HANFORD IFRC QUARTERLY REPORT ~ January 2010

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I. Overview and Highlights

This Quarterly Report for the Hanford IFRC project summarizes significant progress for the period of October 2009 to January 2010. Three major highlights deserve mention for this reporting period.

1.) Planning has been initiated for the installation of approximately 10-13 new monitoring wells in spring 2010.
2.) A reactive tracer experiment involving U was performed in late October 2009. This was our first U experiment, and a primary experimental objective was to evaluate field procedures and associated issues before conducting a subsequent, more comprehensive experiment. The feasibility test involved the injection of Br^- spiked, up-gradient groundwater with low U concentration (~5 ppb) into the IFRC well field where concentrations ranged between 25 and 40 ppb U. Plume movement was monitored by down-hole specific conductance probes, and laboratory analyses of collected samples for Br and U. While the test was successful, a number of issues were identified that require resolution before our comprehensive experiment.
3.) A multi-month study has been completed on vertical flows in select fully screened IFRC wells using the electromagnetic flow-meter. Both upward and downward flows were observed that correlated with changes in river stage. These observations pose important implications and are causing us to look at past field tracer data from a new perspective, and to devise additional modeling activities for interpretation. Another complication is that all wells do not behave in unison, with some wells flowing upward while others are flowing downward. The vertical flows are caused by the interaction of river stage induced pressure gradients with our heterogeneous hydraulic conductivity field.
4.) As part of SESP's performance evaluation metric, the Hanford IFRC project developed a report in December 2009 describing how physical heterogeneity in our experimental site was being quantified using a number of different methods (http://esd.lbl.gov/research/projects/ersp/generalinfo/milestones/milestones/ersd_data10.html).
5.) The IFRC project team presented 12 oral presentations and posters at the fall American Geophysical Union meeting in San Francisco, and held a project team meeting to discuss new wells and the vertical flow issue.

Discussions in this report will focus primarily on items 1-3 above.

II. Significant Changes

There have been no significant changes to the project scope or objectives since the last quarterly report in October 2009.

III. Management & Operations

Management and operations of the Hanford IFRC have proceeded without major problems over the past reporting quarter. Characterization, lab and field experimentation, and modeling, and project spending has proceeded as planned, and the project overall is on schedule with milestones.

However two issues have recently become evident based on our attempts to model our tracer injection and passive monitoring experiments for publication.

1.) The IFRC well-field requires select new monitoring wells to improve: a.) tracer mass balance, b.) boundary head quantification, and c.) access to depth discrete intervals with different hydrologic properties.

2.) Vertical flows are common in our fully screened monitoring wells, meaning that well water concentrations of tracers and U at any given time are dominated by the signature of either the upper or lower high conductivity zones in complex fashion correlated with river stage. Moreover, flow reversals, and consequently chemical signature changes, occur frequently.

Resolving these issues will require diversion of FY10 budget that was originally planned for additional field experimentation. Re-budgeting to accomplish this necessary scope is currently underway.

IV. Quarterly Highlights

<u>Task 1. Project Management</u>

IFRC project management is proceeding smoothly and there are no outstanding issues with finances, staffing, subcontracts, project productivity, site infrastructure or access, schedule, or modeling. The project team is actively working to complete manuscripts on physical/geophysical, hydrologic, and geochemical characterization; the initial injection and passive experiments, and the development of improved site hydrogeologic and geochemical conceptual and numerical models. Active planning is underway for the April peer review and the installations of a series of new wells that is described immediately below. A project meeting to discuss these issues was held in San Francisco at the Fall AGU meeting with most principal investigators in attendance.

<u>Task 2. Site Design and Installation</u>

The initial IFRC well field was designed and installed with little concrete knowledge of site geologic or hydrologic details. In spite of this, it has served us well in that tracer trajectories have fallen along expected vectors within the well-field allowing for a successful series of injection and passive experiments. However, modeling of the experiments for interpretation and publication has revealed some inadequacies in monitoring access and coverage that can be resolved by new well placements (see Figure

1). An initial financial analysis indicates that we can afford to install approximately 10-13 new wells. A preliminary drilling specifications package has been developed around Figure 1 that has been submitted to the Hanford Drilling Contractor for formal cost analysis, with an early spring date proposed for installation. The figure identifies 13 potential new wells (in red) to enhance the current IFRC well-field. The new wells fall within three categories.

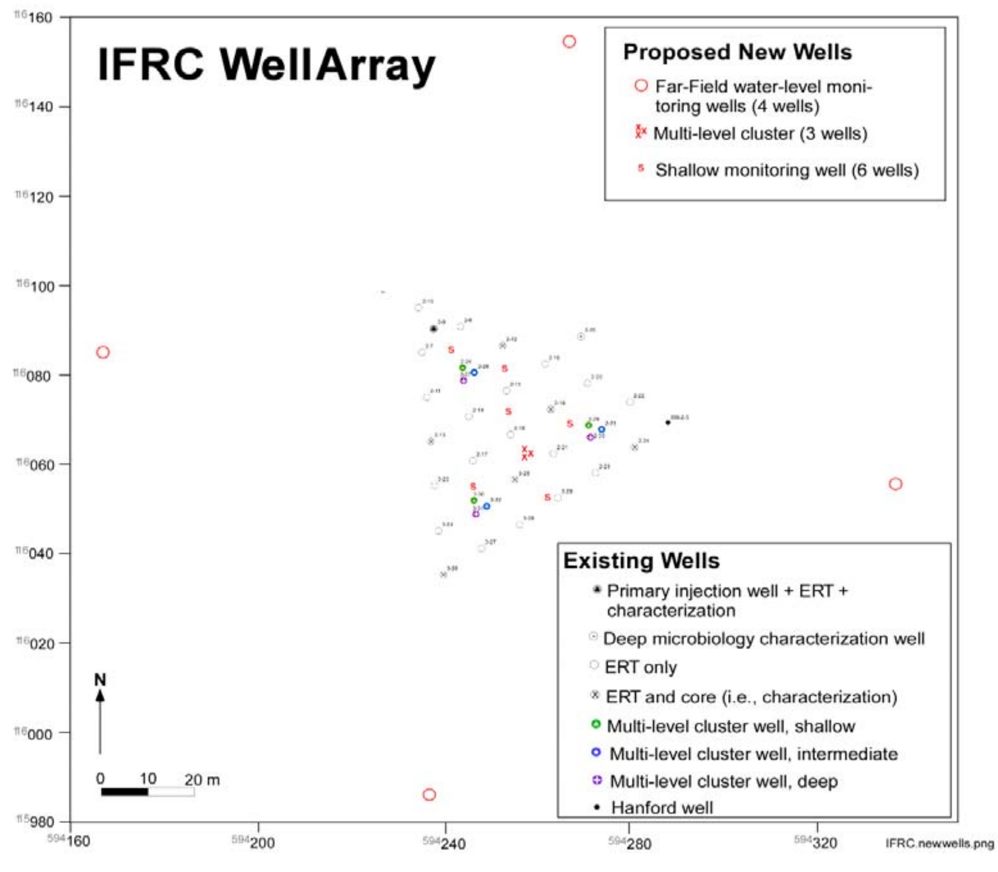

Figure 1. Locations (red) being considered for new wells in the IFRC site.

1.) Four, far-field water level monitoring wells have been proposed to better quantify boundary conditions for hydrologic modeling. The hydrologic gradient across the IFRC site is very small, on the range of millimeters. We have often found inconsistencies with water level measurements performed within the well-field because the wells are used for multiple purposes (e.g. downhole geophysical measurements; microcosm studies; water quality sampling; etc.). These activities can disturb highly sensitive water level measurement sensors causing errors in millimeter scale measurements. The new wells would be dedicated to water level measurements only, and would be installed at greater spatial separation to allow quantitative measurements of hydraulic gradient across the experimental site. The wells would be situated at the corners of the domain being used for numerical flow and transport modeling of field experiments (see Figure 2).

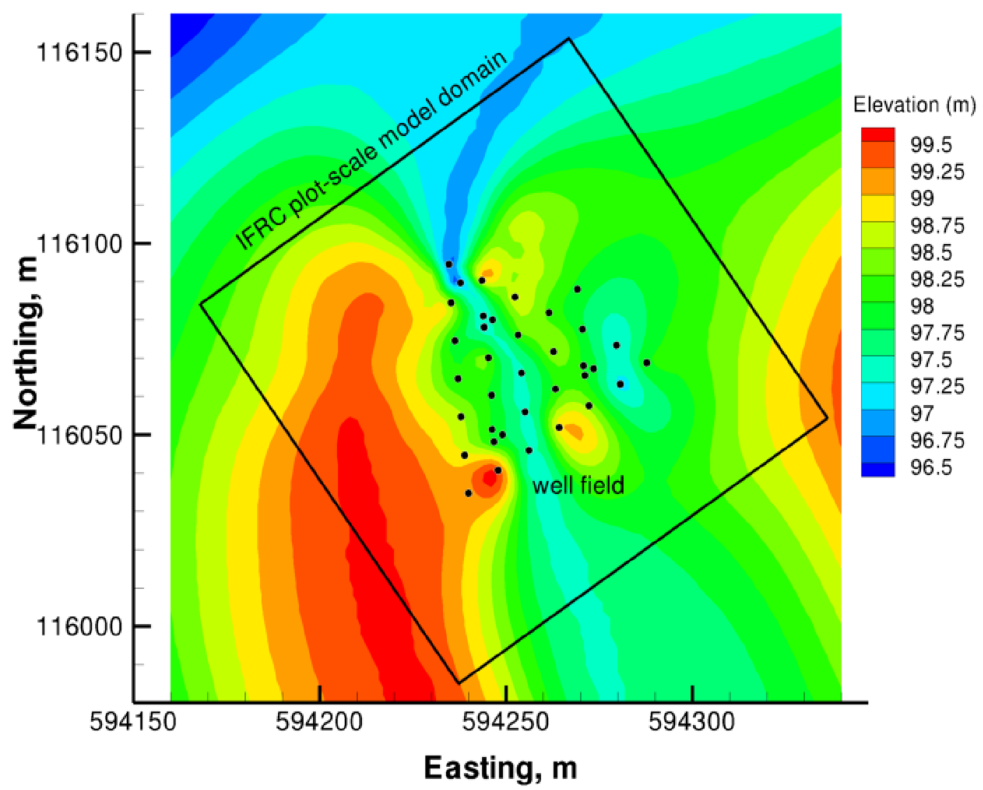

Figure 2. Elevation of the Hanford-Ringold contact. A paleo-erosional channel is believed to run through the center of the IFRC site and to effect transport.

2.) A new multi-level cluster (3 wells) is proposed for the central region of the well field. The completion depths (shallow, medium, and deep) would correlate with the three-tiered hydraulic conductivity structure known to exist at this location. Tracer experiments have suggested the presence of a macroscopic preferential flow path through this location associated with an erosional channel in the surface of the Ringold formation (Figure 2). This structural feature focuses transport through the central domain of the well-field. This proposed cluster would provide depth-resolved sampling access in a region through which all of our tracer experiments have passed. In contrast, none of the tracer experiments have yet to pass through our well cluster containing wells 2-29, 2-30, and 2-31.

3.) A series of shallow monitoring wells is proposed to better monitor the release of sorbed contaminant U(VI) from the lower vadose zone during the spring high water table, and its subsequent transport. The wells would be screened in the upper high hydraulic conductivity zone only, and the screen would extend upwards to slightly above the elevation of the highest water table expected. These new wells would support a more robust spring monitoring experiment of the U(VI) solubilization process as well as tracer experiments within the upper hydrologic zone that carries the annual resupply of U to the aquifer.

Task 3. Website and Data Management

The IFRC database continues to be populated with data from laboratory characterization measurements of different kind, field hydrologic testing and geophysical characterization, and field injection and monitoring experiments.

Task 4. Field Site Characterization

Samples obtained from the IFRC well field during the drilling campaign continue to be characterized according to the Hydrologic and Geochemical Characterization Plan that is posted on the web. Phase I of the Characterization Plan has been completed and results are being incorporated into a series of manuscripts. A new series of approximately 100 samples are currently being selected for a second round of Phase I characterization measurements. This second set of Phase I samples will include approximately 50 samples from the new wells that will be installed in spring 2010.

Geophysical Characterization

No new progress to report. Results generated to date are being readied for publication.

Geochemical Characterization

No new progress to report. Results generated to date are being readied for publication.

Hydrologic Characterization

Concern has been growing over the importance, significance, and implications of vertical flows in our fully screened wells. The IFRC well-field has 26 of these. In order to evaluate this matter, one of our two electromagnetic borehole flowmeters (EBF) was deployed to well 2-21 for 850 hours beginning 4/21/09. The EBF was located near the sampling pump approximately half-way down the well screen. Recall that the EBF was used to quantify downhole variations in relative hydraulic conductivity, as described in a previous quarterly report and shown in Figure 3. These EBF surveys lead to the general conclusion of vertical stratification in hydraulic conductivity of high-low-high over the IFRC well-field. During these earlier EBF surveys, ambient flows were observed in select wells that sparked initial concern over this issue.

Vertical well-bore flows were observed in well 2-21 that closely correlated with river stage (Figure 4a). Flows ranged from 0 to 5 litres per minute (LPM) within the 4” well bore, and were either up (+) or down (-). Upward flow (+) is taken to represent water entering from the deeper high K zone that is exiting in the shallow high K zone. Downward flow represents the reverse; water entering from the shallow high K zone that is exiting from the deeper high K zone. The correlation between river stage and borehole flow was not direct in that a river stage of a given value did not give rise to a unique value or direction of borehole flow.

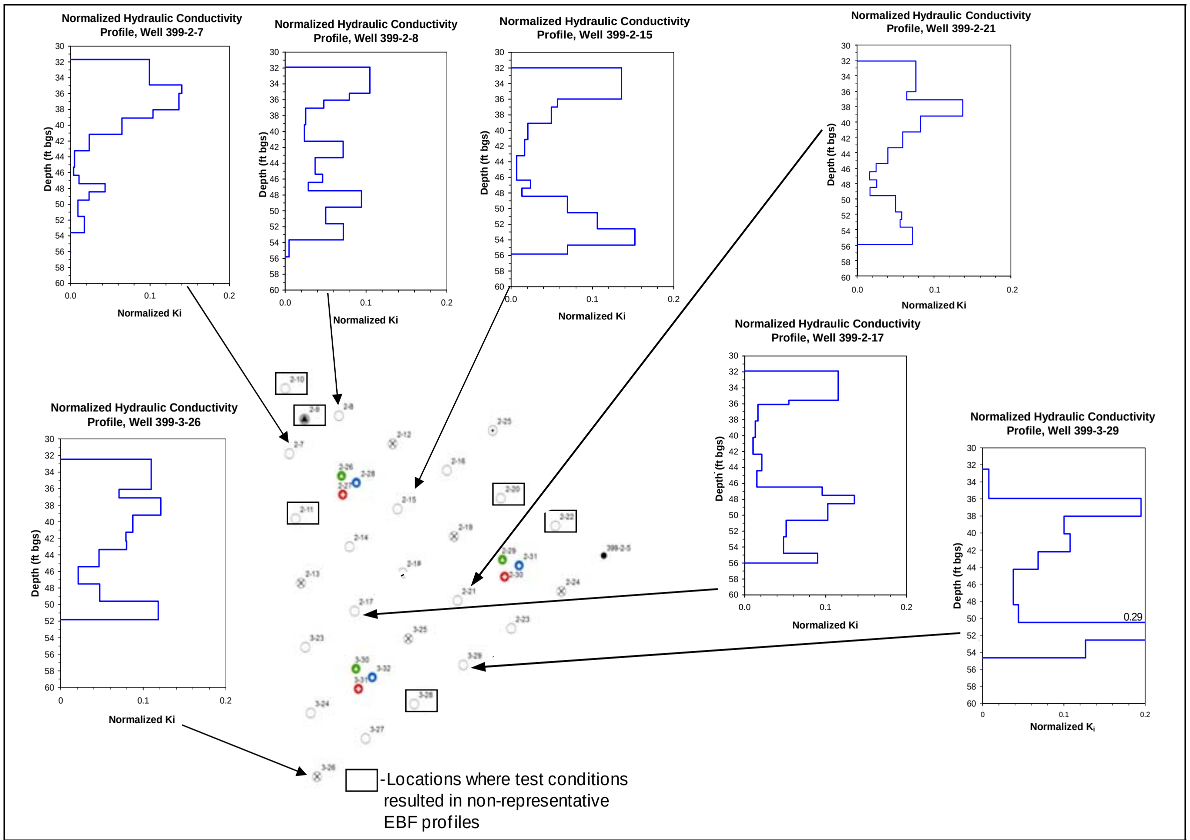

Figure 3. Relative hydraulic conductivity (K) profiles measured with the electromagnetic borehole flowmeter (EBF).

The first 450 hours of river and well flow data were used to develop a predictive model based on the multiple regression deconvolution method (MRD). In this method the influences of river stage changes on well flow are described by a response function obtained by regressing each well flow observation against river stage. This response function was then used to predict the observed well flow observations for the last 400 hours of observation (Figure 4b). As is evident from Figure 4b, the model well-predicts the observed magnitude and complex trends in well bore flows, except for the anomalous sharp spikes that are believed to be artifacts from geophysical measurement campaigns. Thus, while vertical well bore flows may be problematic as will be discussed in Task 6, their magnitude may be predictable from well calibration measurements. Since the well flows result from the interaction of river-induced pressure gradients with the heterogeneous hydraulic conductivity field, it is possible that unique response functions may exist for each of our 26 fully screened wells that would require explicit calibration (more on this later).

It should be emphasized that this vertical movement does not occur in-situ, or within the discrete depth well clusters, as it is blocked by the low K zone at intermediate depth. The vertical flows only occur in the fully screened wells that create artificial communication between the upper and lower high K zones. Well-bore flows are known and acknowledged to be problematic in the hydrologic field. A subroutine exists for the MODFLOW code, an IFRC project model, to calculate well-bore flows resulting from dynamic boundary conditions of the sort present at our site. Dr. Zheng, one of our project participants and a co-developer of the MODFLOW code, has initiated the modeling of these complex effects.

A modest field campaign was initiated over the holidays using test well 2-21 (e.g., Figure 4) to assess whether the installation of strategically placed packers could suppress or eliminate these vertical flows. We were uncertain as to whether this would be an effective strategy as the fully screened wells were completed with a continuous, medium-sand filter pack. The preliminary observations from this campaign, however, are very promising (Figure 5). In this experiment, an inflatable packer was installed from 47-50' bgs with the EBF deployed at 42' in well 2-21. Shown in Figure 5 are EBF measurements before and after packer installation. Before installation EBF flows vary markedly in both positive and negative direction in response to river stage. After packer deployment, the EBF records slightly positive but constant borehole flows. It is unclear whether the slightly positive flows are real or a measurement artifact. Regardless, well flows were markedly suppressed by packer installation. The installation of a second packer would lead to further improvements if needed. River stage data are not yet available for these recent measurements to quantify system behavior. They will soon be available from the COE (Corps of Engineers).

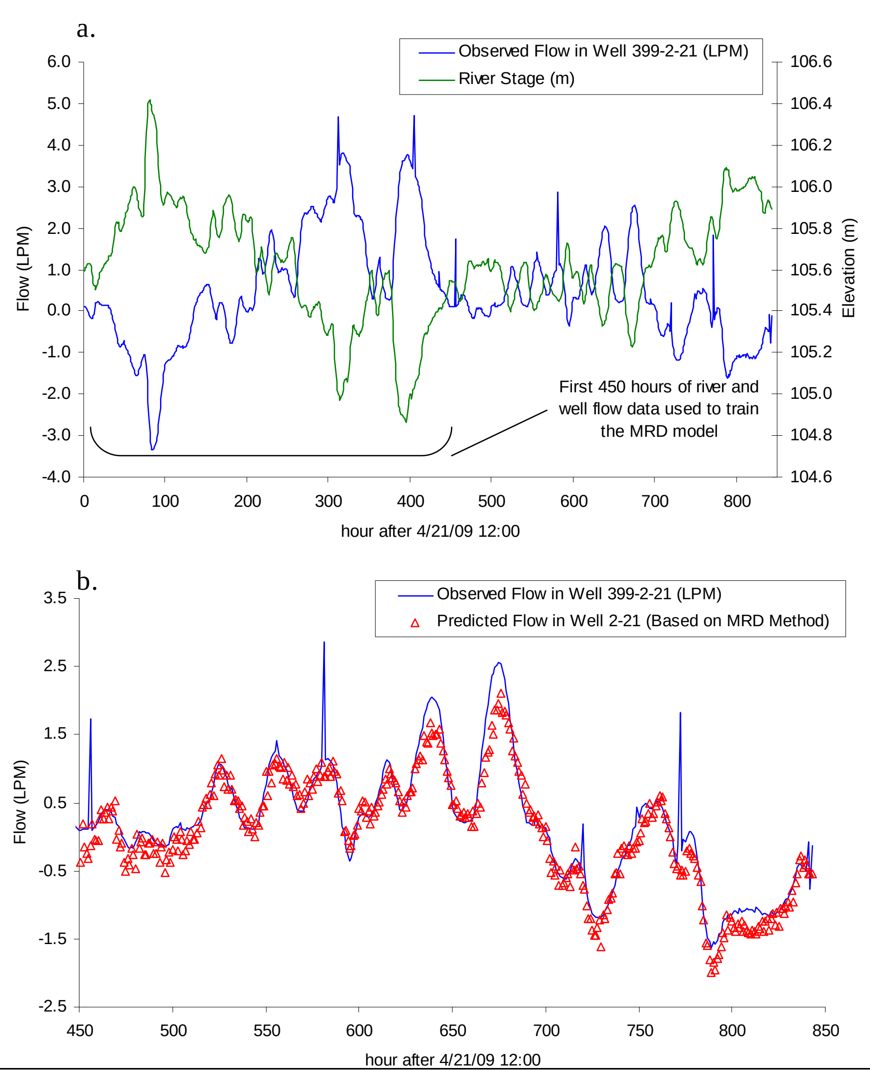

Figure 4. a.) EBF measured borehole flows in well 2-21 and river stage over the study period and b.) predicted borehole flows for the last 400 h of observations using a model based on multiple regression deconvolution (MRD).

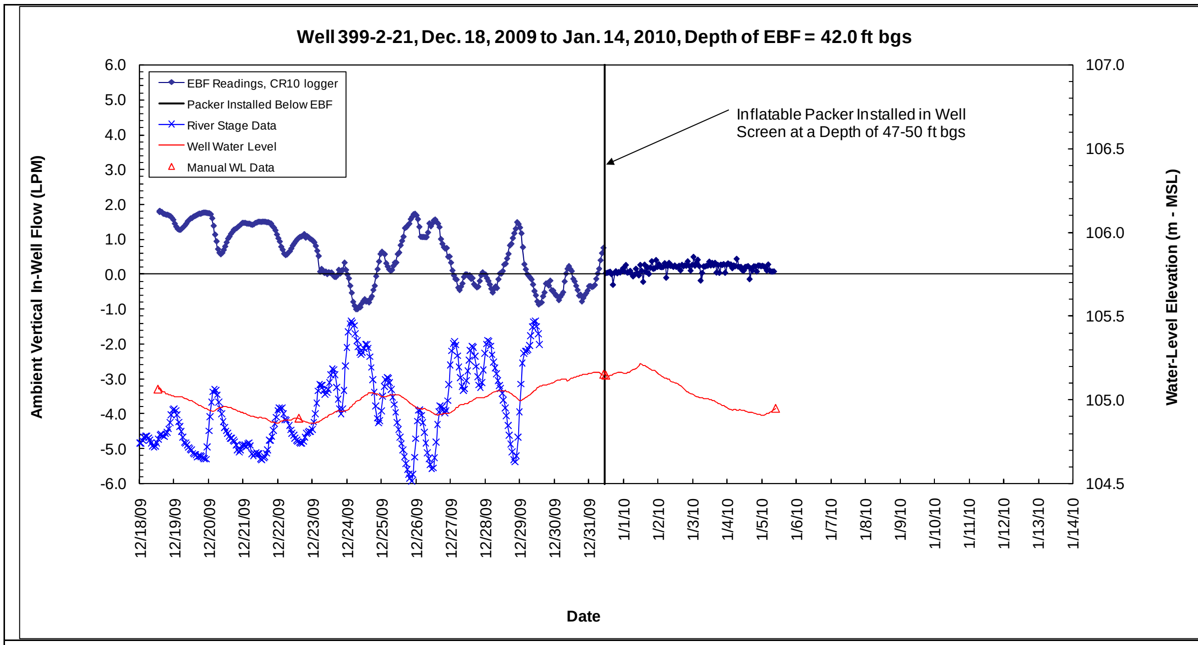

Figure 5. Effect of packer installation in well 2-21 above the high K lower zone on vertical borehole flows measured by EBF. Packer installation significantly reduces vertical flow.

Task 5. Vadose Zone Experimental Program

No new progress to report.

Task 6. Saturated Zone Experimental Program

For the purposes of this report we focus our discussion here to the evidence for vertical well-bore flows in the fully screened wells and their implications to field experimental data of two types: 1.) dissolved U(VI) measurements from the spring 2009 passive monitoring experiment and 2.) specific conductivity and U(VI) measurements from the November 2009 U-desorption experiment. These examples will reveal why an explicit strategy is needed to deal with this issue in future experiments.

1.) The spring 2009 passive monitoring experiment

We have previously reported on our successful passive experiment that was performed from March 2009-June 2009. In that experiment select multi-level wells and fully screened wells were monitored as the water table rose into the lower vadose zone. Both surface-bailed and pumped samples were collected from the fully screened wells to define soluble U enrichment at the top of the aquifer as the water table rose into sediments with higher adsorbed U concentrations. While this experiment clearly revealed that the lower vadose zone was, indeed, the undocumented source for annual contaminant U recharge to the aquifer, data from the fully screened wells displayed high variability that was initially disconcerting and difficult to rationalize. As we show below, we now recognize that this unexplained variability resulted from vertical borehole flows.

The passive experiment focused on the distal three well clusters 3-30, 3-31, and 3-32 and 2-29, 2-30, and 2-31 and nearby fully screened wells. Because of concern that well bore-flows might occur during water table rise, the EBF was deployed to nearby, fully screened well 2-21 (note Task 4 above) during the course of the monitoring experiment. Well 2-21 is immediately proximate to the multi-depth well cluster 2-29, 2-30, and 2-31. While the results are complex, they are adequately summarized by Figure 6. The monitoring results displayed that U concentrations in the shallow (2-29) and deep (2-30) cluster wells remained constant over the period of water table rise. However, U concentrations in these two wells were significantly different with the shallow well averaging ~60 ug/L and the deeper well averaging around ~26 ug/L. Fully screened well 2-21 displayed markedly different behavior with surface-bailed U concentrations exceeding those of the pumped samples by variable factors up to 2x. Both the bailed and pumped 2-21 samples displayed concentration variations that were roughly correlated, but that were difficult to resolve given our conceptual model of U solubilization from the deep vadose zone.

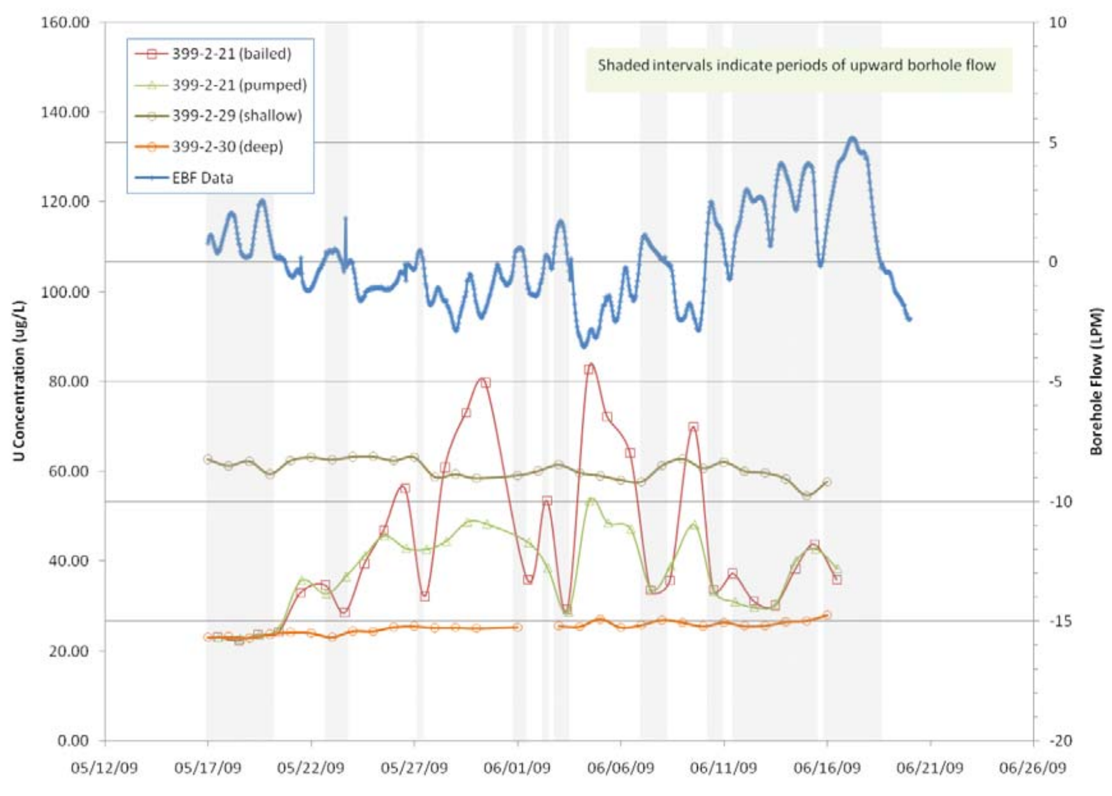

Figure 6. Uranium concentrations observed in depth discrete well 2-29 and 2-30, and fully screened well 2-21 during spring high water. Borehole flows measured in 2-21 by EBF over this time period are displayed in blue. Shaded areas represent periods of upward borehole flow.

Shown also on Figure 6 (in blue with axis on right) are EBF data from well 2-21. The EBF data show significant variation, and in spite of a generally increasing water table, borehole flows are both upward (+) and downward (-). There are virtually no periods where borehole flow does not occur. These variations result from Columbia River stage oscillations occurring during a generally high river stage period. Periods of upward well-bore flow are shaded. Concentrations in both bailed and pumped samples are highest during periods of downward flow, and lowest immediately following periods of upward flow. U concentrations following upward flow in well 2-21 are closely similar to average concentrations in the lower, high conductivity zone (e.g., well 2-30; 26 ug/L). This behavior is fully consistent with a conceptual model where: i.) seasonal U release from the deep vadose occurs during periods of high water table, ii.) evidence for this U resupply from pumped, fully screened wells depends on the direction of borehole flow at the time of sampling, iii.) upward borehole flows displace solubilized U from the well leaving a signature of deep, low U concentration groundwaters, and iv.) downward flows carry solubilized U from the top of the water table down to the pump location yielding a complex, integrated concentration value.

Historical monitoring data for the 300 A plume has been collected solely from fully screened wells. Generally, that monitoring data and seasonal differences noted have not been interpretable with any conceptual or numerical model applied. Our results suggest that this historical monitoring data base is complicated and confused by the effects of borehole flows of variable direction, rate, and duration.

2.) The fall 2009 U desorption experiment

We performed an injection experiment with low U groundwater (~ 5 ug/L as compared to IFRC site waters of 25-40 ppb) to study the in-situ desorption of U from saturated zone sediments. The injected waters had identical macro-ion composition and pH to the IFRC site waters. It was a preliminary test designed to evaluate various infrastructure, analytical, and hydrogeochemical issues associated with this experiment type prior to performing a more comprehensive, “keeper” desorption experiment. As an example of these issues, the experiment required the transport of over 70,000 gallons of groundwater from an up-gradient extraction well 1 km distant to our IFRC well field. This transport had to be performed without groundwater storage, without CO_2 de-gassing, or without significant temperature or pH change. Additionally, the groundwater compositions at that time afforded only a 5-8 fold dilution factor ($C_{IFRC}/C_{upgradient}$) for U which is low for a tracer experiment. At the time of experiment performance (late Nov 2009), we did not have the capability to pre-model the expected U behavior in the plume. However, we decided to perform the experiment in the absence of pre-modeling to take advantage of a stable, low river stage forecast period (by the COE) on the Columbia River. This stability, unfortunately, did not continue over the later stages of the injection experiment and the resulting effects provided dramatic evidence for the effects of vertical borehole flows on tracer experiment results.

Since the last reported tracer experiments (e.g., March 2009 and August 2009), all IFRC monitoring wells have been instrumented with continually recording specific conductance probes and pressure transducers to monitor well-specific water levels. Additionally the previous tracer tests have revealed that the average tracer velocities in our three hydraulic conductivity (K) layers (e.g., Figure 3) may be approximated as follows: deep high K > shallow high K >> intermediate low K.

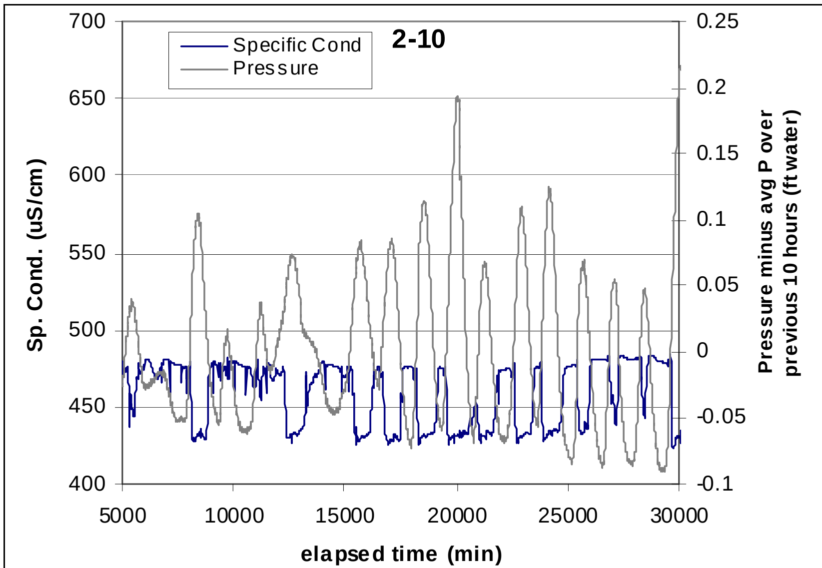

Figure 7. Specific conductance and well pressure head measured in well 2-10 during the later stages of the preliminary U desorption experiment. U injection began at an elapsed time of 0.

While we are just beginning rigorous interpretation of the data from this experiment, preliminary correlations between field-measured specific conductance values, well heads, and U concentrations provide further evidence for vertical bore-hole flows that must be explicitly considered. Figure 7 displays field-measured specific conductivity and pressure head change for the latter period of the injection period for well 2-10. The oscillations in pressure head reflect systematic, low discharge period, river stage variations. The extent of pressure head variations that were observed during a period when groundwater flow is predominantly toward river were unexpected, but documented throughout the well-field. There is an obvious correlation between pressure head and specific conductance; specific conductance decreases with increase in pressure head. Additionally, the variation in specific conductivity magnitude is uniform, with a value of ~430 and ~475 recorded at high and low heads respectively. Given the measured specific conductance of the upper and lower high K groundwaters as influenced by natural conditions and residual tracer Br-, we conclude that these variations are caused by well-bore flows. At high head, well bore flow is upward, carrying lower specific conductance groundwater past the pump. At low head, flow is downward with higher conductivity waters from the upper high K zone dominating well water composition. Similar oscillatory behavior was noted at all other wells monitored, however the correlation between high head and low specific conductivity was either positive or negative depending on well location.

The concentrations of U during the latter stages of the experiment also displayed correlations with head and specific conductance, providing further support for a conceptual model of well concentrations influenced by vertical borehole flow (Figure 8 for well 2-10). At this time in the tracer experiment (+2000 min) the low concentration U pulse had moved through this area of the well field and groundwater concentrations had returned to the ambient state. In proximity of well 2-10 the ambient U concentrations in the lower K zone were ~24 ug/L, while those in the upper K zone were ~40 ug/L. Oscillations in U concentration around these two values were observed in laboratory analyses of well samples collected during the experiment. The correlation extent was not robust because of the frequency of U sample collection during the later time (e.g., > 16000 min). However, higher U concentrations were invariably observed when specific conductance was high, head was low, and well flows were downward. Lower U concentrations occurred when specific conductance was low, head was high, and vertical flow was upward. Thus the data are fully supportive of the conceptual model described in the preceding paragraph.

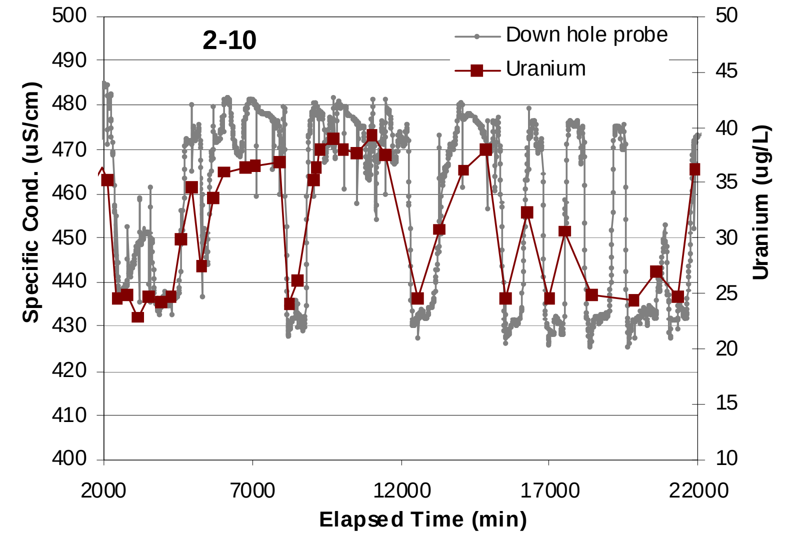

Figure 8. Continual monitoring of specific conductivity and uranium concentrations measured on sampled groundwaters during the latter stages of the preliminary uranium injection experiment.

Data observations of the kind portrayed in Figures 7 and 8 were made at all wells during the course of the U desorption experiment. Many wells displayed complex temporal U concentration trends like that shown in Figure 8. These initially puzzled us, but now we know the cause. Two general patterns were observed (Figure 9). For well 2-10 and others marked in green, the specific conductance and U concentration in well water decreased with head increase indicative of upward well flow. For others marked in orange, specific conductance and U concentration increased with head increase indicating downward well flow. Thus the response of the well field is not uniform. We do not know the flow directions with head increase for other wells that were not in the main line of tracer migration. Understanding and quantifying these relationships is critical to defining the true breakthrough behavior of injected pulses of groundwater containing lower or higher concentrations of U, and field efforts over the next reporting period will focus on this quantification.

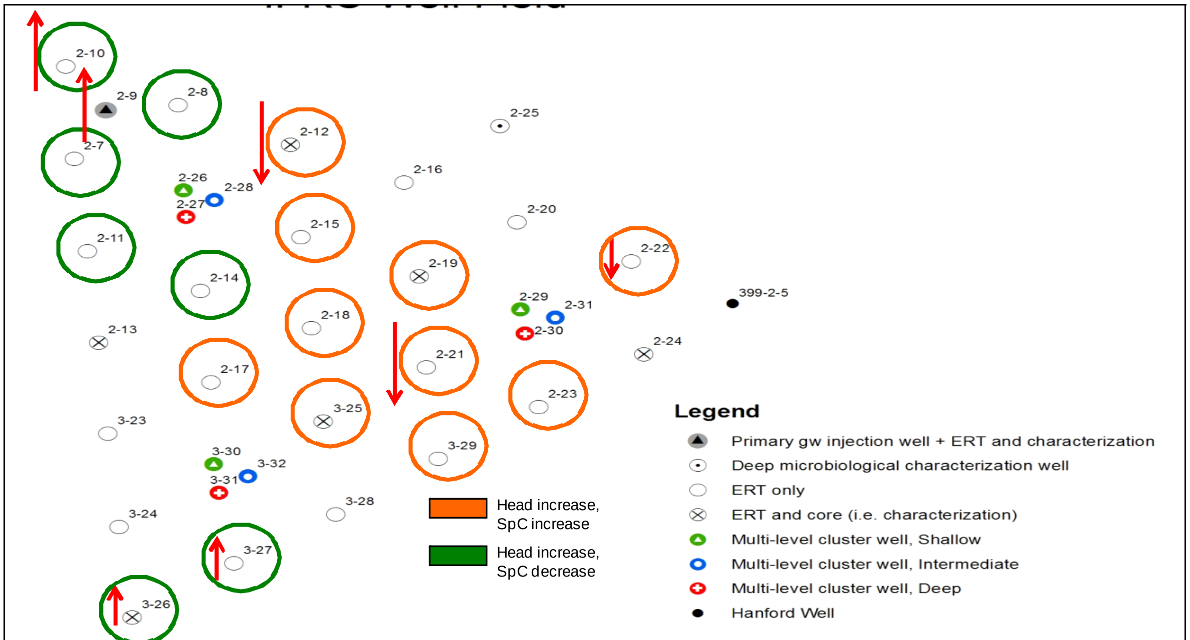

Figure 9. Patterns of well-bore flows observed during the uranium injection experiment. Green – upward flows with head increase. Orange – downward flows with head increase.

<u>Task 7. Modeling and Interpretational Program</u>

In the last quarterly report we provided an extensive summary of modeling activities. For this reporting period we simply list the significant activities that have been underway.

1.) Two publications on 3-D hydrologic modeling the first and second non-reactive tracer experiments are nearing completion.
2.) A first version of our site geostatistical model of hydraulic conductivity has been completed. It integrates data from multiple sources including: borehole geophysical logging, downhole EBF measurements and constant rate injection tests, and laboratory characterization. Surface and cross-hole geophysical measurements will soon be included to further condition and refine the model. Multiple realizations of this model have been integrated within the PFLOTRAN code to simulate breakthrough curves at select wells from the March 2009 tracer experiment. The computed breakthrough curves are being compared to field observations to identify hydraulic conductivity realizations that most agree with field observations.
3.) We are nearing the completion of our first reactive transport simulator for U(VI) that is specific to the IFRC field site. One global set of reaction parameters for the distributed rate model has been fit to the effluent data from the three column experiments with intact cores from the IFRC saturated zone. The fitting utilized surface complexation reaction constants and site concentrations developed by the USGS team, and other sediment properties (e.g., extractable U, surface area, etc.) measured as part of Phase I characterization activities. The STOMP reactive transport model was used. This "geochemical reaction model" will be integrated with the site geostatistical model of hydraulic conductivity within STOMP to aid in

interpretation of the October 2009 U(VI) desorption experiment, and to premodel various injection scenarios for the next comprehensive U injection experiment.

4.) Because of the importance of well-bore flows and their impact on the various field experiments performed to date, modeling activities have been initiated with both MODFLOW and STOMP to predict their magnitudes and directions for: i.) comparisons to direct EBF measurements (e.g., Figure 4), and ii.) for interpretation of highly variable field data of the sort shown in Task 6 (Figures 7-9). Accurate predictions of well-bore flows require quantitative measurements of IFRC site boundary conditions and a realistic depiction of the heterogeneous site hydraulic conductivity field and its spatial structure. Achieving an accurate end-state to these predictions will require multiple iterations between modeling, additional data collection, and integration within the site geostatistical model.

<u>Task 8. ERSD Outreach</u>

ERSD Outreach (Site Interactions, Outreach, Etc.)

A site tour and poster session was given on the Hanford IFRC to Dr. William Brinkman, head of DOE's Office of Science on a cold, rainy day in early November. Hard to tell how the presentation was received as Dr. Brinkman did not appreciate the weather conditions. For some reason the PNNL PR team huddled comfortably under umbrellas by the van; while Brinkman, Ray (PNNL Associate Lab Director), Kluse (PNNL Director), and I stood in the rain.

A meeting was held with a newly funded ERSD research team (Fred-Day Lewis, P.I.) at the AGU meeting in Dec. 2009 to discuss their needs and schedule for IFRC sample materials and infrastructure support for field experiments. Within the course of this meeting an update was provided to the project team on all new findings on the IFRC site that were relevant to their project hypotheses and research scope, as well as infrastructure improvements that are expected over the coming fiscal year. Agreements were made with a number of the Co-P.I.s regarding access to the IFRC sample inventory to begin laboratory measurements in FY10. Dr. Lewis will be visiting PNNL in January or February of 2010 to finalize selection of IFRC core materials for their research among other activities.

V. Non-IFRC Project Activities

The PNNL Scientific Focus Area (SFA) project focused on subsurface transition zones has been using three IFRC wells (3-24, 3-27, and 2-25) for down-hole biogeochemical studies. Down-hole microcosm strings containing site sediments, Fe(III) oxides, basalt coupons, magnetite, bio-sep beads for microbial capture, and aqueous and gas phase diffusion cell samplers (Figure 10) were deployed at three depths in wells 3-24 and 3-27 in mid-October 2010. The objective is to evaluate the microorganisms that colonize these different substrates, and observe the chemical and physical effects that they mediate. The sampling depths include: i.) within the Hanford formation, ii.) above the redox transition zone in upper Ringold formation, and iii.) below the redox transition zone in the upper Ringold formation. The microcosm strings will collect various types of data that will help assess the biogeochemical workings of the groundwater system. The first set of samples was retrieved from well 3-24 in December and the samples are now being analyzed. The bio-sep beads contained micro-organisms of interesting appearance (Figure 11).

Figure 10. One of three microcosm strings deployed to well 3-24 by PNNL SFA researchers for in-situ biogeochemistry studies.

A 25’ multi-level sampling string (MLS) was deployed in well 2-25 (the deep microbiology characterization borehole) across the redox transition zone in the upper Ringold formation. This zone of generally fine-textured sediments exists below the depth of intense monitoring in the IFRC well-field proper. The intent of this sampling was to obtain water composition data that could be correlated with information on the microbial ecology that was previously determined by measurements on fresh borehole sediments. The emerging water composition data (e.g., Figure 12) reveals distinct changes in select water quality parameters across the dramatic interface at 62’. A peak in dissolved sulfide was also observed at this location. The MLS has been recently redeployed over the depth interval of 82-107’ below the ground surface, and results will be available in approximately 2 months.

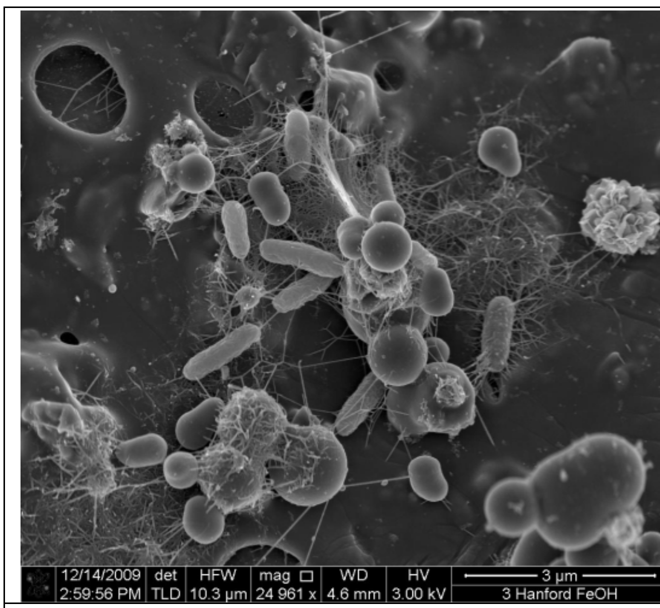

Figure 11. Microorganisms collected on bio-sep beads during 2 month immersion in well 3-24.

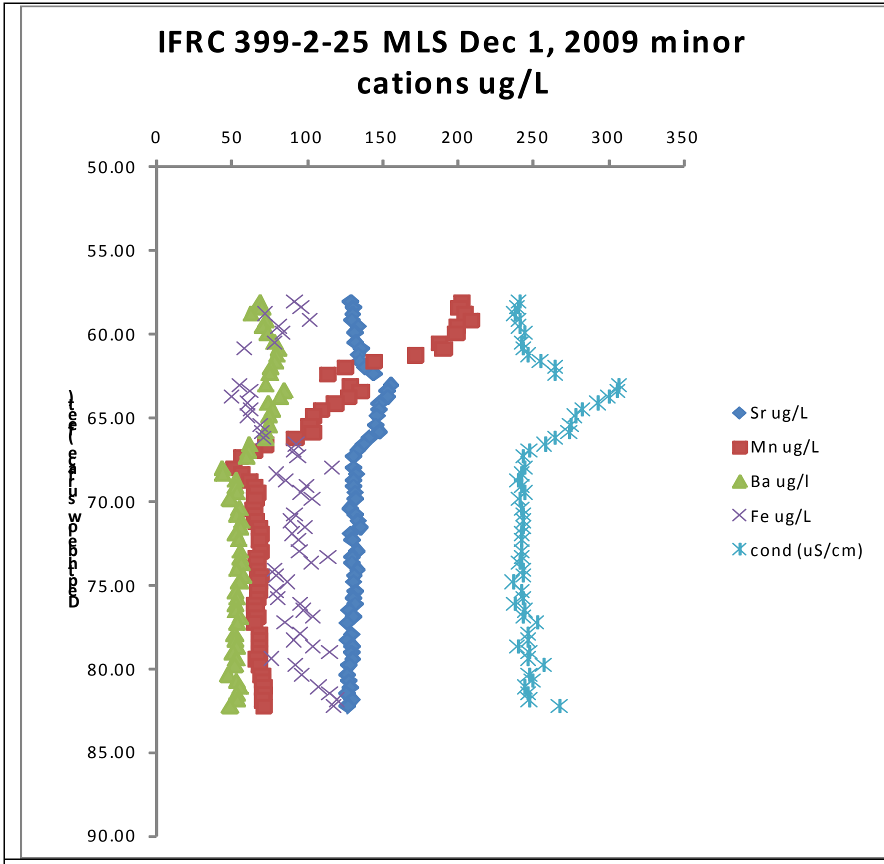

Figure 12. The multi-level sampler retrieved water samples every 6" during the course of a 1 month equilibration period. The redox interface exists at 62'. Shown here are selected minor cations including two with TEAP significance (Mn and Fe). A comprehensive suite of analytes was measured.

VI. Funding Issues

The financial status of the Hanford IFRC is good with dollars budgeted to necessary activities and productive PNNL and external collaborators. The project carried over $255 K of FY09 funds to FY10. The carryover will be used for new well installation for which a total budget of $438 K has been identified. Hydrologic studies on well-bore vertical flows were not originally anticipated in our FY10 budget, but are now being pursued because of necessity. It is estimated that $100-200 K may be spent to resolve this issue. We are planning for a major passive monitoring experiment in the spring and early summer of 2010, and a comprehensive U injection experiment in September 2010.

VII. Plans for Next Quarter (January – March 2010)

- Prepare for March ERSP contractors meeting and IFRC project review.

- Complete publications on site characterization, the site geostatistical model, and initial tracer experiments.
- Assess modeling approaches to simulate vertical well flows and compare to tracer experiment results.
- Complete hydrologic evaluations of vertical flows in representative wells and the testing of ameliorative strategies.
- Develop project strategy for dealing with the vertical flow issue.
- Finalize plans for new wells and initiate installation in time for spring high water.
- Begin reactive transport modeling of various injection scenarios for the September 2010 U injection experiment.

VIII. Peer Reviewed Publications, Presentations, Posters, Abstracts, and Report

Publications (A full accounting of publications will be provided in the Annual Report to be submitted on Feb. 15, 2010)

Hammond, G. E. and P. C. Lichtner (2009) Field-scale model for the natural attenuation of uranium at the Hanford 300 area using high performance computing. *Water Resources Research* (Accepted).

Johnson, T., R. Versteeg, A. Ward, F. Day-Lewis, and A. Revil (2009) Improved hydrogeophysical characterization and monitoring through parallel modeling and inversion of time-domain resistivity and induced polarization data. *Geophysics Journal* (Submitted).

Rubin, Y., X. Chen, H. Murakami, and M. Hahn (2009) A Bayesian approach for inverse modeling, data assimilation, and conditional simulation of spatial random fields. *Water Resources Research* (Submitted).

Presentations and Posters from the Fall AGU Meeting

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