Air Force Civil Engineer Center

Integrity - Service - Excellence

Complex Remediation Case Study Air Force Plant PJKS

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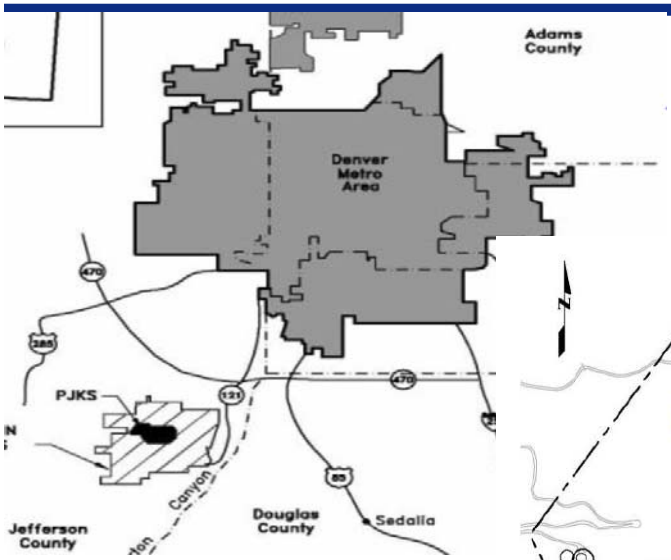
14 November 2012

Complex Case Study PJKS Site Description

- Fuel Test/Development Facility
  - (1957–Present)
- NPL Site and Order on Consent established State of Colorado as Lead Agency
- Record of Decision Complete
- Soils Closed
- Three Ground Water Plumes
- Two COCs, TCE and NDMA
- Seven poorly-defined bedrock source areas
- Two types of bedrock,
  - Fractured sandstone
  - Fractured crystalline rock

Complex Case Study PJKS Site Description



53 soil sites – all are closed
36 closed without restriction
12 closed with restriction
5 closed with restriction plus limited cover

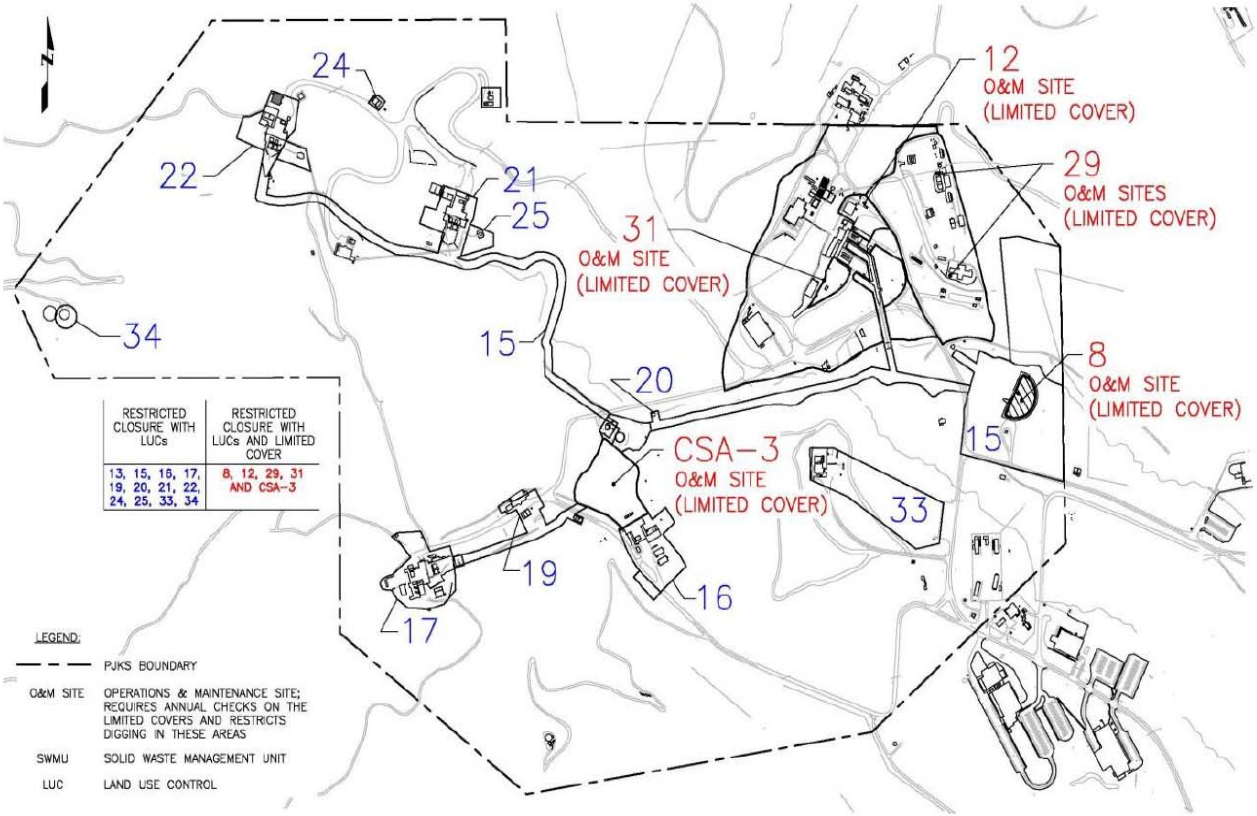
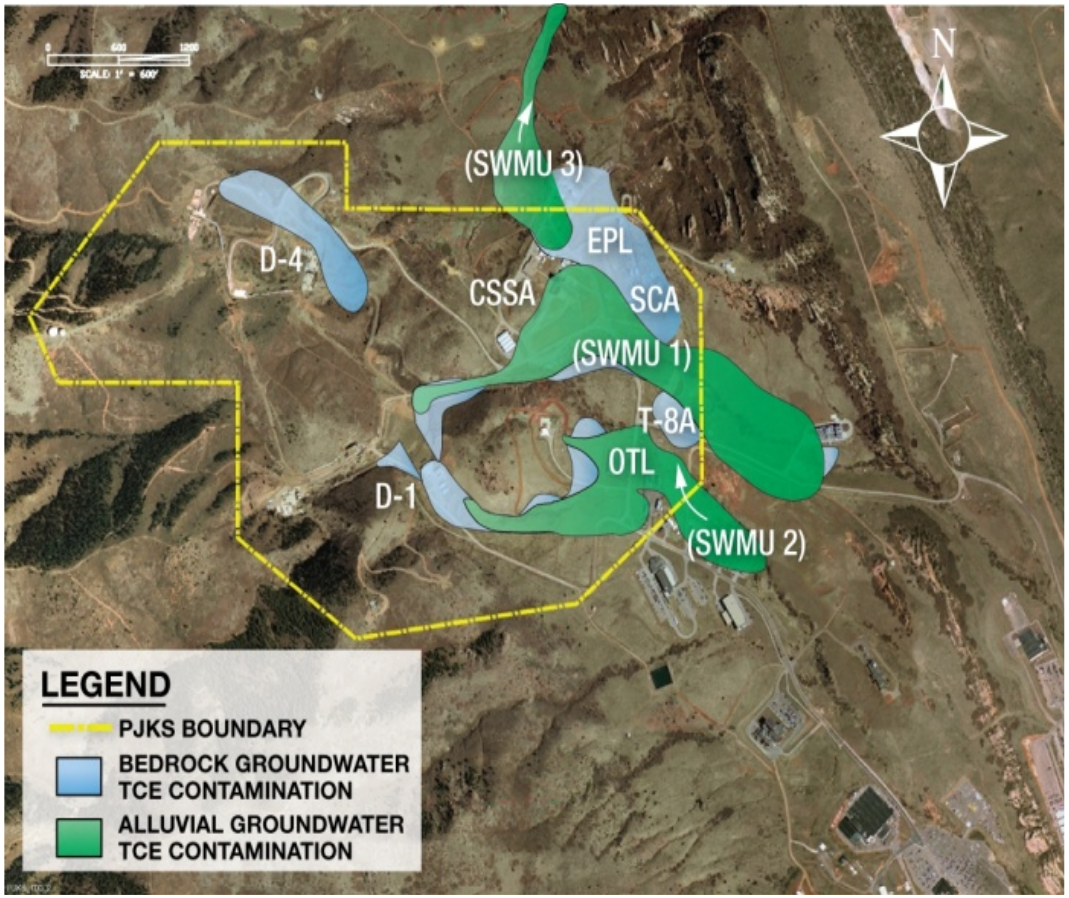


Figure 3: Soil SWMUs with Restricted Closure

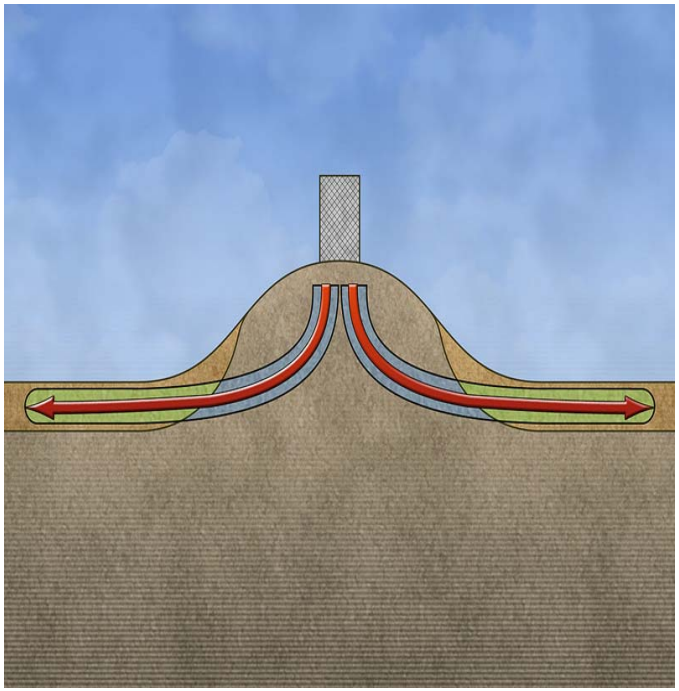
Complex Case Study PJKS
Results of Investigations

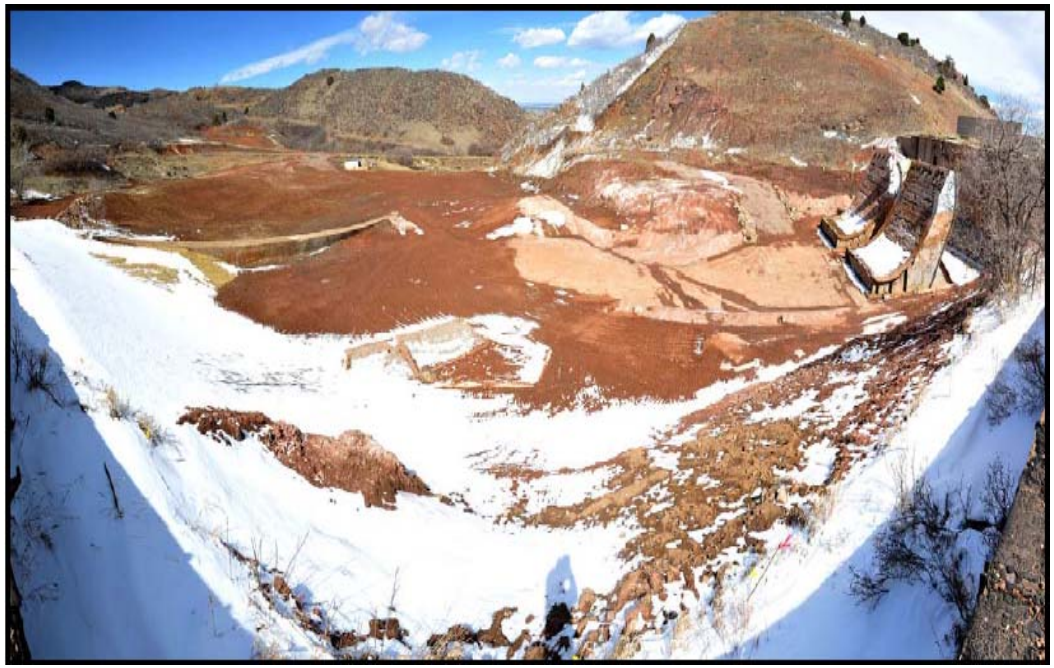


- 3 groundwater plumes with associated bedrock source areas
- 2 COCs -TCE & NDMA
- TCE plume boundaries are stable
- Vapor Intrusion not significant
- NDMA plumes are stable & boundaries within TCE Plumes

Complex Case Study PJKS Conceptual Site Model

- Diffuse bedrock source areas
- 100 to 135 Ft bgs
- Low porosity/low transmissivity,
- Bedrock/alluvium flux @ ≈ 25 Ft bgs





Complex Case Study PJKS Remediation Risk Management[1]

- Identifying Technical Challenges to Groundwater Restoration
  - Contaminant-Related Challenges (TCE, NDMA)
  - Hydrogeologic Challenges
    - Low porosity/low transmissivity & depth
  - Other Challenges
    - Plume migration to adjacent property and "inordinate cost"
- Evaluating the Likelihood of Technical Cleanup Challenges
  - Technology Performance Assessments, pilot- or full-scale
  - Site data assessment
  - Integration into the CSM
- Evaluating the Adverse Impacts of Technical Cleanup Challenges
  - Noncompliance with regulations, remedies do not achieve ARARs
  - Long-term property restrictions
  - Public perception
  - Litigation
  - Destabilize plume boundaries

Complex Case Study PJKS Pilot Study Results

PJKS Pilot Studies:

- **TCE – Enhanced Bioremediation 12,000 µg/L to 25 µg/L @ D-1 site**
- **NDMA – no in-situ approach**
  - **Reducing conditions – did not work**
  - **Co-metabolism – (TCE toxic to process) equivocal preliminary success with methane, butane, & propane**
- **Ex-situ technology – UV oxidation is Standard**
  - **Expensive to operate**
  - **Energy intensive**
- **Tested ex-situ nickel hydrogen treatment - technology not scalable**

Complex Case Study PJKS Performance Model

Site data assessment:

PJKS TCE Source Area Treatment

Source Area	Current source area TCE concentration	Distance from source area cross-over point to property boundary (feet)	Source area TCE concentration needed for natural attenuation to achieve CBSG at property boundary (ppb)	Time required to reduce source area to concentration needed for natural attenuation to achieve CBSGs by property boundary
EPL	6,600	0 (N)	5	49 months
		1400 (S)	1400	11 months
SCA	1,700	0 (N)	5	40 months
	10,000	700 (S)	80	31 months
D-1	7,200	2700 (N)	>20,000	0 months
		2000 (S)	16,000	0 months
CSSA	460	200 (N)	10	25 months
		1200 (S)	600	0 months
OTL	140	900	180	0 months
T-8A	190	0 (N)	5	25 months
		400 (S)	25	14 months

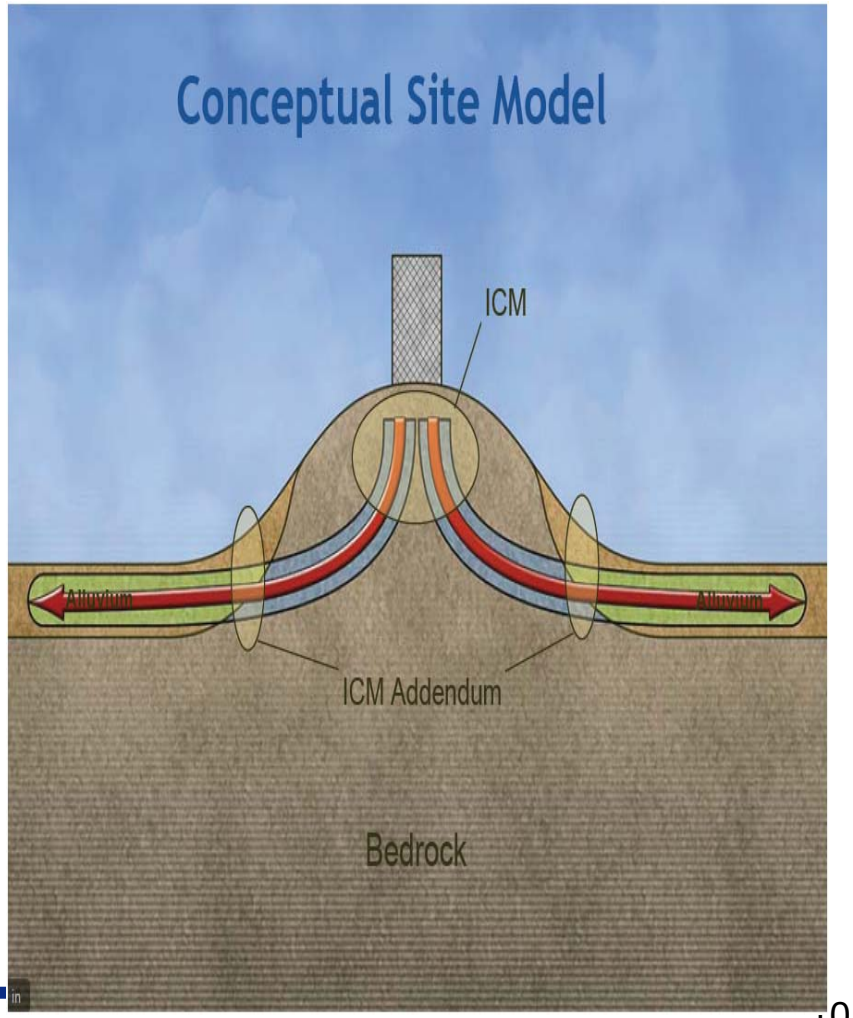
Complex Case Study PJKS Groundwater RAOs

- The State of Colorado promulgated groundwater standards (e.g. CBSGs) are the basis of the media cleanup standards (MCSs) for individual COCs in PJKS groundwater
- USAF, EPA, and CDPHE established Preliminary RAOs for groundwater at PJKS in Dec 2005
  - RAOs may reduce exposure or reduce chemical concentrations
  - Not always possible to remediate all groundwater to unrestricted exposure levels
- Groundwater is not currently used on site
- The RAO to protect human health is intended to prevent future use until concentrations are reduced to the point use can be unrestricted and exposure unlimited
- Use will be restricted through the LUCs imposed by the Environmental Covenant

Complex Case Study Groundwater RAOs (Cont.)

RAOs for TCE:

- **Reduce TCE contamination at the transition points (where bedrock groundwater transitions into the alluvial system)**
- **Reduce TCE concentrations in bedrock source areas to levels that achieve CBSGs for groundwater beyond the PJKS point of compliance**
- **Projected in approximately 10-20 years considering uncertainty about response to in-situ treatment**



Complex Case Study Groundwater RAOs (Cont.)

RAOs for NDMA:

- **Protect human health by preventing contact with, and ingestion of, TCE or NDMA contaminated groundwater until unlimited use/unrestricted exposure levels are achieved.**
- **Contain NDMA in the alluvium through the continued monitoring of the plume stability until the groundwater is remediated to beneficial use, except where a waiver is justified based on technical impracticability.**
  - **No physical remedial system is required since the NDMA alluvium plume is stable.**
- **Utilize a technical impracticability waiver for restoring NDMA within bedrock groundwater in a reasonable timeframe.**
  - **Protectiveness in this zone will rely on Land Use Controls and monitoring.**

Complex Case Study PJKS Groundwater Selected Remedy

Remedial Action for TCE:

- **In-situ bioremediation with environmental covenant selected for TCE**
- **TI waiver with environmental covenant selected for NDMA in contaminated bedrock groundwater**
- **Operate and Maintain Interim Groundwater Remedial Actions**
  - **Remedial action performance monitoring**
  - **Assess remedial action progress**
  - **Optimize performance monitoring**

Complex Case Study PJKS Groundwater Selected Remedy

Remedial Action Construction for TCE:

- Interim remedies address seven bedrock TCE source areas in contaminated bedrock groundwater
- Bioremediation – carbon source, nutrients & bioaugmentation
- Carbon source installed using vertical and horizontal wells and temporary injection points
- Biobarrier installation at bedrock/alluvium transition

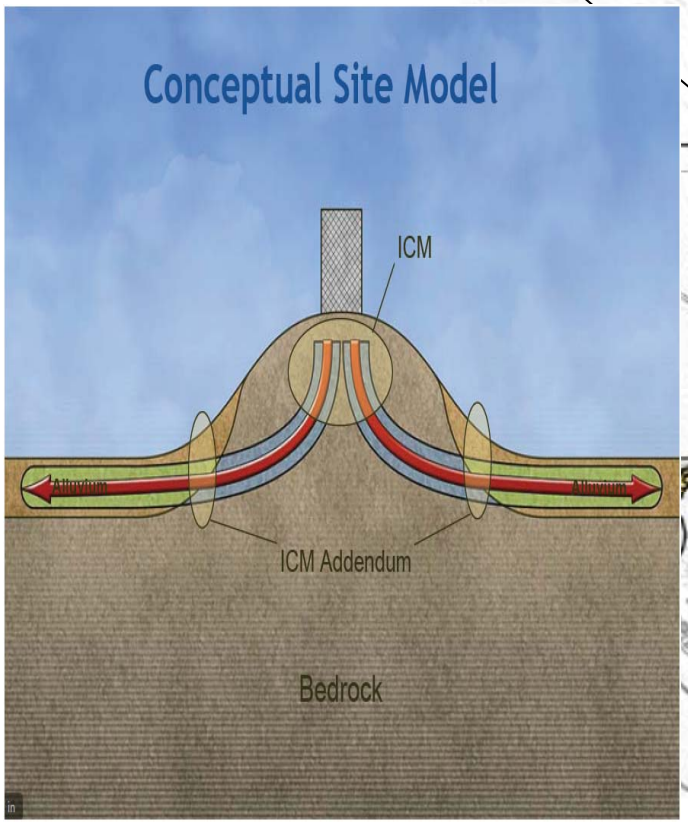
- Operate and Maintain Interim Groundwater Actions
  - Remedial action performance monitoring
  - Assess remedial action progress
  - Optimize performance and monitoring
- Industrial land use restriction in warranty deed at transfer
- Negotiated landowner agreement to implement enforceable environmental covenant upon completion of ROD

Complex Case Study PJKS Groundwater Remedy Construction

Remedial Action Construction for NDMA:

- CDPHE approved a technical impracticability (TI) waiver for restoring NDMA within bedrock groundwater in a reasonable timeframe
- Basis for TI waiver
  - Large volume of NDMA contaminated bedrock
  - Poor permeability of bedrock (i.e., pumpability) and inability to access contaminated groundwater
  - Fractured bedrock with unpredictable flow characteristics and associated matrix back diffusion
  - Pumping with ex-situ treatment in PJKS bedrock groundwater is not technically or economically practical
- Contain NDMA in alluvium through monitoring of plume stability
  - No physical remedial system required (the alluvial plume is stable)
  - Protectiveness in this zone will rely on Land Use Controls and monitoring.

Complex Case Study PJKS Groundwater Remedy Construction

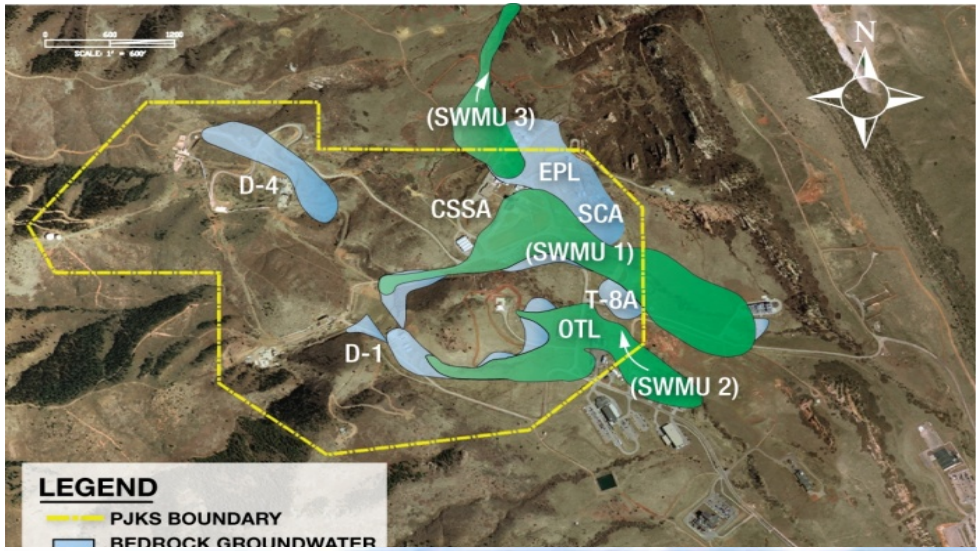


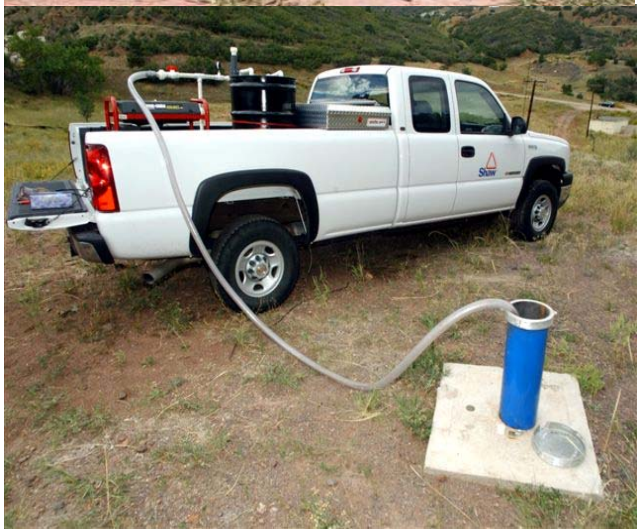
Property Boundary

Point of Compliance

Adjacent Property – Environmental Covenant

Complex Case Study PJKS Groundwater Remedy Construction





Complex Case Study PJKS Horizontal Well Locations

Complex Case Study PJKS Adaptive Site Management

- Implement Environmental Covenant to assure Protective Criterion
- Alternative Point of Compliance
- Implement Innovative Technology for in-situ remediation of ground water in plume
  - AFCEE BAA Project (follow-on to ESTCP Project)
  - Nutrient Supplementation (Propane or methane)
- Employs Treatment Train Concept – remediate TCE to reduce inhibition of NDMA bioremediation – followed by nutrient supplement tailored to NDMA
- Address Performance Objectives, Remediation Schedule and Contingency Planning
- Evaluate post remediation TI waver for TCE @ asymptotic effect

Complex Case Study PJKS Summary

- USAF, Regulators and Property owner worked together for sustainable remedies
- CERCLA and RCRA Programs can work together
- Remediation team agreed to:
  - Protect human health and the environment
  - Do the best we can
  - Don’t spend unrealistic amounts of money
- Made reasonable judgments as a team
  - Used simple assessments & appropriate tools
  - Long-term focus
  - Implemented phased approaches

Complex Remediation Case Study
Air Force Plant PJKS

Questions?

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