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Sent: Monday, February 12, 2007 7:37 PM
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Subject: FYI: Further explanation to the NAS on the trends in dissolved zinc in the LANL wells
Attachments: NAS-FI-1.DOC

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Subject: Further explanation to the NAS on the trends in dissolved zinc in the LANL wells

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Comment by Robert H. Gilkeson to the National Academy of Sciences on the trend in dissolved zinc in the water samples produced from the LANL characterization wells

February 12, 2007

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The Los Alamos National Laboratory (LANL) has installed a very large network of "characterization wells" over the past ten years with the intention that the wells become the monitoring well network required by the Resource Conservation Recovery Act (RCRA). Many of the new wells are a multiple-screen design for a total of over 100 discrete screened intervals in the network including wells in both perched zones of saturation and in the regional aquifer. A major mistake in the LANL project is that the wells were all installed with drilling methods that allowed the invasion of organic drilling fluids and/or organic foams into all of the screened intervals. In addition, fifteen of the screened intervals are invaded with bentonite clay drilling muds.

In 2004, I presented a report to the Northern New Mexico Citizens Advisory Board (CAB) to bring attention to the overall failure of the LANL scientists to install a network of monitoring wells to meet the requirements of RCRA. One of the concerns in my report was the well-known fact in the technical literature that the bentonite clay and the organic fluids and foams would establish a new mineralogy (*i.e.*, chemistry) in the screened intervals with strong properties to mask the detection of LANL contaminants in the water samples produced from the wells. The new mineralogy would exist for a period of time greater than the 50-year scheduled life of the wells.

An additional well-known fact across the monitoring well industry is that the hydraulic force of the drilling operation for injecting the water-based drilling fluids and foams into the aquifer strata is several orders of magnitude greater than the hydraulic force that is available for removing the drilling additives from the screened intervals. The large hydraulic force for invading the strata is a combination of the pumping power of the drill rig and the weight of the column of drill fluid in the deep boreholes. The ability to remove the drilling additives from a screened interval is also limited because of:

- 1). the inherent "sticky" properties of the drilling additives to resist removal
- 2). the great depth of the wells,
- 3). the small 4.5-in. inside diameter of the wells, and
- 4). the restrictive design of the well screens and filter pack sediments.

The LANL scientists now acknowledge that the well development procedures used in the 48 screened intervals in the multiple-screened wells were insufficient to remove the drilling additives. However, the present claim by the LANL scientists that the well development procedures have sufficiently recovered all of the drilling additives from the single-screen wells is technically incorrect and without basis to the laws of hydraulics or the water quality data for the single-screen wells.

In 2005 and 2006, reports by the Environmental Protection Agency (EPA) and the Inspector General (IG) of the Department of Energy (DOE) concurred with the findings in my 2004 report. The reports are listed below.

Gilkeson, Robert H., 2004. "Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory," published in LANL Report "Response to Concerns About Selected Regional Aquifer Wells at Los Alamos National Laboratory," by Bitner et al., (LA-UR-04-6777, September 2004).

Ford, R., S.D. Acree, and R.R. Ross. 2006. Memorandum to Richard Mayer, U.S. EPA, Region 6: Los Alamos National Laboratory, Los Alamos, NM (05RC06-001) – Review of LANL *Well Screen Analysis Report* – Ada, Oklahoma: United States Environmental Protection Agency, National Risk Management Research Laboratory, Ground Water and Ecosystems Restoration Division. Final Report, February 16, 2006.

Ford, R., S.D. Acree, and R.R. Ross. 2006. Memorandum to Richard Mayer, U.S. EPA, Region 6: Los Alamos National Laboratory, Los Alamos, NM (05RC06-001) Impacts of Hydrogeologic Characterization Well Construction Practices. Ada, Oklahoma: United States Environmental Protection Agency, National Risk Management Research Laboratory, Ground Water and Ecosystems Restoration Division. Final Report, February 10, 2006.

Ford, R., S.D. Acree, and R.R. Ross. 2005. Memorandum to Richard Mayer, U.S. EPA, Region 6: Los Alamos National Laboratory, Los Alamos, NM (01RC06-001) Impacts of Well Construction Practices. Ada, Oklahoma: United States Environmental Protection Agency, National Risk Management Research Laboratory, Ground Water and Ecosystems Restoration Division. Draft Version, September 30, 2005.

DOE/IG. 2005. United States Department of Energy Office of Inspector General Inspection Report 0703 – *Characterization Wells at Los Alamos National Laboratory*, DOE/IG-0703, September 2005.

Because of the reports, the DOE requested the National Academy of Sciences (NAS) to perform a study of Groundwater Protection Issues at LANL. The study is by a committee of volunteers who do not have sufficient time to carefully investigate the nature of the problem with the poor performance to install the needed network of monitoring wells by the LANL scientists, the DOE managers/regulators, and the regulators of the New Mexico Environment Department (NMED) under DOE Orders, the federal Resource Conservation and Recovery Act (RCRA) and New Mexico Hazardous Waste Act. Instead of performing original research, the NAS Committee has relied on presentations by the LANL scientists at three public meetings.

The LANL scientists informed the NAS committee of their scientifically unsound opinion that the effects of the drilling additives were temporary, and that eventually the wells would clean up to produce reliable and representative water samples. The LANL scientists do not acknowledge the large body of technical literature that show the drilling additives have formed a new mineralogy in the screened intervals with strong properties to remove many LANL contaminants from the water produced from the wells.

In 2005, the DOE instructed the LANL scientists to assess the ability of each screened interval to produce reliable and representative water samples. The scientifically unsound findings of the study are presented in the LANL *Well Screen Analysis Report* (WSAR) (LA-UR-05-8615, November 2005). The poorly conceived study was only an assessment of the chemistry of the water samples produced from the discrete screened intervals, although the LANL scientists were advised by scientists in the Environmental

Protection Agency (EPA) that the study of water quality alone could not guarantee that a well impacted by drilling additives was producing reliable knowledge of the presence of contamination. In addition, the EPA scientists advised LANL of the need to study all of the water quality data produced from a well and not the limited examination of only the most recent water samples as was done in the LANL study.

Furthermore, the LANL scientists did not study the other factors that prevent the wells from being in compliance with RCRA. The other factors include:

- 1). the no-purge sampling methods that collect stagnant water samples,
- 2). long well screens that provide dilution of contamination in discrete strata,
- 3). screens installed too deep below the water table,
- 4). screens installed in geologic formations of very low permeability, and
- 5). wells not installed near sources of contamination.

The LANL WSAR presented an incorrect finding that dissolved zinc was present in all of the wells that were drilled with bentonite clay muds and therefore, the wells produced water samples that were reliable for the detection and the measurement of the strongly adsorbing metals/trace elements and radionuclides, including cobalt-60 and cesium-137. Four single-screen wells and eleven screened intervals in multiple-screen wells are invaded with the combination of bentonite clay and organic drilling additives.

I have reviewed the water quality data for the four single-screen wells because of the claim by the LANL scientists and DOE project managers that the well development methods had removed the bentonite clay from the well screens. In addition, the single-screen wells are equipped with submersible pumps and a volume of water is purged from each well before samples are collected for the analytical suite. In contrast, the multiple-screen wells are equipped with the Westbay^R no-purge sampling equipment to collect stagnant water samples that were in contact with the new mineralogy formed by the drilling additives for a long period of time.

The LANL report on background chemistry in groundwater (LANL, 2005, 090580), lists the maximum, mean, and median groundwater background concentrations of dissolved zinc in the regional aquifer as 80, 13.3, and 5 ug/L, respectively. The maximum level of 80 ug/L is far above the natural background range for dissolved zinc. The LANL *Interim Measures Investigation Report of Chromium Contamination in Groundwater* (LANL EP2006-1038, November 2006) describes zinc as a possible contaminant in the groundwater in the regional aquifer because zinc phosphate and zinc dichloride were used as corrosion inhibitors in the cooling towers at the TA-03 power plant. As with the liquid chromium wastes, the liquid zinc wastes from the power plant were discharged to Sandia Canyon. The high level of dissolved zinc of 80 ug/L was measured in a water sample collected in 1997 from Los Alamos County Supply Well Otowi-4. The source of the zinc contamination that is occasionally measured in the drinking water supply well is not known, but possibly is the liquid zinc wastes discharged from the power plant to Sandia Canyon.

Dissolved zinc concentrations in water samples collected in 2006 from Los Alamos County supply wells PM-1 and PM-3 were 2.9 and 6 ug/L, respectively. These levels are within the expected range for natural background. Dissolved zinc has a ubiquitous presence in the regional aquifer. The level of dissolved zinc from natural sources in the aquifer strata will be in equilibrium and will vary little over time in the water samples collected from the regional aquifer at the discrete screens in the characterization wells.

A marked increase or decrease over time in the measured levels of zinc in the collected water samples will be the result of the new local chemical environment because of the drilling additives or because of the zinc contamination from LANL wastes.

A shortcoming of the LANL WSAR is that it was only a study of the three most recent water samples produced from each screened interval and often only a study of one or two water samples from each discrete screen. The EPA reports pointed out a need to study the early water samples and to study the trends over time from the first water samples to the most recent to accomplish the best assessment. Table 1 presents the dissolved zinc data for the four single-screen characterization wells that were drilled with the mud-rotary drilling method that caused the screened intervals to be invaded with a combination of bentonite clay mud and organic additives.

Table 1. Dissolved Zinc Data For the LANL Single-Screen Characterization Wells Drilled With the Mud-Rotary Method Into the Regional Aquifer.

The well screens are invaded with both bentonite clay and organic drilling additives. The wells were assigned grades of "Good" and "Very Good" in the LANL *Well Screen Analysis Report (WSAR)*

- Well No.	GRADE IN WSAR	Dissolved Zinc Concentration ^A	
		ug/L	
- R-2	Good	10* (04-26-05)	< 2 PEB (Performance Evaluation Blank)
		< 7* (08-09-05)	
		5.6 (11-09-05)	
		< 7.3 (02-27-06)	< 2.3 FB (Field Blank)
		< 8 (07-24-06)	
- R-4	Good	29 (10-10-03)	
		8* (04-27-05)	
		< 4* (08-08-05)	
		< 2 (11-04-05)	
		< 4.4 (02-28-06)	< 3.2 FB
		< 3.5 (07-25-06)	< 3.1 FB
- R-6	Good	< 8.7* (08-23-05)	< 6.9 FD (Field Duplicate) < 3.1 FB
		< 2 (11-17-05)	
		3.7 (03-01-06)	< 2 FB
		< 10.2 (05-11-06)	< 3 FB
		< 6.4 (07-26-06)	
- R-23 ^B	Very Good	1.1 (12-17-03)	0.883 ug/L zinc – unfiltered sample
		30 (03-23-04)	
		11.7 (06-29-04)	
		< 5.5 (09-24-04)	
		17.2 (07-14-05)	
		2.5 (08-15-06)	< 2 FD
		< 2.2 (12-18-06)	< 2 FD

^A The numbers accompanied with the < symbol designate that zinc was not detected in the water samples. The posted number is the limit of detection. See discussion in text.

* Sparse data used in the WSAR to assess the presence of dissolved zinc in the water produced from the wells. See discussion in text.

^B The WSAR did not identify well R-23 as a mud rotary well with a screen invaded with bentonite clay. The mud rotary drilling is described in the LANL Well R-23 Completion Report.

Table 1 shows the sparse data in the assessment by the LANL WSAR – only two samples from wells R-2 and R-4, one sample from well R-6, and no samples were studied from well R-23 because the WSAR did not identify that the screen in well R-23 is invaded with the bentonite clay drilling mud.

Table 1 illustrates the importance to study the early data and all of the dissolved zinc data collected over time. The table is definitive evidence that dissolved zinc is absent from the water produced from wells R-4 and R-23 because of the new mineralogy produced by the drilling fluids. **The evidence of the absence of dissolved zinc is the identical < values measured for the water samples compared to the field blanks and the performance evaluation blanks.**

The level of dissolved zinc has declined over time in the water produced from wells R-2 and R-6 because of the new mineralogy. However, the absence of dissolved zinc is not proven because the < values measured in the water samples from the wells are higher than the values measured in the blanks. **Nevertheless, the variation over time in the zinc data for the two wells show that the wells do not produce reliable water samples for the detection and measurement of many LANL contaminants, and especially the radionuclide contaminants produced by the research, development and manufacturing of nuclear weapons.**

The LANL WSAR did not specifically describe dissolved zinc as a parameter that was used to study the representativeness of water samples produced from the screened intervals that are invaded only by organic drilling fluids and/or organic foams. This is an important study because the new iron and manganese precipitates formed in the screened intervals by the microbial degradation of the organic additives have exceptionally strong properties for the removal of many LANL contaminants from the water produced from the wells, including zinc. Therefore, Table 2 presents the dissolved zinc data for the single-screen wells installed in the regional aquifer. The LANL WSAR assigned grades of “Good” and “Very Good” to all of the single-screen wells assessed by the WSAR.

Table 2. Dissolved Zinc Data For the LANL Single-Screen Characterization Wells In the Regional Aquifer With Screens Invaded With Organic Drilling Additives.

The Wells Received Grades of “Good” and “Very Good” in the LANL Well Screen Analysis Report (WSAR).

Well No.	Grade in WSAR	Dissolved Zinc Concentration ^A ug/L
R-1	Very Good	7.3 (05-19-05) < 2 FB (Field Blank)
		< 2 (11-28-05)
		< 2 (01-25-06) < 2 PEB (Performance Evaluation Blank)
		4.5 (07-06-06)
		< 2 (10-26-06)
R-9	Very Good	< 3.4 (02-28-00)
		< 1.6 (12-12-03)
		< 2.6 (04-28-05)
		< 2 (07-31-06) < 2.3 FB

Table 2. continued.

Well No.	Grade in WSAR	Dissolved Zinc Concentration ^A		
R-11	Very Good	14	(11-28-05)	
		17	(02-03-06)	
		32	(07-10-06)	
		17.5	(10-10-06)	
R-13	Good	5.78	(07-03-02)	
		< 2	(02-02-06)	
		< 2.4	(07-03-06)	
		< 2.1	(10-25-06)	2.5 FB
R-15	Very Good	7.1	(02-15-01)	
		< 0.31	(05-22-01)	
		< 2.1	(12-15-03)	
		< 0.9	(06-10-04)	
		< 9.1	(08-31-05)	
		< 2	(01-30-06)	
		< 2.9	(07-03-06)	
		< 2.3	(10-24-06)	
R-16r	Not Graded	57	(10-17-05)	
		< 5.5	(12-19-05)	
		< 7.1	(03-08-06)	< 2 FB
		< 9.3	(05-24-06)	< 2.3 FB
		< 7.4	(08-17-06)	< 10 FB
		12.7	(11-01-06)	< 2 PEB
R-18	Very Good	< 2.6	(08-25-05)	
		< 2	(12-01-05)	
		2.5	(05-16-06)	< 2 FB
		< 4	(08-15-06)	
		< 2.1	(12-18-06)	
R-21	Very Good	6.0	(03-31-04)	
		7.8	(06-30-04)	
		< 2	(06-06-05)	
		< 3	(07-07-06)	
		< 2.7	(11-06-06)	< 2.9 FB
R-28	Very Good	11	(05-20-05)	< 2 FB
		< 5.5	(01-26-06)	
		< 4	(07-05-06)	
		3.6	(10-26-06)	
R-34	Good	4	(06-07-05)	< 2 FB
		2	(09-07-05)	
		< 2	(11-29-05)	
		2.6	(01-31-06)	
		< 3.6	(07-17-06)	

^A The numbers accompanied with the < symbol designate that zinc was not detected in the water samples. The posted number is the limit of detection. See discussion in text.

Table 2 presents the dissolved zinc data for ten single-screen LANL characterization wells installed in the regional aquifer. The data show that the organic drilling additives have formed a new mineralogy in the screened intervals and that the dissolved zinc levels have declined over time in all of the wells and have essentially disappeared from seven of the wells. The high level of zinc in well R-11 is probably evidence of zinc contamination and this finding is supported by the presence of chromium contamination in the water samples produced from the well.

The level of zinc measured in well R-28 has declined over time from 11 ug/L to 3.6 ug/L. The decline is probably evidence of the new mineralogy in the screened interval. Well R-28 is at the location of the highest measured values of the chromium contamination in the regional aquifer. There is a need to conduct continuous pumping tests for a period of up to several days with time-series sampling of a set of water parameters and analytes to investigate the impact of the drilling additives on masking the detection of contaminants from well R-28. The continuous pumping and time-series sampling should be performed at many of the single-screen wells listed in Table 1 and Table 2 to gain knowledge of the impact of the drilling additives on the water quality data.

The very high level of dissolved zinc measured in the first water sample produced from well R-16r may also be evidence of contamination by LANL zinc wastes. The decline in measured zinc in the later samples may be because the new mineralogy formed in the screened interval by the organic drilling additives is masking detection of the zinc. The continuous pumping and time-series sampling is an important activity at well R-16r.

Well R-16r is one of the most recent wells installed at LANL. The LANL scientists and DOE project managers claim that "new and improved" well development methods recovered all of the drilling additives from well R-16r. This claim is not supported by the laws of hydraulics, the water quality data, or the record of the pumping test performed after the completion of well development. The pumping test reported interference by the presence of drilling air that remained in the aquifer strata. The organic drilling foam is a medium that releases drill air over a long period of time as the foam degrades.

In addition, the claim by LANL and DOE that the single-screen wells were adequately developed with aggressive well development methods is contradicted by the anecdotal discussion in many of the pumping test reports for the characterization wells. For example, the excerpt below is from the pumping test report for the single-screen well R-4 that was drilled with the mud-rotary method:

"Once the pumping rate was stabilized to a little over 13 gpm, the water levels remarkably rose throughout the remainder of the test. The discharge rate declined steadily from 13.7 gpm to 13.1 gpm during the test. However, the magnitude of water level rise exceeded what would be predicted based on the discharge rate reduction alone. Therefore, the conclusion was that the well efficiency had increased during the test, i.e., the well continued to develop, simply by pumping" [Emphasis Added].

The negligent work by the LANL scientists, the DOE project managers, and the NMED regulators is not an issue on the vanguard of science to be studied by the NAS. Instead, there is a requirement for a new team of independent competent professionals to remedy the mistakes and install the necessary network of monitoring wells to protect the valuable groundwater resource that are at risk for contamination by the LANL wastes. This is an emerging environmental emergency. Please contact me with any questions.