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**John Young**

LANL GW Wells [HWP]

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**Cc:** Rhgilkeson@aol.com

**Subject:** Reply by Robert H. Gilkeson to the EPA Ada Conference call on April 12,2005

My written reply to the EPA Ada conference call on April 12, 2005 is a document that will be a resource for the meeting with CCNS, NMED, and EPA on May 19,2005.

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**Reply to EPA Ada Conference Call on April 12, 2005. The conference call was to address concerns for groundwater contamination beneath the Los Alamos National Laboratory. Reply by Robert H. Gilkeson on May 16, 2005.**

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## Synopsis

On April 12, 2005, EPA/Ada, EPA Region VI, LANL, DOE, NMED, and NNMCAB participated in a conference call to review progress and concerns with characterization of the regional aquifer, as specified by the LANL Hydrogeologic Workplan. I was a listener on the conference call. This document provides my response to the discussions of April 12.

As detailed in my previous reports (references), many of the LANL characterization wells do not provide reliable data regarding the presence or absence of contaminants in the aquifer. This failure of the groundwater investigation is due to several causes, including the use of inappropriate drilling fluids, the mixing of waters from different aquifers, cross-communication across confining layers within the regional aquifer, and sampling at inappropriate strata within the regional aquifer. The problems with the characterization wells for 1). detection of contamination, and for 2). measurement of the permeability of aquifer strata are described in my previous reports.

Indeed, LANL reports acknowledge that many of the characterization wells do not currently provide groundwater samples with chemistry that is representative of the aquifer because of the presence of drilling fluids, drilling foam, and clay drilling muds. My response to the conference call is based upon my concern that the effects of the drilling fluids, foam, and muds may conceal the presence of contamination in the regional aquifer at this time, and reduce the possibility for detecting contaminants of concern for the next fifty years.

Contaminants of concern that are detected in the regional aquifer include tritium, strontium-90, technetium-99, perchlorate, solvents (VOCs), semivolatile organic compounds (SVOCs), and high explosives. Other contaminants may be present. The measured levels of most contamination are low. It is very important to understand that the low levels may be because of 1). the improper methods that were used for the installation of the LANL characterization wells, and 2). the improper methods that are used for the collection of water samples from the wells. The actual nature and extent of the contamination in the regional aquifer is not known.

## 1.0 Overview of problems with the LANL characterization wells

- Mr. Johansen (DOE Project Manager) reported that LANL/DOE completed the installation of the thirty two characterization wells required by the LANL Hydrogeologic Workplan.

I regard this statement by Mr. Johansen as a dubious achievement because of the large set of problems with the installed set of LANL characterization wells. Many of the wells do not provide the necessary information for presence of contamination, background water quality, and aquifer properties. Many of the LANL wells do not meet the requirements of RCRA-compliant monitoring wells as described in the EPA RCRA Manual[47] and the NMED LANL Consent Order[45]. Many of the LANL wells do not meet the requirements of DOE Orders 435.1[4], 450.1[3], and 5400.5[5] for monitoring wells on DOE facilities. Many of the LANL wells have little value other than window dressing[48]. There is a need for an immediate study to determine the value of the individual wells, identify the wells than may be rehabilitated, identify the wells that require replacement, and to determine a priority for replacement.

The problems with the LANL characterization wells are described in my 2004 report[12] "Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory", my 2005 report[11] "Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory: Part Two", my 2005 report[10] "Notes on LANL Characterization Wells R-4, R-26. and R-34", the annotated transcript[13] of my presentation to the Northern New Mexico Citizens Advisory Board (CAB), and in my written replies[14,15,16] to the reviews of my 2004 report[12].

LANL reports[22,23,32] acknowledge that many of the LANL characterization wells do not provide groundwater samples with a chemistry that is representative of the aquifer because of the damage caused by the biodegradable drilling fluids, the biodegradable drilling foam, and the bentonite clay drilling muds. The reasons for why many of the LANL characterization wells do not meet requirements for knowledge of the presence of contamination, knowledge of aquifer properties, and the RCRA and DOE requirements for monitoring wells include

1. improper drilling procedures that have caused damage to the chemistry and permeability of the screened intervals by invasion with the drilling additives, (e.g., wells R-4, R-7, R-9i, R-12, R-16, R-19, R-22, R-26, R-32, R-34, etc.),

2. improper drilling procedures that allowed cross-communication (and often cross-contamination) between perched zones of saturation and the regional aquifer (e.g., wells R-7, R-12, R-19, R-23, R-25, R-26, CdV-R-15-3, CdV-R-37-2, etc.),

3. improper drilling procedures that allowed cross-communication (and often cross-contamination) across confining layers within the regional aquifer (e.g., wells R-15, R-22, etc),

4. improper installation of very long well screens that may cause dilution of contamination (e.g. wells R-7, R-13, R-15, R-22, R-23, etc.),

5. failure to install well screens in the strata with high permeability, the very strata that are important for monitoring (wells R-7, R-13, R-15, R-16, R-22, R-26, R-32, etc. ),

6. drill casing and conductor casing installed deep below the static water table prevents monitoring of important strata near the top of the regional aquifer (e.g., wells R-16 and R-32),

7. installation of well screens in inappropriate strata (e.g., wells R-12, R-13, R-20, R-22, R-26, etc.), and

8. improper methods used for the collection of groundwater samples from the single-screen and multiple-screen LANL characterization wells.

A section in my Part Two report[11] assesses the total number of screened intervals in the LANL characterization wells that provide groundwater samples with spurious chemistry for many contaminants of concern to be approximately 40. The actual number of screened intervals that are irreparably damaged for groundwater samples representative of aquifer chemistry will not be known until proper methods are used to collect the groundwater samples. The concerns for the methods used by LANL for the collection of groundwater samples from the LANL characterization wells are described in section 5.0 of this report.

## 2.0 Drilling methods used for installation of the LANL characterization wells

- Mr. Johansen (DOE Project Manager) thanked EPA/Ada for reviewing the several issues concerning the LANL characterization wells as the issues were often discussed over the past two years.

It was a serious mistake for DOE and LANL to install characterization wells at LANL when there was any indecision about the methods that were being used. The process of applying data quality objectives (DQOs) to define acceptable drilling methods is well-understood by environmental consultants and is a requirement of EPA and DOE.

The focus of DOE and LANL was to lower the cost for installation of the LANL characterization wells at the sacrifice of the well-understood monitoring well

industry standard practice for installation of monitoring wells to meet data quality objectives. Apparently, LANL and DOE did not understand the important difference between monitoring wells and wells that are installed for a water supply.

During the drilling of the open boreholes for water supply wells, the purpose of the water-based drilling fluids that are used with the fluid-assisted drilling methods is to invade and stabilize the aquifer strata that surround the borehole. The greatest invasion of the drilling fluids is into the strata with high permeability, the very strata that are important for knowledge of the presence of contamination, for long-term monitoring, and for knowledge of permeability. The types of drilling additives used in the LANL boreholes include biodegradable fluids, biodegradable foam, and bentonite clay muds.

During the development of water supply wells, chemicals are used to destroy the biodegradable drilling additives so that they are not available as a food source by microbes to cause the well known "biofouling plugging" of the aquifer strata, the filter pack sediments, and even the openings in the well screen. LANL did not use chemicals to prevent the "biofouling plugging" process from occurring. For water supply wells drilled with the mud rotary method, chemicals are used to disaggregate and disperse the bentonite clay muds that have stabilized the borehole. LANL used chemicals to disperse the clay outward in the aquifer strata that surround the well screens. However, the chemicals did not destroy the preferential properties of the clay for removal of radionuclide and trace metal contaminants from groundwater.

The claim by LANL and DOE that the geologic strata beneath LANL required the use of the mud rotary and the fluids-assisted air rotary drilling methods to drill open boreholes is <u>wrong</u>. The advantage for using these methods was to lower the cost for installation of the wells. However, the LANL well geochemistry reports and other LANL reports[22,23,32] document the damage that occurred to the screened intervals in the wells because of the failure of the well development procedures to remove the drilling additives from the aquifer strata.

The data quality objectives of the LANL characterization wells prohibit the invasion of the strata that are important for characterization with water-based biodegradable drilling fluids, biodegradable foam, bentonite clay muds, and other borehole stabilization materials. The drilling additives greatly reduced the permeability of the aquifer strata that surround the screened intervals in the wells and caused changes to the chemistry of the aquifer strata. The changes to the chemistry have great potential to prevent detection of many contaminants of concern including radionuclides for a period of time that is greater than the scheduled fifty year life of the impacted monitoring wells.

**2.1** LANL wells installed in boreholes drilled with casing-advance methods

The appropriate drilling method for installation of LANL monitoring wells is the air rotary underreamer casing-advance method with retractable drill casings used to stabilize the borehole. This drilling method was used for the installation of many of the LANL characterization wells. Mr. Nylander advised EPA/Ada that it was necessary to use water-based fluids with the open hole rotary drilling methods because of the recurrent problems with the retractable drill casing becoming seized within the boreholes. I disagree with Mr. Nylander's assessment of the casing-advance drilling method.

The following is an incomplete list that contains examples of LANL wells installed with the casing-advance method, the total depth drilled, TD, and the depth drilled into the regional aquifer, RA:

well R-9, TD – 771 ft, RA – 82 ft:
well R-12, TD – 886 ft, RA – 81 ft;
well R-14, TD – 1327 ft, RA – 145 ft;
well R-15, TD – 1107 ft, RA – 143 ft;
well R-16, TD – 729 ft, RA – 108 ft;
well R-22, TD – 1489 ft, RA – 447 ft;
well R-23, TD – 887 ft, RA – 58 ft;
well R-25, TD – 1942 ft, RA – 656 ft; and
well R-31, TD – 1103 ft, RA – 569 ft.

Most of the boreholes in the above list were drilled with biodegradable drilling additives or bentonite clay muds to provide lubrication between the drill casing and the borehole wall. However, the boreholes for wells R-9[42] and R-12[41] were drilled through the entire thickness of the unsaturated strata into the top of the regional aquifer with the dry air rotary underreamer casing-advance drilling method.

The well installation record of the Hydrogeologic Workplan is proof that the air-rotary casing-advance drilling method has installed monitoring wells deep into the regional aquifer at locations distributed across the Laboratory facility. Furthermore, well's R-14[29] and R-23[26] are two examples of the failure of the mud rotary drilling method to drill a stable borehole. For these wells, it was necessary to use the air rotary underreamer casing-advance drilling method with retractable drill casing to stabilize the borehole for installation of the wells.

Prior to my involvement with the drilling activities of the LANL Hydrogeologic Workplan, I supervised drilling activities for the LANL Environmental Restoration Project. This supervision included the successful drilling of boreholes to depths as great as 700 ft using the dry air rotary underreamer casing advance drilling method

with retractable drill casing of a single diameter. Drilling to the 700 ft depth was accomplished without telescoping down to a smaller diameter drill casing.

The drilling method that is appropriate for the installation of monitoring wells beneath LANL in perched zones of saturation and in the regional aquifer is air rotary underreamer casing advance with a minimum of three sets of telescoped retractable drill casings and the use of an appropriate drilling fluid on the backside of the retractable drill casings for lubrication. For drilling in the unsaturated zone, dry air rotary core drilling, and open hole drilling can be performed in advance of the drill casing to explore for perched zones and to collect information on the in situ moisture content of the rock and sediments.

It is very important to avoid the invasion of biodegradable drilling fluids, biodegradable foams, and bentonite clay muds into the aquifer strata where screens are installed. It is not necessary to use the liquid or foam drilling additives for drilling with the air rotary underreamer casing-advance drilling method.

## 2.2 LANL wells installed in boreholes drilled with the mud rotary method

Activities of the LANL Hydrogeologic Workplan were reviewed by an external group of expert consultants known as the External Advisory Group (EAG). The EAG Semi-Annual Report (EAG, Dec. 23, 1999)[9] lists 17 disadvantages for installing monitoring wells in boreholes that were drilled with the mud rotary method. The EAG report contains the following summary statements concerning use of the mud rotary drilling method:

"The use of mud-rotary drilling techniques is largely inappropriate for the goal of the LANL Hydrogeologic Workplan. Drilling with mud carries the risk of adsorbing contaminants onto the bentonite that permeates into the pore space around the well screen and is not removed by well development. Should this occur, it could result in reduced concentrations or non-detects on contaminants that are actually present in the vicinity of the well."

"The artificial entrainment of bentonite clay drilling muds in the pore space around a monitoring well is clearly not desirable. This is because these materials can remove from solution the very constituents that need to be monitored by the well. This is a significant concern for LANL since radionuclides are known to be adsorbed by these clays. That the drilling mud, i.e., bentonite, penetrates into the aquifer strata is not disputed. It is reasonable to assume that fairly extensive intrusion of the bentonite into the aquifer strata can be expected. It is argued that well development, via high-flow pumping, using surge blocks, etc. is sufficient to remove blockage and create adequate flow through the well screen when a well has been drilled with mud. This is generally true. However, sufficient water flow is not the only consideration here. It is extremely unlikely that such well development techniques can remove the extruded

bentonite sufficiently to assure that residual clay materials are not present in the pore space around the wells and serving as an adsorptive barrier to contaminant detection and quantification. Unfortunately, if no contamination is detected then there is simply no way (without drilling another well by a different technique) to determine whether the contaminant is truly absent at this point or whether it is being adsorbed by residual drilling fluids."

**"The EAG would therefore caution LANL about using mud drilling techniques for the installation of the deep regional monitoring wells. If bentonite clay drilling mud is to be used, it should be used sparingly (e.g., as a lubricant only) and it would be best to avoid it altogether when drilling zones where the well screens will be located."**

**2.3** Properties of the bentonite clay for adsorption of trace radionuclide and metal contaminants

Dr. Longmire told EPA/Ada that the presence of dissolved concentrations of strontium at background levels in groundwater samples collected from the LANL characterization wells where the borehole was drilled with bentonite clay drilling mud was proof that the bentonite clay was not a concern for adsorption of radionuclide contaminants. I disagree with this statement by Dr. Longmire because the adsorption properties of bentonite clay for the trace levels of the actinide radionuclide contaminants (e.g. plutonium, cesium, and americium) are very different and much stronger than the adsorption properties of the clay for removal of strontium from groundwater. The preferential adsorption properties of bentonite clay to remove radionuclide and metal contaminants from groundwater are described in Appendix D in my Part Two report[11] and are summarized here:

The text book *Environmental Chemistry* by Langmuir (1997)[21] describes the preferential adsorption of trace contaminants as follows:
"Adsorption (onto bentonite clay) of a dissolved ionic species is always part of an (ion) exchange reaction that involves a competing ionic species. The desorbing species creates the vacant site to be occupied by the adsorbing one. As the trace metal (or radioactive contaminant) level drops relative to that of a competing major ion, adsorption of the trace species is increasingly favored relative to competing major species."

The text book *Aquatic Chemistry* by Stumm and Morgan (1996)[46] describes the preferential adsorption of trace contaminants by bentonite clay as follows:
"The sorption of alkaline and earth-alkaline cations (e.g., strontium) on expandable three-layer clays (e.g., bentonite clays) can usually be interpreted as stoichiometric exchange of interlayer ions (ion exchange). To understand binding of trace heavy metals (e.g., also the trace radioactive contaminants such as plutonium, cesium, and

americium) on clays, one needs to consider – in addition to ion exchange – the surface complex formation on end–standing functional OH groups. Three layer silicates (e.g., bentonite clays) contain on the crystal edges (broken bonds) end-standing OH groups which can interact with (remove from groundwater) metal ions (and many radionuclide contaminants)."

An Australian drilling manual[1] cautions against the use of the drilling additives when radionuclides are contaminants of concern. "*DRILLING – The Manual of Methods, Applications and Management*" (1986).

From page 480 of the Drilling Manual:
"Drilling fluids, if used, must be carefully chosen to avoid contamination or alteration of final water (chemistry of groundwater produced from monitoring wells) or soil chemistry (chemistry of aquifer strata)."

"When metals or radionuclides are the target compounds, bentonite muds must be avoided. They have cation-exchange properties, and bind up these constituents."

Mr. Nylander told EPA/Ada that the adsorption properties of the bentonite clay would become exhausted. I disagree with this statement by Mr. Nylander because the radionuclide and metal contaminants will only be present in groundwater at trace levels that will not exhaust the preferential properties of bentonite clay to remove the contaminants from groundwater for a period of time that is much greater than the scheduled fifty-year life of the LANL characterization wells.

**2.4** Properties of the biodegradable drilling additives to cause removal of radionuclide and other contaminants from groundwater

Dr. Longmire and Mr. Nylander assured EPA/Ada that the biodegradable drilling additives were used sparingly, and that only minimal amounts of the drilling additives remained in the aquifer strata after the well development procedures. Their statements are contradicted by the information presented in the LANL well completion reports on volumes of drilling additives and on the description of well development procedures (e.g., no well development performed in screened intervals #1 in wells R-7 and R-22, and minimal well development performed in screened intervals in wells R-7, R-9i, R-12, R-19, R-22, etc.).

The problem of the biodegradable drilling additives to cause "biofouling plugging" of the screened intervals in wells is well-understood in the water well industry[11]. NMED advised LANL to use a chemical dispersant to breakdown the biodegradable drilling additives. This is a common practice in the water well industry. From page 191 of the NMED LANL Consent Order[45]:
"-organic polymer drilling muds have been observed to facilitate bacterial growth,

which reduces the reliability of sampling results. If polymer emulsions are to be used in the drilling program at the Facility, polymer dispersion agents shall be used at the completion of the drilling program to remove the polymers from the boreholes. For example, if EZ Mud® is used as a drilling additive, a dispersant (e.g., BARAFOS® or five percent sodium hypochlorite) shall be used to disperse and chemically breakdown the polymer prior to developing and sampling the well."

However, LANL did not use a chemical to breakdown the biodegradable drilling fluids with the result that the "biofouling plugging process" has caused great damage to the screened intervals in many of the LANL characterization wells. An additional problem with the LANL multiple-screen wells is the passage of a large amount of time between invasion of the aquifer strata with the biodegradable drilling additives, and when the well development procedures were performed. For many screened intervals, the onset of the "biofouling plugging" of the screened intervals occurred <u>before</u> well development procedures were performed.

The concentration of dissolved iron in LANL monitoring wells that are impacted by biodegradable drilling additives are commonly greater than several mg/L, and even greater than 10 mg/L (e.g., screen #3 in monitoring well R-7[38] and screen #1 in monitoring well R-22[34]). The high iron concentrations are direct evidence of the biofouling plugging process to cause a great reduction in permeability for the screened interval due to the precipitation of ferric oxyhydroxides and hydrous ferric oxides as blanket deposits on the aquifer strata, on the filter pack sediments, and even on the well screens.

The biofouling plugging of well screens is described in the book "*Groundwater and Wells, Second Edition*" (1986)[6]:

From page 455:
"If the iron content of the groundwater exceeds 0.5 mg/l. precipitation of iron is likely, although some precipitation may begin at concentrations as low as 0.25 mg/l."

From page 456:
"The most common bacteria affecting the condition of a well are iron bacteria. Iron bacteria are nuisance organisms that cause plugging of pores in water-bearing formations and openings in well screens. Iron bacteria produce accumulations of slimy material of gel-like consistency, and oxidize and precipitate dissolved iron and manganese. The combined effect of growing organisms and the precipitating minerals can plug a well almost completely within a short time. Cases have been reported where a 75-percent reduction in well yield has occurred in three months to a year."

The chemistry of the iron precipitates is described in the book *"Aqueous Environmental Geochemistry"* (1997)[21]:

From page 436:
"Crystallization of hydrous ferric oxide (HFO) takes years in waters low in iron, but may occur in a few hours or days, in the presence of several mg/kg (mg/L) of dissolved iron."

From page 462:
"They (iron precipitates) are especially a problem in fouling of iron pipes in water supply systems and well screens. They can cause a loss of up to 90 % in the productivity of a well."

From Page 538:
"Among common minerals, the strongest sorbents for most actinide cations (e.g., cations of uranium, plutonium, americium, and cesium) are the ferric oxyhydroxides and especially hydrous ferric oxide."

The chemical record in many LANL well geochemistry reports is evidence that many of the screened intervals in the LANL characterization wells are surrounded by an extensive envelope of iron precipitates on the well screen, filter pack sediments, and aquifer strata. The iron precipitates are stable[21] as the natural, oxidizing chemistry of the regional aquifer is reestablished in the strata surrounding the screened intervals.

Dr. Longmire claims that the return of the oxidizing chemistry to the groundwater samples collected from the impacted screened intervals is evidence that the natural "representative" chemistry has been restored. I disagree with Dr. Longmire's analysis. The return of an oxidizing chemistry will not repair the major change that has occurred to the chemistry and permeability of the filter pack sediments and aquifer strata surrounding the well screens in the impacted wells.. The change was caused by the "biofouling plugging process" that results from invasion of aquifer strata with biodegradable drilling fluid and biodegradable foam.

Table 4 in the LANL report by Bitner et al.[22] is mistaken to describe the water samples with an oxidizing chemistry that are collected from screen #1 in well R-7 as "representative of pre-drilling water chemistry". Dissolved uranium was present in the groundwater sample collected from the perched zone of saturation in the well R-7 borehole[37] but is absent in groundwater samples[38] collected from screened interval #1 in well R-7. Screened interval #1 was installed in the perched groundwater.

EPA/Ada was assured that LANL went to extra efforts to appraise the impacts that the biodegradable drilling additives would have on the validity of the contaminant chemistry in groundwater samples collected from LANL characterization wells. EPA/Ada needs to be aware of the studies concerning the properties of the

biodegradable drilling fluid EZ-MUD*. A LANL document (LANL, OCT. 2000)[43] describes the sorption properties of the BAROID EZ-MUD* biodegradable polymer-based drilling fluid that was used in the boreholes for many LANL monitoring wells as follows:

"The EZ-MUD* drilling fluid has a negative charge density of 30% which may enhance the polymers ability to adsorb the cations $Sr^{2+}$, $PuO_2^{1+}$, $UO_2^{2+}$, and $AmCO_3^{1+}$."

"EZ-MUD* is strongly hydrophobic (high molecular weight polymer), which probably has the ability to adsorb organic compounds such as RDX, HMX, and TNT."

It is important to note that the drilling of the boreholes for many LANL monitoring wells with the use of EZ-MUD* was after LANL released the information on the adsorption properties of the drilling fluid for contaminants of concern. It was inappropriate to use drilling fluids that have sorption properties for many contaminants of concern in groundwater beneath the Laboratory facility.

**3.0 Well development procedures in the LANL characterization wells.**

The LANL staff referred the EPA/Ada staff to Table 5 in the LANL report by Bitner et al.[22] as a table that described the well development procedures in the LANL characterization wells that were a concern in the 2004 report by Gilkeson[12]. The Gilkeson report described the poor development of the screened intervals in LANL characterization wells R-7, R-9i, and R-22 and ascribed the biodegradable drilling fluids that were not removed from the screened intervals as responsible for preventing accurate knowledge of the presence of radionuclides and other contaminants in groundwater samples collected from the three wells. The contaminants affected by the drilling additives include the following:

**well R-7**[37] – strontium-90, uranium, and other contaminants including SVOCs and VOCs.
**well R-9i**[35] – plutonium-238 and uranium.
**well R-22**[33] – technetium-99, uranium, and other contaminants including VOCs, SVOCs, and possibly, high explosive contaminants.

Please note that the three wells are not included in Table 5 in the Bitner et al. report[22]. LANL should explain the omission of the wells from the table. The LANL well completion reports[37,33] show that no well development activities were performed in screen #1 in wells R-7 and R-22 because the groundwater had drained from the aquifer strata present at the screened intervals in the multiple-screened wells. The return of groundwater to the screened intervals occurred after the drainage of groundwater was stopped by the installation of the Westbay* sampling system in the multiple-screen wells. In addition, information in the LANL well R-7 completion

report shows that well development activities were terminated in screen #3 in well R-7 before the measured turbidity in groundwater samples met RCRA requirements[47] for low turbidity.

LANL is mistaken to claim the large volume of groundwater pumped during well development activities, and the low values of turbidity in the pumped water, as proof that most of the drilling fluids have been removed from the filter pack and aquifer strata that surround the screened intervals in the LANL characterization wells. Table 5 in the Bitner et al. report[22] documents the total volume of groundwater that was pumped from the wells, but does not identify the amount of groundwater pumped from each discrete screened interval. This is an important omission because knowledge of the discrete screened intervals where small amounts of water were pumped is important. For example, Table 8.1-1 in the LANL well R-20 well completion report[25] lists the total volume of water produced during the development of the three screened intervals as 87,008 gallons, but only reports 113 gallons as the amount of water produced from screen #1. Table 8.1-1 lists the turbidity of the water produced from screen #1 as 227 NTU's compared to the value of 1.11 NTU's in Table 5 in the Bitner et al. report.

The EPA RCRA Manual[47] requires that well development procedures provide groundwater with turbidity values less than 5 NTU's. Except for the discrepancy in turbidity values, Table 8.1-1 and Table 5 present identical values for total volume of water produced, pH, temperature, and specific conductance for the groundwater produced from screen #1. The LANL well R-20 report[25] describes the well development performed at screen #1:

> "After withdrawing approximately 100 gallons from the well by pumping at this screen, the water level dropped below the pump intake."

The well R-20 report also explains that screen #1 did not produce a sufficient amount of water to permit sampling for a limited suite of constituents.

Another discrepancy between the well R-20 report and Table 5 in the Bitner et al. report are the turbidity values for groundwater samples collected from screen #3. The well R-20 report lists a turbidity value of 43.7 NTU's as compared to the muh lower turbidity value of 4.2 NTU's in the Bitner et al. report. LANL should explain the discrepencies between the well R-20 report and the Bitner et al. report concerning the turbidity data for screened intervals #1 and #3 in well R-20.

The "not representative chemistry" of groundwater samples collected from many LANL characterization wells and the acknowledgement in a LANL report[23] that the groundwater samples from LANL characterization wells R-7, R-9i, R-12, R-19, R-22, and R-32 will have a "not representative chemistry" for a period as great as 10 years are proof that the well development procedures in many wells were unsuccessful. Table 4 in the Bitner et al. report[22] acknowledges that the groundwater samples

collected from the screened intervals in many of the LANL wells (including well R-16 in Table 5) are not representative of aquifer chemistry because of the altered chemical environment that was caused by the drilling fluids that were not removed by the well development procedures. It is important to note that during the conference call EPA/Ada was assured that the impact of the drilling additives on groundwater chemistry was a short term phenomenon, whereas a LANL report[23] estimates an impact for a period of ten years.

The presence of elevated values of turbidity and/or TOC in the groundwater samples are proof that the well development procedures have not removed the drilling additives. However, the measurement of low values of turbidity and TOC does not prove that the drilling additives have been removed. Furthermore, pumpage of large volumes of water from the screened intervals does not prove that much of the drilling additives have been removed.

The proof that the drilling additives have been removed would be
1. an accurate record of the quantity of drilling additives that have invaded the strata surrounding the screened interval compared to an accurate record of the volume of drilling additives that were removed by the well development procedures, and
2. the collection of ground water samples with a representative chemistry for several quarterly samples collected after the completion of well development procedures. LANL has not provided this record.

Important information that is missing from Table 5 in the Bitner et al. report is the very large quantity of drilling additives that have invaded the aquifer strata. The LANL well completion reports do not list an accurate record of the drilling fluid that has invaded the aquifer strata as a function of depth in the borehole. For the wells listed in Table 5, of the Bitner et al. report, the LANL well completion reports contain the following documentation of quantities of drilling fluids:

Well R-14: The static water level for the regional aquifer at well R-14 was measured at a depth of 1182 ft bgs. The LANL well completion report for Well R-14[29] lists the following drilling additives for the borehole depth interval of 848 to 1315 ft bgs, the total depth of the borehole: 28,250 lb of bentonite clay, 175 gal of Quik-FOAM*, 22 gal of Liqui-Trol*, 700 lb of Pac-L*, 1830 lb of N-Seal* and 2160 lb of Magma Fiber*. The majority of materials on this list were used during drilling in the regional aquifer with the mud rotary method. The drilling additives Pac-L*, N-Seal* and Magma Fiber* were used in the unsuccessful attempt to stabilize the mud rotary borehole in the regional aquifer. Ultimately, well R-14 was a multiple-screen characterization well installed in a borehole drilled to total depth with the fluid-assisted air rotary casing advance underreamer drilling method.

Well R-16: The static water level for the regional aquifer at well R-16 was measured at a depth of 621 ft bgs. The LANL well completion report[28] lists the following

drilling additives for well R-16 in the depth interval of 0 to 729 ft bgs: 20,000 lb of bentonite clay, 100 gal of Liqui-Trol*, 650 gal of Quik-FOAM*, and 400 lb of soda ash. The report lists the following drilling additives for well R-16 in the depth interval of 729 ft to 1287 ft bgs, the total depth of the borehole: 31,100 lb of bentonite clay, 25.5 gal of EZ-MUD*, 5 gal of Liqui-Trol*, 800 lb of Magma Fiber*, 50 lb of Pac-L*, 800 lb of N-Seal*, and 100 lb of soda ash. Groundwater samples collected from Well R-16 are identified in the Bitner et al. report[22] as not representative of aquifer chemistry because of the drilling fluids.

Well R-20: The static water level for the regional aquifer at well R-20 was measured at a composite depth of 832.3 ft bgs. The Schlumberger* geophysics[25] identified the static water level at a depth of possibly 755 ft bgs. The LANL report[25] lists the following drilling additives for well R-20 in the depth interval of 0 to 780 ft bgs: 26,565 lb of bentonite clay, 135 gal of Liqui-Trol*, 483 gal of Quik-FOAM*, and 536 lb of soda ash. The report lists the following drilling additives for well R-20 in the depth interval of 780 ft to 1365 ft bgs, the total depth of the borehole: 7,000 lb of bentonite clay, 87 gal of Liqui-Trol*, 620 lb of Magma Fiber*, 200 lb of Pac-L*, and 100 lb of N-Seal*.

Well R-21: The static water level on the regional aquifer was measured at a depth of approximately 800 ft below ground surface. Drilling activities for well R-21 are described in a report[20] by the consulting firm Kleinfelder. The borehole was drilled with a conventional circulation fluid rotary drill rig that used 112 gal of Quik-FOAM* for the depth interval of 563 to 995 ft, the total depth of the borehole. The high value for total organic carbon (5.90 mgC/L) listed in Table 5 of the Bitner et al. report is evidence that well development procedures were not successful to remove the biodegradable drilling additives from the strata that surround the screened interval.

Well R-23: The static water level on the regional aquifer was measured at a depth of 829 ft below ground surface. The LANL well completion report[26] lists the following drilling additives for well R-23 from 0 to 923 ft bgs, the total depth of the borehole: 28,250 lb of bentonite clay, 550 gal of Quik-FOAM*, 46 gal of Liqui-Trol*, 41 lb of soda ash, 700 lb of Pac-L*, 1830 lb of N-Seal*, and 2160 lb of Magma Fiber*. The mud rotary drilling method would not provide a stable borehole for well construction. The single-screen well with a screen length of 57 ft was installed inside retractable drill casing that was drilled to a depth of 887 ft bgs with the air rotary underreamer casing advance drilling method.

Well R-32: Information in the LANL well R-32 report[28] is uncertain about the depth of the water table on the regional aquifer. The depth is possibly as shallow as 722 ft bgs and was measured at a composite level of 783.4 ft bgs in the multiple-screen well before installation of the Westbay* packer system. The well completion report lists

the following drilling additives for the depth interval of 0 to 792 ft bgs: 20,000 lb of bentonite clay, 175 gal of Liqui-Trol*, 550 gal of Quik-FOAM*, and 400 lb of soda ash. The well R-32 report lists the following additives for the depth interval of 792 to 1008 ft bgs, the total depth of the borehole: 25,000 lb of bentonite clay, 25.5 gal of EZ-MUD*, 5 gal of Liqui-Trol*, 50 lb of Pac-L*, 800 lb of N-Seal*, and 800 lb of Magma Fiber*. Groundwater samples collected from Well R-32 are identified in a LANL Report[23] as <u>not representative of aquifer chemistry</u> because of the drilling fluids.

Additional evidence that large quantities of bentonite clay drilling mud has invaded the aquifer strata that surround the screened intervals in many LANL characterization wells was the necessity to use chemical agents to disaggregate and disperse the drilling mud outward in the aquifer strata an unknown distance, but certainly a distance beyond recovery by the well development procedures that can be deployed in the very deep, small diameter LANL characterization wells equipped with well screens with 0.01-inch slot openings that are surrounded by a filter pack of medium-grained 20/40 sand. The great difficulty for well development procedures to remove the drilling additives from screened intervals in the LANL monitoring wells is described in Article A-2. in Appendix A of my Part Two Report[11].

Table 5 in the Bitner et al. report[22] lists the chemicals that were used to disaggregate and disperse the bentonite clay that plugged the aquifer strata surrounding the screened intervals in LANL characterization wells R-14, R-16, R-20, and R-32. The EPA RCRA Manual[47] for construction of monitoring wells cautions against the use of chemical drilling additives to develop screened intervals that are surrounded by bentonite clay drilling mud:

> "Additives to modulate the viscosity and density of the bentonite muds may also introduce contaminants in the groundwater or force large, unrecoverable quantities of mud into the formation." (EPA RCRA Manual, page 6-12)

### 3.1 <u>The poor development of screened intervals in LANL well R-22</u>

Dr. Longmire cited screened interval #1 in LANL well R-22 as an example of where aquifer strata with low permeability presented a problem to removal of the bio-degradable drilling additives by the LANL well development procedures. I disagree with this assessment by Dr. Longmire as the LANL well R-22 completion report[33] shows that the improper drilling methods used in the well R-22 borehole breached a confining layer located below the strata where screen #1 is installed with the result that the contaminated groundwater at the top of the regional aquifer at a location immediately downgradient of MDA G (the LANL facility for landfill disposal of low-level radioactive waste) was allowed to drain down the borehole to contaminate groundwater deep in the regional aquifer. The regulations of EPA[47], NMED[45], DOE[3,4,5], and "common sense" prohibit the drilling of boreholes that cause cross-communication of contamination within an aquifer. The drilling of a borehole with

methods that allowed cross-communication with deeper aquifer strata of the in situ contaminated groundwater at the top of the regional aquifer immediately downgradient of MDA G was a serious mistake.

After the borehole for well R-22 was drilled to the total depth of 1489 feet bgs, the static water level was measured at a depth greater than 955 feet bgs, a depth of greater than 70 feet below the static water level on the regional aquifer of 883 feet bgs, the depth to the static water level when the borehole was first drilled into the regional aquifer. Screen #1 was installed to straddle the water table of the regional aquifer. There was no water in screen #1 until the Westbay* sampling system was installed in the multiple-screen well. Because there was no water, there were no well development procedures performed in screen #1.

I disagree with the assessment of Dr. Longmire that the aquifer strata at the top of the regional aquifer downgradient of Area G have a low permeability. The drilling record in the well R-22 completion report[33] documents that strata with high permeability are present in the depth interval of 893 ft to 903 ft bgs as there was "lost circulation" of the biodegradable drilling fluid and biodegradable drilling foam during the drilling in this interval of strata. The "lost circulation" is direct evidence of permeable strata that were invaded by a large volume of the biodegradable drilling fluid (Baroid EZ-MUD*) and biodegradable foam (Baroid Quik-FOAM*) that were used for drilling the well R-22 borehole. In addition, the geophysical logs and well screen locations displayed in Figure 5 in the Bitner et al. report[22] document the presence of permeable strata at the location of screen #1 in well R-22.

### 3.2 The biodegradable drilling additives used in the borehole for well R-22 prevent knowledge of the properties of the unsaturated strata beneath MDA G and of the presence of contamination in groundwater.

It was a serious mistake for LANL to drill the borehole for well R-22 through the unsaturated sediments and deep into the regional aquifer with drilling methods that invaded the unsaturated strata and the strata in the regional aquifer with the water-based biodegradable drilling additives. At the location of well R-22, there is a critical need for knowledge of the properties of the unsaturated strata for transport of contamination released from waste disposal pits and shafts at MDA G to the regional aquifer. The water-based drilling additives used for the well R-22 borehole prevented the collection of core and cuttings for a profile of water content in the unsaturated sediments and profiles of chloride content, stable isotopes, etc. The water-based drilling fluids also increased the possibility to not identify the presence of perched zones of saturation. An additional advantage of dry drilling methods is the capability to sample the in situ air in the unsaturated strata for VOCs. A large VOC plume is present in the unsaturated strata beneath MDA G.

The LANL well R-22 geochemistry report[35] documents the serious damage to the chemistry and permeability of the strata in the regional aquifer that was caused by the biodegradable drilling additives. The groundwater samples collected from well R-22 are spurious for knowledge of many contaminants of concern because of the unnatural chemistry caused by the drilling additives, and also because of the biofouling plugging of the permeability of the impacted strata. There is a critical need for knowledge of VOC contaminants in groundwater in the regional aquifer beneath MDA G. The unnatural chemistry in groundwater samples because of the biodegradable drilling additives will conceal the presence of many VOC contaminants in groundwater.

The properties of the biodegradable drilling additives to prevent accurate knowledge of the presence of VOC and SVOC contaminants in groundwater from the regional aquifer are discussed in section 4.2 of this report for groundwater samples from well R-7. Section 2.4 of this report describes the properties of the biodegradable drilling additives to prevent the detection of radionuclide and other contaminants in groundwater.

### 3.3 The poor development of screened intervals in recently installed LANL wells

The poor development of the screened intervals in the LANL wells was an important concern of my 2004 report[12]. Messrs. Johansen and Whitacre from DOE, and Mr. Nylander (LANL Project Manager) and Dr. Longmire (LANL geochemist) attended my presentation of this report to the Northern New Mexico Citizens Advisory Board (CAB) in June, 2004. The DOE and LANL staff took umbrage to my claim that the LANL well development procedures were not successful to remove the drilling fluids (e.g., biodegradable fluids, biodegradable foam, bentonite clay drilling muds, and borehole stabilization materials) that invaded the strata surrounding the screened intervals in many of the LANL characterization wells. The DOE and LANL staff informed the CAB that over time modifications were made to improve the well development procedures. The annotated transcript[13] of the discussion during my presentation to the CAB is available from the CAB.

The claim by LANL and DOE that the recently installed characterization wells were properly developed to remove the drilling additives convinced me to review the LANL characterization wells that were recently installed and directly managed by DOE through an interagency contract with the U.S. Army Corps of Engineers. My review[10] of LANL characterization wells R-4[17], R-26[18], and R-34[19] determined that the well development procedures were <u>not</u> successful in the three wells, and that the pumping tests and injection tests performed in the three wells had generated spurious values for aquifer permeability because of the plugging caused by the invasion of the aquifer strata with combinations of bentonite clay drilling mud, biodegradable drilling fluid, and biodegradable foam. The groundwater samples collected from the three wells are spurious for knowledge of the presence of many contaminants. Other

reasons the three wells are not in compliance with RCRA and DOE requirements for monitoring wells are described in my report[10].

## 4.0 Groundwater contamination in the regional aquifer at LANL well R-7

### 4.1 Strontium-90 in groundwater at LANL characterization well R-7

Strontium-90 is a contaminant of concern in the regional aquifer at the location of well R-7 because of the presence of strontium-90 in the groundwater in alluvial sediments along Los Alamos Canyon. Dr. Longmire acknowledged that the altered chemistry caused by the biodegradable drilling fluids is responsible for the elevated strontium concentrations in groundwater samples collected from screen #3 of well R-7. Dr. Longmire argued that the elevated strontium levels are proof that strontium-90 is not present because the chemical environment that is responsible for the elevated presence of strontium would also cause strontium-90 to be present at elevated levels if strontium-90 contamination was present in the aquifer strata. I disagree with this argument because a trend analysis[12] of the strontium concentrations and of the strontium-90 activities measured in the groundwater samples exhibit the declining trend that is expected because strontium-90, strontium, and the other alkaline-earth metals calcium and magnesium are being precipitated out of groundwater because the groundwater is in transition from an anaerobic to an aerobic chemistry. I describe the dynamics of the major ion chemistry in groundwater at well R-7 in my reply[15] to the review of my 2004 report[12].

The trend analyses in my 2004 report[12] are evidence that strontium-90 was present in the first groundwater samples collected from well R-7, and the unnatural chemical environment that surrounds the well screen is responsible for the removal of strontium-90, uranium, and possibly other radionuclide and chemical contaminants including perchlorate from groundwater. Dissolved uranium was present in the groundwater sample collected from the top of the regional aquifer in the well R-7 borehole[37] but is absent in groundwater samples[38] collected from screened interval #3 installed across the water table of the regional aquifer in well R-7.

### 4.2 Perchlorate and organic contamination in groundwater at well R-7

Groundwater present in the alluvial sediments along Los Alamos and Mortandad Canyon are often contaminated with high concentrations of perchlorate. Perchlorate is very mobile for transport in the unsaturated sediments and is a contaminant of concern for the regional aquifer at the location of well R-7. Thermodynamic calculations show that perchlorate will be removed from the unnatural, strongly anaerobic groundwater[38] that surrounds screen #3 in well R-7. The biodegradable drilling fluids are responsible for the anaerobic chemistry. During the EPA/Ada

conference call, Dr. Longmire reported that LANL had performed informal laboratory tests that showed perchlorate to be stable in anaerobic groundwater, and therefore, the absence of perchlorate in groundwater samples from screen #3 was evidence that the regional aquifer at the location of well R-7 was not receiving recharge from LANL effluent waste released historically to Los Alamos Canyon.

The LANL laboratory tests on perchlorate stability do not prove that the unnatural chemistry surrounding screen #3 has not removed perchlorate and other contaminants from the groundwater. Furthermore, the detection of a suite of organic contaminants in the quarterly groundwater samples[38] collected from screen #3 are proof of recharge to the regional aquifer of groundwater contaminated with LANL waste effluents:
Contaminants in 1st quarter samples-
Acetone, 51 ug/L; Benzoic Acid, 13 ug/L; Methylphenol[4-], 58 ug/L;
Phenol, 11ug/L
Contaminants in 2nd quarter samples-
Acetone, 44 ug/L; methylphenol[4-], 1.8 ug/L
Contaminants in 3rd quarter samples-
DDT [4,4-], 0.0077 ug/L; isopropylbenzene, 0.55 ug/L
Contaminants in 4th quarter samples-
Acetone, 5.6 ug/L; isopropylbenzene, 0.94 ug/L;
nitrosodiphenylamine[N-], 9.6 ug/L

The LANL well R-7 geochemistry report[38] summarizes the occurrence of the organic contaminants in groundwater:
" Several VOCs and SVOCs (validated results) were detected at well R-7, -- Laboratory blanks did not contain any VOCs, which suggests that meaningful and accurate analytical results for volatile organic compounds were provided. Additional sampling for VOCs and SVOCs is recommended at well R-7 to determine the long-term presence of these chemicals, which are possibly false positives produced by residual drilling fluid."

The well R-7 geochemistry report describes the biodegradable drilling additives as responsible for the "false positive" detection of the acetone. The interference of detection of contamination that results from "false positives" are another reason that it was a serious mistake to allow the drilling additives to invade the aquifer strata where well screens were installed. The unnatural, strongly anaerobic chemistry caused by the biodegradable drilling additives prevents accurate knowledge of the nature and extent of the contamination that is present in the regional aquifer in the vicinity of LANL characterization well R-7.

## 5.0 The necessary changes to the methods used for sampling LANL wells

LANL characterization wells R-7 and R-22 are examples of the need to use a low-flow pumping system for the collection of groundwater samples in order to purge the "stagnant" groundwater from the immediate environment of the Westbay* sampling ports. Presently, groundwater samples are collected from the sampling ports in the Westbay* sampling system with a small evacuated cylinder that only collects water from the "stagnant zone" of water within the well, the filter pack sediments, and the strata with altered chemistry surrounding the well. During the EPA/Ada conference call, Michael Dale of NMED expressed a concern for the sampling of "stagnant water" from the LANL multiple-screen characterization wells.

### 5.1 LANL sampling methods for the multiple-screen characterization wells

Presently, LANL does not use a low-flow pump system or a flow-through cell to collect groundwater samples from the multiple-screen characterization wells. Instead, an evacuated container (the Westbay* MOSDAX tool) is deployed to collect water samples from the discrete sampling ports in the Westbay* sampling systems. Many trips with the container may be necessary to collect the volume of groundwater required for the analytical suite. At LANL, no volume of groundwater is purged from the screened intervals prior to the measurement of groundwater parameters and the collection of groundwater samples. In addition, the field-measured parameters including temperature, specific conductance, dissolved oxygen, and turbidity were measured when the groundwater was in contact with the atmosphere (LANL Well R-7 Geochemistry Report, 2002)[38].

The fact that a pumping system is not used to purge a volume of groundwater from the multiple-screen wells is a special concern because of the invasion of drilling additives into the strata that surround the screened intervals. The drilling additives have caused damage to the chemistry of the aquifer strata and have lowered the permeability of the aquifer strata. The groundwater samples collected from these wells have been in contact for a long period of time with aquifer strata that have an altered chemistry. For many of the impacted screened intervals, groundwater samples are collected from a "stagnant zone" that is cut off from active circulation with groundwater in the aquifer. The inappropriate methods used at LANL for measurement of important sensitive parameters and collection of analytical samples compromise data quality and prevent accurate knowledge of aquifer chemistry.

The failure of LANL to a). use a flow-through cell for the measurement of sensitive parameters, and to b). purge an appropriate volume of water before the collection of water samples for the analytical suite does not meet the following requirements in the NMED LANL Consent Order[45]:

**I.A.1.a.i IX.B.2.i.i Well Purging**

"All zones in each monitoring well shall be purged by removing groundwater prior to sampling in order to ensure that formation water is being sampled. Purge volumes shall be determined by monitoring, at a minimum, groundwater pH, specific conductance, dissolved oxygen concentrations, turbidity, redox potential, and temperature during purging of volumes and at measurement intervals approved by the Department. The groundwater quality parameters shall be measured using a flow-through cell and instruments approved by the Department. The volume of groundwater purged, the instruments used, and the readings obtained at each interval shall be recorded on the field monitoring log. Water samples may be obtained from the well after the measured parameters of the purge water have stabilized to within ten percent for three consecutive measurements." (NMED LANL Consent Order, March 1, 2005).

The LANL EAG (2001)[8] recognized the need to use a low-flow pumping system for the collection of groundwater samples from the LANL multiple-screen monitoring wells as follows:

"The presence of residual drilling additives is disappointing, but not surprising; it is both difficult (perhaps impossible) and expensive to develop wells at this depth sufficiently to completely remove such materials. The Westbay* tool (MOSDAX) currently being used for sampling provides no capability for avoiding sample contamination with the residual drilling additives; in fact, it probably maximizes it. This is because the tool almost passively collets the groundwater from the immediately adjacent zone of the sand pack/borehole wall/formation. In the absence of drilling additive contamination, this would be a desirable outcome, but not when it is present. Since the additives are impacting the samples and their subsequent evaluation, the EAG has one recommendation for altering the manner in which samples are being collected until the additives are no longer an issue.
**RECOMMENDATION:**
**Temporarily discontinue use of the measurement port and MOSDAX probe in the Westbay* wells. Instead, collect samples with the pump and the Westbay* pumping port via low-flow sampling techniques with equilibration of indicator parameters using a flow-through cell.**
This sampling approach would increase the likelihood that groundwater from outside the borehole zone contaminated with drilling additives could be acquired."

"Observation of the stabilization of purging indicator parameters, such as dissolved oxygen, Eh, and conductivity, during the low-flow purging process can be used to detect this continuity with the aquifer water. Although the acquired water would still have to travel through the additive contaminated zones (the zones of altered chemistry that are contaminated with residual drilling fluids), the amount of contamination imparted to the samples during this brief contact should be minimal relative to the MOSDAX samples that have set in this zone for some time."

LANL has not followed the advice of the EAG for using a low-flow pumping system for collection of groundwater samples from the multiple-screen wells.

**5.2** LANL sampling methods for the single-screen monitoring wells:

Most LANL single-screen monitoring wells are installed with a long well screen that straddles the water table. A high-flow submersible pump is installed in the single-screen wells with the pump intake located near the bottom of the screened interval. For most of the single-screen wells, there is a concern for knowledge of the presence of contamination at the top of the regional aquifer. The long well screens with pump intake located at the bottom of the screens will cause dilution of contamination that is present in the strata at the top of the screen. The LANL EAG has written a report[7] to recommend changes in the design of the single-screen wells and in the methods that are used for the collection of groundwater samples from the existing wells:

"The EAG is somewhat concerned with the GIT (LANL Groundwater Integration Team) response to recommendation 12-01-19. The GIT merely disagrees with the need to carry out low-flow rate purging and sampling of the single completion wells without offering any rationale other than that the pumps that are currently installed are inappropriate for such sampling, a condition that might be correctable. The GIT then states that the procedures appear to be adequate because the samples are "consistent and representative of the aquifer." That sample consistency can be obtained in some wells by high flow rate sampling techniques is not surprising, but this is a matter of precision, not accuracy. The statement that the samples are "representative of the aquifer" does pertain to accuracy, but we would argue that it is impossible to know whether the samples obtained are truly representative of the aquifer in the absence of some sort of comparison to other sampling techniques, notably low-flow purging and sampling techniques."

A change that should be made to the LANL single-screen wells is removal of the high-flow pumps and profiling water quality over the length of the well screen by using a low-flow pumping system installed between a set of packers. The results from the profiling would identify the optimum depth in the screen for quarterly sampling.

## 6.0 The LANL Hydrogeologic Workplan allowed drilling in the regional aquifer with water-based drilling fluids

Mr. Nylander explained to EPA/Ada that the LANL Hydrogeologic Workplan[44] allowed the use of the conventional mud rotary drilling method with water-based drilling fluids for drilling boreholes in the regional aquifer. When I was hired as a consultant to design the drilling methods that would be used for installing the characterization wells in the regional aquifer beneath the LANL facility, I advised

LANL that the Hydrogeologic Workplan should not allow the mud rotary drilling method because of the data quality objectives for 1). characterization of contamination, especially radionuclide contaminants, and 2). characterization of aquifer permeability by testing the properties of the strata surrounding the screened intervals

The irreparable damage that was caused by biodegradable drilling fluids, biodegradable foam, bentonite clay drilling muds, borehole wall stabilization materials, and chemicals used for well development was known from the first LANL characterization wells where these materials were used (e.g., wells R-7, R-9i, R-12, R-14, R-16, and R-22). It was a serious mistake for LANL and DOE to continue the use of drilling methods that allowed the invasion of these drilling additives into the aquifer strata where well screens were installed. The fact that the LANL Hydrogeologic Workplan allowed the use of inappropriate drilling methods was not license for continued use of these drilling methods after there was knowledge of the irreparable damage caused by the drilling additives.

## 7.0 Monitoring wells at other locations are installed in boreholes drilled with water-based drilling fluids

The LANL and DOE staff advised EPA/Ada that drilling fluids are routinely used for installing multiple-screen Westbay*monitoring wells at other locations in New Mexico and across the nation. This statement is not relevant to the problems that have resulted from the use of drilling fluids in the boreholes for multiple-screen wells equipped with Westbay* sampling systems at LANL. The serious problems were known after the installation of the first multiple-screen wells.

The contaminants of concern for the LANL characterization/monitoring wells prohibited the use of the drilling fluids for drilling into the strata where well screens were installed. In addition, the requirement for measurement of the aquifer permeability prohibited the use of drilling fluids for drilling into the strata that would be tested for permeability.

## 8.0 The important issues that were not discussed during the EPA/Ada conference call

The EPA/Ada conference call did not discuss many of the concerns for the poor performance of the LANL Hydrogeologic Workplan that are identified in my reports[10,11,12]. It is important to understand that the review by staff at EPA Ada cannot be the final resolution of the poor performance. There is a need for a panel of experts to review all the activities of the Hydrogeologic Workplan for identification and resolution of problems.

The review by the panel of experts would include the following activities:

1. A review of all of the LANL contaminant data to identify data that are spurious because of the drilling additives. My preliminary assessment[11] is that the chemical data from approximately 40 screened intervals are spurious

2. A review of all data including borehole logs, drillers logs, borehole geophysics, etc. to determine if screened intervals are installed in appropriate strata.
   - Well R-22 is an example of where screened intervals are not installed in "fast pathway strata" that are very important for monitoring.
   - Well R-26 is an example of where the screened interval is installed in inappropriate strata for monitoring background water chemistry.
   - Wells R-16 and R-34 are examples of where steel drill casing and cemented conductor casing installed deep into the regional aquifer prevent monitoring important strata near the water table.

3. An analysis of each characterization well to identify wells that may be converted to monitoring wells, wells that require rehabilitation, wells that require replacement, and locations where additional wells are needed.

4. The use of the correct methods (i.e., a low-flow pumping system and a flow-cell for monitoring sensitive parameters) for purging and sampling of the wells for a complete characterization of groundwater chemistry and contaminant chemistry. This activity is important for knowledge of the future value of each well. The use of an appropriate pumping system in the multiple-screen wells will also identify screened intervals that are plugged because of the failure of well development procedures to remove the drilling additives.

5. The assessment of the value for performance of additional well development procedures to rehabilitate the poorly developed wells.

6. An identification of the locations for additional boreholes and monitoring wells because LANL has not acquired the necessary knowledge of the properties of the strata that comprise the regional aquifer. LANL is relying on a computer generated 3-D geologic model[50] to define the physical properties of the regional aquifer over large areas where there is <u>no</u> information from boreholes. An example is the large area with no boreholes between sites of contamination at LANL (e.g., MDA G, TA-21, Mortandad and Los Alamos Canyons, etc,) and the important water supply for Santa Fe at the Buckman well field. The computer generated "virtual knowledge" of the strata in the regional aquifer does not replace the need for real knowledge from boreholes and correctly installed monitoring wells. There is a requirement for accurate knowledge of the impact of LANL waste disposal practices on groundwater supply wells. Currently, the

threat of contamination in the regional aquifer beneath LANL to the supply wells is not known.

7. A review of the knowledge of aquifer properties that are important to the direction and speed of travel for groundwater in the regional aquifer. LANL uses the potentiometric surface on the water table of the regional aquifer as the direction of groundwater travel. The direction of travel for groundwater in "fast pathway strata" may be different from the direction predicted by the potentiometric surface. The "fast pathway strata" in the regional aquifer beneath MDA G is one example of where LANL does not have knowledge of the presence of contamination, or the direction and speed of travel of groundwater. LANL reports present much spurious data on the permeability of aquifer strata. The poor knowledge that LANL has for the permeability of strata in the regional aquifer are described in my reports[10,11,12].

8. A review of the LANL studies for transport of contaminants through unsaturated strata to the regional aquifer. The poor knowledge that LANL has for travel of contamination in unsaturated strata is demonstrated by the contamination that is present in the regional aquifer beneath MDA G[34]. The contamination includes elevated levels of tritium, technetium-99, and a number of organic contaminants. A LANL report[51] predicts a travel time for contaminants released from MDA G to the regional aquifer of 600 years. In reality, the travel time is less than 50 years. The presence of contamination in the regional aquifer beneath MDA G requires 1). the drilling of boreholes through the unsaturated strata with <u>dry</u> drilling methods that allow in situ characterization of the properties of the unsaturated strata for transport of contaminants and 2). the installation of additional monitoring wells in the regional aquifer in the vicinity of MDA G.

9. The presence of radionuclide and chemical contamination in the regional aquifer beneath MDA G requires an assessment of the immediate need to install monitoring wells in the regional aquifer in the immediate vicinity of all of the LANL waste disposal sites that contain chemical and legacy radioactive wastes.

10. There is a need to review the LANL regional groundwater flow model[50] for the credentials of this model to analyze the threat of LANL contamination to groundwater supply wells in Los Alamos County, San Ildefonso Pueblo, the Buckman well field, etc. Of special concern is the ability of the LANL regional model to identify the "fast pathway strata" in the regional aquifer. The very long travel times of thousands of years calculated by the regional model[49] for travel of groundwater from LANL waste disposal sites to the Buckman well field are <u>wrong</u> for several reasons including the failure of the model to represent "fast pathway strata", and the use of unreasonably low values for the permeability of aquifer strata as shown by the following examples.

Permeability values[49] in the LANL regional groundwater model:

- Chaquehui Formation, 0.16 ft/day - The Chaquehui strata have high transmissivity and are the most important strata for the Los Alamos County supply wells. Discrete intervals of strata within the Chaquehui Formation warrant an estimated permeability greater than 50 ft/day.
- Puye Formation, 0.02 ft/day - The Puye sediments include the Totavi Lentil river gravel strata with estimated permeability as great as 350 ft/day. The river gravel strata are present beneath MDA G
- Cerros del Rio Basalts, 1.91 ft/day - The borehole record for well R-22 illustrates the presence of fast pathway strata in the basalt located beneath MDA G with estimated permeability in the range of 50 to 400 ft/day.

11. A review of the borehole geophysics performed by Schlumberger is needed. My preliminary review[11] documents 1. the failure of the geophysics to identify highly permeable strata in the regional aquifer, 2. the failure of the geophysics to identify water-saturated strata, and 3. the spurious values of permeability calculated from the geophysics. LANL placed undue reliance on the geophysics[22] to locate the placement of screened intervals in the characterization wells.

12. There is a need to assess application of a suite of borehole geophysics in the long screened intervals in the Los Alamos County supply wells to identify the discrete strata with high permeability, and the hydraulic communication of the permeable strata between proximal supply wells and the screened intervals in the nearby LANL characterization wells.

13. A review is necessary of the available water level data for the LANL characterization wells to identify water level changes in the screened intervals of the characterization wells that result from pumpage of the supply wells. This review is important to identify which LANL characterization wells are located within the capture zones of the Los Alamos County supply wells. This activity may require the collection of additional water level data. The need for this review is illustrated by the water level data[41] collected in LANL well R-12. This well was installed as an "early warning well" for LANL supply well PM-1. A comparison of the available water level data for well R-20 and supply well PM-1 reveals that the fluctuation of water levels in well R-20 are not related to the pumping cycles for well PM-1. Furthermore, the static water level measured in well PM-1 is higher than the static water level measured in well R-20. The water level data is evidence that the screened interval in well R-20 is not in active hydraulic communication with the screened interval in supply well PM-1, and well R-20 does not meet the requirements of an "early warning well" for the supply well. In addition, it is important to note that the bottom of the screened interval in well R-12 is located above the top of the screened interval in supply well PM-1 by a vertical distance of 42 feet. The basalt strata that are present in the 42 foot interval have a low permeability and form a confining layer.

**References**


1. ATSDR, 2005. The website of the Agency For Toxic Substances and Disease Registry. www.atsdr.cdc.gov

2. Australian Drilling Committee, 1997. DRILLING – *The Manual of Methods, Applications, and Management.* Australian Drilling Industry Training Committee Industry. CRC Press LLC.

3. DOE, 2005. DOE Order 450.1 (chg 1), Environmental Protection Program. (Order, 01/15/2005, EH)

4. DOE, 2004. DOE M 435.1-1. Radioactive Waste Management Manual. 160 pages.

5. DOE, 1993. DOE Order 5400.5. Change 2: Radiation Protection of the Public and the Environment.

6. Driscoll, F. G., 1986. *Groundwater and Wells.* Johnson Division, St. Paul, Mn

7. EAG, 2002. "Semi-Annual Report to the Groundwater Integration Team (GIT) of the Los Alamos National Laboratory. Meeting dates – April 9-12, 2002.

8. EAG, 2001. "Semi-Annual Report to the Groundwater Integration Team (GIT) of the Los Alamos National Laboratory. Meeting dates – March 19-23, 2001.

9. EAG, 1999. "Semi-Annual Report to the Groundwater Integration Team (GIT) of the Los Alamos National Laboratory. October 13-15, 1999.

10. Gilkeson, R. H., 2005. "Notes on LANL Characterization Wells R-4, R-26, and R-34," Version March 7, 2005. Report available from the Northern New Mexico Citizens Advisory Board.

11. Gilkeson, R. H., 2005. *Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory: Part Two,* version March 07, 2005. Report available from the Northern New Mexico Citizens Advisory Board.

12. Gilkeson, R. H., 2004. *Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory,* version July 13, 2004. Report available from the Northern New Mexico Citizens Advisory Board.

13. Gilkeson, R.H., 2004. Annotated transcript of the presentation of the report "*Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory*", to the June 9, 2004 Meeting of the Northern New Mexico Citizens Advisory Board (CAB).

14. Gilkeson, R. H., 2004. Reply to Comments of D. Porterfield and C. Timm on "Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory," Version June 26, 2004.

15. Gilkeson, R.H., 2004. Reply to Comments of M. Dale and S.Yanicak on "Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory, version July 13, 2004.

16. Gilkeson, R.H., 2004. Reply to the Review by Mr. Shanahan of the Report "Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory", version June 26, 2004.

17. Kleinfelder, January 14, 2005. Final Completion Report Characterization Well R- 4, Los Alamos National Laboratory, Los Alamos, New Mexico, Revision 1. Project No. 37151/7.12. Prepared for the United States Department of Energy and the National Nuclear Security Administration through the United States Army Corps of Engineers, Sacramento District.

18. Kleinfelder, January 25, 2005. Final Completion Report Characterization Well R-26, Los Alamos National Laboratory, Los Alamos, New Mexico, Revision 1. Project No. 37151. Prepared for the United States Department of Energy and the National Nuclear Security Administration through the United States Army Corps of Engineers, Sacramento District.

19. Kleinfelder, November, 2004. Final Completion Report Characterization Well R-34, Los Alamos National Laboratory, Los Alamos, New Mexico. Project No. 37151. Prepared for the United States Department of Energy and the National Nuclear Security Administration through the United States Army Corps of Engineers, Sacramento District.

20. Kleinfelder, 2003. Final Completion Report Characterization Well R-21, Los Alamos National Laboratory, Los Alamos, New Mexico. Project No. 37151. Prepared for the United States Department of Energy and the National Nuclear Security Administration through the United States Army Corps of Engineers, Sacramento District.

21. Langmuir, D., 1997. *Aqueous Environmental Geochemistry.* Prentice-Hall, Inc., Upper Saddle River, New Jersey.

22. LANL, 2004. "Response to Concerns About Selected Regional Aquifer Wells at Los Alamos National Laboratory," LANL Report LA-UR-04-6777, September, 2004.

23. LANL. 2003. Minutes of the Los Alamos National Laboratory Groundwater Protection Program Annual Meeting, March 18, 2003.

24. LANL, 2003. *Characterization Well R-13 Completion Report,* LA-UR-03-1373.

25. LANL. 2003. *Characterization Well R-20 Completion Report,* LA-UR-03-1839.

26. LANL. 2003. *Characterization Well R-23 Completion Report, LA-UR-03-2059.*

27. LANL, 2003. *Characterization Well R-32 Completion Report,* LA-UR-03-3984.

28. LANL. 2003. *Characterization Well R-16 Completion Report,* LA-UR-03-1841.

29. LANL. 2003. *Characterization Well R-14 Completion Report, LA-UR-03-1664.*

30. LANL. 2003. *Characterization Well CdV-R-37-2 Completion Report,* LA-14023-MS.

31. LANL, 2003. *Characterization Well R-25 Completion Report,* LA-13909-MS.

32. LANL, 2002. . Minutes of the Los Alamos National Laboratory Hydrogeologic Characterization Program Quarterly Meeting, October 29-31, 2002.

33. LANL. 2002. *Characterization Well R-22 Completion Report,* LA-13893-MS.

34. LANL. 2002. *Characterization Well R-22 Geochemistry Report,* LA-13986-MS.

35. LANL. 2002. *Characterization Well R-19 Geochemistry Report,* LA-13964-MS.

36. LANL. 2002. *Characterization Wells R-9 and R-9i Geochemistry Report,* LA-13927- MS.

37. LANL. 2002. *Characterization Well R-7 Completion Report,* LA-13932-MS.

38. LANL. 2002. *Characterization Well R-7 Geochemistry Report,* LA-14004-MS.

39. LANL. 2002. *Characterization Well CdV-R-15-3 Completion Report,* LA-13906-MS.

40. LANL. 2001. *Characterization Well R-31 Completion Report,* LA-13910-MS.

41. LANL. 2001. *Characterization Well R-12 Completion Report,* LA-UR-00-3785.

42. LANL. 2001. *Characterization Well R-9 Completion Report,* LA-UR-00-4120.

43. LANL, 2000. Hydrogeologic Characterization Program Quarterly Meeting / EAG Semi-Annual Meeting, October 3-5, 2000.

44. LANL. 1998. Hydrogeologic Workplan. Los Alamos National Laboratory, Los Alamos, New Mexico.

45. NMED, 2005. NMED LANL COMPLIANCE ORDER ON CONSENT. March 1, 2005, 276 pages.

46. Stumm, W., and J. J. Morgan, 1996. *Aquatic Chemistry. 3rd Edition.* John Wiley and Sons, Inc., New York.

47. US EPA. 1992. "RCRA Groundwater Monitoring: Draft Technical Guidance," November 1992. EPA 530-R93-001.

48. Webster's New World Dictionary, 1990. **window dressing 1** the display of goods in a store window **2** that which is meant to make something seem better than it really is (i.e., the display of the large number of "monitoring wells" installed at LANL gives the appearance of protection of groundwater).

49. LANL, 2002. *"Analysis of Capture Zones of the Buckman Wellfield and a Proposed Horizontal Collector Well North of the Otowi Bridge"* authored by Velimir V. Vesselinov and Elizabeth H. Keating, May, 2002.

50. LANL, 2001. "A Regional Flow and Transport Model for Groundwater at Los Alamos National Laboratory." LANL Report LA-UR-01-2199.

51. LANL, 1997. "Simulations of Groundwater Flow and Radionuclide Transport in the Vadose Zone and Saturated Zones beneath Area G," LANL Report LA-UR-97-157.