RPP-6909-FP
Revision 0

Preliminary Results of flow and Transport Modeling at the 241-S-SX Tank Farms, Hanford Site

A.J. Knepp
CH2MHILL Hanford Group, Inc.

Date Published
December 2000

To be Presented at
2000 Fall Meeting of the American Geophysical Union
San Francisco, CA
December 15, 2000

Chris Willingham 12-18-00
Release Approval Date

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

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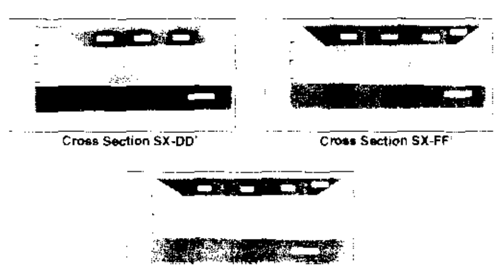
A-6001-401 (02/98)

Preliminary Results of Modeling Vadose Zone Flow at the 241-S-SX Tank Farms, Hanford Site

ABSTRACT

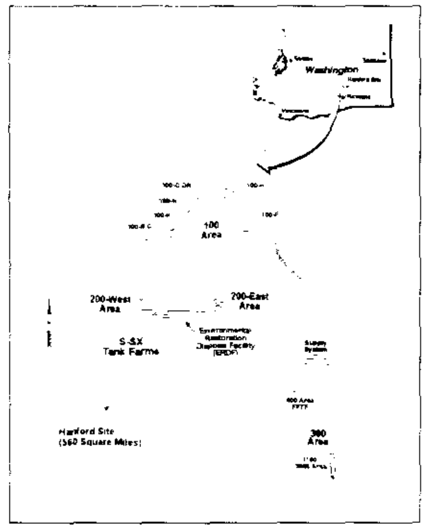
The U.S. Department of Energy (DOE) has initiated a Resource Conservation and Recovery Act (RCRA) Corrective Action process to address the impacts of past and potential future tank waste releases to the vadose zone at the 241-S-SX single-shell tank farms at the Hanford Site in southeastern Washington. The corrective actions include evaluation of impacts to groundwater resources (i.e., the concentration of contaminants in groundwater) and long-term risk to human health (associated with groundwater use). Numerical models have been developed that consider the extent of contamination presently within the vadose zone, contaminant movement through the vadose zone to groundwater, and contaminant movement in the groundwater to points of compliance. Results are included on analysis of laboratory measurements for physical and hydraulic properties for soil samples in the vicinity of the 241-S and 241-SX tank farms, and upscaling of small-scale measurements for soil moisture characteristics. The two-dimensional model considers the accelerated movement of water around and beneath single-shell tanks that is attributed to bare, gravel surfaces and thus enhancing net infiltration of meteoric water (from winter precipitation and snowmelt). Water influx, possibly exceeding 100 mm/yr, is further amplified in the tank farm because of the umbrella effect (i.e., the effect of percolating water being diverted by an impermeable, sloping surface), created by large, 24-m diameter, buried tank domes. The enhanced recharge can potentially mobilize tank leak wastes and result in an earlier arrival of contaminants at the water table. Preliminary modeling results are presented.

Geologic Cross-Sections

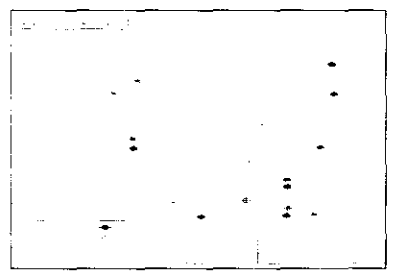


Timeline estimates for emplacement of interim and closure barriers and the corresponding recharge rates

Condition Simulated	Recharge Estimate (mm/y)
No Barrier [2000-2010]	100
Interim Barrier [2010-2040]	0.5
Closure Barrier (1st 500 yrs) [2040-2540]	0.1
Degraded Closure Barrier (post 500 yrs [2540-3000]	3.5



Location of S-SX Tank Farms



WMA S-SX and Surrounding Facilities

COMPUTER CODES USED

The computer code used is STOMP (Subsurface Transport Over Multiple Phases), developed by Pacific Northwest National Laboratory. The simulator was specifically designed to provide scientists and engineers from varied disciplines with multidimensional analysis capabilities for modeling subsurface flow and transport phenomena.

Macroscopic Anistotropy Relationships: Polmann (1990)

$$<LnK> = <LnK_s> - A<\psi> - \sigma^2_{LnKs}\lambda[p - p^2<\psi> - \zeta^2<\psi>]/(1+A\lambda)$$

$$\sigma^2_{LnK} = \sigma^2_{LnKs}[(1 - p<\psi>)^2 + \zeta^2<\psi>^2]/(1+A\lambda)$$

$$K_h^{eq} = \exp[<LnK> + (\sigma^2_{LnK}/2)]$$

$$K_v^{eq} = \exp[<LnK> - (\sigma^2_{LnK}/2)]$$

σ^2_{LnK} = variance of log unsaturated conductivity, which depends on mean tension
$<\psi>$ = mean tension
σ^2_{LnKs} = variance of lnKs
$<LnK_s>$ = mean of lnKs
p = slope of the β versus lnKs regression line
ζ = ... standard deviation of the residuals in the β versus lnKs regression
A = mean slope, β, for lnK versus ψ
λ = vertical correlation lengths for lnKs (assumed to be same as that of β)
K_h^{eq} = equivalent unsaturated horizontal conductivity, and
K_v^{eq} = equivalent unsaturated vertical conductivity

Polmann, D.J. 1990. Application of Stochastic Methods to Transient Flow and Transport in Heterogeneous Unsaturated Soils. Ph.D Thesis, Massachusetts Institute of Technology, Cambridge, MA.

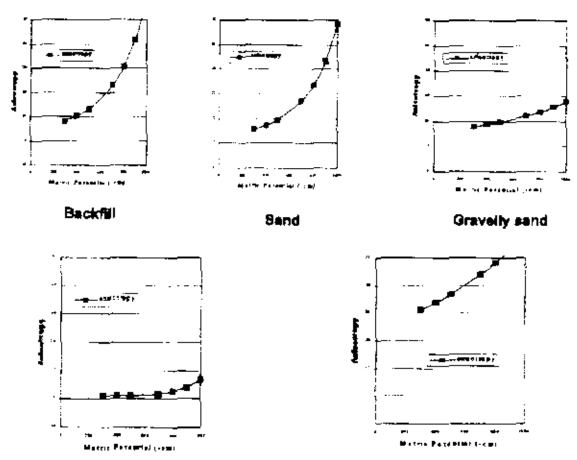
Macroscopic Anistotropy Relationships: Polmann (1990)

Strata	Number of samples	$<LnK_s>$	$\sigma^2_{LnK_s}$	P	ζ	λ (cm)	A
Backfill (1)	8	-15.3	1.83	-5.6E-4	5.16E-4	50	0.00415
Sand (2)	12	-14.6	1.50	-7.2E-4	6.55E-4	50	0.00620
Gravelly Sand/Sandy Gravel (3)	11	-14.85	1.94	-2.6E-4	2.50E-4	30	0.00368
Plio-Pleistocene (4)	4	-10.43	1.01	2.4E-3	9.34E-4	50	0.0104
Sandy Gravel (5)	10	-15.76	3.56	-1.1E-4	1.84E-4	30	0.00371

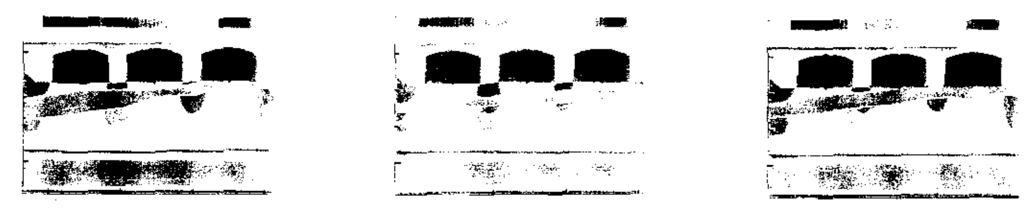
Composite van Genuchten-Mualem Parameters for various strata at the S-SX Tank Farms

Strata	Number of samples	θs	θr	α (1/cm)	n	l	Fitted K_s (cm/s)
Backfill (1)	8	0.2688	0.0151	0.0197	1.4194	0.5	5.15E-04
Sand (2)	12	0.3819	0.0443	0.0117	1.6162	0.5	9.88E-05
Garvelly Sand/Sandy Gravel (3)	11	0.2126	0.0032	0.0141	1.3730	0.5	2.62E-04
Plio-Pleistocene (4)	4	0.4349	0.0665	0.0085	1.8512	0.5	2.40E-04
Sandy Gravel (5)	10	0.1380	0.0100	0.0210	1.374	0.5	5.60E-04

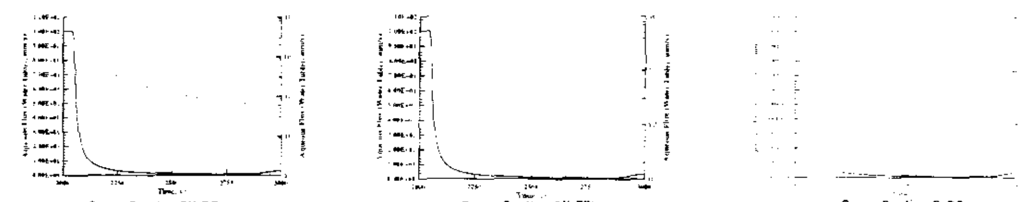
Calculated macroscopic anisotropy for different strata



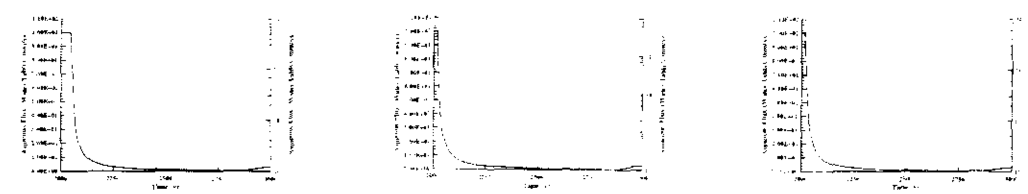
Enhanced Water Movement Around the Tank Domes



No Barriers: Distribution of Fluxes at the Water Table



Surface Barriers: Distribution of Fluxes at the Water Table



Saturation Distribution Due to Water Line Leak (25,000 Gallons over 5 days)

SUMMARY

- A suite of two-dimensional simulations were used to investigate the impact of surface barriers and water line leaks
- The simulations consider the accelerated movement of water around the tank domes and the saturation-dependent anisotropy for the heterogeneous media
- The surface barriers, as expected, reduce magnitude of fluxes to the water table
- The water line leak (25,000 gals over 5 days) was sufficient to saturate the soil near the tanks, but the saturated plume diffused rapidly as it migrated through the vadose zone, having negligible impact below the Plio-Pleistocene layer.

U.S. Department of Energy
Office of River Protection

Raz Khaleel
(509) 376-6903
Fluor Federal Services

Mark White
(509) 372-6072
Pacific Northwest National Laboratory

Phillip Rogers
(509) 372-9234
Jacobs Engineering Group