General

LANL GW Wells [Hwr]

Agenda for Meeting with CCNS, EPA, and NMED on 05-19-05

Agenda by Robert H. Gilkeson, Registered Geologist
P.O. Box 670, Los Alamos, NM 87544
505-412-1930
RHGilkeson@aol.com

1. The DQO's for the LANL single-screen and multiple-screen characterization wells
   - The DQO's for the LANL single-screen and multiple-screen characterization wells prohibit the invasion of aquifer strata with biodegradable drilling fluids, biodegradable foam, and bentonite clay mud.
   - 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.

2. Concerns for well development procedures in LANL characterization wells

3. The poor record of LANL and DOE for well development is documented in the published well completion and well geochemistry reports.

4. LANL reports acknowledge that the groundwater samples collected from many LANL characterization wells are not representative of the aquifer chemistry because of the drilling additives.

5. The serious problems because of the improper installation of LANL characterization well R-22.

6. Data gaps in the knowledge of properties of the strata within the regional aquifer with special concern for poor knowledge of strata that are fast pathways for travel of contaminated groundwater to supply wells.

7. The serious mistake in 1). drilling boreholes with methods that allowed cross-contamination between perched zones of saturation and the regional aquifer, and 2). in the construction of multiple-screen wells with screened intervals installed in the perched zones of saturation and also in the regional aquifer.

8. The long well screens installed in many LANL monitoring wells may cause dilution of contaminated groundwater present in discrete strata

9. The necessary changes to the methods used for sampling LANL wells

13919

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P.O. Box 670, Los Alamos, NM 87544
505-412-1930
RHGilkeson@aol.com

1. The DQO's for the LANL single-screen and multiple-screen characterization wells

- Monitor appropriate strata for "early detection" of contamination
- Monitor strata that are "fast pathways" for travel of contaminated groundwater
- Collect groundwater samples with a chemistry that is representative of the aquifer strata
- Screened intervals shall provide accurate measurement of aquifer permeability
- All data collected from the characterization wells shall be scientifically sound and legally defensible

Fundamental Fact – The **DQO's** for the LANL single-screen and multiple-screen characterization wells prohibit the invasion of aquifer strata with biodegradable drilling fluids, biodegradable foam, and bentonite clay mud. The listed drilling additives have properties to prevent detection of contaminants of concern, and have properties to reduce the permeability of the aquifer strata. The **DQO's** prohibit the use of the drilling additives because of the following factors:

- Screened intervals shall be in open hydraulic communication with the aquifer
- Aquifer strata that surround screened intervals shall have in situ properties
  - the drilling methods shall not alter the chemistry of the aquifer strata
  - the drilling methods shall not plug the permeability of the aquifer strata
- Screened intervals shall provide groundwater samples that are representative of the aquifer. Groundwater samples shall be scientifically valid and legally defensible for contaminants of concern.

All of the screened intervals in the LANL characterization wells were installed in aquifer strata that were invaded with drilling additives. For many of the LANL wells, the LANL well completion reports, well geochemistry reports, and other reports document the serious, and possibly, irreparable damage that the drilling additives have caused to the chemistry of groundwater samples and to measurements of the permeability of the aquifer strata.

- **Drilling methods were available for the LANL characterization wells that would not have caused invasion of aquifer strata with the drilling additives.**
  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. At LANL, boreholes have been drilled through the entire thickness of the vadose zone and into the regional aquifer with the air rotary underreamer casing advance drilling method without the use of any drilling additives.

2. Concerns for well development procedures in LANL characterization wells

A. The properties of the drilling additives to 1). plug the aquifer strata, and to 2). prevent the detection of many contaminants, requires complete removal of the drilling additives from the screened intervals in the LANL characterization wells. The record shows that the drilling additives were not sufficiently removed.

B. The removal of the drilling additives from the screened intervals in the LANL characterization wells that were installed in open boreholes is essentially impossible, and cost prohibitive because of

a). the large quantity of additives that have invaded the aquifer strata,
b). the restrictive design and great depth of the wells limits the energy that is available for well development,
c). the drilling additives plugged the permeability of the invaded strata which increased the difficulty for removal of the additives,
d). the passage of much time between when the drilling additives invaded the aquifer strata and the performance of the well development procedures increased the action of the drilling additives to plug the aquifer strata.
e). LANL and DOE did not use chemicals to destroy the biodegradable drilling additives in order to prevent the "biofouling plugging" of the screened intervals, and
f). LANL and DOE did use chemicals to disaggregate and disperse the bentonite clay outward into the aquifer strata beyond a distance for recovery.

C. The drilling additives decreased the permeability of the aquifer strata which created a zone of "stagnant groundwater" in the strata surrounding the screened intervals. Groundwater samples in the multiple-screen wells are collected from the stagnant zone of water that has a "not representative" chemistry because of the drilling additives.

D. LANL used chemicals to disaggregate and disperse the bentonite clay muds outward an unknown distance in the aquifer strata that surround the screened intervals. The preferential properties of bentonite clay to remove actinide radionuclide and trace metal contaminants from groundwater pose a serious problem to the collection of legally defensible contaminant data from the impacted single-screen and multiple-screen wells.

E. The plugging action of the drilling additives cause an underestimation of the permeability of the strata by pumping or injection tests performed in the impacted screened intervals. For the screened intervals that are invaded with bentonite clay, LANL cannot prove that the chemicals used to disperse the clay has restored the in situ permeability to the aquifer strata. Much of the LANL permeability data collected in the LANL characterization wells are spurious.

3. The poor record of LANL and DOE for well development is documented in the published well completion and well geochemistry reports.

A. No well development was performed in some screened intervals:

1). Screen # 1 in well R-22. The biodegradable drilling additives have caused great damage to this screened interval because of biofouling plugging. Screen #1 in well R-22 is at a critical location for knowledge of contamination released from MDA G to the regional aquifer.

2). Screen #1 in well R-7. LANL cites the "oxidizing" chemistry in groundwater samples as evidence of groundwater that represents the aquifer. However, the absence of uranium in the groundwater samples collected from screen #1 is proof that the drilling additives are removing uranium from groundwater. The chemical processes that remove uranium will also remove the other actinide radionuclides and trace metals. The groundwater samples from screen #1 prove that the return of an "oxidizing" chemistry does not repair the damage caused by the drilling additives

B. Insufficient well development was performed in many screened intervals:

1). Screen #3 in well R-7. The development of this screened interval was by bailing. Surge block and pumping methods were not used in this screen. The turbidity in groundwater samples measured 20 NTU's when the development by bailing methods was terminated. The data in the LANL well R-7 geochemistry report is evidence of great damage to this screened interval by the "biofouling plugging" process.

2). Screen #1 and #3 in well R-20. The LANL report by Bitner et al. presents multiple-screen well R-20 as an example of proper application of well development procedures. However, the LANL well R-20 completion report describes the well development procedures in screen #1 as being terminated after extraction of only 113 gallons of water with turbidity of 227 NTU's. The well R-20 report states that screen #1 did not produce sufficient water for the analytical suite. In addition, the well R-20 report lists a turbidity value of 43.7 NTU's for the groundwater sample that was collected from screen #3 for the analytical suite.

3). Screen #3 in well R-31. An interesting feature in the LANL hydrologic tests report is the performance of injection tests before and after all development procedures were performed in screen # 3 in well R-31. The higher hydraulic

conductivity of 1.95 feet/day measured in the first injection test compared to the significantly lower value of 0.48 feet/day for the second test after "full development" of the screened interval is evidence that the well development procedures increased the "plugging" of the filter pack sediments and the aquifer strata in the impacted zone that surrounds the screened interval. A disturbing fact is that the drilling record, borehole video record, and description of cuttings are information that support an estimated hydraulic conductivity of 50 to >100 ft/day for the strata where screen #3 is installed

My limited review identified the LANL characterization wells where insufficient well development was performed to include wells R-7, R-9i, R-12, R-13, R-16, R-19, R-20, R-22, R-25, R-31, R-32, CdV-R-15-3, CdV-R-37-2, and all of the wells installed in boreholes drilled with the mud rotary drilling method with bentonite clay muds.

C. The unsuccessful well development procedures in recently installed LANL wells

LANL cites Table 5 in the Bitner et al. report as documentation that well development procedures were successful for removing most of the drilling additives. Table 5 describes the well development procedures in wells R-14, R-16, R-20, R-21, R-23, and R-32. The unsuccessful development of screened intervals in well R-20 are described in section **3.B.** of this agenda report.

Important information that is missing in Table 5 of the Bitner et al. report is that LANL reports acknowledge that the chemistry of water samples collected from wells R-16 and R-32 are not representative of aquifer chemistry because of the drilling additives. The LANL reports cite the cause of the "not representative chemistry" in well R-16 to be the bentonite clay muds, and the cause of the "not representative chemistry" in well R-32 to be the biodegradable drilling additives.

With the exception of well R-21, the drilling additives used in all of the boreholes listed in Table 5 include biodegradable additives and bentonite clay muds. The borehole for well R-21 was drilled only with the biodegradable additives (e.g., Quik-foam and EZ-MUD). The high level of TOC (5.90 mgC/L) measured in the groundwater sample collected from well R-21 after the completion of well development procedures is evidence that the well development procedures were not successful for removal of the biodegradable drilling additives, and a large amount of organic fuel is available for the "biofouling plugging" process to cause damage to the screened interval.

It is important to note that the TOC levels listed in Table 5 of the Bitner et al. report are elevated above background for all of the wells except well R-23. The high levels of TOC are evidence that the well development procedures have not removed the

drilling additives. However, a measurement of a low level of TOC does not mean that the drilling additives have been removed. In addition, TOC is not diagnostic for the removal of bentonite clay, and a very large quantity of bentonite clay was used for drilling all of the boreholes in Table 5 except the borehole for well R-21.

D. The unsuccessful well development procedures in LANL wells that were installed under direct management by DOE

For approximately the last two years, DOE has taken direct control of the installation of the LANL characterization wells. I presented my concerns for the failure of the well development procedures to remove the drilling additives from the LANL characterization wells to the June, 2004 meeting of the CAB. My presentation was attended by Messrs. Whitacre and Johansen from DOE and Mr. Nylander and Dr. Longmire from LANL. The DOE and LANL staff assured the CAB that the well development procedures were successful and even improved upon over time. This claim of improvements in the well development procedures for the wells that were installed with direct oversight by DOE caused me to review the well completion reports for wells R-4, R-26, and R-34. My review determined that the well development procedures in the three wells were unsuccessful for the removal of the drilling additives. The information presented in the three well completion reports are direct evidence that the well development procedures were unsuccessful, and that the drilling additives caused spurious values of aquifer permeability from pumping tests and injection tests. The drilling additives will prevent the collection of legally defensible data concerning the nature and extent of contamination. I have written a report that addresses my concerns for wells R-4, R-26, and R-34. The report is titled "Notes on LANL Characterization Wells R-4, R-26, and R-34".

4. LANL reports acknowledge that the groundwater samples collected from many LANL characterization wells are not representative of the aquifer chemistry because of the drilling additives.

A. Strata invaded with bentonite clay drilling mud. Many of the LANL characterization wells were installed in boreholes drilled with the mud rotary drilling method with bentonite clay mud used to stabilize the open borehole. An incomplete list of wells installed in strata that was invaded with large quantities of bentonite clay include R-2, R-4, R-14, R-16, R-20, R-23, R-26, and R-32. Well R-25 was installed in a borehole drilled with casing advance methods with bentonite clay used as a lubricant between the borehole wall and the drill casing.

- LANL well R-16. Table 4 in the Bitner et al. report acknowledges the damage caused by the bentonite clay to the screened intervals in well R-16 with the following statement:

  " Screens 2, 3, and 4 are not yet representative of pre-drilling chemistry. They are affected by bentonite mud."

The evidence of the effect of the bentonite on groundwater chemistry is elevated concentrations of sodium, sulfate, and uranium in the groundwater samples. LANL has not performed any additional well development procedures to remove the bentonite clay. Actually, the performance of additional well development procedures to remove the bentonite clay would be unsuccessful for most screened intervals because of 1). the restrictive design of the wells, 2). the very large quantity of bentonite clay that has invaded the aquifer strata, and 3). LANL used chemicals to disaggregate and disperse the bentonite clay outward in the aquifer strata a distance beyond recovery. The bentonite clay does nor remain suspended in groundwater as colloids. Instead, the bentonite clay settles out of the water to adhere to the surface of the aquifer strata.

LANL's plan is to observe the decline in dissolved concentrations of sodium, sulfate, and uranium to background levels. They will then claim that the groundwater samples are "representative of the aquifer pre-drilling chemistry". In reality, the aquifer strata are invaded with a large quantity of bentonite clay and the clay has preferential properties for removing actinide radionuclide and trace metal contaminants of concern from groundwater.

The damage caused by the bentonite clay to water samples collected from well R-16 is not limited to only well R-16. Similar damage has occurred to all wells installed in open boreholes drilled with bentonite clay drilling muds.

- LANL well R-32. The strata that surround the three screened intervals in this multiple-screen well are invaded with both bentonite clay mud and biodegradable drilling additives. A LANL report predicts the water samples collected from this well will not be representative of aquifer chemistry for a period as great as ten years. Well R-32 was installed to monitor impacts of wastes released from MDA's G, L, H, and J on the regional aquifer.

- Will EPA and NMED accept the return of groundwater from wells R-16 and R-32 to "background chemistry" as proof that the bentonite clay surrounding the well screens does not have properties to prevent the detection of many radionuclide and trace metal contaminants? Will EPA and NMED wait for 10 years for the wells to provide "scientifically sound and legally defensible data"?

The standard practice in the monitoring well industry is to perform well development procedures until all drilling additives are removed, the aquifer strata surrounding the screened interval are restored to in situ permeability, and the screened interval provides groundwater samples that are representative of the aquifer. When groundwater samples have a spurious chemistry because of the drilling additives, additional well development procedures are performed immediately. The well is replaced if the screened intervals cannot provide groundwater samples that are scientifically sound and legally defensible.

- Why has LANL been allowed a variance on the performance standards for monitoring wells?

B. Rehabilitation of screened intervals that are invaded with bentonite clay. Where actinide radionuclides and trace metals are contaminants of concern, rehabilitation of screened intervals that are invaded with large quantities of bentonite clay is probably not feasible. LANL wells such as R-16, R-20, R-23, and R-32 require replacement. Rehabilitation may be possible for screened intervals in wells such as R-25 where the concern is high explosive contaminants. The first activity that should be performed at well R-25 is to use a low-flow pumping system to purge groundwater from all of the screened intervals. If the screened intervals will provide sufficient flow of groundwater, then remedial measures to remove the bentonite clay may not be necessary.

Remedial measures in well R-25 may require removal of the Westbay* sampling system which would allow cross-contamination of the regional aquifer by high explosives contaminated groundwater in the perched zone. At well R-25, the installation of screened intervals in both the perched zone of saturation and in the regional aquifer was a serious mistake, and is a factor to consider in a decision to have the well properly abandoned and replaced. The information gathered from using a low-flow pumping system to collect groundwater samples from the screened intervals in the well will be important for the decision on the value of well R-25 as a monitoring well.

C. Strata invaded with biodegradable drilling additives. Table 4 in the Bitner et al. report acknowledges the damage caused by the biodegradable drilling additives to screened intervals in wells R-7, R-9i, and R-22. In addition, other LANL reports acknowledge damage from the biodegradable drilling additives to screened intervals in wells R-7, R-9i, R-12, R-19, R-22, and R-32, with a prediction that groundwater samples will not be representative of pre-drilling chemistry for a period of possibly 10 years.

- LANL well R-7 is located in Los Alamos Canyon where shallow groundwater in alluvial sediments is contaminated with radionuclides and chemicals. Strontium-90 and several organic contaminants are detected in groundwater samples collected from screen #3 installed across the water table of the regional aquifer. Because of "biofouling plugging", the water samples are collected from a stagnant zone of groundwater. A pumping system should be used for purging the stagnant water from the two screened intervals in well R-7.
- LANL well R-12. (See section **6.B.**)
- LANL wells R-22 and R-32 are part of the network of six wells for monitoring waste disposal sites in TA-54 including MDA's G, L, H, and J. (See the discussion of well R-22 in section **3.A** and **5,** and well R-32 in section **4.A**)

- Will EPA and NMED wait for the ten year period for the impacted wells to provide groundwater samples with a "pre-drilling chemistry"? In reality, for many of the LANL wells, the damage caused by the drilling additives will persist for a period much longer than ten years, and possibly for longer than 50 years, the planned life of the wells.

LANL has not performed additional well development procedures in the wells that are impacted by the biodegradable drilling additives. The LANL plan is to observe the return of an "oxidizing" chemistry to groundwater samples and then claim that the damage caused by the biodegradable drilling additives has been remediated. This position by LANL is contradicted by the technical literature that document the extensive, and often permanent damage that results from the "biofouling plugging" process that results from the invasion of aquifer strata by the biodegradable drilling additives. The technical literature is summarized in my report "*Groundwater Contamination in the Regional Aquifer Beneath the Los Alamos National Laboratory: Part Two*".

- Will EPA and NMED accept the return of an oxidizing chemistry to wells impacted by the biodegradable drilling additives as proof that the wells are providing groundwater samples that are legally defensible for contaminants of concern?

Rehabilitation of the screened intervals that are damaged by the biodegradable drilling additives. It is very likely that chemicals can be used to restore permeability to the screened intervals that are plugged by the biofouling plugging process. The ability of chemicals to remove all of the iron and manganese precipitates from the screened intervals so that groundwater samples are valid for detection of actinide radionuclides and trace metal contaminants is not known, but should be investigated. The first phase of an investigation would be to use a continuous low-flow pumping system to collect groundwater samples from all of the screened intervals in the multiple-screen wells. A flow cell would be used to monitor sensitive parameters during the pumping to identify when it is appropriate to collect water samples for the analytical suite. A series of samples should be collected for some parameters. The sampling activity with the low-flow pumping system would identify the screened intervals where extensive plugging has occurred.

5. The serious problems because of the improper installation of LANL characterization well R-22.

Well R-22 is a multiple-screen well with five screened intervals that is located immediately downgradient of MDA G. The well is at a critical location for knowledge of contamination in the regional aquifer by wastes disposed of at MDA G. The serious mistakes in the installation of well R-22 include the following:

A. The flooding of the borehole with water-based biodegradable drilling fluids for drilling the borehole through the entire thickness of the unsaturated strata to the top of the regional aquifer

1). prevented knowledge of the presence or absence of perched zones of saturation beneath MDA G. and

2). prevented collection of important knowledge of the in situ properties of the unsaturated strata (e.g., profiles of in situ moisture content, chloride content, and stable isotope content, and collection of core for a). characterization of contamination, and b). physical properties that control travel of contamination).

B. The use of biodegradable drilling additives have caused biofouling plugging of the screened intervals. The biofouling plugging process has caused changes to groundwater chemistry in the strata surrounding well R-22 that will prevent detection of many contaminants of concern in groundwater beneath MDA G. LANL reports predict a period of up to ten years before screened intervals in well R-22 will provide representative groundwater samples. It is very possible that the altered chemistry will prevent collection of scientifically sound and legally defensible data for a period of fifty years, the scheduled life of the monitoring well.

C. The drilling breached a confining layer in the basalt strata at a shallow depth in the regional aquifer with the result that the in situ contaminated groundwater at the top of the regional aquifer was allowed to drain down the open borehole. The contamination that is measured in the deep screened intervals in well R-22 may be due to cross-contamination from groundwater at the top of the regional aquifer. Well R-22 is an example of the importance of using a pumping system to purge water from the screened intervals to determine the source of the contamination.

D. There were no well development procedures performed in screen #1 located across the water table of the regional aquifer. The open borehole allowed the groundwater to totally drain from the strata where screen #1 is installed. The great dilution in the groundwater samples collected from screen #1 is shown by the tritium level of 109 pCi/L that was measured in the water sample collected from the borehole at the water table compared to the tritium values of 2 pCi/L that are measured in the quarterly samples.

E. The groundwater contamination detected in water samples collected from well R-22 include tritium, technetium-99, VOC's, SVOC's, and high explosives. LANL has described the drilling additives as responsible for "false positive" detection of acetone and the high explosives. In addition, the anaerobic chemistry and iron precipitates caused by the drilling additives will prevent the detection of many contaminants including the actinide radionuclides, technetium-99, and many chemical contaminants. The analytical data from well R-22 is proof that MDA G has caused contamination of the regional aquifer. However, the nature and extent of the contamination is not known because of the improper installation of the monitoring well.

F The borehole record for well R-22 shows the presence of several discrete intervals of highly permeable strata in the regional aquifer beneath MDA G. The permeable strata include three intervals in the basalt, and an interval of river gravel strata in the Puye Formation sediments beneath the basalt. Screen #1 is installed across an interval of highly permeable strata in the basalt. The permeable strata is documented by the

borehole log and by the Schlumberger geophysics. During the EPA Ada conference call on April 12, 2005, Dr. Longmire was mistaken to describe the strata surrounding screen #1 in well R-22 as having low permeability. There is great "biofouling plugging" damage to the permeability of the strata surrounding screen #1 by the biodegradable drilling additives.

Except for screen #1, well R-22 does not have screened intervals installed in any of the three other discrete intervals of aquifer strata with high permeability.

- Do EPA and NMED recognize the presence of highly permeable strata in the regional aquifer beneath MDA G based on the drilling and geophysics record for borehole R-22?

The presence of contamination in the regional aquifer beneath MDA G is a very serious problem because of the fast pathways in the regional aquifer. There is a critical need to understand the nature and extent of the contamination and the threat of the contamination to the supply wells of Los Alamos County, San Ildefonso Pueblo, and Santa Fe.

- Do EPA and NMED recognize the immediate need for the installation of monitoring wells downgradient of MDA G in the strata with high permeability that are not currently monitored? Monitoring the strata is a requirement of DOE Orders for active low-level waste disposal facilities. In addition, monitoring the strata is a requirement under RCRA because of the disposal of "mixed wastes at MDA G.

LANL and DOE do not acknowledge the poor understanding of the impact of MDA G on contamination of the regional aquifer as proven by their presentations to the public at the MDA G forum held in Santa Fe on May 02, 2005. Apparently, LANL and DOE are adhering to transport calculations that predicted contamination from MDA G would not reach the regional aquifer for 600 years. In reality, the travel time for radionuclide and chemical contaminants from MDA G to the regional aquifer is less than 50 years. The presence of contamination in the regional aquifer beneath MDA G is very disconcerting to LANL and DOE because they have used the 600 year calculated time for travel of contamination as proof that the installation of monitoring wells at the other LANL waste disposal sites is unnecessary.

The detection of contamination in groundwater samples from well R-22 now requires the installation of additional monitoring wells at MDA G, and the installation of monitoring wells at the other LANL waste disposal sites including MDA L, MDA C, MDA H (because of close proximity to supply well PM-2), the disposal sites at TA-21, and the disposal sites at TA-49.

- Do EPA and NMED recognize the need for the installation of monitoring wells at the other LANL waste disposal sites? Mixed wastes are disposed of at many of the sites.

6. Data gaps in the knowledge of properties of the strata within the regional aquifer with special concern for poor knowledge of strata that are fast pathways for travel of contaminated groundwater to supply wells.

A. One example is the poor knowledge that LANL has of the travel time for groundwater beneath the LANL facility to supply wells for the city of Santa Fe in the Buckman well field that is located downgradient of MDA G. The two characterization wells located between MDA G and the Buckman well field are wells R-22 and R-16. LANL reports acknowledge that the chemistry of water samples collected from both wells do not represent the chemistry of groundwater in the regional aquifer because of the drilling additives. The borehole records for both wells are evidence of the existence of "fast pathway strata". The fast pathway strata are not adequately monitored in either well. LANL does not have the required knowledge of connection of the fast pathway strata at well R-22 to the fast pathway strata at well R-16 and the continuation of the fast pathway strata on eastward to the Buckman well field. The distance between wells R-22 and R-16 is greater than 4 miles.

Calculated travel times with the LANL Regional Groundwater Model have created an image of false safety for the impact of MDA G (and other LANL waste release sites) on the Buckman well field. The LANL groundwater model predicted a travel time of 25,000 years for groundwater to travel from MDA G to the Buckman well field. The groundwater model did not recognize the existence of fast pathway strata at wells R-22 and R-16. The LANL model used unreasonably low permeability values for the strata in the regional aquifer. The values are low 1). based on common knowledge of aquifers, and 2). when compared to the historic published LANL permeability data.

- The LANL model used a permeability value of 1.91 ft/day for the Cerros del Rio Basalt, whereas the drilling and borehole geophysics records for well R-22 warrant the fast pathway strata in the basalt beneath MDA G to have permeabilities in the range of 50 to 400 ft/day.
- The LANL model used a permeability value of 0.02 ft/day for the Puye sediments, whereas the drilling record for well R-22 warrants an estimated permeability of 150 to possibly 350 ft/day for the interval of river gravel strata that are present in the Puye sediments.
- The LANL model used a permeability value of 0.16 ft/day for strata in the Santa Fe Group, whereas information from the well R-16 borehole warrants an estimated permeability of greater than 100 ft/day for the interval of fast pathway strata where the mud rotary drilling method lost circulation of the bentonite clay drilling fluids and the borehole stabilization materials.

- Do EPA and NMED recognize the need for knowledge of the threat of MDA G to the Buckman well field, and the requirement for scientifically valid and legally defensible data for the groundwater flow away from MDA G in terms of 1). presence of contamination, 2). direction of travel, and 3). speed of travel?

The LANL regional groundwater model may not have the credentials to analyze the travel of contamination in the regional aquifer to the Los Alamos County supply wells, to San Ildefonso Pueblo, to the proposed collector well for the city of Santa Fe, and to the supply wells for the city of Santa Fe at the Buckman well field. There is a need for an expert review of the LANL regional groundwater model.

B. A second example of the poor knowledge that LANL has for the impact of groundwater contamination on supply wells is the improper installation of LANL characterization well R-12. This well is an "early warning well" for Los Alamos County supply well PM-1. A LANL report acknowledges that groundwater samples collected from well R-12 are not representative of aquifer chemistry because of the biodegradable drilling additives that were used in the borehole. The LANL Report predicts the "not representative chemistry" might persist for a period of ten years. An additional problem with well R-12 as an early warning well is that the study of water level data from well R-12 and from the supply well show that the screened interval in well R-12 is hydraulically isolated from the screened interval in the supply well by a layer of basalt that forms a confining layer. The bottom of the screened interval in well R-12 is located a vertical distance of 42 feet above the top of the screened interval in the supply well. The basalt present in this 42-foot interval forms a confining layer.

- Do EPA and NMED recognize that well R-12 does not meet requirements as an "early warning well" for supply well PM-2?

C. A third example of the poor knowledge that LANL has for the protection of supply wells is multiple-screen well R-20 that is installed as an early warning well for Los Alamos County supply well PM-2. The screened intervals in the well are invaded with bentonite clay and biodegradable drilling additives as shown by the elevated levels of turbidity in groundwater samples collected from screens #1 and #3, and elevated levels of TOC in all three screened intervals. The well R-20 completion report describes the plugging of screen #1 as preventing the collection of an adequate volume of groundwater for the analytical suite. The well R-20 report documents the validated detection of acetone, strontium-90, and toluene in groundwater samples collected from screens #2 and #3. The acetone may be a "false positive" detection because of the biodegradable drilling fluid. Well R-20 is another example of where it is important to use a continuous low-flow pumping system for the collection of groundwater samples so as to purge the stagnant water that surrounds the screened intervals in an attempt to sample groundwater that is representative of the aquifer strata. The rehabilitation of the screened intervals in well R-20 should be investigated.

- Do EPA and NMED recognize that well R-20 does not provide the scientifically sound and legally defensible contaminant data that are required as an "early warning well" for supply well PM-2.

D, Four additional examples of where LANL has insufficient knowledge of the presence of contamination in the regional aquifer, and the threat of contamination to supply wells are LANL wells R-4, R-7, R-15, and R-34. I have described the problems with the four wells in my reports.

7. The serious mistake in drilling boreholes with methods that allowed cross-contamination between perched zones of saturation and the regional aquifer, and with the construction of multiple-screen wells with screened intervals installed in the perched zones of saturation and in the regional aquifer.

There are many LANL characterization wells with screened intervals installed in both perched zones of saturation and in the regional aquifer. An incomplete list includes wells R-7, R-12, R-19, R-25, R-26, R-31, CdV-R-15-3, and CdV-R-37-2.

- Did the requirements of the 1994 HSWA module of the Laboratory's RCRA Permit apply to the installation of the LANL characterization wells? Section 4 of the HSWA module: "Protection of the Main Aquifer" specifies that borings that reach the regional aquifer shall ensure that the regional aquifer is hydraulically isolated from perched aquifers with conductor casing or bentonite seals.

- Did NMED grant LANL a variance from compliance with the HSWA module for the above list of multiple-screen wells that have screened intervals in perched zones of saturation and also in the regional aquifer?

LANL well R-25. During the long period of time for drilling of the borehole and installation of the multiple-screen well, serious contamination of the regional aquifer with high explosives occurred because of the high explosive contamination that is present in a thick perched zone of saturation.

LANL well R-26. Well R-26 is a multiple-screen well located upgradient of well R-25 for information on background chemistry in the perched zone and in the regional aquifer. The drilling of an open borehole allowed cross-contamination of water in the perched zone into the regional aquifer. The flow of perched water down the open borehole prevented identification of the water table on the regional aquifer with the result that the screened interval was installed at a depth of 557 ft below the water table of the regional aquifer. The screen is installed in strata with low permeability by the described lithology, and an even much lower permeability because of the plugging action by bentonite clay drilling muds and biodegradable drilling additives. The borehole log identifies strata with high permeability at a shallow depth in the regional aquifer. Well R-26 does not provide the necessary knowledge of "background chemistry" for the regional aquifer.

- Do EPA and NMED recognize the requirement to replace well R-26?

8. <u>The long well screens installed in many LANL monitoring wells may cause dilution of contaminated groundwater present in discrete strata</u>

Most LANL multiple-screen wells have a long well screen installed across the top of the water table. For many of the wells, the long screened intervals installed across the water table were poorly developed with the result that great damage to the screened interval has occurred by the biofouling plugging process. Some examples are screened intervals in wells R-7, R-12, R-19, R-20. R-22, etc.

Most LANL single-screen monitoring wells are installed with a long well screen that straddles the water table. Screen lengths of 40 feet are common. 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 intakes 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 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 concerns of the EAG are summarized in my written reply to the discussions of the EPA Ada conference call on April 12, 2005.

A change that should be made to methods that are used for sampling 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 with a low-flow pumping system.

<u>LANL well R-15</u>. A special problem that exists with well R-15 is the presence of low levels of strontium-90 and perchlorate contamination in the ground-water samples collected from the 40-ft screened interval that straddles the water table. The screened interval was improperly installed across a confining layer with the result that the water above the confining layer is in cross-communication with water below the confining layer. The result is mixing and dilution and confusion about the presence of contamination in the regional aquifer at a location beneath Mortandad Canyon where liquid waste effluents were released to the floor of the canyon for decades. Well R-15 is located within the center of much production of groundwater by the Los Alamos County supply wells. There is a need to rehabilitate or replace well R-15.

9. 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 on April 12, 2005, Michael Dale of NMED expressed a concern for the sampling of "stagnant water" from the LANL multiple-screen characterization wells.

9.1 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).

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:

"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).

A report written by the LANL EAG in 2001 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.

9.2 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 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 with the low-flow pumping system

- Has NMED granted LANL a variance that allows the current practice for collecting groundwater samples from the single-screen and multiple-screen wells?