Design of a Permeable Reactive Barrier for Chloroethenes and Hexavalent Chromium Treatment in Groundwater at the Former Kelly AFB

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Under contract to the
Air Force Real Property Agency (AFRPA)

Overview

- **Remedial Objective**
- **Design Basis**
  - Column Study for Kinetic Data
  - Groundwater Model for Velocity Profile
- **Design**

Remedial Objective

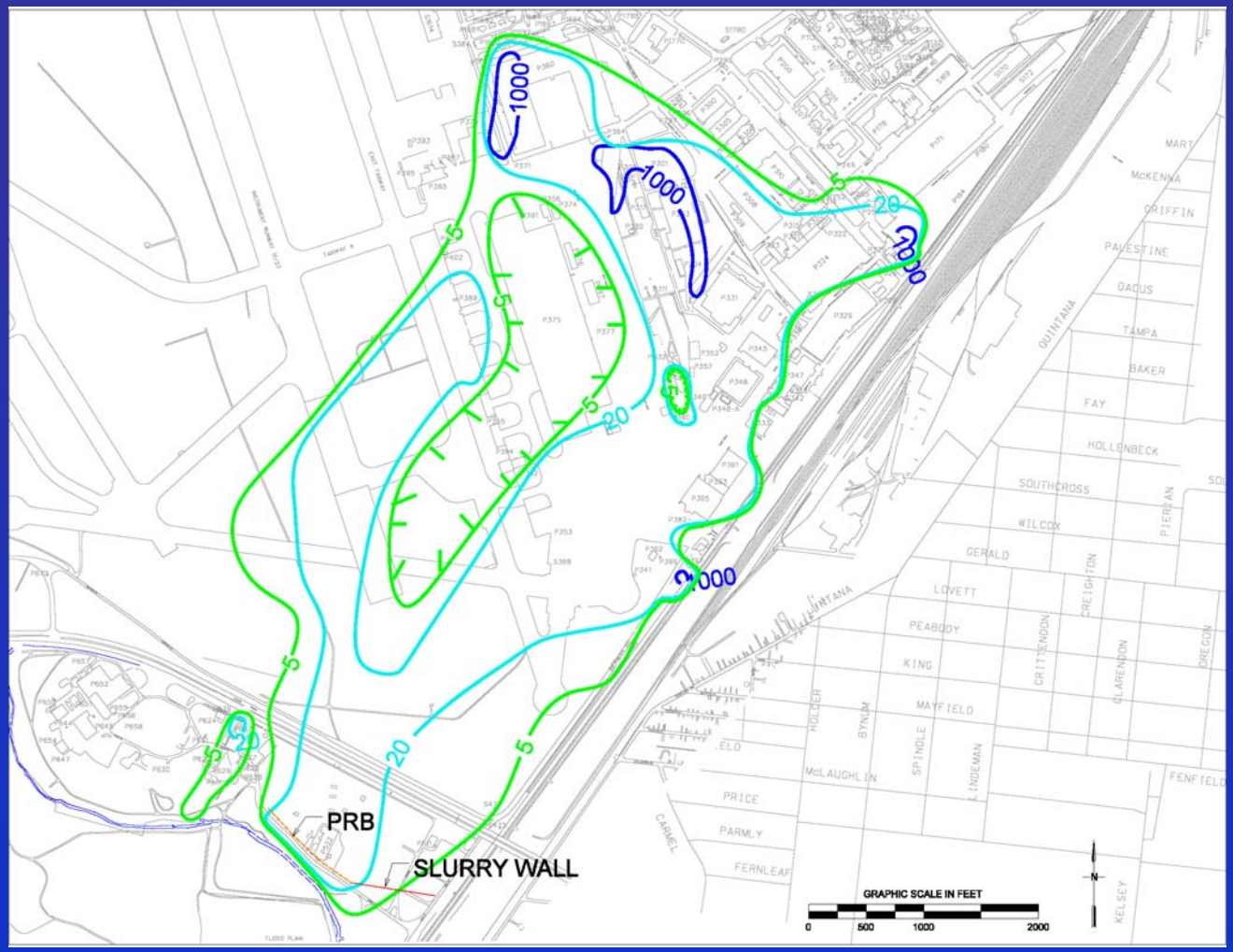
OBJECTIVE: to hydraulically contain the contaminated groundwater from further migration.

SOURCE: Interim Stabilization Measures for Site CS-2NB, USAF 1999.

Remedial Objective--Containment

- Contain contaminants prior to discharge to Leon Creek (Zone 2)
- Solvent contamination originates from industrial area of Kelly and flows southward
- Hexavalent chromium (Cr^{6+}) contamination originates in several areas in western Zone 2
- Current recovery system consists of six wells along Citrus Road, parallel to Leon Creek
- Air Force goal for final remedies is passive systems where possible

Remedial Objective



Plume originates from solvent sources at Building 360. Source area is now cut off by PRB located around building.

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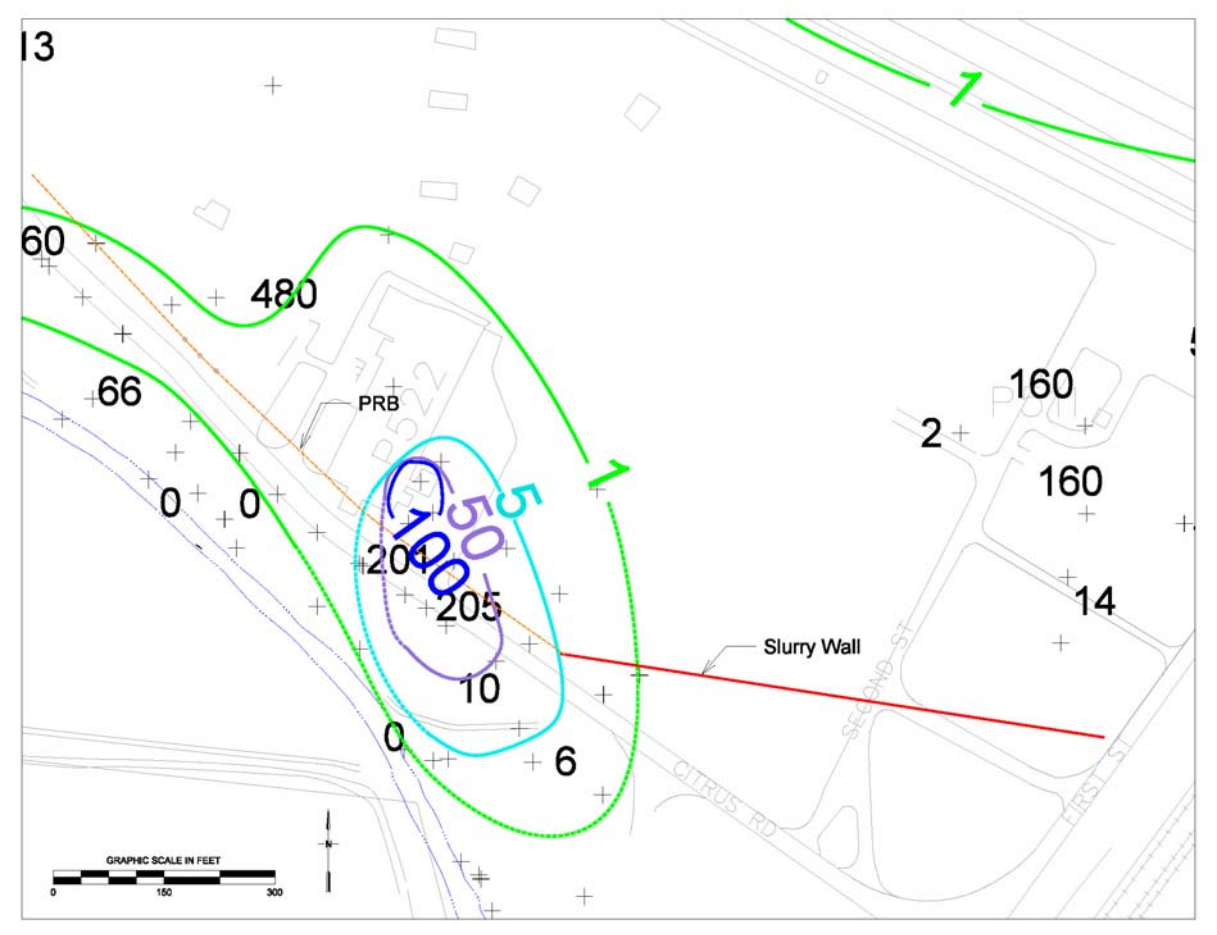
Remedial Objective



In Zone 2, plume consists primarily of PCE, with TCE present in the southeastern portion due to Building 522 source area, and Cr^{6+} in the southwestern portion

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Remedial Objective

Existing recovery well system includes four wells adjacent to Citrus Road (100-200 feet up gradient of Leon Creek), and two wells (in high permeability channels) slightly up gradient.

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Design Basis—Primary Design Inputs

- Kinetics for contaminant destruction in Zone 2 groundwater
- Groundwater flow velocities along PRB alignment
- Depth to aquitard

Design Basis—Kinetic Parameters

- Kinetic parameters necessary for PRB thickness calculation
- Previous column studies provided kinetic parameters for other sites at Former Kelly AFB, however separate study performed for Zone 2 PRB due to:
  - **Presence of Cr^{6+}**
  - **Potential effect of NO_3 (significant kinetic effect at Building 360 PRB)**

Design Basis—Kinetic Parameters

- Groundwater samples collected from two areas of the Zone 2 plume, to represent greatest treatment challenges
  - **Western end of plume--highest Cr^{6+} concentration**
  - **Eastern end of plume--highest TCE concentration (near Building 522)**
- Samples collected from recovery wells

Design Basis—Kinetic Parameters

- Column study performed by Envirometals Technologies Inc.
- Kinetic degradation parameters determined for PCE, TCE, and DCE
- Kinetics for Cr^{6+} not determined due to :
  - **Lower than expected sample level**
  - **Complete reduction to Cr^{3+} prior first sample point**
- NO_3 does not have deleterious effect on kinetic parameters for solvents in this area of Zone 2

Design Basis—Kinetic Parameters

- Half-life values for solvents (includes temperature correction from column study data)
  - **PCE = 2.3 hours**
  - **TCE = 1.4 hours**
- Degradation constant for Cr^{6+} (from ETI database) = 2.0 mg/gram of iron

Design Basis—Groundwater Model

- Model needed to estimate flow velocities at proper scale of PRB design problem
- Model grid small enough to reflect heterogeneities of conductivity and gradient in flow channels leading to Leon Creek

Design Basis—Groundwater Model

- Groundwater model developed as submodel of existing basewide model, using 50’ x 50’ grid.
- Model updated with new lithology and aquitard data in proposed alignment area
- Model calibrated with data from two synoptic water level surveys in Zone 2 area, under non-pumping conditions.

Design Basis—Groundwater Model

- Steady state runs of calibrated model used to provide velocity profiles.
- High groundwater velocities ranged from 5 to 25 feet per day along the alignment
- High groundwater velocities indicate thicker PRB necessary for complete contaminant degradation.

Design Basis—Groundwater Model

Comparison of Model Velocities (ft/day) Along Citrus Road Alignment

Distance (ft)	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050
CMI	2	4	7	16	25	20	16	16	15	13	13	13	10	6	4	5	19	29	12	5	5	3
CMS	5	7	8	8	9	9	10	10	11	11	12	11	9	20	5	4	4	4	3	4	1	<1
B522	10	13	15	15	18	22	21	22	20	17	12	10	10	11	11	11	12	11	9	10	13	2

Other models show similar variation in velocity profiles

Design Basis—Aquitard Data

- Existing data from recovery wells and monitoring wells along Citrus Road and in Bldg 522 Area used to establish aquitard depth along PRB alignment

PRB Design

- PRB location options

Along northern bank of Leon Creek

Adjacent to Citrus Road

Constructability issues indicated the Citrus Road location was the most feasible

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PRB Design

- Influent concentrations combined with kinetic data and groundwater velocity to determine PRB thickness
- Excessive thickness (approx. 15 feet) required for treatment of solvents to MCL
- AFRPA altered goal--minimize contaminant effluent levels from PRB, within budget constraints

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PRB Design—Iron Proportioning

- Iron was proportioned among 5 sections of the PRB, with more iron designated for sections with higher groundwater velocity and/or higher influent solvent concentrations
- Performance in each section gauged as residual of effluent concentrations (effluent minus MCL) for each contaminant
- Iron proportions between sections were fine tuned based on minimizing the sum of the effluent residuals

PRB Design—Iron Proportioning

Contaminant	PRB Section	Influent Concentration (µg/L)	% Iron	Groundwater Velocity (ft/day)	Effluent Concentration (µg/L)
PCE	A	23	25%	9.0	18.0
PCE	B	23	40%	19.3	17.6
PCE	C	67	40%	10.6	35.4
TCE	C	110	40%	10.6	38.5
PCE	D	67	100%	12.0	15.5
TCE	D	110	100%	12.0	9.9
PCE	E	38	40%	15.3	24.8
TCE	E	23	40%	15.3	11.4

PRB Design

- PRB monitoring well locations selected based on areas of potential for highest concentration breakthrough
- Existing recovery wells will be used for backup in case breakthrough is observed
- Moderate alkalinity and high groundwater velocity suggests carbonate precipitation on iron media may occur sooner than anticipated

Zone 2 PRB Construction is Underway!

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