SGW-38572-VA
Revision 0

Iron Injection Treatability Test

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

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Iron Injection Treatability Test

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Iron Injection Treatability Test

Scott Petersen, Fluor Hanford

July 29, 2008

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Soil & Groundwater Remediation Project

Accelerate Cleanup in 100-D: Mend the ISRM Barrier by Injecting Micron- to Nanometer- size Iron

<u>Problem</u>

Portions of the ISRM barrier are losing their reductive capacity, diminishing effectiveness to intercept chromium before it enters the river

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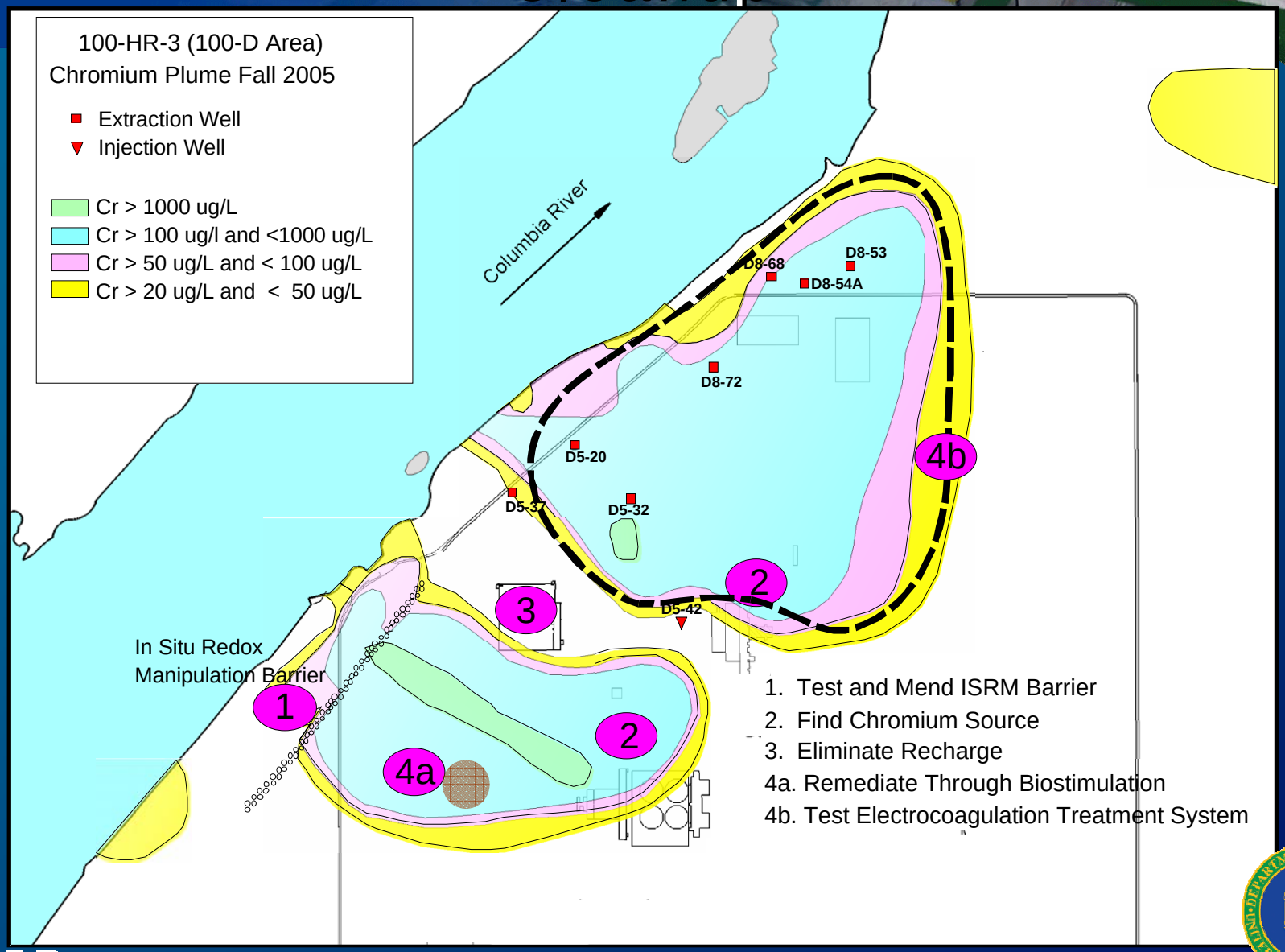
Approach to Accelerating Chromium Cleanup



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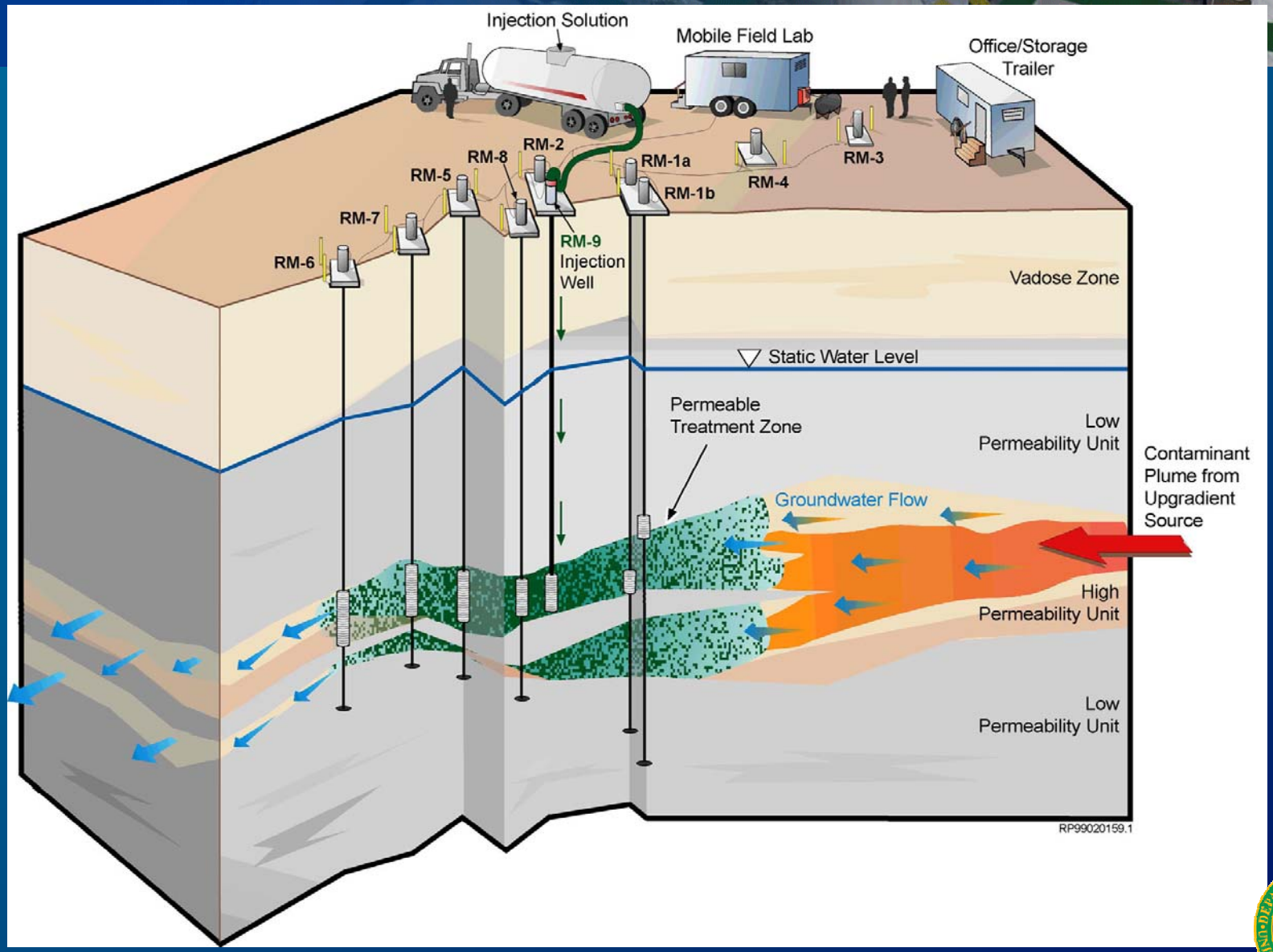
In Situ Redox Manipulation



Accelerate Cleanup in 100-D: Mend the ISRM Barrier by Injecting Micron-size Iron

Solution

Inject micron-size iron into deteriorating parts of the ISRM barrier

Approach

- **A turnkey contract was competitively bid and included laboratory work, modeling, and injection through existing barrier wells into more permeable layers**
- **Post-injection monitoring and verification will be conducted by Fluor Hanford**

Status of Iron Injection

- MSE completed initial column and batch tests on S-3700 iron in May 2007, found that it does not effectively reduce hexavalent chromium, oxygen, or nitrate
- Alternative iron products were identified, screened, and tested
- Eight compounds out of an initial 32 were identified for testing
- Two compounds were selected for more detailed physical and chemical testing
- Laboratory tests completed in May 2008

Laboratory Testing of Zero Valent Iron

- **Batch tests**
  - Determine the ability of the candidate materials to remove chromium from a mixture of silica sand and water. Performed in triplicate
- **Injection tests**
  - Assess
    - **changes in permeability of the soils**
    - **amount of iron that can be injected into soils**
    - **physical stability of the iron after injection**
  - Data from these test will be used to select the best performing ZVI materials for geochemical testing
- **Column tests**
    - **Screen the ZVI materials that passed the first two tests**
    - **Used to assess reactivity of the different ZVI materials**
      - **performed at two iron concentrations**
- **Detailed column tests**
  - Evaluate the one or two iron compounds that are most promising from the above screening tests

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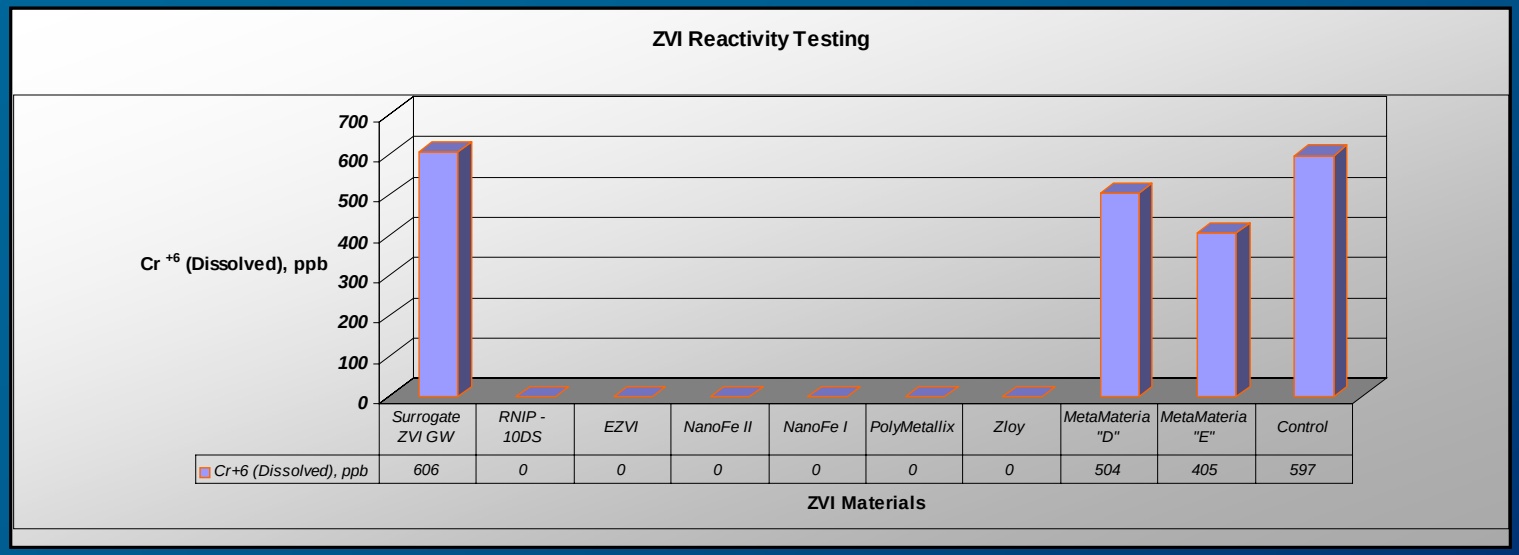
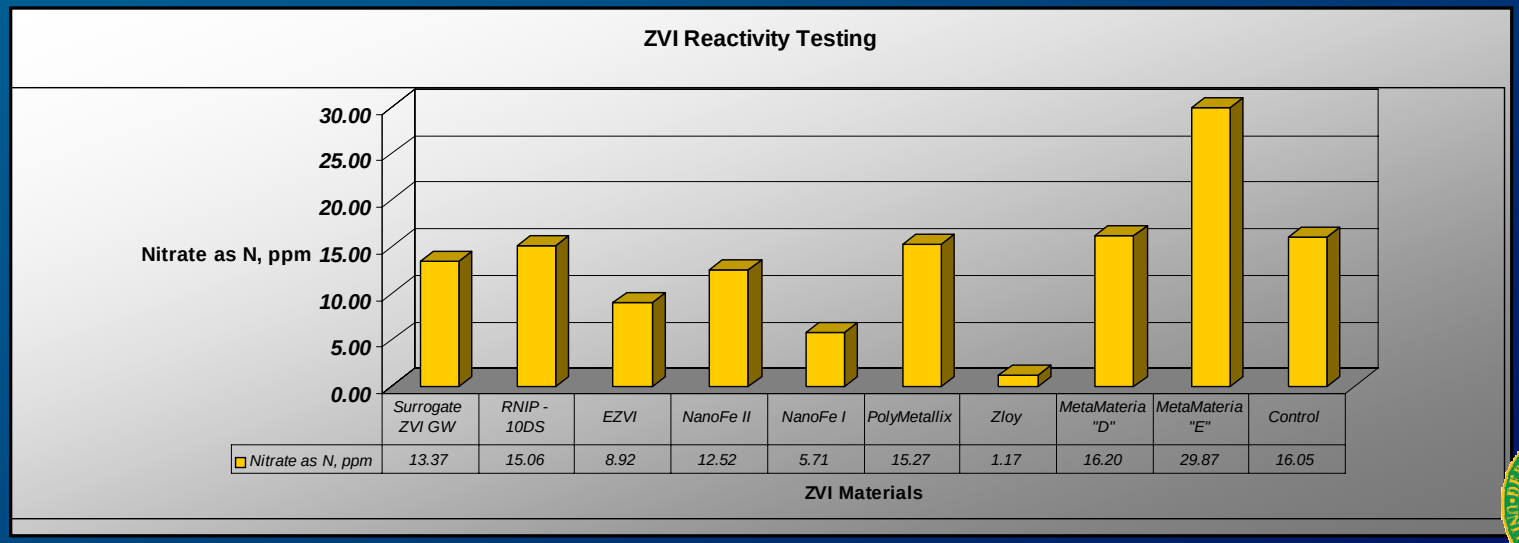
Batch Test Results





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4.5 PV's Injected

20 PV's Injected

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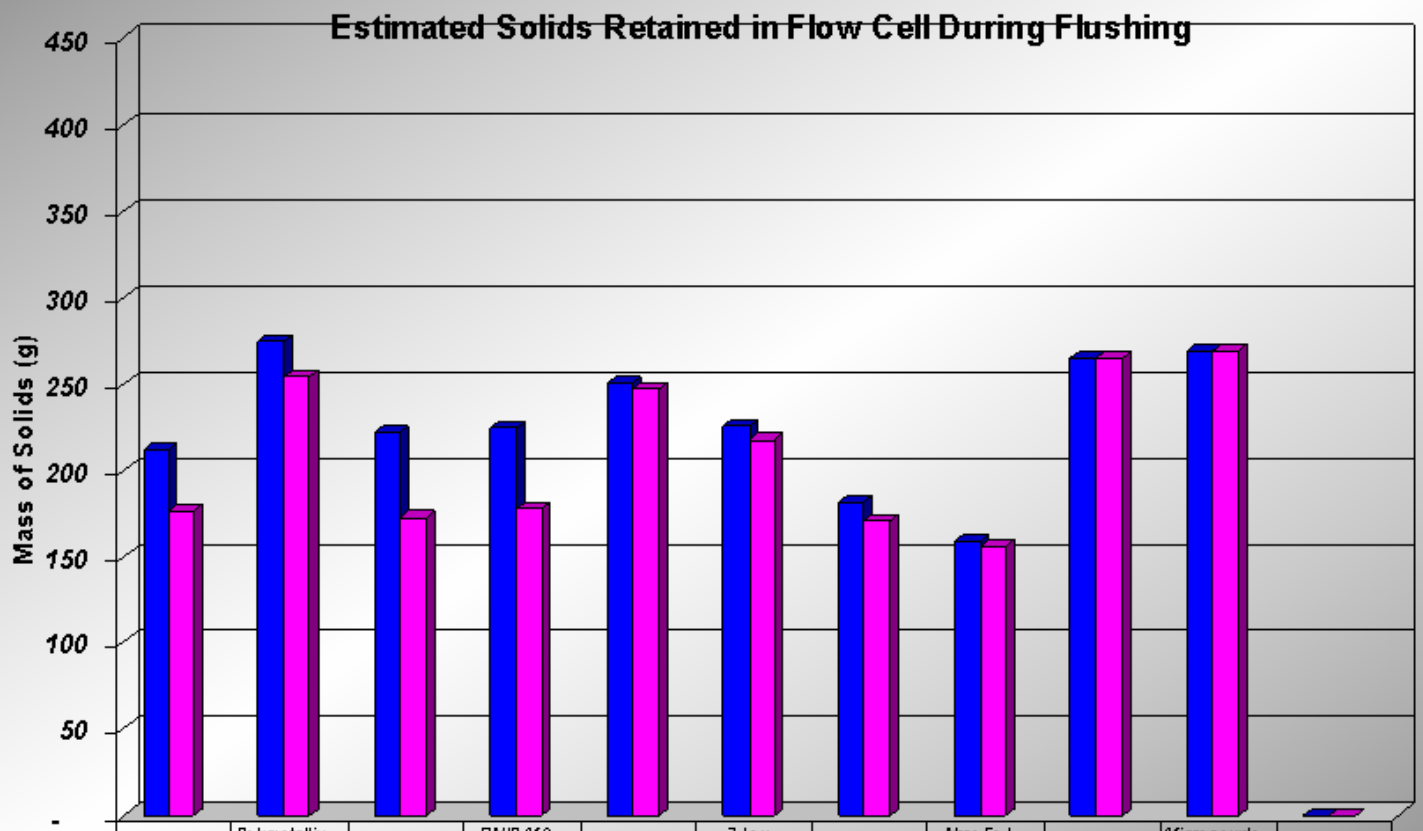

	Polymetallix-Test Cell	Polymetallix-Duplicate Cell	RNIP-M2 Test Cell	RNIP-M2 Duplicate Cell	Z-Loy-Test Cell	Z-Loy-Duplicate Cell	Nano Fe I-Test Cell	Nano Fe I-Duplicate Cell	Micropowder-Test Cell	Micropowder-Duplicate Cell	Control
Est. Solids in Cell before Flushing	212	274	222	225	251	226	182	159	265	269	0
Est. Solids in Cell after Flushing	176	254	173	178	247	218	171	156	265	269	0
Estimated Percent Solids Flushed	17	7	22	21	1	4	6	2	-	-	-

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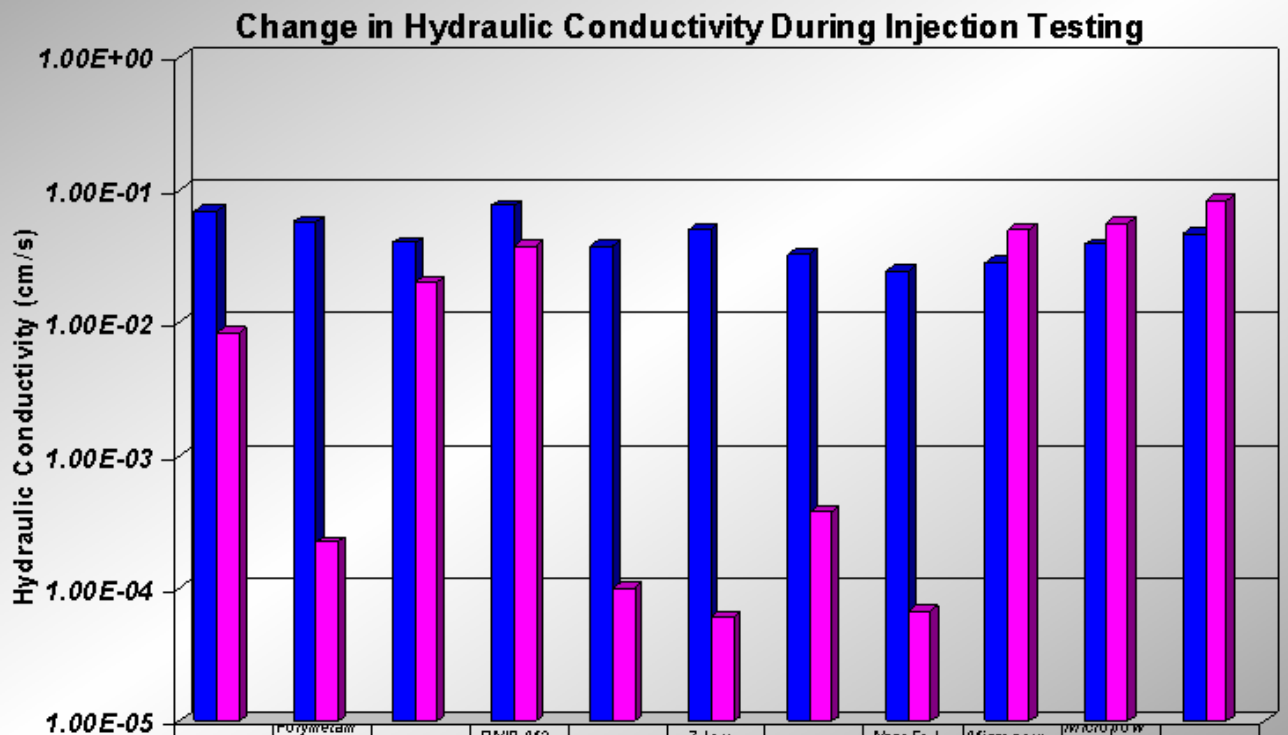

	Polymetallix-Test Cell	Polymetallix-Duplicate Cell	RNIP-M2 Test Cell	RNIP-M2 Duplicate Cell	Z-Loy-Test Cell	Z-Loy-Duplicate Cell	Nano Fe I-Test Cell	Nano Fe I-Duplicate Cell	Micropowder-Test Cell	Micropowder-Duplicate Cell	Control
Hydraulic Conductivity Before Injection	6.89E-02	5.72E-02	4.00E-02	7.63E-02	3.81E-02	5.03E-02	3.31E-02	2.48E-02	2.82E-02	3.86E-02	4.66E-02
Hydraulic Conductivity After Flushing	8.48E-03	2.25E-04	2.03E-02	3.79E-02	9.97E-05	6.09E-05	3.77E-04	6.76E-05	5.09E-02	5.65E-02	8.22E-02
Change in Hydraulic Conductivity During Testing (Multiplier)	-8.1	-254.5	-2.0	-2.0	-382.3	-825.8	-87.8	-367.2	1.8	1.5	1.8

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Final Injection Column Tests

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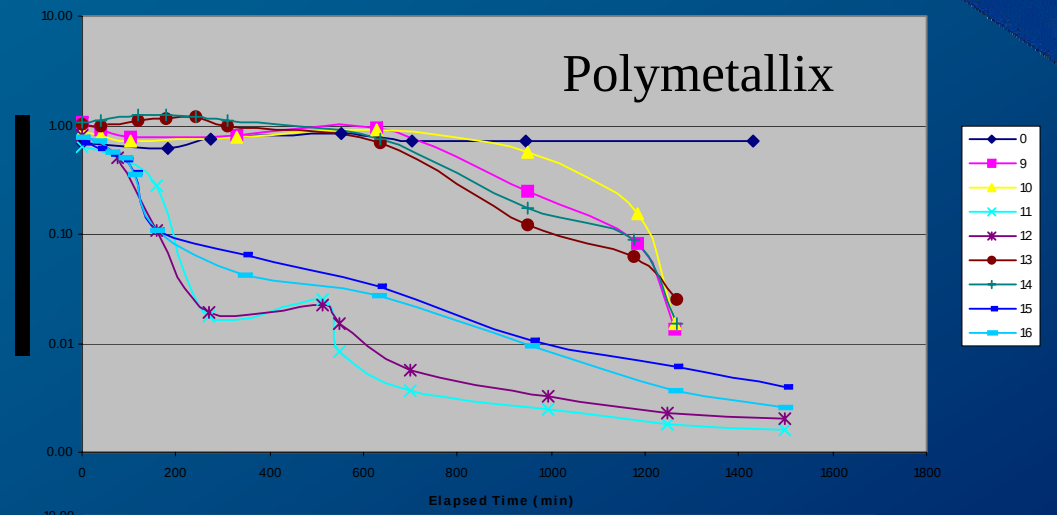
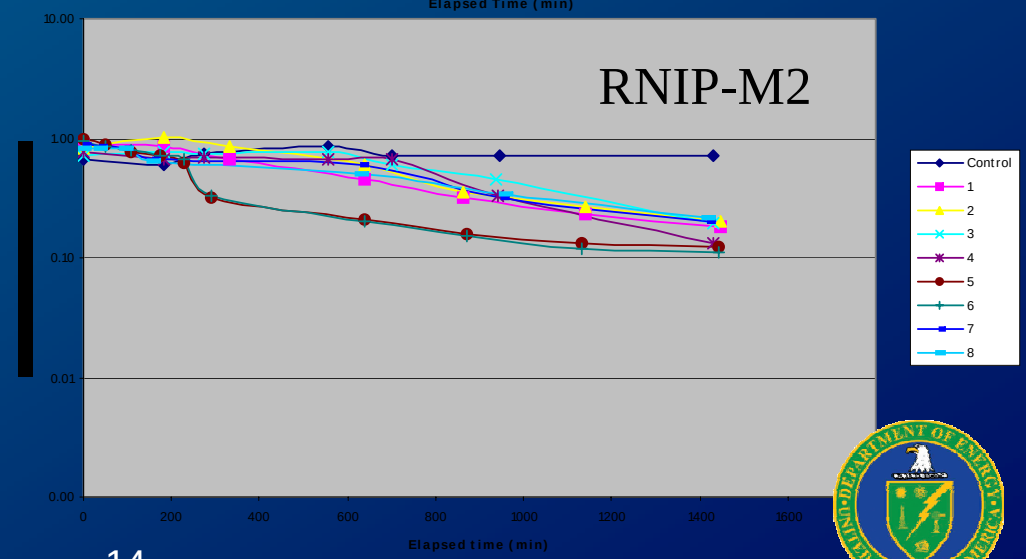
Laboratory-Scale Injection Test Results

Flow Cell	Material	Flow Rate (mL/min)	ZVI Front Distance (cm)
1	RNIP	14	43.8
2	RNIP	14	41.6
3	RNIP	32	95.9
4	RNIP	32	127.6
5	RNIP	75	>305
6	RNIP	75	>305
7	RNIP	172	>305
8	RNIP	172	>305
9	Polymetallix	14	33
10	Polymetallix	14	34
11	Polymetallix	32	>305*
12	Polymetallix	32	>305*
13	Polymetallix	75	>305
14	Polymetallix	75	>305
15	Polymetallix	172	>305
16	Polymetallix	172	>305

Calculated K Variation vs. Elapsed Time





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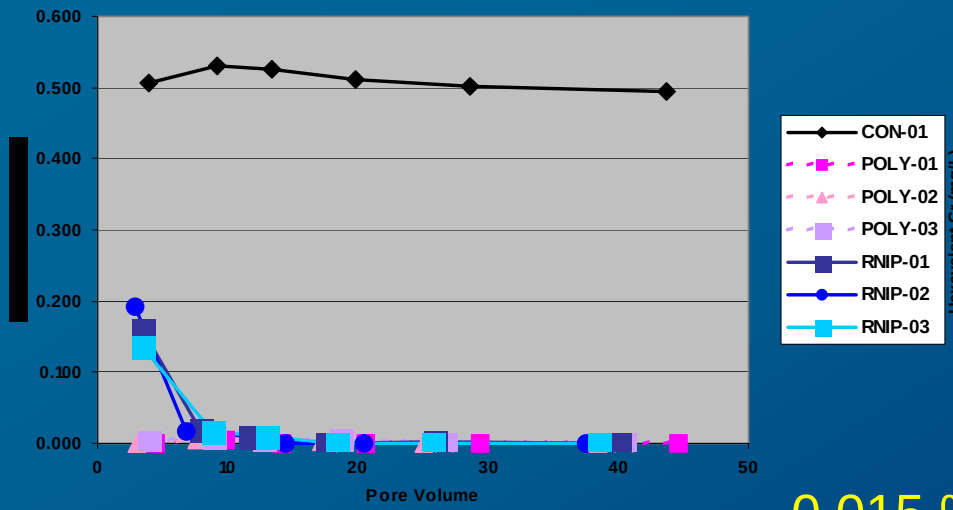
Geochemical Column Tests, Phase II

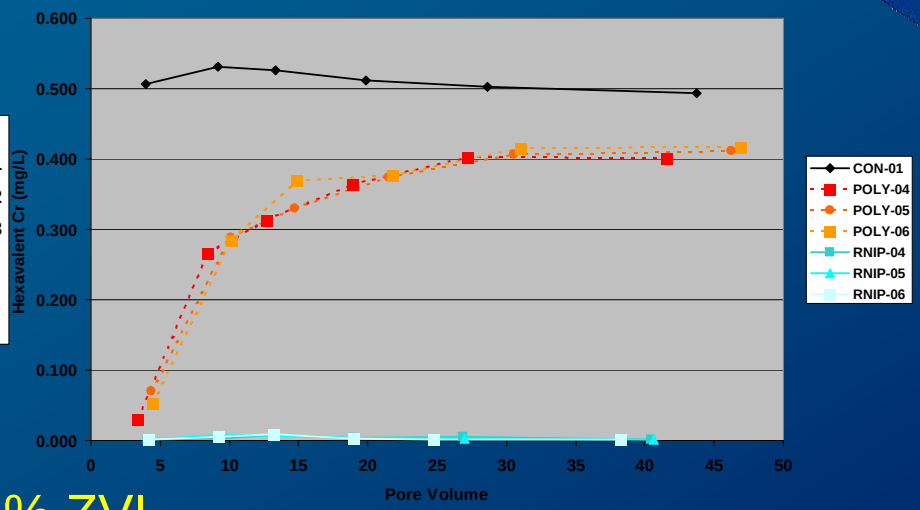
- **55 centimeters long, 7.6 centimeters in diameter**
- **Used Ringold Formation Soil**
- **Flushed from bottom to top with surrogate groundwater**
- **Three concentrations of each ZVI material, triplicate columns for each**
  - 1.5 wt%, 0.15 wt%, 0.015 wt%
- **Approximately 40 pore volumes passed through each column**
  - Collected at approximately 3, 8, 12, 18, 25, and 40 PV
  - Analyzed for pH, ORP, SC, DO, T, N (nitrate, nitrite, ammonia), alkalinity, sulfate, iron speciation, and total and hexavalent chromium

Geochemical Column Test Results

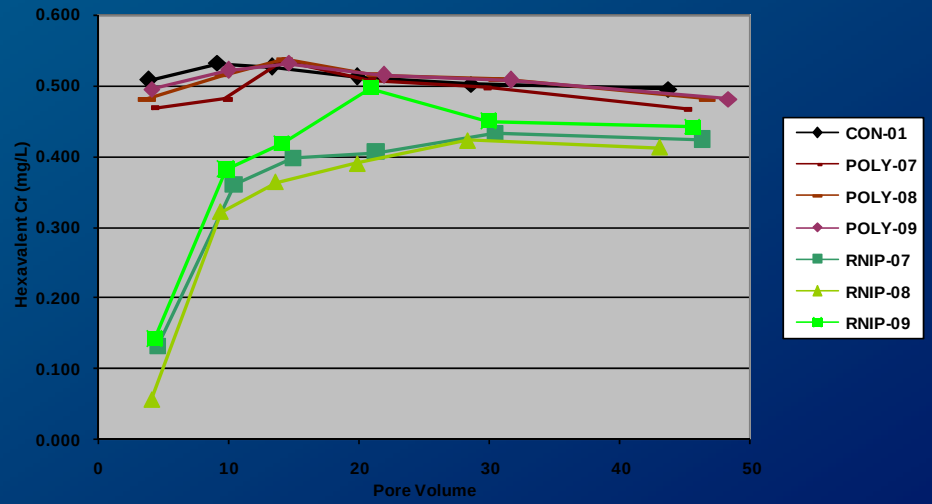
1.5 % ZVI



0.15 % ZVI



0.015 % ZVI



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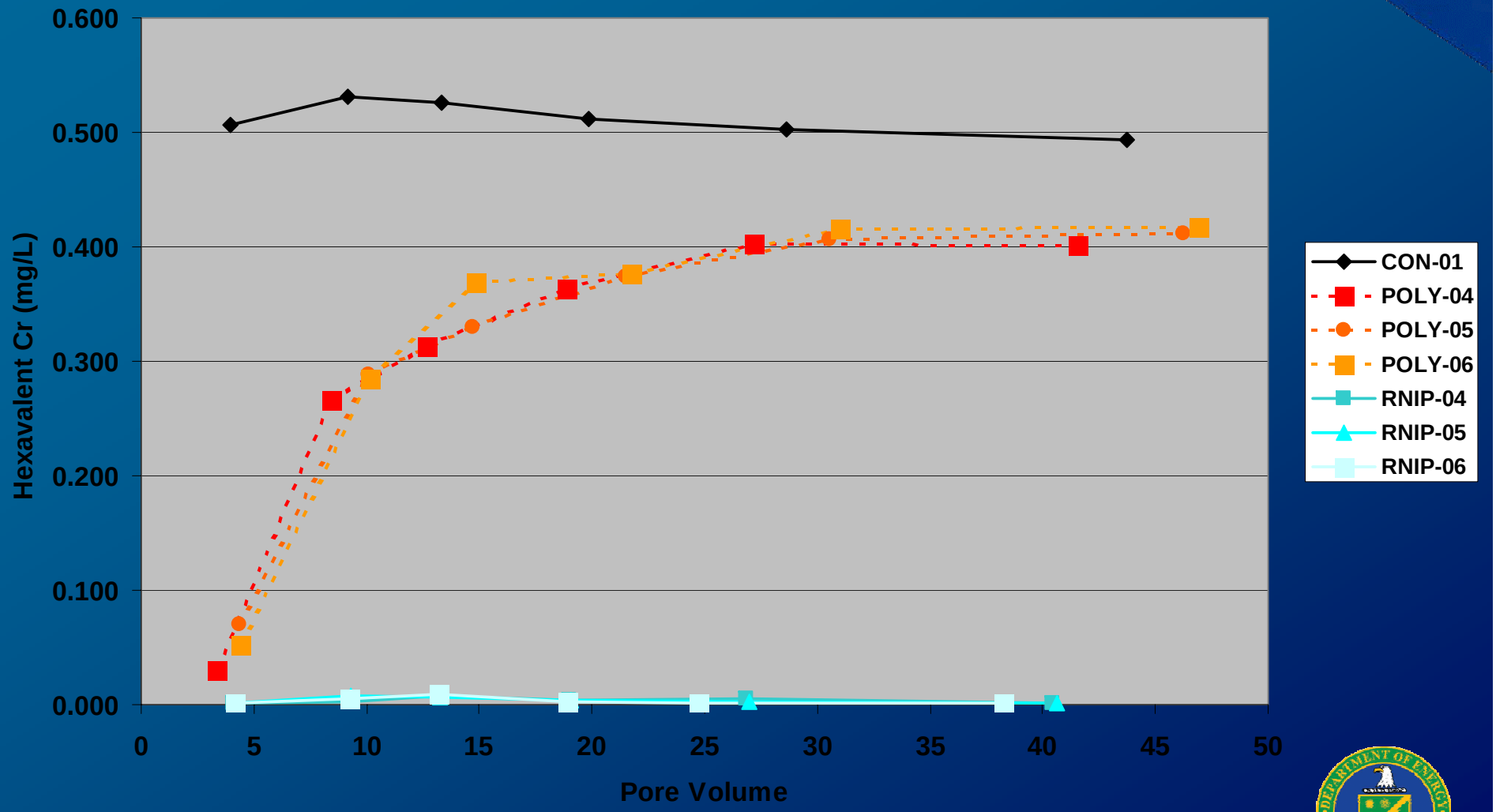
$Cr6^+$ Reduction in the Preferred Materials

0.15 wt. % nZVI



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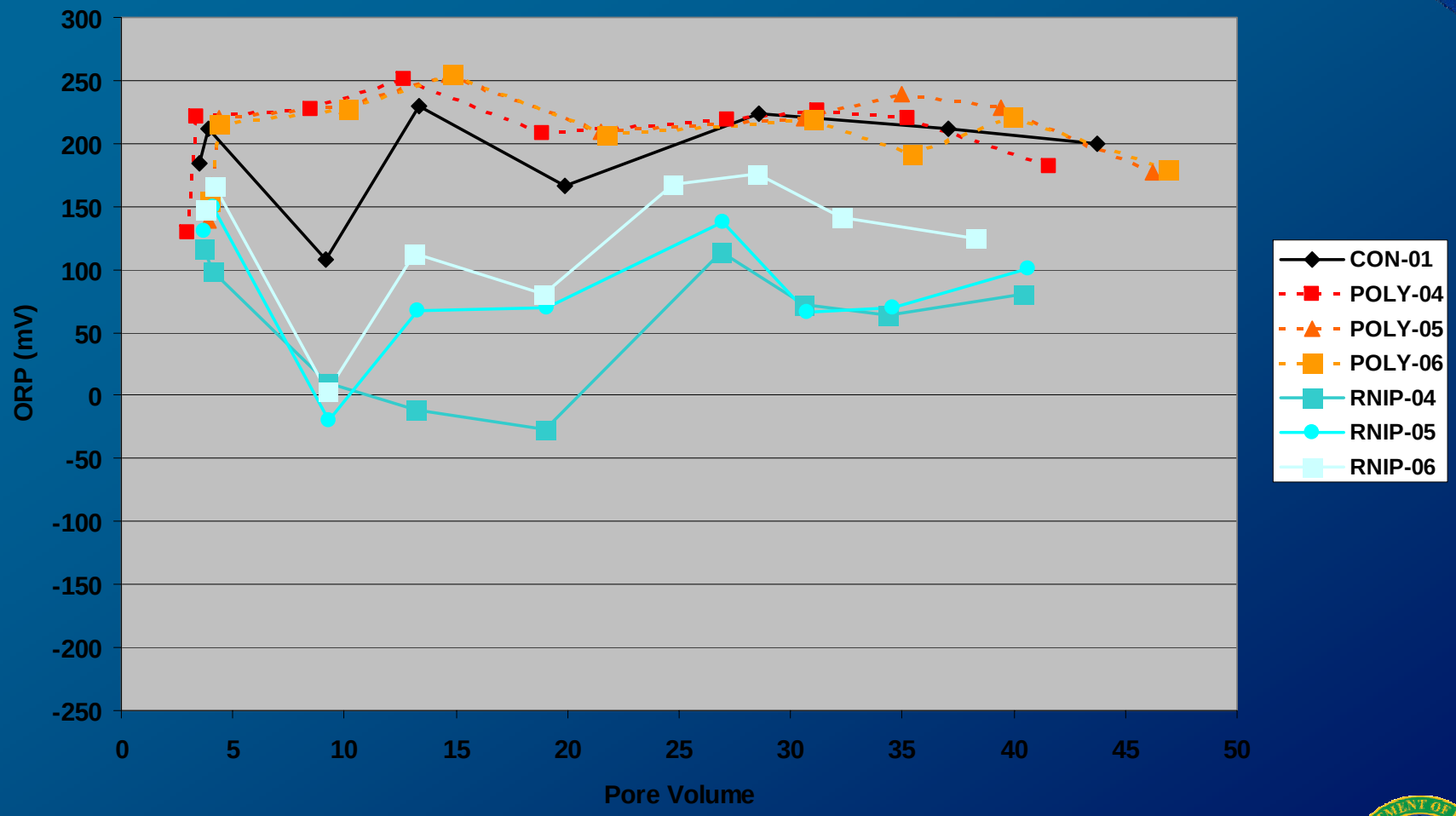
ORP in the 0.15 wt% Materials



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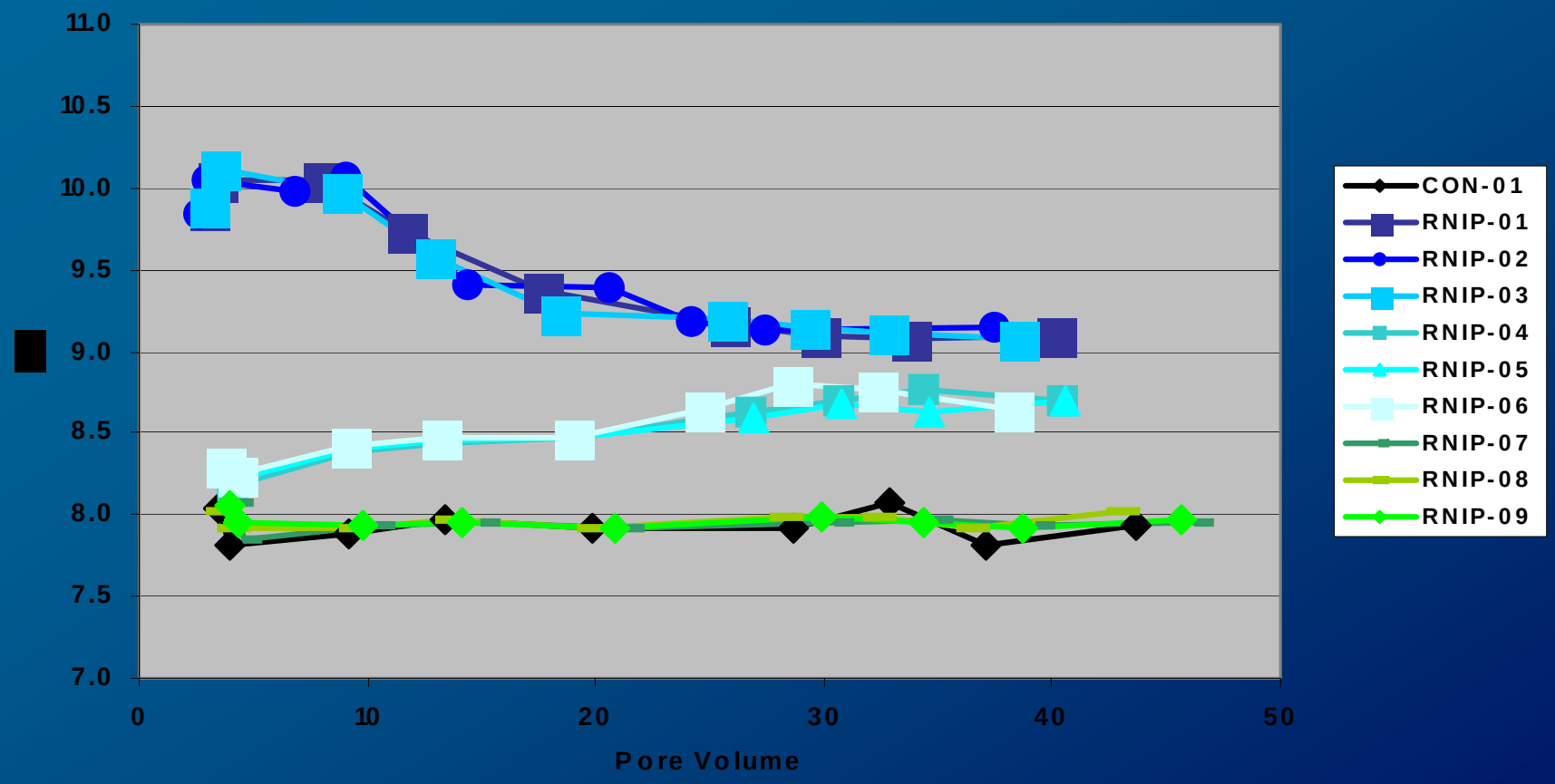
pH in the 0.15 wt% Materials



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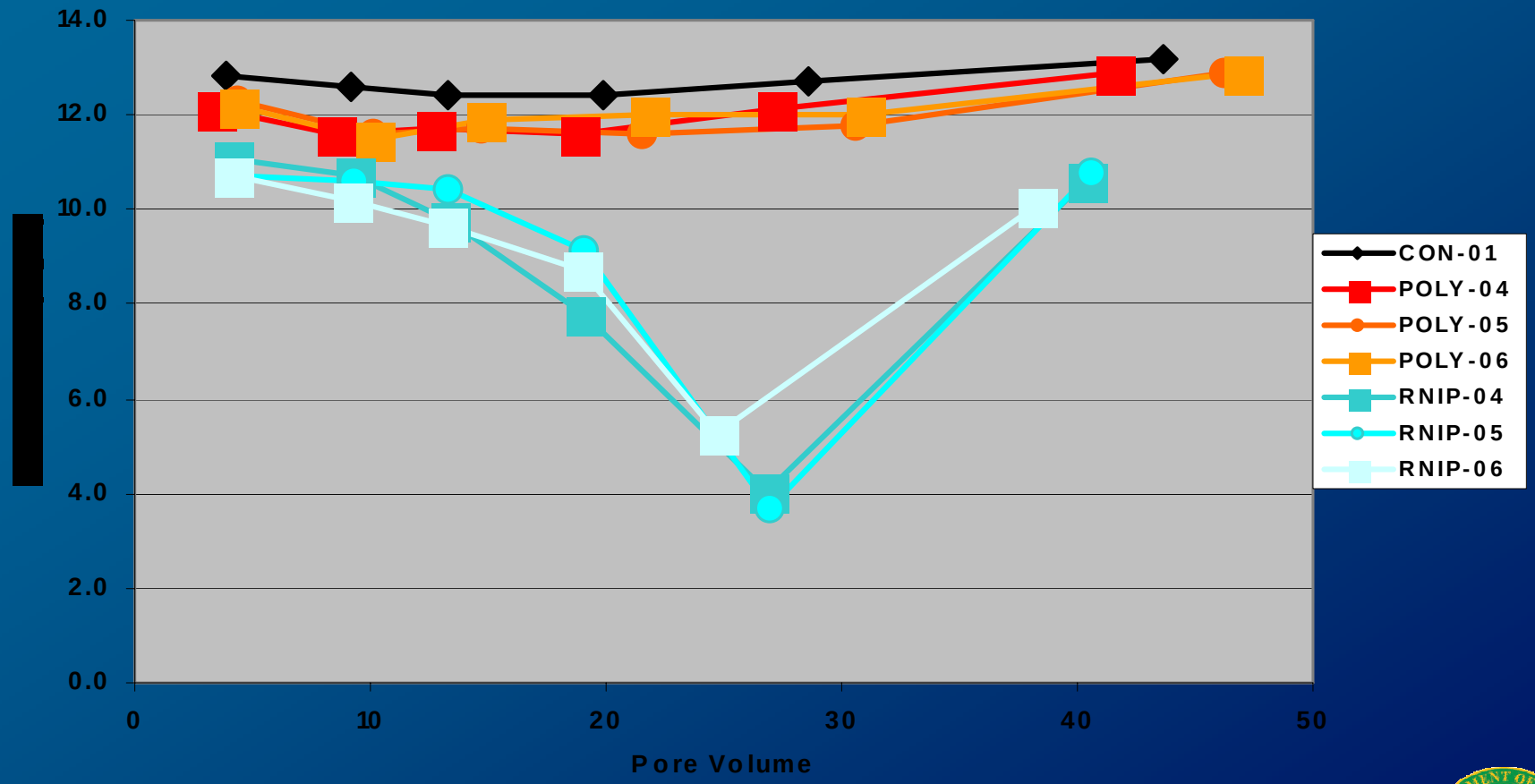
Nitrate in the 0.15 wt% Materials



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Other Laboratory Tests

Numerical Modeling of ZVI Injection

- **Develop estimates of the extent that ZVI can be injected**
- **Evaluate the injection parameters (injection parameter sensitivity analysis)**

Tank-scale Injection

- **An intermediate step between the lab studies and field injection**
- **Opportunity to physically verify that iron can be injected**

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Site Setup

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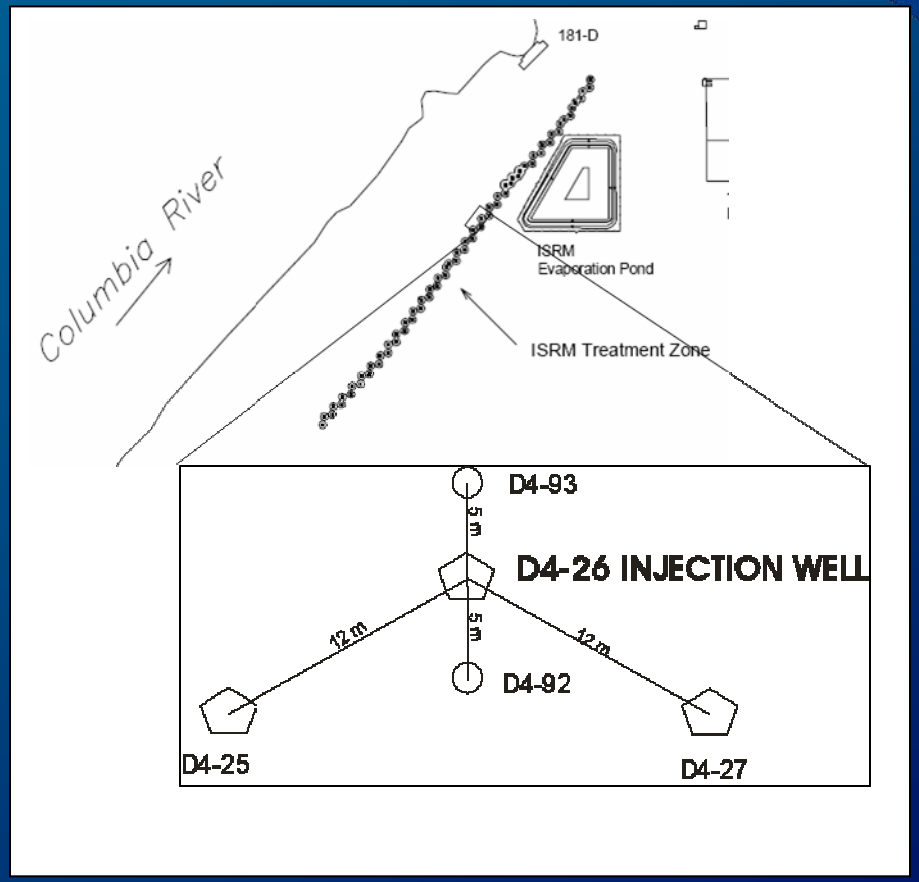
Field Injections

- Perform geophysical characterization before, during, and after injections
- Inject 2,400 kg of RNIP-M2 in ~370,000 L of water
- Collect data from the four wells surrounding 199-D4-26 before and after injections



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Schedule

- **Field injections: August 4-15, 2008**
- **Final Report: December 15, 2008**