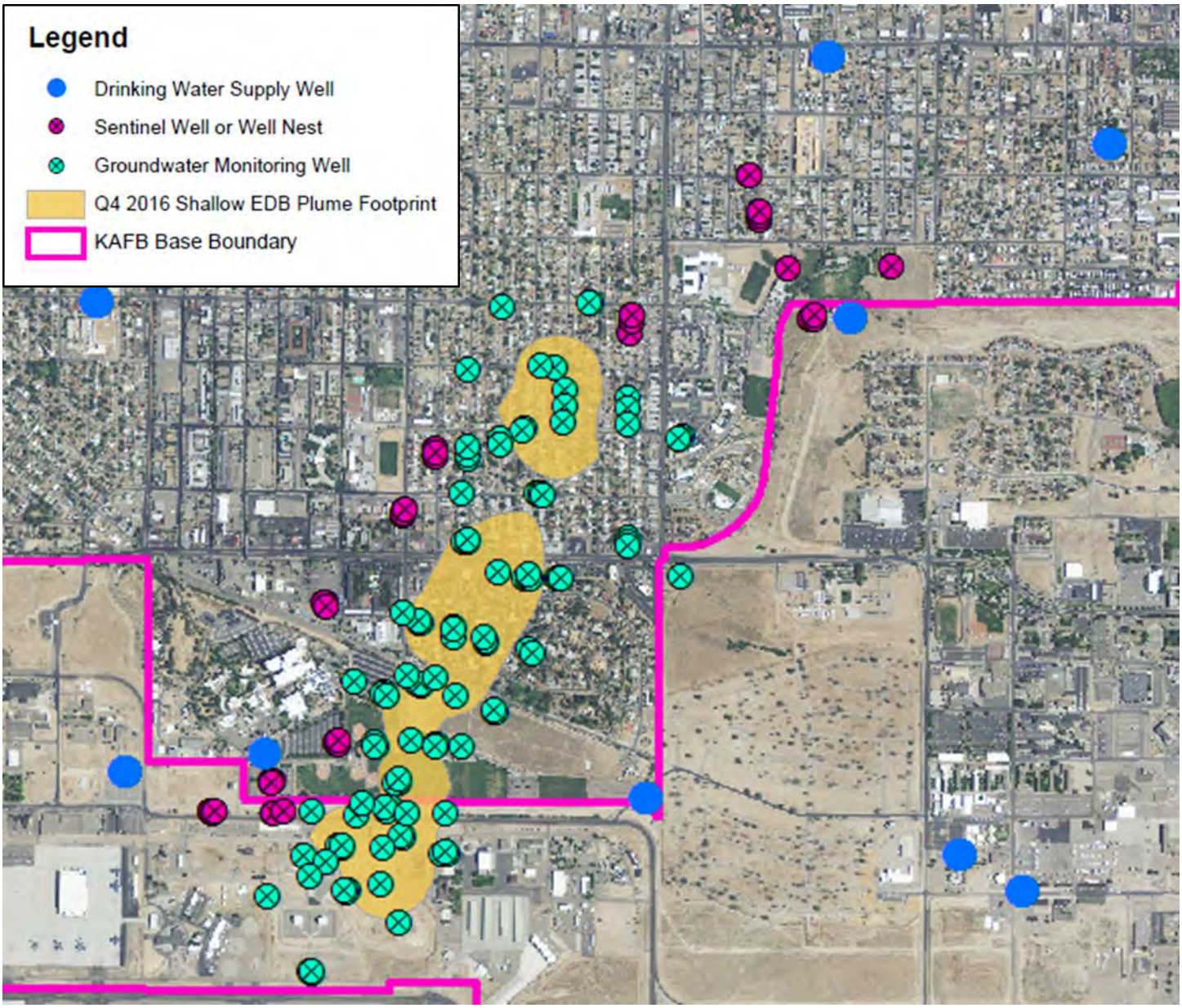
The Air Force will be submitting a RFI Report in January 2017 presenting the nature and extent of fuel-related contamination at the BFF site resulting from the fuel leak. A risk assessment will be submitted in February/March 2017 and will evaluate potential risk to human health and the environment. NMED and KAFB have developed a risk dashboard for the site as well as an information sheet on gardening (Appendix C).

The NMED will oversee the following actions to identify and address data gaps:

- Review RFI Report and risk assessment.
- Review passive diffusion sampling validation study.
- Review sampling results from data gap groundwater monitoring wells installed in 2016.
- Drilling and characterization of continuous cores collected in source area for LNAPL data gap.

The figure below illustrates the known extent of EDB in shallow groundwater relative to sentinel and water supply wells. Sentinel wells provide a mechanism for early detection of contamination migration, ensuring our ability to protect water supply wells.

EDB in Shallow Groundwater at KAFB



Performance Measures and Timeline

The success of Strategy 1 will be measured by:

- Continued non-detectable test results in all sentinel wells and drinking water wells;
- Continued compliance with GWQB and RCRA permit monitoring requirements;
- Completion of coring and analyses by Winter 2017 to characterize nature and extent of the LNAPL;
- Implementation of further optimization of the groundwater monitoring program; and
- Submittal of RFI Report and risk assessment.

If contaminants of concern are detected in any of the sentinel or drinking water wells during monthly sampling , there will be increased monitoring and/or intervention and the Water Authority will shut down any impacted production wells.

STRATEGY 2

Deploy multiple cleanup technologies, both simultaneously and sequentially, to clean up soil and groundwater.

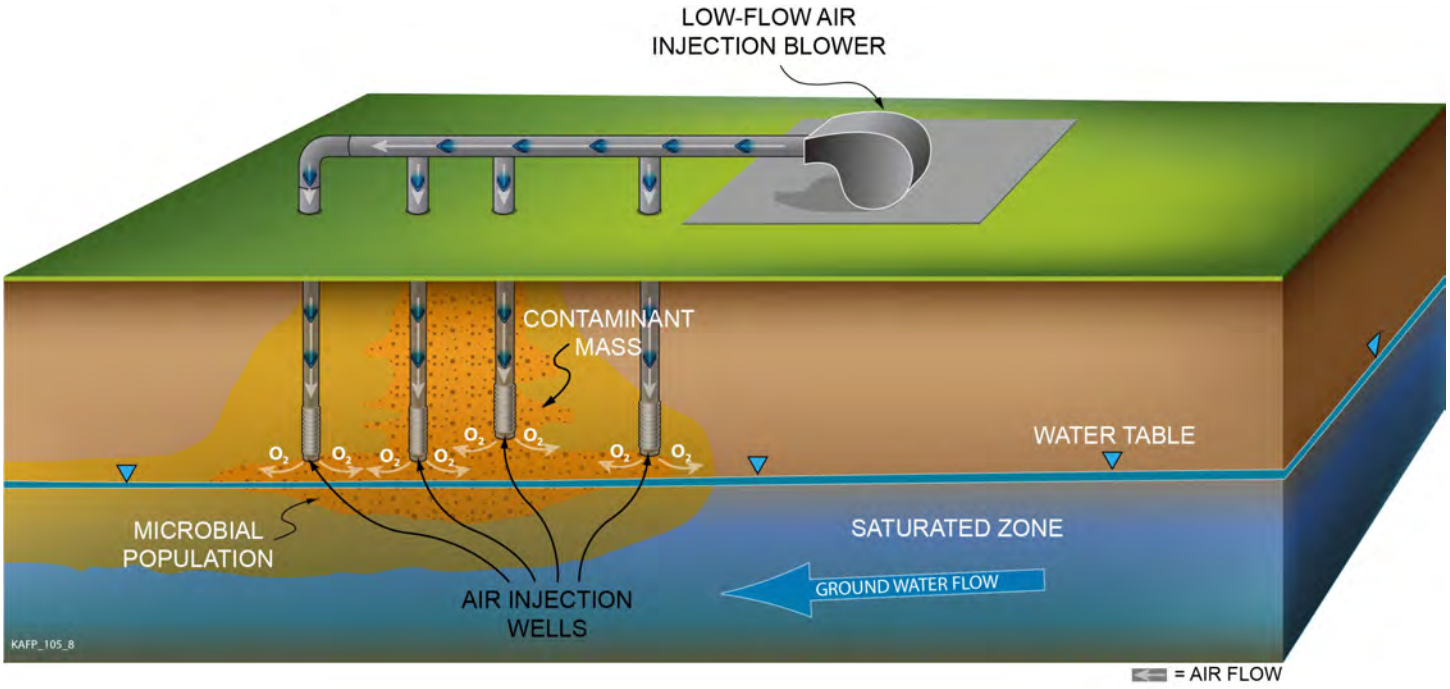
2017 Strategy

Through continued collaboration with stakeholders and the technical working groups, develop data quality objectives for design and implementation of pilot tests of remediation technologies to evaluate performance and effectiveness of soil, LNAPL, and groundwater treatment

Interim Measures—Soil

The Vadose Zone technical working group reviewed site investigation data collected during the in situ rebound and respiration shutdown test to evaluate potential cleanup strategies to be implemented as pilot test interim measures. The shutdown test data identified two areas of residual contamination and data indicated that biodegradation successfully degrades fuel contamination in the soil and therefore bioventing was identified as a pilot test to be implemented at the BFF site. Bioventing is the process of stimulating the natural in situ biodegradation of contaminants in soil by providing air or oxygen to existing soil microorganisms. Moisture may be added to the air in order to further stimulate naturally occurring biodegradation.

Conceptual Diagram of Bioventing

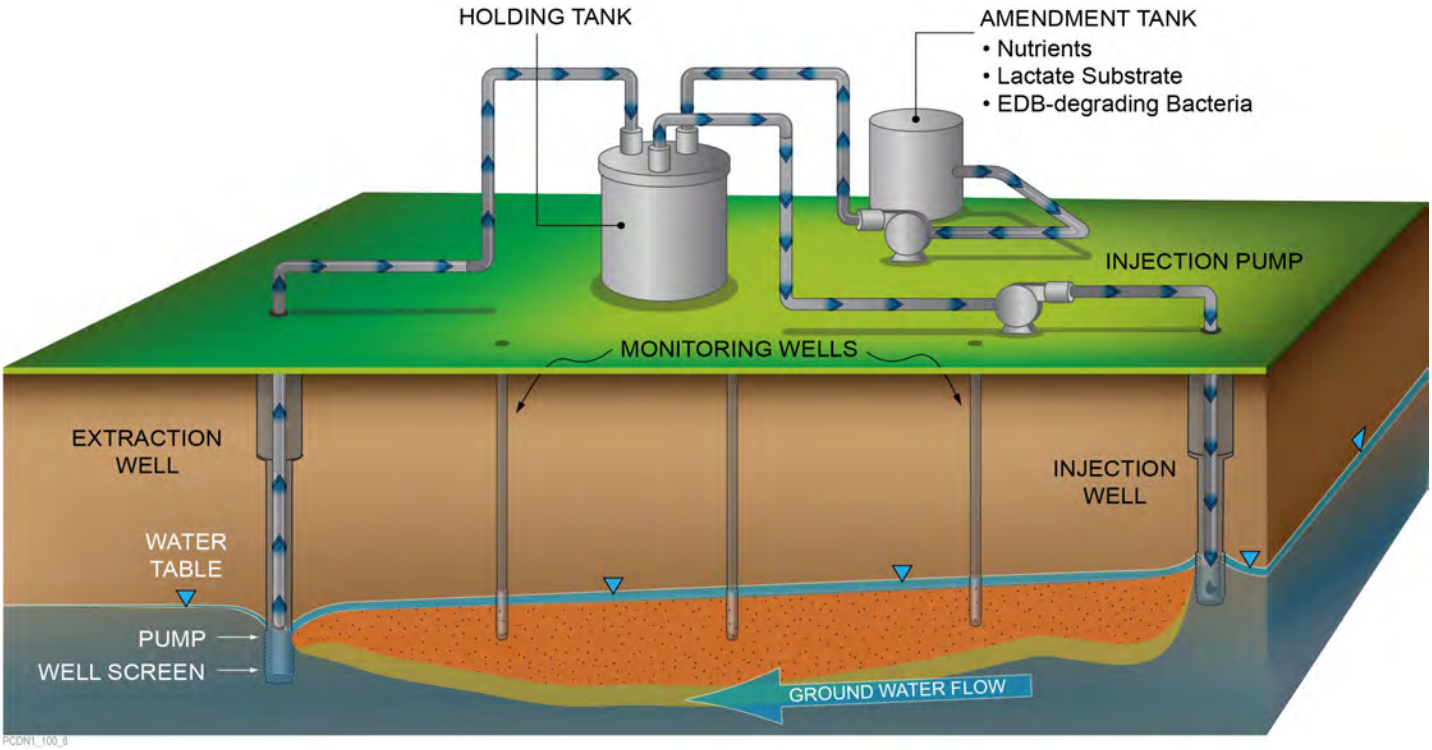


Bioventing will target a zone of 50 to 300 feet below the ground surface where the greatest amount of rebound was observed during the shutdown test. A work plan will be submitted to NMED for review and approval in Spring 2017.

Interim Measures—LNAPL

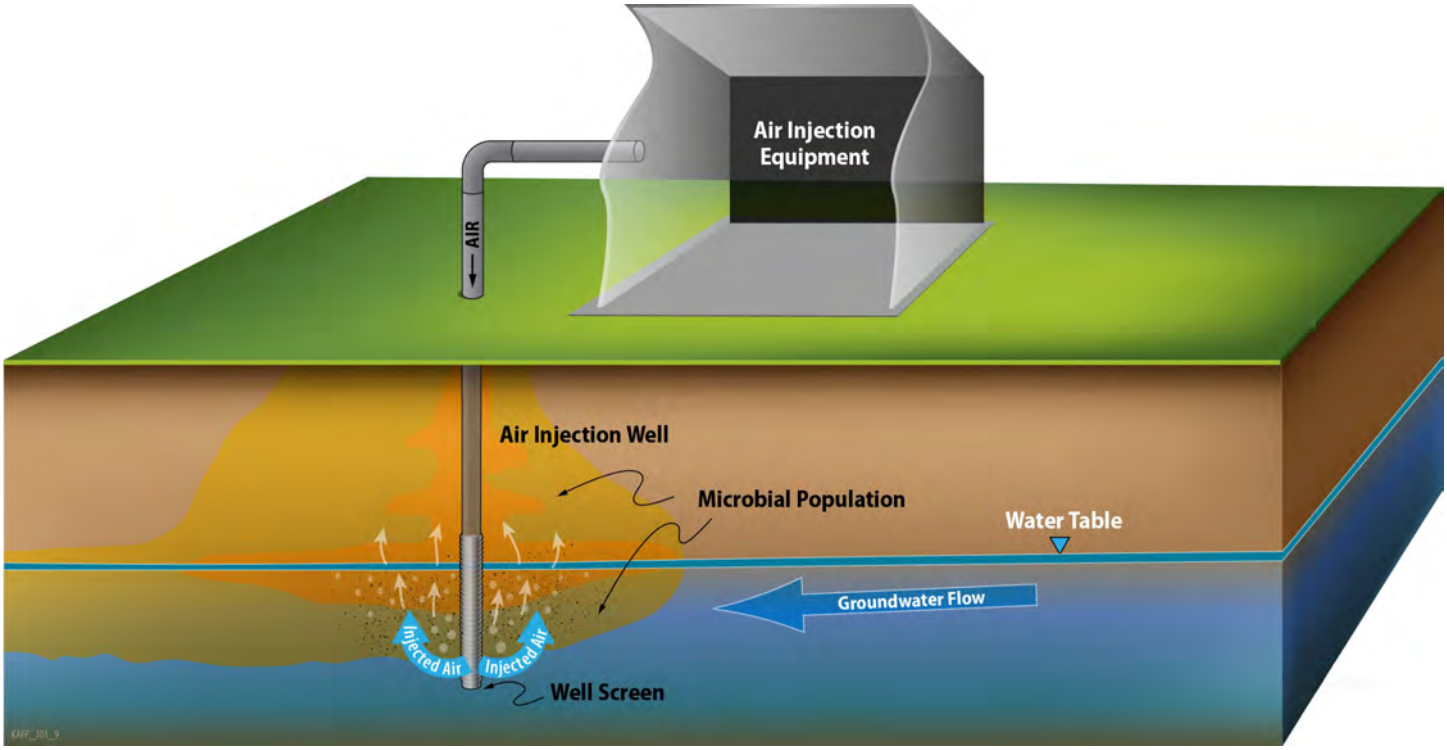
A work plan for in situ anaerobic bioremediation recirculation pilot test was approved by the NMED in December 2016 with field work slated to begin in January 2017. This pilot test involves the mixing of amendments into the groundwater in order to stimulate natural bacteria so that they can do a better job of biodegrading contaminants (see figure below). This pilot test is the field-scale continuation of laboratory studies conducted using soil and groundwater from the site. Results of the pilot test will be evaluated to determine which potential amendments are effective at stimulating EDB biodegradation. If successful, this treatment technology may be applied at the BFF site to address EDB in the source area that has been trapped in smeared LNAPL.

Conceptual Diagram of Bioremediation Recirculation



The soil vapor hydrocarbon rebound and biorespiration test data also supports the design and construction of an air-lift enhanced bioremediation pilot test to target smeared LNAPL at depth through aerobic degradation. The air-life enhanced bioremediation technology involves simultaneous groundwater and vadose zone treatment through in situ groundwater circulation and bioventing. As air is injected into the groundwater, a zone of aeration is created, supporting aerobic degradation of residual fuel contamination. The injection of air also support biodegradation of fuel contamination in the vadose zone.

Conceptual Diagram of Air-Lift Enhanced Bioremediation



Interim Measures—Dissolved-phase EDB

In 2015 KAFB began operation of a robust GWTS designed to:

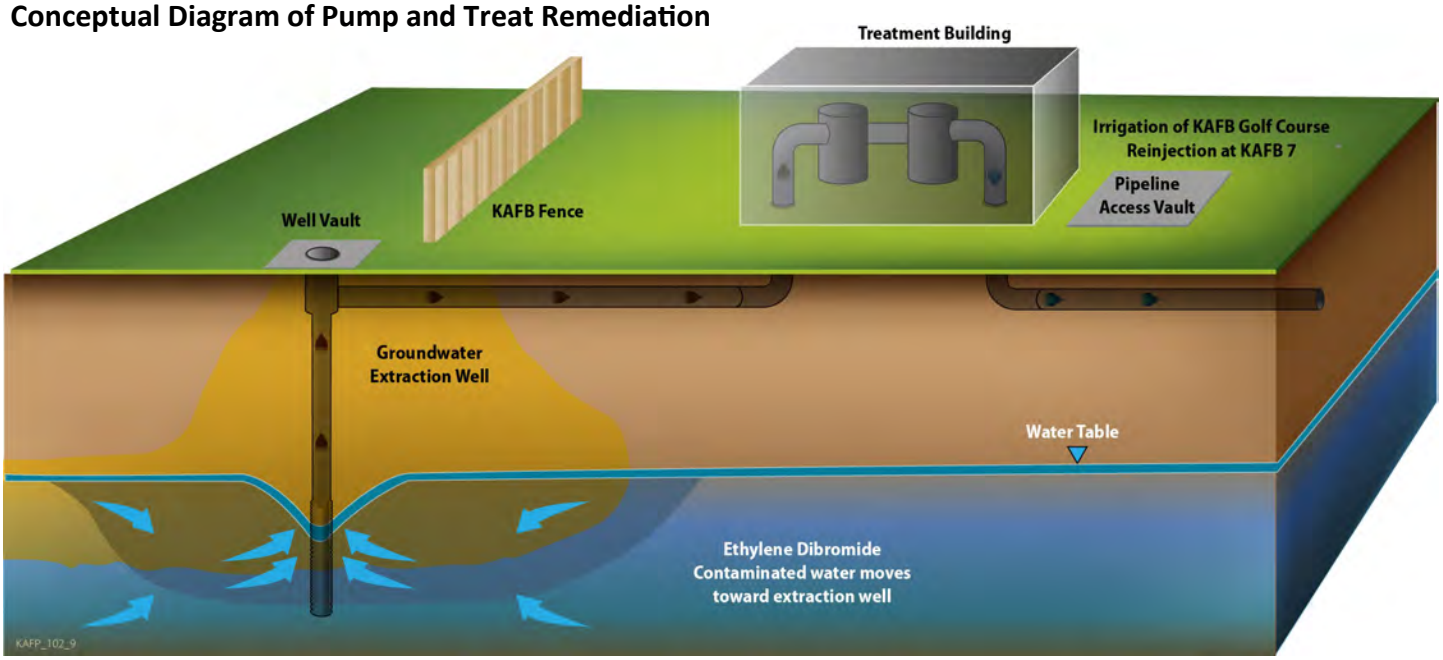
- ⇒ Stop migration of EDB towards drinking water wells;
- ⇒ Extract and treat EDB contaminated groundwater; and
- ⇒ Collapse the EDB plume back towards the KAFB boundary.

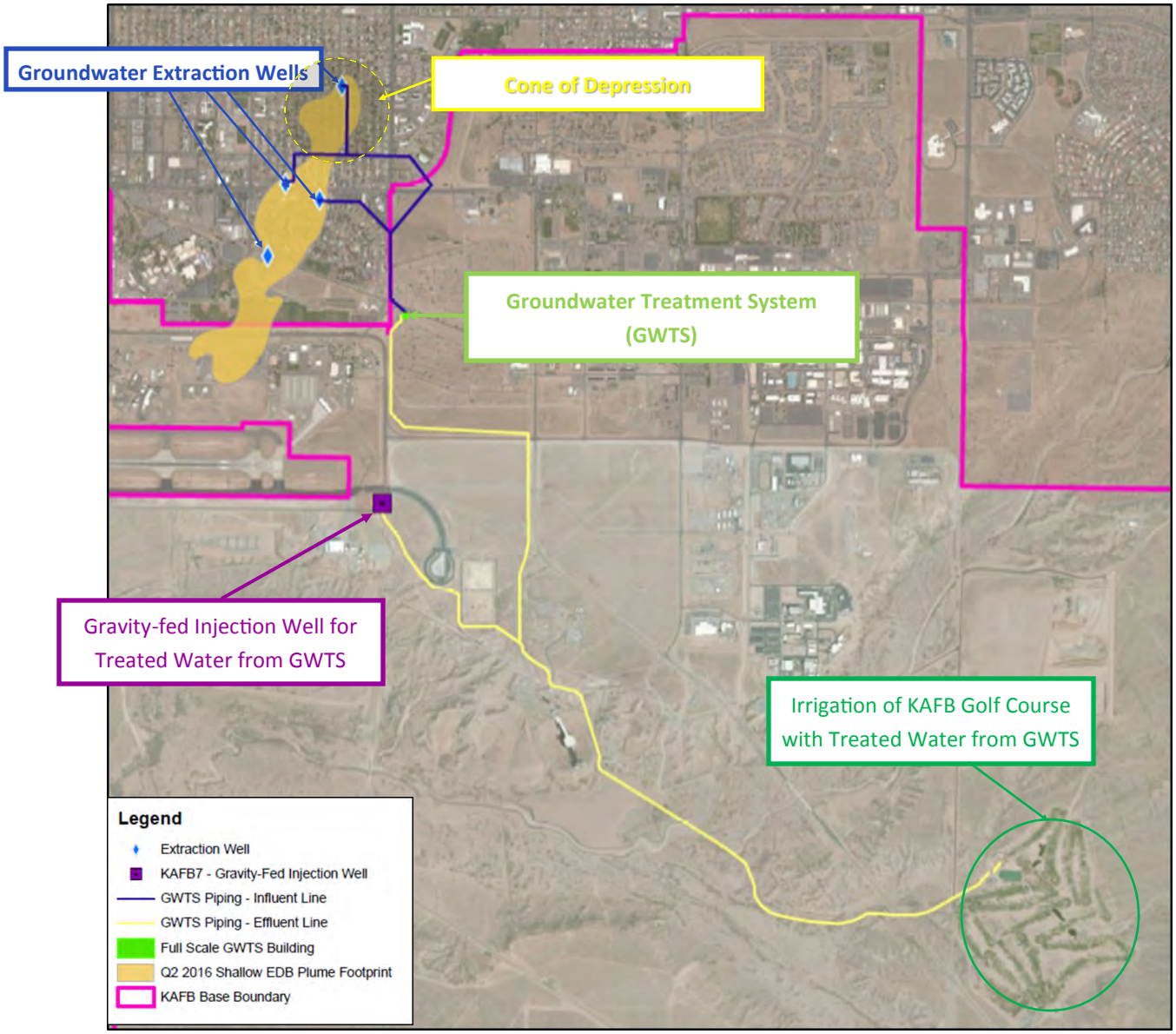
Collapsing the dissolved-phase EDB plume refers to the collective actions of a multi-well pump and treat system that will create localized groundwater depressions, pulling the EDB contamination into extraction wells where it is conveyed to the GWTS and treated. At the GWTS, extracted groundwater is treated to drinking water standards and discharged either to the KAFB Golf Course Main Pond where it is used for irrigation of the golf course or to gravity-fed injection at well KAFB-7. Water discharged into KAFB-7 returns to the aquifer and is considered a beneficial use.

The GWTS currently operated with two groundwater extraction wells in operation of the three that are installed and connected. Well KAFB-106233 was taken offline in June 2016 due to fouling issues at the treatment system originated from the well. Following a thorough evaluation of data collected from the well and treatment system, it was determined that well KAFB-106233 requires rehabilitation and re-development before resuming operation. This process will take 5-6 weeks and is anticipated to begin in February/March 2017. Additionally, the NMED is currently reviewing a proposal from the Air Force to install sand filters at the treatment building to prevent fouling of the treatment system as KAFB-106233 comes online and additional wells are added to the treatment system.

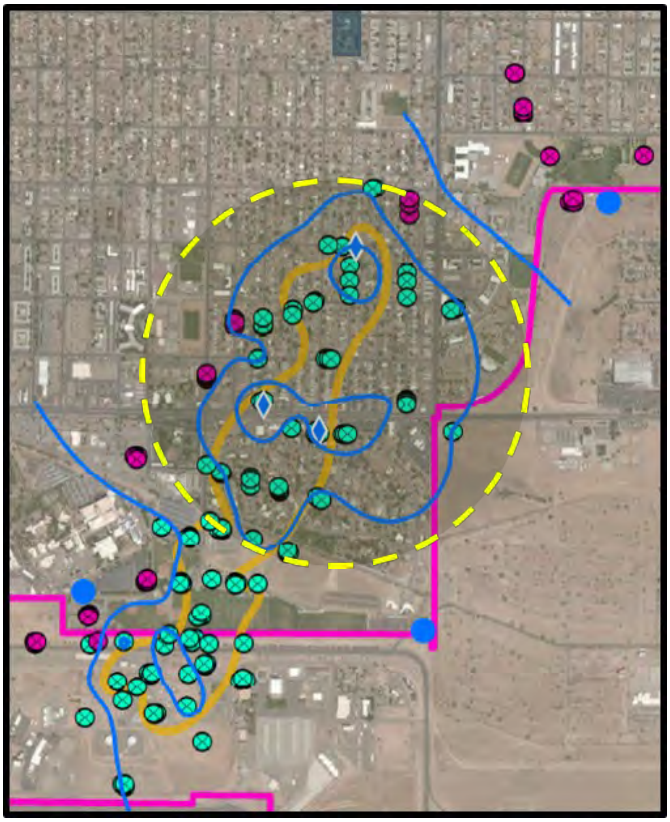
In 2016, KAFB added two more 20,000 pound GAC tanks, bringing the treatment capacity of the GWTS up to 800 gallons per minute. A 4th extraction well was drilled at the end of 2016 and is anticipated to be online by March 2017 following well development and construction of conveyance pipeline.

Conceptual Diagram of Pump and Treat Remediation



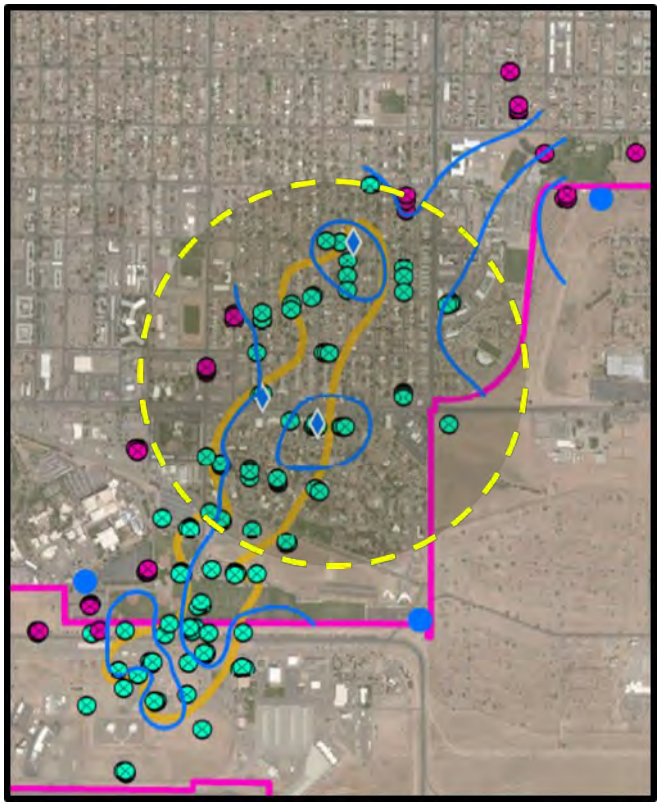


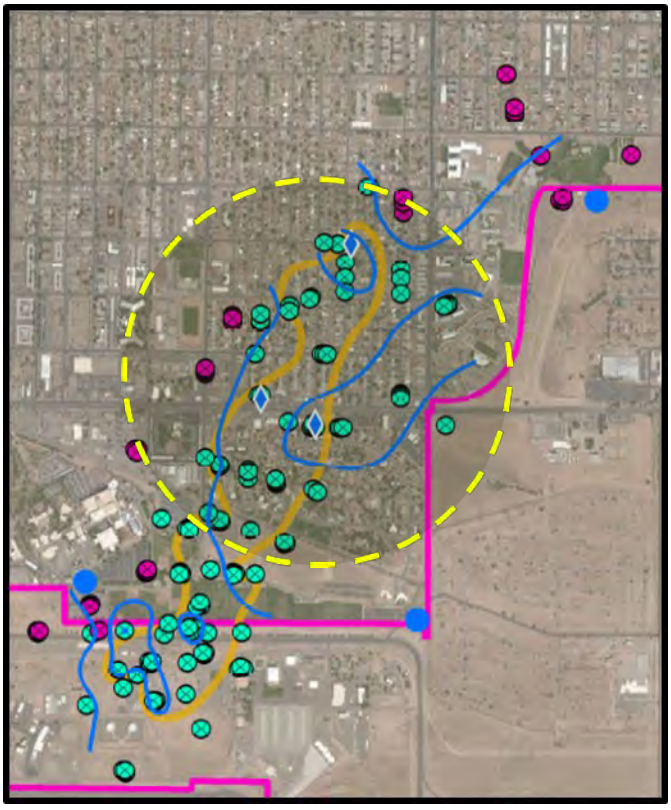
In March 2016, after three months of operating the first three groundwater extraction wells, a cone of depression was observed in the northern extent of the EDB plume. The cone of depression was the first milestone towards containment and collapse of the dissolved-phase EDB plume. The cone of depression appears to persist throughout 2016 even after groundwater extraction well KAFB-106233 is taken offline.



2nd Quarter 2016 Groundwater

3rd Quarter 2016 Groundwater Contours

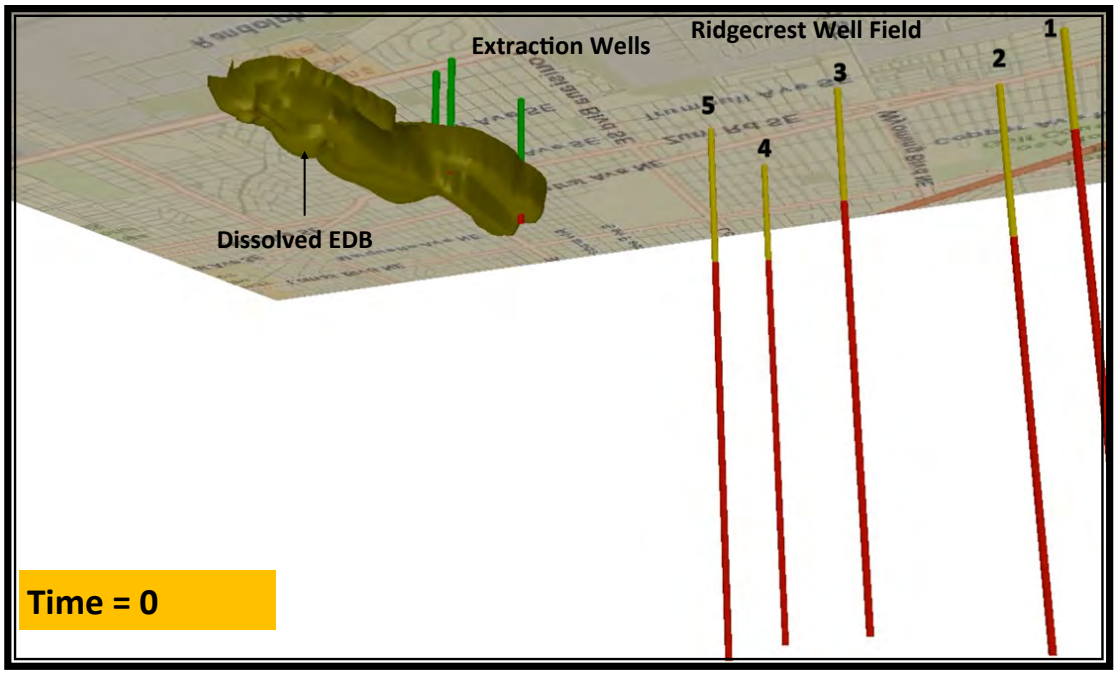


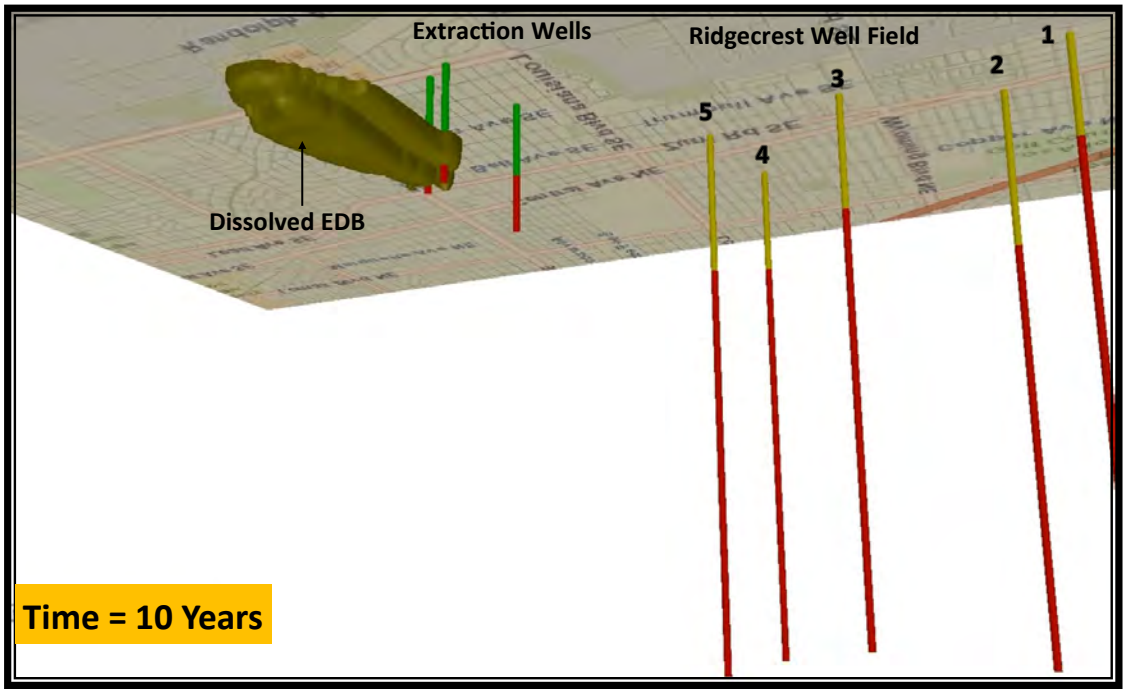


4th Quarter 2016 Groundwater Contours

An animated model produced by scientists at EPA can be found on the NMED website: https://www.env.nm.gov/NMED/Issues/KirtlandFuelPlume/KAFBProjectImages.html

Below are two still images from the animated model.





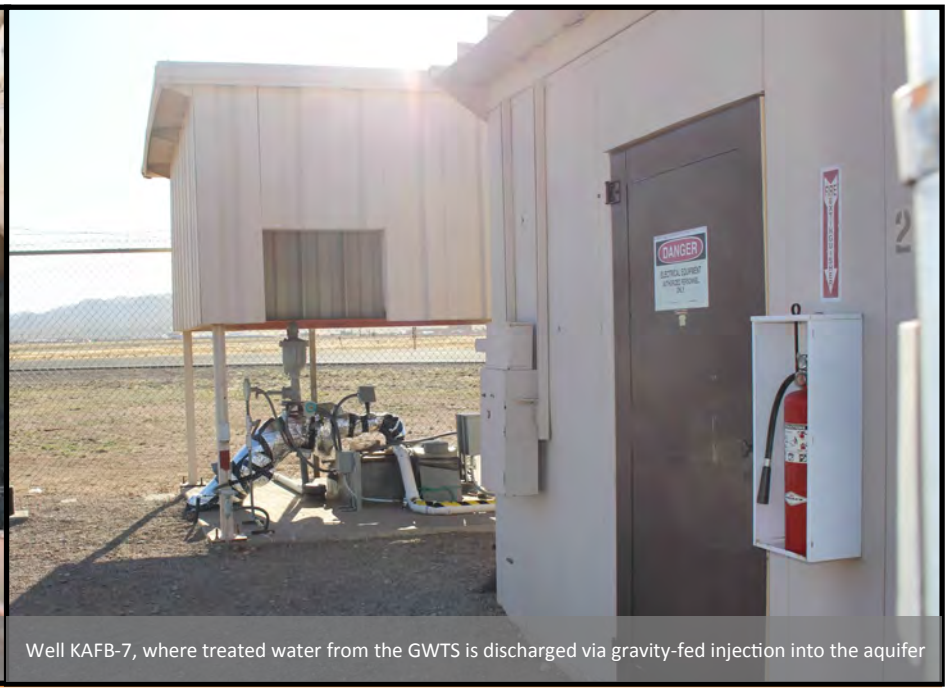
NMED and the Air Force continue to evaluate options for discharge of the treated groundwater from the EDB plume collapse interim measure. The evaluation looks at technical feasibility, sustainability, infrastructure and schedule constraints, and infrastructure costs. Currently, the discharge option that best fits all of those factors is reinjection into the aquifer using gravity-fed injection wells.

2017 Strategy

NMED will oversee the following actions to be performed by the Air Force and their contractors:

- Develop data quality objectives for remediation of the vadose zone and groundwater.
- Review of work plans submitted for bioventing and air-lift enhanced bioremediation pilot tests.
- Installation of wells and infrastructure for the in situ bioremediation recirculation pilot test.
- Field activities associated with construction of the bioventing and air-lift enhanced bioremediation pilot tests.
- Use pilot test data to determine if data quality objectives are being met and to inform evaluation of cleanup technologies for implementation.
- Use hydrogeological and analytical laboratory data and to evaluate plume capture and collapse.
- Installation of conveyance pipeline from the 4th groundwater extraction well to the GWTS.
- Rehabilitation and re-development of groundwater extraction well KAFB-106233.
- Upgrade the current GWTS to include a sand filter to prevent system fouling.
- Evaluate performance data from GWTS to determine progress towards plume capture and collapse.
- Work with technical working groups to evaluate need and placement of additional extraction and gravity-fed injection wells based on data collected during operation of the treatment system.

Mud rotary drilling bit, looking down hole at 4th extraction well (KAFB-106239)



Well KAFB-7, where treated water from the GWTS is discharged via gravity-fed injection into the aquifer

Performance Measures and Timeline

The success of Strategy 2 will be measured by:

- Implementation of in situ bioremediation recirculation pilot test by Spring 2017 with completion of the first two phases by the end of 2017;
- Implementation of bioventing pilot test infrastructure and collection of performance data by Winter 2017;
- implementation of air-lift enhanced bioremediation pilot test infrastructure and collection of performance data by Winter 2017;
- Activation of the full-scale treatment system with the increased capacity of 800 gpm of extracted groundwater from all four groundwater extraction wells;
- Continued monitoring of influent and treated discharge water for the EDB plume collapse treatment system; and
- Plume capture analysis following EPA guidance and industry standard practices.

Final Corrective Measure Evaluation, Selection, and Implementation

- In accordance with the requirements of RCRA, interim measure performance data (e.g. pump and treat capture zones) and other information will be evaluated to select and implement final corrective measure(s) for site remediation. This may include a combination of different remediation technologies.
- Establish metrics to determine when corrective action is complete.
- Implement long-term operation, maintenance, and optimization of final corrective measure(s) until metrics approved by the NMED are met.

STRATEGY 3

Meet or exceed all requirements for providing public information and involvement.

2017 Strategy

Our continued goal is to communicate accurate, comprehensive information to the public. In 2016, in addition to the technical poster sessions, we added technical "deep dive" presentations to provide an in-depth look at specific topics related to the BFF site characterization and interim measures. We also offer workshops and field trips to educate the public on the geology and remediation activities of the area, host public meetings, and post information on our website. The public is invited to attend the public meetings and other numerous outreach opportunities that the NMED provides throughout each step along the path to final remedy.

NMED will oversee and conduct the following actions as part of Strategy 3:

- Continue to maintain the NMED and KAFB fuel leak cleanup websites (links in Appendix B) to make correspondence and technical information readily available to the public. Documents to be posted include, but will not necessarily be limited to, proposed and final work plans, quarterly reports, technical working group meeting minutes, RFI reports, and NMED approval letters.
- Continue to maintain a NMED Listserv to send out periodic messages informing the public of important news and opportunities for involvement.
- Co-host at least 3-4 public update meetings to include informative poster sessions, technical deep dive sessions, general presentations, and an open question / answer session.
- Make presentations, as requested, to neighborhood associations, city and county governmental agencies, legislative committees, and to other organizations interested in the KAFB fuel cleanup.
- Host field trips in coordination with other stakeholders, to inform the public about site geology, hydrology, geochemistry, and cleanup actions.
- Explore potential for facilitated public workshops to address various components of site investigation and cleanup. Work with city neighborhood associations to coordinate outreach efforts.
- Conduct periodic surveys and interviews with area residents to determine specific areas of concern and additional outreach needs.
- Continually identify additional opportunities for constructive public outreach and communication.
- Update this Strategic Plan on an annual basis.

Performance Measures and Timeline

The success of Strategy 3 will be measured by:

- Participation and public satisfaction in three public meetings, spring, summer and fall/winter, 2017;
- Participation and public satisfaction in 1 to 2 field trips;
- Participation and public satisfaction in 1 to 2 technical public workshops;
- Participation and public satisfaction in other organized public participation events; and
- Issuance of a draft 2018 Strategic Plan in December 2017.

Acronyms

BFF	Bulk Fuels Facility
CME	Corrective Measures Evaluation
CSI	Complex Site Initiative
EDB	Ethylene dibromide
EPA	U.S. Environmental Protection Agency
FFOR	Former Fuel Offloading Rack
GWQB	Ground Water Quality Bureau
GWTS	Groundwater Treatment System
KAFB	Kirtland Air Force Base
LNAPL	Light non-aqueous phase liquid
MCL	Maximum Contaminant Level
NMED	New Mexico Environment Department
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SDWA	Safe Drinking Water Act
SVE	Soil vapor extraction
WQCC	Water Quality Control Commission

Glossary of Terms

The terms contained in this glossary are general definitions for common regulatory and scientific terms.

A

Abiotic

A physical process or mechanism that is not associated with living organisms.

Adsorption

A technical term referring to the bonding of a substance to soil or another medium.

Aerobic Biodegradation

The breaking down of organic contaminants by microorganisms when oxygen is present. In aerobic biodegradation, organisms convert oxygen to water in the process of transforming other components to simpler products.

Alluvial Fan

A triangle-shaped deposit of gravel, sand, and fine-grained sediment (clay or silt). This sediment referred to as alluvium.

Alluvium

Material such as clay, silt, sand, and/or gravel deposited by rivers and streams.

Anaerobic Biodegradation

The degradation of compounds by microorganisms in the absence of oxygen. Common substitutes for oxygen include nitrate, sulfate, and iron.

Aquifer

A zone of soil or rock below the surface of the earth capable of producing water.

B

Bio-augmentation

The addition of bacteria, nutrients, and other growth factors to enhance the efficacy of biodegradation of contamination in soil and/or groundwater.

Biodegradation

The breaking down of organic substances by microorganisms through the breaking of intramolecular bonds.

Bioremediation

The use of living organisms to cleanup contaminants from soil, water, or wastewater.

Bioventing

Bioventing is the process of stimulating the natural in situ biodegradation of contaminants in soil by providing air or oxygen to existing soil microorganisms. This technology uses low air flow to provide just enough oxygen to sustain microbial activity within the vadose zone.

C

Calibration

A process to ensure accuracy of measurement by a particular analytical method or instrument.

Capture Zone

The three-dimensional region that contributes to groundwater extracted by one or more groundwater extraction wells. The capture zone is equivalent to the zone of hydraulic containment.

Cleanup

The removal of a chemical substance or hazardous material from the environment to prevent, minimize, or mitigate damage to human health, or the environment, that may result from the presence of the chemical substance or hazardous material. The cleanup is carried out a specific cleanup criteria.

Compound(s)

A thing that is composed of two or more separate elements.

Concentration

The amount of a chemical or substance in a given environmental medium.

Conceptual Site Model (CSM)

A conceptual site model is a way to organize and communicate technical information about a site. The CSM reflects the best interpretation of available information on how and where contaminants are expected to move and what impacts such movement may have.

Cone of Depression

A cone of depression occurs in an aquifer when groundwater is pumped from a well. In an unconfined aquifer it is an actual depression of the water levels and can be defined through the measurement of groundwater levels in monitoring wells. It forms as water is pulled from all directions into the pumping well and can be used to define the area of influence and capture zone.

Confined Aquifer

An aquifer bounded above and below by confining beds and completely filled with water under pressure.

Contaminant

Any physical, chemical, biological, or radiological substance in air or soil or water that has an adverse effect. Any substance whose concentration exceeds background concentrations or which is not naturally occurring in the environment.

Corrective Action

The term corrective action typically refers to the cleanup process or program under RCRA and all activities related to investigation, characterization, and cleanup of a release of hazardous wastes or hazardous waste constituents. The term may also refer to a specific action taken to remediate contamination at a given facility.

Corrective Measures Evaluation (or Study)

Before choosing a cleanup approach or set of final remedies, a range of measures will be analyzed and evaluated for their advantages and disadvantages relative to the site-specific conditions. Corrective Measures may address air, soil, sediment, surface water, or groundwater. Significant public participation is encouraged during this portion of the corrective action process.

D

Data Quality Objectives

Qualitative and quantitative statements of the overall level of uncertainty that a decision-maker will accept in results or decisions based on environmental data.

Dissolved Phase

The part of hydrocarbon contamination which has partitioned into a body of water.

E

Effluent

Treated (or un-treated) wastewater that flows out a treatment plant.

Ethylene Dibromide (EDB)

A colorless, heavy, synthetic liquid that was primarily used in anti-knock gasoline mixtures, particularly aviation fuel. The maximum contaminant level for EDB in groundwater is 0.05 micrograms per liter (or 0.05 parts per billion), as defined by the NMED and EPA.

Extraction Well

A well specifically designed for the removal of groundwater or air.

F

Fate and Transport

A term used to discuss the movement of chemical contaminants through water or air, the synergistic effects of the contaminants in that environment, and the eventual disposition of that contaminant.

G

Granulated Activated Carbon

A porous adsorbent material created through the heating of organic material such as coal, wood, or coconut shell, which is then crushed into granules. The granular activated carbon is positively charged and therefore able to remove dissolved organic solutes by adsorption onto the activated carbon.

Groundwater

Water under the subsurface of the earth that fills pores in soil or opening in rock. When groundwater accumulates in sufficient quantities and quality, it may be used as a source of drinking water.

H

Hydrocarbons

Chemical compounds that consist primarily of carbon and hydrogen, such as petroleum.

Hydrolysis

Chemical degradation of a compound resulting from a reaction with water.

I

Influent

Untreated wastewater flowing into a treatment plant.

In situ

Where contaminated material(s) are treated, in place, without prior excavation or extraction from the ground.

Interim Measure

Actions necessary to minimize or prevent the further migration of contaminants and limit actual or potential human and environmental exposure to contaminants while long-term corrective action remedies are evaluated and, if necessary, implanted. An interim measure is a step preceding the final corrective measures and often occurring while site characterization is underway.

L

Lithology

A term used to describe the physical and mineralogical characteristics of rock. Common names may denote a specific type of rock (e.g., sandstone, granite, etc.) or may denote the general mode of rock formation (e.g., sedimentary).

M

Maximum Contaminant Level

The maximum permissible level of a contaminant; an enforceable standard.

Media

The fundamental components of the environment including water, sediment, soil, and biota.

Microorganism

A microscopic organism, especially a bacterium, virus, or fungus.

Migration

The movement of chemicals, bacteria, and gases in flowing water or vapor in the subsurface.

Model

A conceptual, mathematical, or physical system intended to represent a real system. The model is used to understand processes in the physical system that are analogous.

Monitoring

The continuous or periodic measurements at a site to determine the ongoing nature and performance of remediation. Monitoring also includes measurements taken for compliance purposes.

Monitoring Well(s)

A well that provides access to groundwater or soil vapor for field measurements and the collection of samples for laboratory analysis.

N

Non-Aqueous Phase Liquid (NAPL)

Contaminants that remain undiluted as the original bulk liquid in the subsurface (e.g., free product).

P

Paleochannel

A remnant of an ancient river or stream channel either filled in or buried by younger sediment. Paleochannels can often act as conduits for groundwater contamination.

Pathway

The means by which a hazardous substance, or agent, comes into contact with a receptor.

Plume

A visible or measurable discharge of a contaminant from a given point of origin.

Plume Capture

Hydraulic containment of contaminated groundwater.

R

RCRA (or ACT)

Resource Conservation and Recovery Act (RCRA) of 1980 (as amended), is the principle federal law in the United States governing the disposal of solid waste and hazardous waste.

Receptor

A person, organism, habitat, or controlled water that is being, or could be, harmed by a potential contaminant.

Remediation

An action taken to improve a contaminated site in order to prevent, minimize, or mitigate damage to human health, or the environment. Remediation includes the development and application of a planned approach that removes, destroys, contains or otherwise reduces the availability of contaminants to

Remediation Criteria

Numerical limits or narrative statements specific to individual variables or substances in water, sediment, or soil which are recommended to protect and maintain the specific use of a contaminated site (e.g., residential use, etc.). When measurements of a particular variable indicate that the remediation criteria are being exceeded, the need for remediation is indicated.

Respiration

A process in living organisms involving the production of energy, typically with the intake of oxygen and the release of carbon dioxide, from the oxidation of complex organic substances.

Risk Assessment

The scientific examination of the nature and magnitude of risk to define the effects of contaminant(s) on humans and other receptors.

S

Saturated Zone

The zone where voids of the soil or rock are filled with water. In an unconfined aquifer, the water table forms the upper boundary of the saturated zone.

Soil Vapor (Soil Gas)

The vapor or gas phase of a substance that is found in the unsaturated zone.

Soil Vapor Extraction (SVE)

A physical treatment process for remediation of volatile contaminants in a vadose zone.

Surfactant

A chemical substance that lowers the surface tension of a liquid in which it is dissolved.

U

Unconfined Aquifer

An aquifer where the water level (water table) is free to rise and fall. The pressure is atmospheric at the water table.

V

Vadose Zone

The zone between the earth surface and the water table within which the moisture content is less than saturation. The soil pore space typically contains air or soil vapor. This zone is also referred to as the Unsaturated Zone.

Vapor Intrusion

Vapor intrusion is a process by which chemicals in soil or groundwater migrate to indoor air above a contaminated site.

Volatile Organic Compounds (VOCs)

Human-made hydrocarbon compounds that have low boiling points and therefore evaporate readily. Propane, benzene, and other components of gasoline are all volatile organic compounds.

W

Water Level

The upper limit of the saturated zone. It is measured by installing wells that extend a few feet into the saturated zone and then recording the water level in those wells.

Water Table

The level of groundwater.

Well Rehabilitation

Restoration of a well to its most efficient condition. Well rehabilitation can be accomplished through various treatments or reconstruction methods.

New Mexico Environment Department:

⇒ KAFB Jet Fuel Plume Remediation web section: www.nmenv.state.nm.us/NMED/Issues/KirtlandFuelPlume

- **Project Documents Page: Groundwater Extraction Pilot and Additional Characterization**
  - KAFB workplan, August 1, 2014 Link to PDF on NMED website
  - NMED approval letter, August 20, 2014 Link to PDF on NMED website

- **Public Outreach Page: Public Meeting Presentations and Field Trip Handouts**
  - Risk Dashboard (English, Spanish, and Vietnamese)
  - Garden Fact Sheet (English/Spanish and English/Vietnamese)
  - Conceptual Site Model Animation

- **Site also includes:** additional documents, modeling videos, biographies of technical working group members

- **Historical Reports and Correspondence** (dating back to 1999)
  - NMED Hazardous Waste Bureau Webpage link http://www.nmenv.state.nm.us/HWB/kafbperm.htm

Kirtland Air Force Base:

⇒ Project website: http://www.kirtlandjetfuelremediation.com

- **Project Documents Page: Quarterly Monitoring and Site Investigation Reports** (full text, figures and tables)

- **Site also includes:** past meeting materials, maps & photos, frequently asked questions, contacts

U.S. Environmental Protection Agency :

- **EPA's RCRA Orientation Manual** http://www.epa.gov/osw/inforesources/pubs/orientat/

Kirtland Air Force Base Bulk Fuel Leak Exposure and Risk Dashboard August 2016

Risk Levels - This dashboard addresses human exposure and risk based on current monitoring data, and will be updated in the future, if necessary, as new data become available.

Safe	Use Caution	Unsafe

Potential Exposure Pathway	Risk Level	Explanation
Drinking Water		**Drinking water provided by the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) continues to be free of any detectable fuel contamination and is safe for all uses.** Public drinking water wells near the groundwater contamination plume are tested monthly, and show no detections of any fuel compounds. Sentinel wells, which are monitoring wells located between the drinking water wells and the contamination plume, are tested quarterly and show no detections.
Surface Soil		**Surface soil contamination never migrated off of Kirtland.** Surface soil contamination has only occurred at the Kirtland Air Force Base Bulk Fuels Facility (BFF) industrial area which is not accessible to the general public. Contaminated soil has been excavated and removed for off-site disposal.
Surface Water		**There is no pathway for contaminants to enter surface water.**
Vapor Intrusion		**Homes and businesses are not at risk for vapor contamination.** There is no off-Base surface or near-surface soil contamination, and groundwater contaminants are too deep, to allow vapors to enter homes and buildings.
Garden Vegetables		**There is no risk of contamination to garden vegetables.** ABCWUA water is safe for irrigation. There is no off-Base surface soil contamination, and vapors from groundwater are too deep, for fuel to contaminate garden vegetables.
Recreational Activities		**There is no risk of contamination to people enjoying recreational activities in Bullhead Park or in the Dog Park.** Reclaimed ABCWUA water is used to irrigate the parks. There is no off-Base surface soil contamination, and vapors from groundwater are too deep, to pose a risk to people in the park areas.

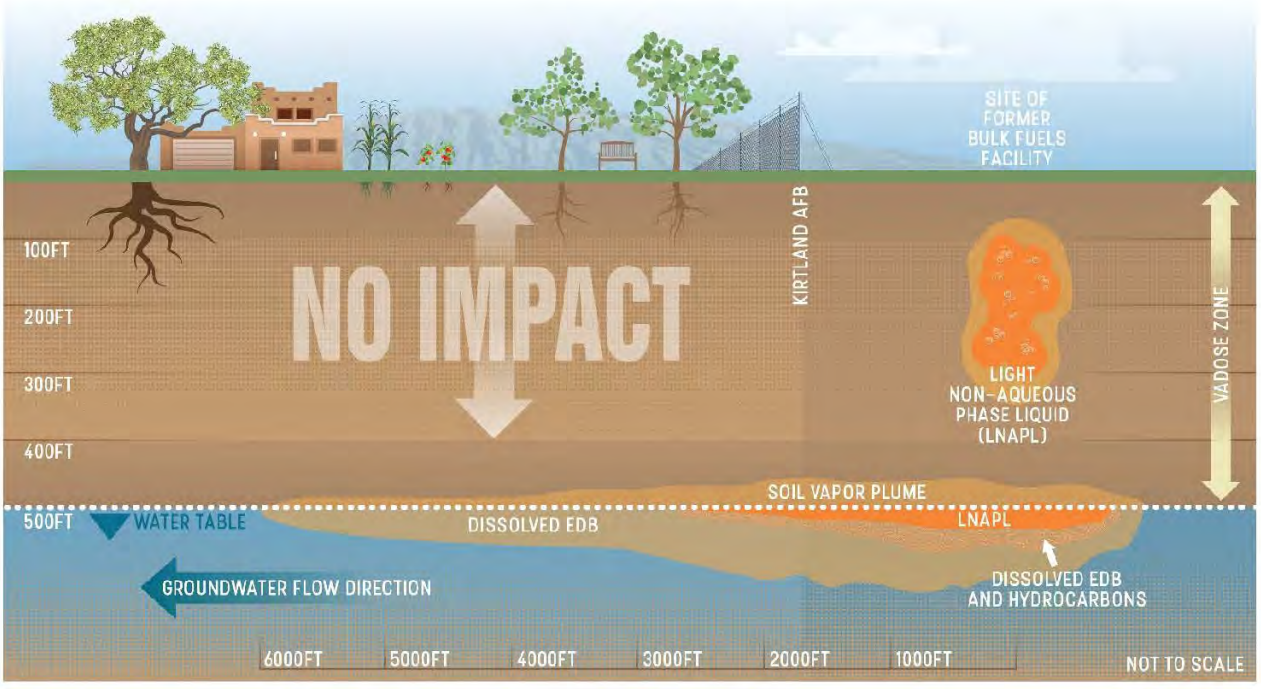
Garden Information Sheet

Thank you for your interest in the Kirtland Air Force Base (AFB) Bulk Fuels Facility (BFF) cleanup project. This update is to share information with Kirtland AFB's neighbors about gardening as we head into spring. The most common question asked of people working on the project is, "Is it safe to garden?" As is explained below, the answer is "Yes."

As you may know, in 1999, an underground, intermittent leak was identified at the fuel facility on Kirtland AFB. The leak was discovered when jet fuel was identified in surface soil at the facility. Over time, the fuel moved down through the soil and reached the groundwater underneath the base, and then moved in a plume north-northeast with the groundwater in a narrow corridor under neighborhoods immediately off base. To date, no fuel-related chemicals have been identified in the drinking water provided to Albuquerque residents. Drinking water production wells are sampled monthly with no detections of fuel-related contaminants. Since June 2015, the pump and treat interim measure has been operating to extract and treat EDB-contaminated groundwater. This system will further reduce the EDB plume concentrations in residential areas.

Below are some facts related to this release and how it may affect you as a neighbor to Kirtland AFB:

- Fuel from the Air Force did not leak at the ground surface in residential areas or parks neighboring the base.
- Fuel contains compounds, some of which can change to a vapor form. The ability for a fuel compound to cause a vapor concern near the surface is dependent on a number of factors such as the concentration of the fuel compound, the depth to the plume, and the types of soil (e.g. cobblestones, sand, silt and/or clays). It is a combination of these factors that we assess to determine if the ethylene dibromide (EDB) plume affects the residential areas above the plume. Based on what we know of these factors, there is no threat of vapor reaching the ground surface.
    - EDB-measured concentrations within residential areas of groundwater are consistently low. These low concentrations limit the amount of EDB vapor that can form in soil air spaces above the groundwater.
    - The EDB plume in residential areas is 455 to 480 feet below the ground surface.
    - Residential soil types are made up of cobblestones, sand, silt, and/or clays which work together to prevent any EDB vapors from reaching the ground surface.
- Most garden plants have roots that are only in the top 3 to 6 feet of soil. Trees have deeper roots. For example, junipers in this area have the deepest roots which can go down to 131 feet; whereas, an apple tree can go down to 10 feet. Therefore, no impacts to residential gardening are possible.



Multidisciplinary working groups have been established to provide detailed review and analysis of highly technical issues pertaining to the investigation and cleanup of the Kirtland Air Force Base fuel leak. The groups consist of staff scientists and engineers from the NMED, Air Force, ABCWUA, City of Albuquerque, EPA, and contractors. Each working group shall prepare minutes documenting the attendance, discussion, and homework assignments from each meeting, and the minutes shall be posted on the NMED web site.

Hydrogeology Working Group

The hydrogeology working group will review published maps and reports, lithologic logs, well records, core samples, drill cuttings, airborne, surface and borehole geophysical data, water level data and other information. The hydrogeology group will use this information to define stratigraphy, structural features, and aquifer hydraulics in the vicinity of the fuel contamination. The hydrogeology group also will define background aquifer geochemistry, but will not address geochemical alterations caused by fuel contamination as that subject will be addressed by the biogeochemistry/LNAPL working group.

The hydrogeology group will have the following specific responsibilities:

1. Assembly or, if necessary, preparation of maps, cross sections, fence diagrams, graphs, Stiff diagrams, trilinear plots, time trends, interpretations and other material as appropriate to document site hydrogeologic conditions.
2. Provide detailed stratigraphic and other geotechnical information to the SVE, biogeochemistry/LNAPL and modeling work groups for their consideration and use in their areas of responsibility.
3. Field oversight of drilling operations, including review and approval of lithologic logs and proposed well completions.
4. Oversee borehole geophysical logging; analysis of logging data.
5. Oversee the design, implementation and interpretation of aquifer performance testing.
6. Develop a conceptual site model in coordination with other technical work groups.
7. Identify and resolve field and laboratory QA/QC issues.
8. Review water-level and water-quality monitoring data from the hydrodynamic dissolved-phase EDB extraction system.
9. Coordinate with ABCWUA, KAFB and NMVAHCS on protection of public drinking water wells.
10. Define background conditions for dissolved oxygen, nitrate, alkalinity, bromide and other parameters of concern.
11. Develop indicator parameter concentrations for sentinel wells that, if observed, would trigger additional review, increased monitoring, or intervention.
12. Plan and host occasional geological field trips for the general public, in coordination with other working groups.
13. Optimize the current groundwater monitoring program including the wells sampled and the laboratory analyses.

Biogeochemistry/LNAPL Working Group

The biogeochemistry/LNAPL working group will investigate and define the physical, microbial, geochemical, and hydrogeological processes that control the fate and transport of dissolved, non-aqueous liquid, gaseous and adsorbed phase contaminants, and evaluate potential remediation options. Dissolved phase contaminants of concern include: ethylene dibromide (EDB), benzene, toluene, ethylbenzene, and xylene isomers (BTEX), polynuclear aromatic and aliphatic hydrocarbons, and 1,2-dichloroethane. Parameters of interest regarding natural and engineered degradation processes include dissolved oxygen, oxidation reduction potential, nitrate, manganese, iron, sulfate, methane, carbon dioxide, alkalinity, bromide, chloride, and stable isotopes of various elements.

The biogeochemistry/LNAPL group will have the following specific responsibilities:

1. Characterize the physical and chemical properties of light non-aqueous phase liquids (LNAPLs) that are submerged within or floating atop groundwater.
2. Identify specific chemical and biological mechanisms that have transformed or degraded contaminants, along with reaction rates and byproducts.
3. Make recommendations for additional sampling and analysis as needed.
4. Use stoichiometric equations to calculate the amounts of contaminants that have been transformed or degraded in the vadose zone and in groundwater.
5. Maintain a running quantification of the amount of EDB that has been removed by the pump-and-treat system.
6. Evaluate potential remediation options for additional removal or destruction of fuel contaminants. Such options may include, but may not necessarily be limited to, pump and treat, air or steam sparging, soil vapor extraction, biostimuation, bioaugmentation, bioventing, surfactant flooding, and monitored natural attenuation.
7. Make recommendations for scaled up laboratory and field-scale pilot tests of potentially viable remediation technologies.

Vadose Zone Working Group

The vadose zone working group will review lithologic data, soil vapor concentrations, and performance data from historical and ongoing SVE operations to make recommendations on increasing the robustness of SVE activities.

The Vadose Zone group will have the following specific responsibilities:

1. Identify soil vapor hotspots needing additional treatment.
2. Recommend locations and completion specifications for additional extraction wells.
3. Identify areas where biodegradation is ongoing and would benefit from active bioventing.
4. In coordination with the biogeochemistry/LNAPL group, maintain a running quantification of the amounts of hydrocarbons that have been removed by SVE and by biodegradation in the vadose zone.

Modeling Working Group

The modeling working group will design, run and calibrate numerical simulations of contaminant transport and fate.

The modeling group will be responsible for the following types of simulations:

1. EDB transport times to drinking water wells in the area under various scenarios.
2. Hydrodynamic capture zones for various configurations of extraction wells with various pumping rates for pump-and-treat remediation.

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