CH2MHILL
Hanford Group, Inc.

Tank Farm Vadose Zone Project

May 2003

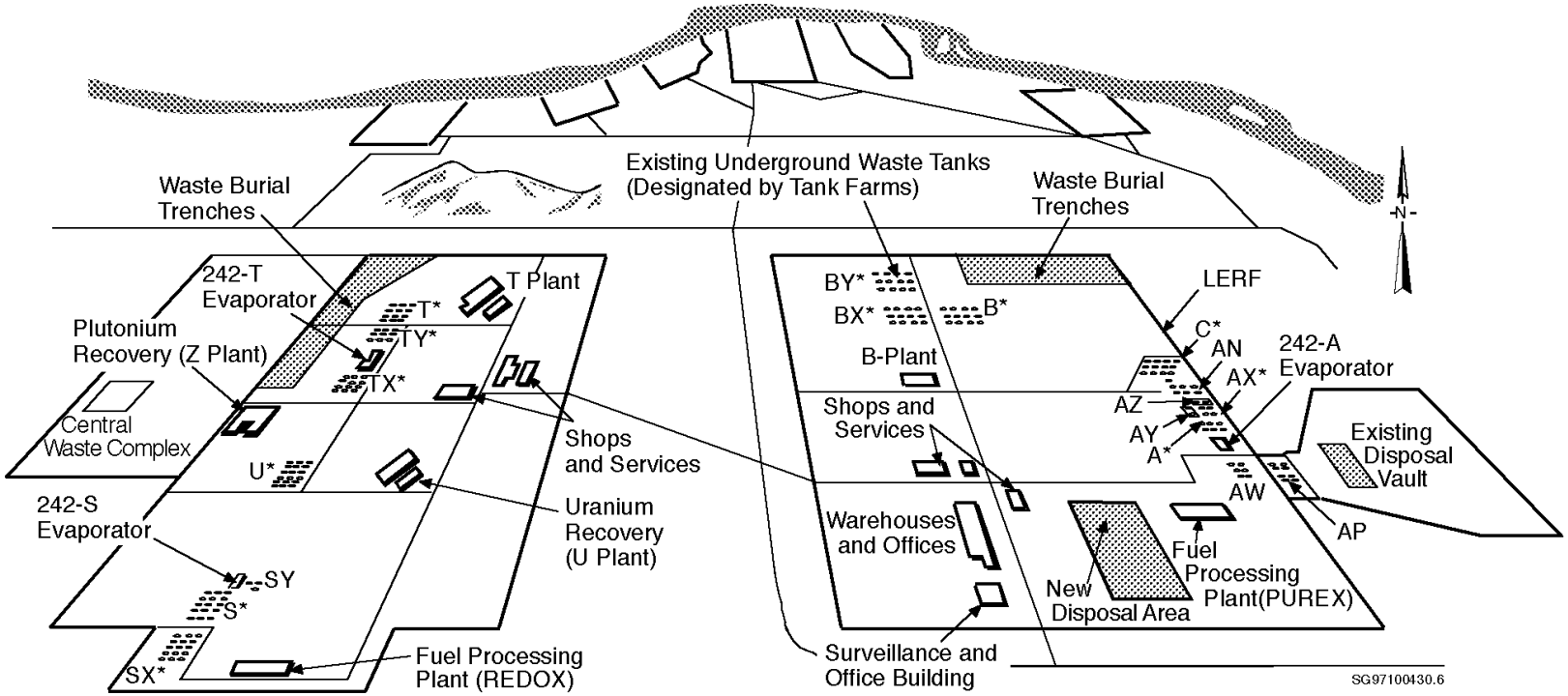
Anthony J. Knepp, CH2M HILL
Frank J. Anderson, CH2M HILL

Opportunities For Science and Technology Research

- CH2M HILL Hanford is the prime contractor for the 200 Area Tank Farms through FY 06.
- Busy times at the Tank Farms.
  - New focus on actual interim closure of tanks.
  - Accelerated schedules.
  - Need for new methods, data and analyses.
  - Need for documentation.

CH2MHILL
Hanford Group, Inc.

Tank Farms in the 200 Area



* Single-shell Tank Farms

200-West Area **200-East Area**

CH2MHILL
Hanford Group, Inc.

Past Vadose Zone Project Use of Science & Technology (S&T) Support

- Two recent significant publications prepared by the Vadose Zone Project being used for interim closure of 200 Area tanks.
  - Field Investigation Report (FIR) for S-SX Waste Management Area (2002) – 24 S&T papers in Appendix D.
  - Field Investigation Report (FIR) for B, BX-BY Waste Management Areas (2002) – 15 S&T papers in Appendix D.
- Environmental Management Sciences Program (EMSP) provided major input to these documents via coordination provided by John Zachara of Pacific Northwest.

CH2MHILL
Hanford Group, Inc.

Letter, J. Hedges, Ecology, to R. M. Yasek, ORP, dated September 9, 2002

This FIR ["Field Investigation Report for WMA S-SX", RPP-7884, TPA Milestone M45-55-T01] represents a significant advancement in knowledge of the wastes leaked from and transported through the vadose zone for WMA S-SX. Streamlining the field investigation process and use of different drilling and sampling techniques bode well for future investigations of the vadose zone surrounding leaking SST's. The focused Science and Technology Program contributed valuable information on the processes involved in the fate and transport of contaminants, notably cesium-137, through the vadose zone and provides a better basis for planning, investigating, modeling, and, ultimately, closure of the two tank farms. This information provides useful data for determining whether additional interim and/or interim corrective measures are needed before waste retrieval, treatment, and facility closure and provides valuable support to tank waste retrieval. It is essential that the knowledge gained in this investigation be transferred to the waste retrieval (and other) projects so that planning, design, and risk/performance evaluation can proceed judiciously with the best and most current information."…The Washington State Department of Ecology looks forward to receipt of future FIRs and the contribution that they can make to complex issues of tank waste retrieval, treatment, and closure of these facilities.

CH2MHILL
Hanford Group, Inc.

Tank Farm Vadose Zone Project

- Project began in FY 97.
- Continuing activities are scheduled through FY 07.
- Regulatory-Based Corrective Action Program.
  - Provide data and analyses to support interim measures and interim corrective measures decisions.
  - Implement such measures, as appropriate.
  - Provide data to support interim tank closure and closure decisions.
- Coordinate with the Hanford Site GW/VZ Program (science and technology, modeling, etc.).

CH2MHILL
Hanford Group, Inc.

What We Do

- Estimate impacts from past, present and future radioactive and chemical contamination events at 200 Area Tank Farms, and evaluate options to mitigate those impacts.
- Events covered:
  - Past leaks.
  - Potential retrieval leaks.
  - Impacts from residual waste.

CH2MHILL
Hanford Group, Inc.

How We Do It

- Gather past information.
- Plan research and development approach (field and lab).
- Implement approach.
- Model or just simulate impacts.
- Document.

CH2MHILL
Hanford Group, Inc.

Tank Farm Vadose Zone Project's Work Schedule

Work Schedule								
Waste Management Area (WMA)/Document	**FY00**	**FY01**	**FY02**	**FY 03**	**FY 04**	**FY 05**	**FY 06**	**FY 07**
S-SX WMA FIR	Field/Lab							
		Reporting						
B, BX-BY WMAs FIR	Planning							
		Field/Lab						
			Reporting					
T, TX-TY WMAs FIR		Planning						
			Field/Lab	Field/Lab				
					Reporting			
A-AX, C, U WMAs FIR					Planning			
						Field/Lab		
							Reporting	
Interim Measures Design & Construction	Well Caps							
		200 West						
			200 East					
RCRA Documents (proposed)							RFI Rollup	
						CMS		
								RFI/CMS

CH2MHILL
Hanford Group, Inc.

We Need Science and Technology Help

I make progress by having people around who are smarter than I am – and listening to them. And I assume that everyone is smarter about something than I am.

Henry J. Kaiser

CH2MHILL
Hanford Group, Inc.

New Support Needs

- Tc-99 release mechanisms from Hanford tank waste.
- Tc-99 beneath SX Farm.
- Uranium transport in Tank Farm Vadose Zone.
- Residual tank waste release models.
- Tank Farm pre- and post-closure (barrier) recharge estimates.
- Role of concrete shell around single-shell tanks (SSTs) in controlling the release of contaminants.
- Liquid Detection Monitoring and Mitigation Research.

CH2MHILL
Hanford Group, Inc.

Tc-99 Release Mechanisms from Hanford Tank Waste

- Development of long-term risk assessments for tank farm closures requires viable waste release mechanisms for key constituents, such as Tc-99, I-129, and Cr(IV).
- Recent laboratory analyses have shown Tc-99 to be ~100% “water soluble” in sludge from tank BX-101 and, at the most, 20% “water soluble” in sludge from Tank AY-102.
- Efforts are currently underway to isolate the tank AY-102 sludge fraction containing the insoluble Tc-99 for characterization.
- Small quantities of these solids should become available for detailed analyses needed to elucidate the Tc/waste component chemistry that is responsible for the Tc-99 solubility behavior.
- A better understanding of Tc-99 chemistry in tank waste matrices would be very helpful for groups attempting to develop “Tc-99 Getters,” not to mention tank release mechanisms.

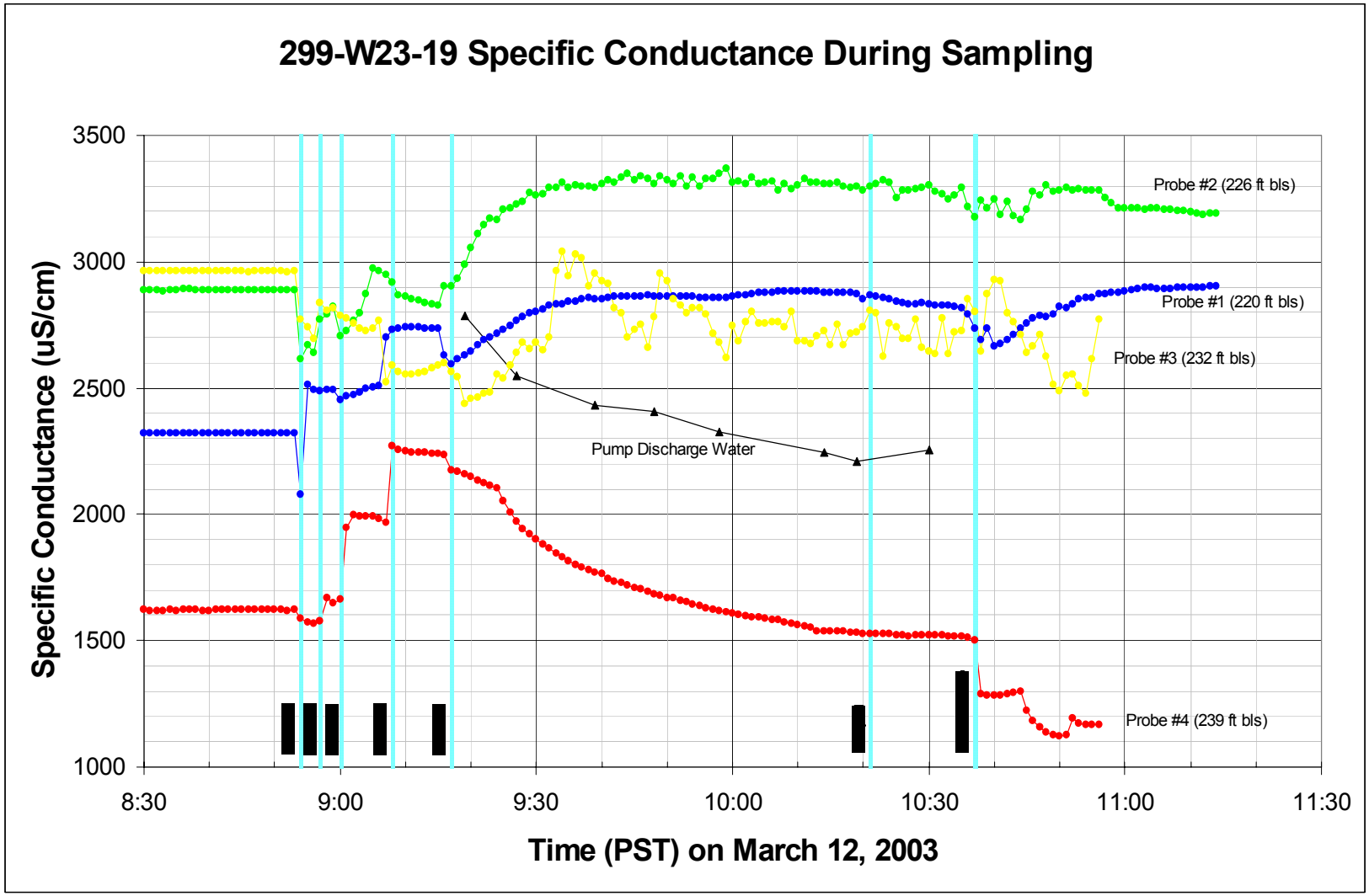
CH2MHILL
Hanford Group, Inc.

Tc-99 Beneath SX Farm

- Well 299-W23-19 has highest Tc-99 activity recorded in Hanford Groundwater. (178,000 pCi/L).
- Tc-99 is correlated to Specific Conductance.
- Conductivity probes have been placed at four elevations.
- Tc-99 distribution not readily explained (vertically or horizontally).
- Distribution data from Pacific Northwest GWM Program.
- How extensive must a cover be to slow/stop mobilizing recharge?

CH2MHILL
Hanford Group, Inc.

299-W23-19 Specific Conductance During Sampling



Data courtesy of PNNL Groundwater Monitoring Project

CH2MHILL
Hanford Group, Inc.

What We Can Provide

- Access to contaminated soil and water samples.
- Access to recent tank farm technical information.
- Technical guidance and support from Tank Farm Vadose Zone Project team.
- Use and exposure of science and technology applications that contribute to remediation and closure of the 200 Area tanks at Hanford.

CH2MHILL
Hanford Group, Inc.

For Further Information Contact: Tank Farm Vadose Zone Project Team

- Frank Anderson (CH2M HILL)
- Mike Connelly (CH2M HILL)
- Bill Deutsch (Pacific Northwest)
- Tom Jones (CH2M HILL)
- Raz Khaleel (FFS)
- Tony Knepp (CH2M HILL)
- Clark Lindenmeier (Pacifc Northwest)
- Dave Myers (CH2M HILL)
- Fred Mann (CH2M HILL)
- Jeff Serne (Pacific Northwest)
- Harold Sydnor (CH2M HILL)
- Marc Wood (FH)

CH2MHILL
Hanford Group, Inc.

Supporting Information

CH2MHILL
Hanford Group, Inc.

S&T Papers in Recent Field Investigative Reports

CH2MHILL
Hanford Group, Inc.

Thanks for the Support: S&T Papers in Appendix D of the S-SX FIR

- Mineralogy – 2
- Cesium geochemical and reactive transport - 7
- Chromium geochemical and reactive transport - 4
- Microbiology - 1
- Isotope geochemistry - 3
- Modeling - 4
- Groundwater recharge - 3

CH2MHILL
Hanford Group, Inc.

Thanks for the Support: S&T Papers in Appendix D of the B, BX-BY FIR

- Strontium - 5
- Uranium - 5
- Fluid migration and transport - 3
- Isotope tracking flow and transport - 2

CH2MHILL
Hanford Group, Inc.

Two Examples
Major Contributions by EMSP/S&T to Tank Farm Vadose Zone Project Understanding of Tank Leaks

CH2MHILL
Hanford Group, Inc.

“Elucidation of The Mechanism of Cs-137 Sorption on Hanford Soils” Led by John Zachara

- An understanding of the dynamics and structural aspects of Cs-137 sorption on Hanford soils provides a much better understanding of Cs-137 migration.
- Understanding Cs-137 migration leads to a better understanding of Cs-137 plume formation from tank leaks.
- Understanding the mechanism of Cs-137 plume formation leads to better interpretations of the extensive tank farm Spectral Gamma Logging Database.
- The spectral gamma logging data coupled with an understanding of Cs-137 sorption chemistry provide very strong arguments for constraining the quantity of Cs-137 lost during a specific tank leak event.
- **Thus, this research provides a scientific basis for the current reassessment of the SST leak histories.**

CH2MHILL
Hanford Group, Inc.

“Reactive Transport Modeling of Tank SX-115 Leak” Lead by Steve Yabusaki

- The tank SX-115 leak history was assumed to be well documented in “Raymond and Shdo, 1965”.
- Reactive transport modeling results were inconsistent with tank SX-115 leak inventory estimates from “Jones et al 2000”.
- Yabusaki’s confidence in his modeling team’s results led him to continue to question the leak inventory estimates.
- A careful re-evaluation of the tank fill history revealed that Raymond and Shdo had not taken into account the final addition of a low-level waste stream to tank SX-115 just prior to the leak and uncovered additional uncertainties in the leak inventory estimate.
- Thus, the leak involved a far more dilute waste than previously thought, resulting in a much lower inventory estimate for the SX-115 leak that are consistent with both the reactive transport modeling and gamma logging results.
- **Resolving the apparent inconsistencies between modeling results and “widely accepted” leak histories has led to a far better understanding of low-activity waste leaks around a number of SSTs.**

CH2MHILL
Hanford Group, Inc.

Selected Areas Where EMSP/S&T Research Is Needed

CH2MHILL
Hanford Group, Inc.

Tc-99 Release Mechanisms from Hanford Tank Waste (Jeff Serne, Bill Deutsch, and Tom Jones)

- Jeff Serne's lab has analyzed tank BX-101 sludge where essentially all of the Tc-99 is recovered in water leach and tank AY-102 sludge (known to have come from tank C-106) where only 20% of the Tc-99 is "water leachable".
- The sludge samples from tank AY-102 that contain the "80% non-water leachable" Tc-99 and the "100% water leachable" Tc-99 from tank BX-101 are available for detailed and sophisticated characterization to elucidate the forms of Tc and to better understand the varying water leach properties.

CH2MHILL
Hanford Group, Inc.

Tc-99 Beneath SX Farm Near Tank 241-SX-115 (Dave Myers, Raz Khaleel, and Marc Wood)

- Vertical monitoring shows a strange relationship in monitoring wells near this tank.
- All the water is contaminated with Tc-99, but levels increase markedly with depth and then decrease near the base of the well.
- The highest Tc-99 contamination level in groundwater in the 200 Area has been measured in a monitoring well.
- Responses to pumping the well are most interesting.

CH2MHILL
Hanford Group, Inc.

Uranium Transport in Tank Farm Vadose Zone (Jeff Serne, Tom Jones, Fred Mann, and Marc Wood)

- CHG has funded bench-scale Bismuth Phosphate process simulations to resolve Tc-99 splits among various process waste streams. A simulated "Metal Waste" was produced.
- A number of waste loss events involved "metal waste", the high uranium waste stream coming out of the bismuth phosphate process.
- Studies are underway (or planned) examining the metal waste/soil interactions.
- It is anticipated that soil samples containing sorbed uranium (and potentially other radionuclides) will be available for detailed and sophisticated solids characterization to elucidate the speciation of uranium associated with the solids. The U speciation investigations of lab generated samples could be compared with actual vadose zone field samples from known uranium plumes near SSTs.

CH2MHILL
Hanford Group, Inc.

Residual Tank Waste Release Models (Mike Connelly)

- In the absence of characterization data for release models, conservative values are being used for diffusion coefficients for stabilized (grouted) tank wastes.
- Three potential release models are being considered: solubility-dominated (salt cake in tank), advection-dominated (sand and gravel fill material in tank), and diffusion-dominated (stabilizing agent in tank, such as grout or concrete).

CH2MHILL
Hanford Group, Inc.

Tank Farm Pre- and Post-Closure (Barrier) Recharge Estimates (Fred Mann)

- Recharge estimates presently being used in flow and transport modeling are based on long-term lysimeter studies for bare, non-vegetated, gravelly sediments.
- While the measurements are conservative, they do not represent site-specific measurements.

CH2MHILL
Hanford Group, Inc.

Role of the Concrete Shell Around Single-Shell Tanks (Mike Connelly)

- The role of the concrete shell around the single-shell tanks in the 200 Area is presently ignored in the calculation of risk.
- What is the effect of the concrete sheath on long-term tank waste release models?

CH2MHILL
Hanford Group, Inc.

Liquid Detection Monitoring and Measuring (LDMM) Research (Dave Myers)

CH2MHILL
Hanford Group, Inc.

Leak Detection Monitoring

- Two geophysical methods have been tested
  - High Resolution Resistivity (Hydrogeophysics).
  - Electrical Resistance Tomography (LLNL).
- Capability range
  - HRR
    - 1,845 gal, method C (P_{FA} = 5%. P_D = 95%).
    - to 3,970 gal, method A (P_{FA} = 0.25%. P_D = 95%).
  - ERT-LET
    - 5,140 gal, (P_{FA} = 5%. P_D = 95%).
    - 9,940 gal, (P_{FA} = 0.25%. P_D = 95%).

CH2MHILL
Hanford Group, Inc.

LDMM Where From Here?

- Get solid estimate of cost to deploy.
- Test in actual tank farm environment.
  - Much depends on availability, timing and cost.
- Baseline moisture measurements are being collected.
- Determine actions to be taken when a tank is determined to be leaking.

CH2MHILL
Hanford Group, Inc.