

Groundwater Remediation at Forbes Atlas S-7 Missile Site Wamego, Kansas

2006 Army Environmental Cleanup Workshop

San Antonio, Texas

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**U. S. Army Corps of Engineers
Kansas City District**

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Atlas Missile Sites Background

- Atlas Missile Program: Important but short-lived element of the United States' Defense system
- Construction started in 1950s, These facilities remained in service from 1961 to 1965
- The Atlas "E" missiles based upon "Semi-hard" facilities designed to withstand nearby nuclear explosion
- Former Forbes Atlas S-7 is one of the Nine Atlas "E" sites assigned to former Forbes Air Force Base in Topeka, collectively know as Atlas Missile Squadron.

Forbes Atlas S-7 Missile Site Project Background

- Atlas S-7 Missile Site is located 38 miles northwest of Topeka, near the town of Wamego
- The former S-7 Missile site is surrounded by residential developments
- Most residents relied on private wells for water
- August 2002 sampling revealed 44 out of 89 water wells contaminated with TCE ranging 0.6 to 79.7 ppb
- 29 of these drinking water wells exceeded the Maximum Contamination Levels for TCE

Interim Remedial Actions

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USACE-KCD Immediate Response

Interim Remedial Actions

- **August, 2002:** Bottled water provided to residences above MCL
- **January, 2003:** Connected 29 residences to Granular Activated Carbon (GAC) water treatment system
- **February, 2003:** Began quarterly monitoring of all GAC systems and 60 private drinking water wells
- **May, 2003:** Began Phase I Remedial Investigation (RI)
- **August, 2003:** Phase I RI completed
- **September, 2003:** Conducted Engineering Evaluation/Cost Analysis (EE/CA) for alternate clean water.

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Interim Remedial Actions (cont.)

- **March, 2004:** Phase I contract award to Rural Water District #1 alternate clean drinking water
- **April, 2004:** Bacteria cleanup treatment completed
- **June, 2004:** Phase II rural water connection contract awarded
- **August, 2004:** Time Critical Removal Action Sump/Sediment Traps Clean up
- **August, 2004:** Phase I design plan for rural water connection completed
- **December, 2004:** Phase II design Plan for rural water connection completed
- **April, 2005:** All 75 residents were connected to rural water

Remedial Investigation

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Forbes Atlas S-7 Remedial Investigation

- Remedial Investigation initiated in May 2003. RI completed in two phases. Phase I involved:
 - the delineation of the TCE Plume
 - identification of source areas via Site characterization and Penetrometer System (SCAPS)
- Phase II involved:
 - Address data deficiencies identified in Phase I
 - Further characterize the nature and extent of contamination in soil and groundwater
- RI (both Phases) was completed in December 2004

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Site Geology/Hydrogeology

- Site geology consists of thin layer of top soil underlain by Kansas Till ranging from 50 to 123 ft in thickness
- Till divided into three stratigraphic layers:
 - An upper layer of silty to sandy clay
 - A middle layer of silt with sand and clay stringers
 - Lower layer of sand and gravel. This layer is typically saturated around 100 feet bgs
- The Kansas Till underlain by bedrock, mostly shale and limestone

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Remedial Investigation (Findings)

- Remedial Investigation findings:
 - Suspected source of TCE: area around the main sump, sediment traps, and connecting underground piping
 - The highest concentrations of TCE (+/- 300ppb) detected in the unsaturated zone at about 40 to 80 ft bgs
 - TCE contamination (250ppb) in groundwater found in 20 ft thick sand/gravel aquifer located 100 ft bgs

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Remedial Investigation (Findings)

- On site the contamination plume splits into:
 - primary and secondary flow path (east and northeast)
- Both flow paths merge and co-mingle immediately east of the site into a single plume
- Plume extends eastward approximately 6000 feet in length and nearly 5000 ft wide
- Aquifer is underlain by shale bedrock at 120 ft bgs

Feasibility Study

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Feasibility Study Pilot Testing

- Feasibility study conducted from June-September 2005
- In-Situ Ozone Injection technology coupled with Soil Vapor Extraction
- Ozone Injection (Ozinox) applied to a 200-by-100-foot area identified as target treatment zone
- This super saturated ozone solution was injected into the subsurface using two injection wells
- Ozone solution was injected into a saturated sand layer immediately above bedrock to oxidize VOCs in the aquifer

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Feasibility Study Pilot Testing (cont.)

- A lesser component of ozone injected at groundwater interface to treat VOCs in the overlying unsaturated zone
- Groundwater movement enhanced by creating groundwater flow gradient by extracting water from downgradient extraction well and injecting ozinated water into two injection wells
- Six SVE wells installed within the contaminated unsaturated zone to enhance the movement of vapor phase ozone through this zone

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Feasibility Study Pilot Tests (Findings)

- Parameters measured to determine the effectiveness include: distribution of ozone, fluoride (tracer), dissolved oxygen and oxidation-reduction potential
- Ozone was not detected in any monitoring wells which indicates that it was either utilized in reactions with VOC compounds or decomposed to oxygen prior to reaching the wells
- The fluoride (used as tracer) was detected in the downgradient wells
- Significant increases in dissolved oxygen concentrations several monitoring wells including extraction well
- Significant decrease in TCE, DCE and total VOC concentrations was observed

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Feasibility Study Pilot Tests (Findings)

- The SVE data indicated that injection of ozone during the Pilot Study resulted in removal of a approximately 7.55 lbs of VOCs from the unsaturated soils surrounding the SVE extraction wells
- Approximately 655 lbs of ozone was injected into the lower part of the aquifer during this 90-day study
- About 2.5 million gallons of water was treated