Kirtland Bulk Fuels Facility Plume: Benefits of CSM-Driven Remediation

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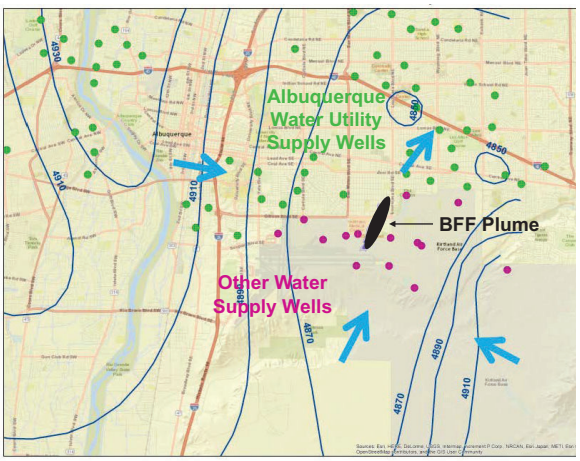
Kirtland Bulk Fuels Facility (BFF)

- Groundwater plume appeared to be migrating toward drinking water supply wells
  - Cleanup has been a top AFCEC priority since 2010
- Remediation success has been driven by adaptive and iterative process
  - Refining the conceptual site model (CSM)
  - Selecting, designing and optimizing remediation systems
- Presentation objective

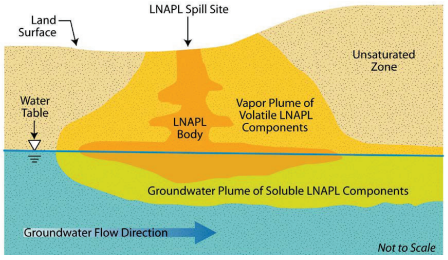
Demonstrate benefits of CSM-driven remediation at a challenging site

Relationship of BFF Plume to Regional Groundwater



Release History

- 1999 : Discovery
  - Jet fuel leak in subsurface piping
  - Large volume released over several decades
  - LNAPL and BTEX in upper half of 500 ft vadose zone

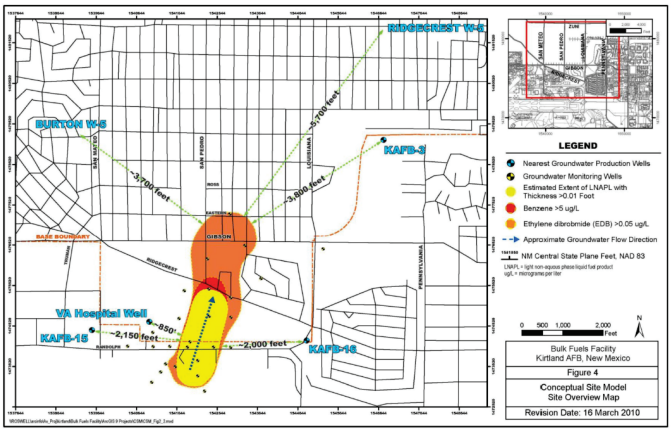


- 2001 : EDB, BTEX detected in groundwater
- 2007 : Free product discovered at water table
  - Offset from release site
- 2009 : Plume detected north of base boundary
  - LNAPL mapped in deep vadose zone

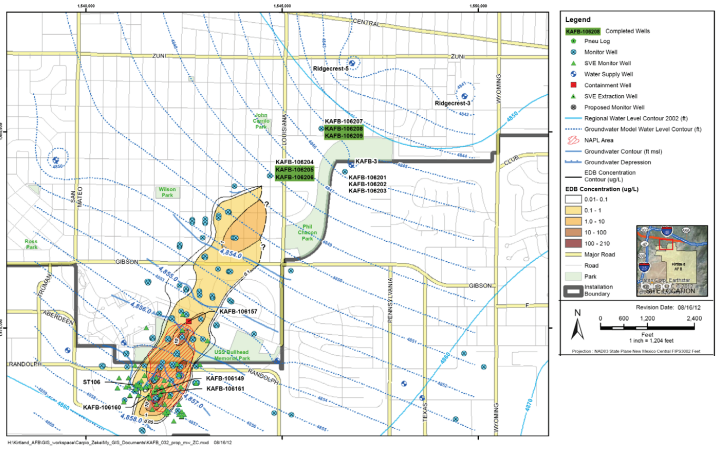
Remediation Challenges

- High visibility with public and Congress
  - Senior leadership committed high level of expertise, contract support and public outreach
  - Diverse stakeholders: AFCEC, NMED, USGS, Water Utility, EPA, Albuquerque, VA Hospital, Citizen Action Group
- Complex site characteristics
  - Deep vadose contamination: LNAPL and vapor phase
  - LNAPL at water table : ~500 ft below surface
  - Large EDB plume with very low MCL : 0.05µg/L
  - Off-base urban infrastructure
- Water table rising as regional water use changes
  - Disappearance of floating LNAPL in groundwater wells
  - Changes in groundwater flow direction

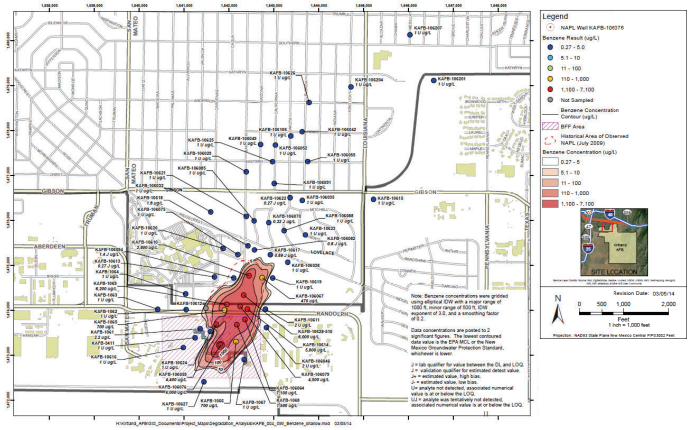
Plume Description: 2010



EDB Plume Chasing: 2012



Stable Benzene Plume Reflects LNAPL Footprint



Leadership Direction

- 2010 : Remediation objectives
  - Ensure drinking water is never contaminated
  - Develop contingency plans with sentinel well clusters for public water supply
  - Stop/collapse ethylene dibromide (EDB) plume
  - Remediate contaminants of concern in accordance with RCRA permit
- 2014 : Establish technical working groups (TWG)
  - Technical experts and site managers/regulators (AFCEC, NMED, Water Utility, EPA, USGS, Albuquerque, VA Hospital)
  - Forum for frequent and transparent collaboration and accountability
  - Evaluate progress on interim measures and work through technical issues

TWG Startup

- Guiding principles
  - Use best available science and data to inform decisions
  - Employ creative technical solutions to address problems
  - Collaborate and engage stakeholders in decisions
  - Ensure meaningful compliance with regulations and permits
- TWG implemented an adaptive and iterative process
  - Improve and refine the CSM
  - Select, design and optimize remediation systems
  - Frequent all-day meetings with action items
  - Small-group spinoffs for data evaluation
- Adaptive approach
  - Emphasize incremental improvements to CSM and remedy
  - 70% solutions, data-driven decisions, collaborative work plans

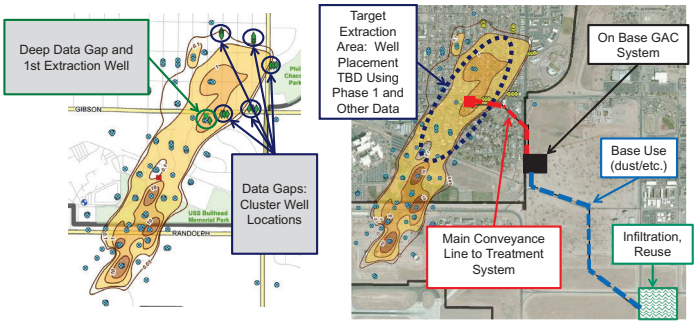
TWG Initial Approach to EDB Plume

Phase 1

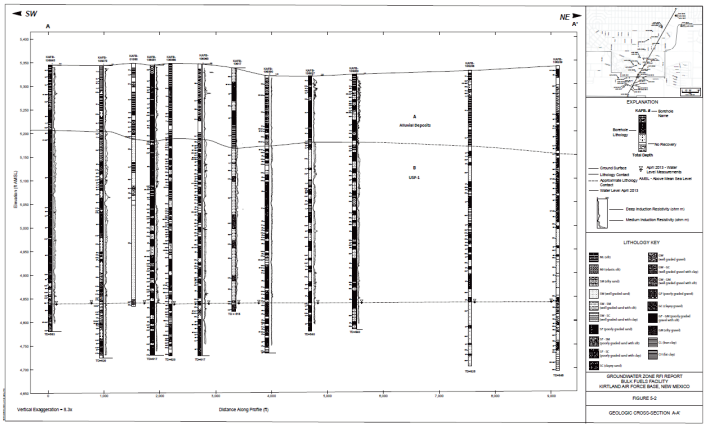
- Interim measure P&T (~100 gpm)
- Characterize plume extent

Phases 2 and 3

- Expand P&T system: 5-7 extraction wells (600-800 gpm)
- System optimization to contain and collapse plume

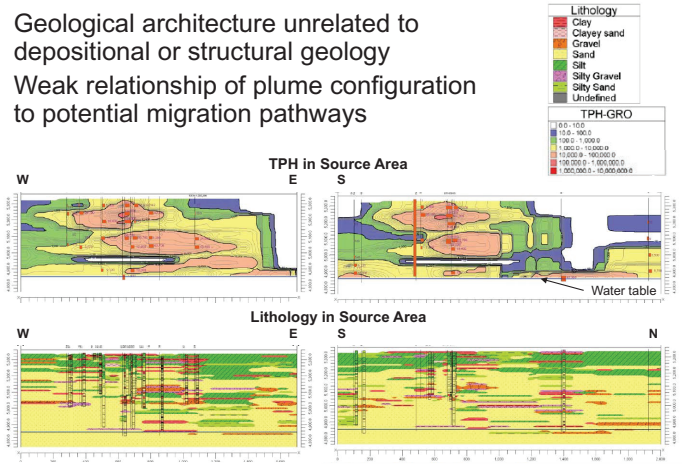


Large Geological Database but Little Analysis Prior to TWG



CSM Evolution: Hydrogeological Framework: 2010

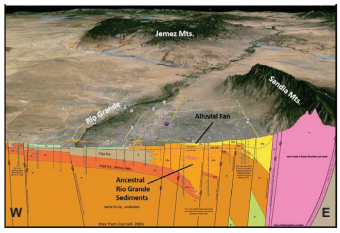
- Geological architecture unrelated to depositional or structural geology
- Weak relationship of plume configuration to potential migration pathways



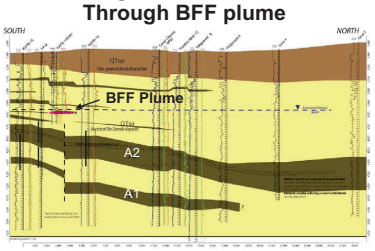
CSM Evolution: 2014 Sequence Stratigraphy

- Hydrogeological framework refined with sequence stratigraphic model
- 2013 hydrogeological & geophysical data base
  - 35 vadose zone locations with 5 depth intervals per location
  - 177 groundwater wells at three depth intervals

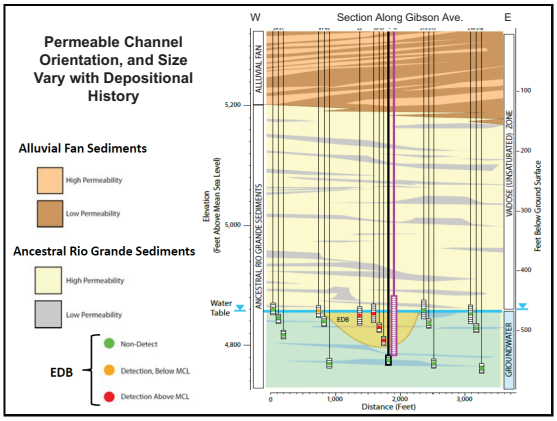
Regional Perspective



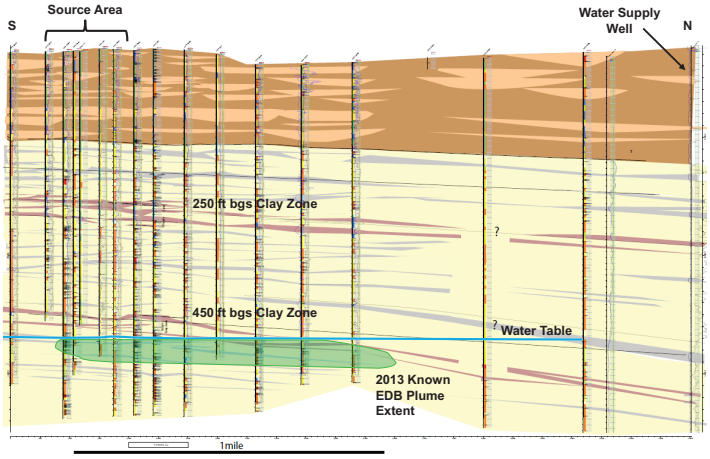
Sub-Regional Cross Section Through BFF plume



CSM Evolution: 2014 Plume-Scale Stratigraphy

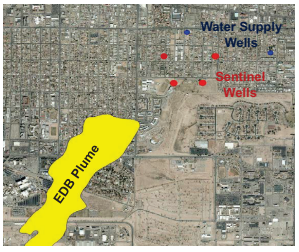


CSM Evolution: Cross Section along Plume Axis

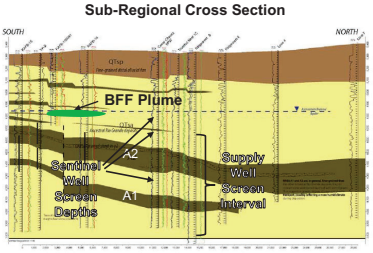


Use of CSM for Sentinel Well Placement

- Sentinel wells give early warning to trigger contingency
- Water supply wells screens at greater depths than plume
- Three screen intervals per sentinel location
  - Water table
  - Above A2 confining unit
  - Below A2 unit



Sub-Regional Cross Section

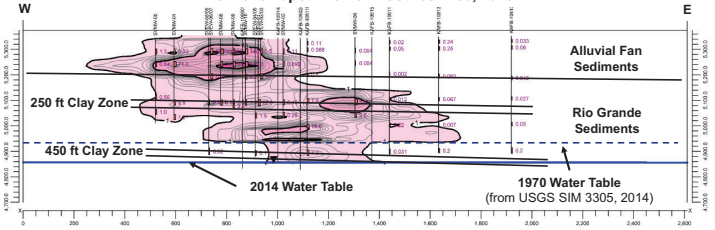


Use of CSM in Vadose Zone Remediation

- Relate LNAPL migration and stratigraphy
- Expand SVE footprint to hot spots
- Perform SVE pilot tests
  - Optimize extraction and treatment
- Collect/evaluate soil cores

Extraction rate increased from 50 to 1,800 cfm

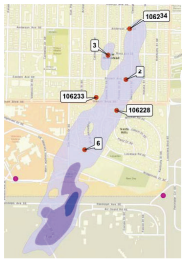
Benzene Vapor Profile in Source Area, 2013



Use of CSM in Distal Plume Remediation

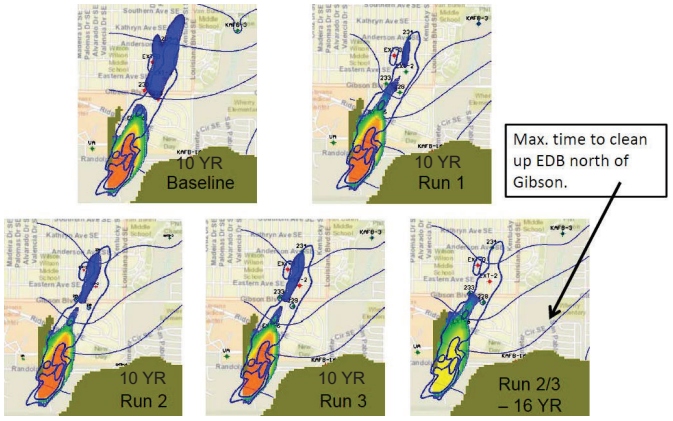
- Key Considerations in P&T system design
  - Flow & transport model recalibrated to address 450 ft bgs clay zone
  - Distribution & orientation of channel deposits
  - Urban infrastructure
- Stepwise approach as each pumping well was brought on line
  - Allowed feedback loop to refine CSM and optimize design of later wells
  - Example: Design alternatives for 4th and 5th extraction wells

Well	Approximate Saturated Screen (ft)	Pumping Rate (gpm)			
		Baseline	Run 1	Run 2	Run 3
KAFB-106228	80	0	-150	-150	-150
KAFB-106233	80	0	-150	-150	-150
KAFB-106234	80	0	-150	-150	-200
EXT-2	80	0	-150	0	0
EXT-3	80	0	0	0	0
EXT-6	80	0	-75	-75	-75
KAFB-7	465	-300	675	525	575



Projected EDB Clean Up for Design Alternatives

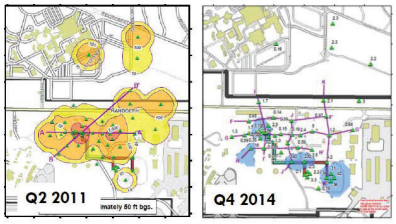
Upper part of plume controls cleanup north of Gibson Blvd

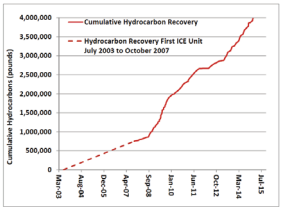


Result of Vadose Remediation

- Soil removal: 5,000 tons
- SVE removed 780,000 gal fuel
  - SVE shutdown: 2015
  - Soil-gas rebound testing
  - Coring of select locations
  - In situ respiration monitoring

Total VOCs at 50 ft





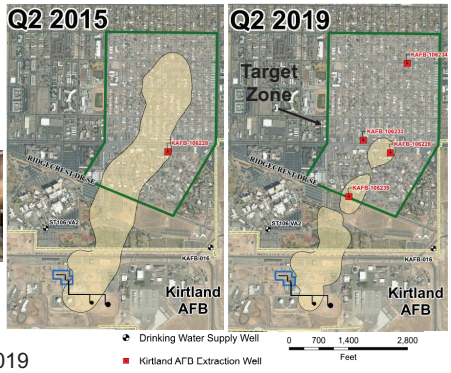
- Rebound and coring identified remaining hot spots
- Respiration monitoring results
  - Correlate with hydrocarbon presence
  - Low respiration rates suggest minimal biodegradation
  - Water content not optimal

Result of Distal Plume Remediation

Extraction Well	Start Date
1	June 2015
2	Dec 2016
3	Apr 2017
4	Feb 2018

Water treatment
- Four 20,000 lb GAC units
- 601.5 Mgal though Mar 2019
- 13 g EDB

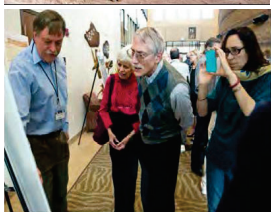
Footprint of Shallow Plume



- Cleanup of middle & lower parts of plume completed

Result: Public and Stakeholder Acknowledgement of Success

- Increased public awareness and involvement
  - Proactive & transparent communication
  - Public meetings, poster sessions, deep dives & field trips
  - Direct public access to technical experts
- Improved public relations
  - Dramatic changes from confrontation to seeking clarification of complex technical topics



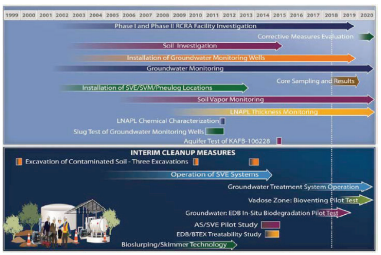
Editorials

Editorial: KAFB, NM have cleanup flowing in right direction

By Albuquerque Journal Editorial Board
Tuesday, July 19th, 2016 at 12:02am

Current Focus of Kirtland TWG

- Goal: Transition to long-term remedy
- Vadose zone: bioventing pilots to promote microbial degradation
  - Raise moisture content
  - Deliver oxygen



- Saturated zone EDB: In situ biodegradation pilot
  - Baseline, recirculation tracer test, passive monitoring (2017)
  - Biostimulation: two designs (2018-2019)
  - Additional passive monitoring (on-going)

Conclusions

- Meeting Kirtland BFF challenges requires rapid deployment of multiple remedial technologies in a complex setting
- Cleanup success driven by an adaptive remedial approach with strong links to an evolving CSM
- A functioning interagency TWG has been key to success
  - Adaptive, transparent and collaborative
  - Data-driven decision process
  - 70% solutions
  - Stepwise design/operation with CSM feedback loops
- Benefits of CSM-driven remediation
  - Builds stakeholder support to remediation approach
  - Shortens time to meet performance objectives
  - Builds confidence among leadership of all agencies and stakeholders

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