3. The NAS Prepublication Copy Misrepresents Casing Advance Drilling.

It is a serious mistake for the NAS committee to present the air-rotary casing advance drilling method as too risky for the installation of monitoring wells in the hydrogeologic setting beneath the Los Alamos National Laboratory (LANL). In fact, the recent success of the dry air-rotary reverse circulation casing advance drilling method for the installation of the two deep R-35 monitoring wells at LANL is proof that casing advance is the preferred method for drilling through the thick vadose zone at any location at LANL and to depths as great as 1000 feet into the regional zone of saturation.

A new generation of powerful dual rotary drill rigs make air-rotary reverse circulation casing advance the optimum method for the installation of monitoring wells at LANL and across the nuclear weapons complex because the casing advance drilling method will preserve a pristine environment in the screened intervals of characterization wells and monitoring wells.

In addition, the drill cuttings produced from the reverse circulation air-rotary drilling method are of high quality for accurate geologic description and for profiling moisture content and matric potential through the entire thickness of the vadose zone. These profiles are important for knowledge of contaminant transport, for optimum identification of perched zones of saturation, and for identification of the need to collect core of the geologic strata.

Furthermore, the ability of the air rotary reverse circulation drilling method to produce *in situ* samples of the formation water in real time during the drilling in perched zones of saturation and at discrete depths in the regional aquifer is another important advantage of using only air as a drilling fluid. The importance of collecting profiles of water chemistry in "real time" while drilling boreholes is illustrated by the recent success of this drilling method for the installation of the LANL monitoring wells R-35a and R-35b. The two new wells were installed to investigate the travel of the known plume of hexavalent chromium to the Los Alamos County drinking water well PM-3. Elevated levels of hexavalent chromium were not present in the water samples collected from the boreholes. However, elevated levels of molybdenum were present. The profiles of water chemistry are displayed in Figure 3-1.

The decision to drill the R-35 wells with only air as a drilling fluid was because of a presentation by R. H. Gilkeson to the March 2007 meeting of the Northern New Mexico Citizens' Advisory Board. The LANL scientists presented the NMED-approved drilling plan for the R-35 monitoring wells to the March 2007 meeting of the Northern New Mexico Citizens' Advisory Board (CAB). The approved drilling plan was with fluid-assisted drilling methods that would invade the screened intervals of the two wells with organic drilling foam at a minimum, and possibly with bentonite clay drilling muds. The fluid-assisted drilling methods in the NMED-approved plan would not have allowed the collection of *in situ* samples of formation water during drilling of the boreholes. Following the LANL presentation, R. H. Gilkeson presented a counter proposal to drill the boreholes for the two wells into the regional aquifer with the air-rotary reverse circulation casing advance drilling methods that prevent the invasion of any drilling additives into the screened intervals other than air. Mr. Gilkeson stressed the importance of drilling only with air for the purpose of profiling water quality in the boreholes and for the purpose of installing monitoring wells that produce reliable and representative water quality data.

The NAS was provided a copy of the written report that R. H. Gilkeson presented to the CAB meeting. The dry air-rotary reverse circulation casing advance drilling method recommended in the Gilkeson report was successfully used to prevent the invasion of any organic or bentonite clay drilling additives into the screened intervals of monitoring wells R-35a and R-35b. In addition, high quality profiles of *in-situ* water chemistry were collected while drilling the boreholes.

Furthermore, air was the only drilling fluid used for the casing advance drilling through most of the vadose zone in the boreholes for wells R-35a and R-35b. Organic drilling foam was used only for drilling intervals in the vadose zone of approximately 100-ft thickness in the boreholes of each well. The success of using only air for drilling in the vadose zone is important because the drill cuttings produced from the reverse circulation air rotary drilling method are of high quality for an accurate geologic description and for profiling moisture content and matric potential through the entire thickness of the vadose zone. These profiles are important for knowledge of contaminant transport and for optimum identification of perched zones of saturation. The matric potential values are measured immediately at the field site with portable equipment. The profiles of matric potential and moisture content guide decisions to collect core of the geologic formations.

At both well locations, drilling into the regional aquifer was with air rotary casing advance using only air as a drilling fluid. The reverse circulation drilling method allowed collection of *in situ* water samples in real time directly from the strata being drilled. Figure 3-1 presents the chemical profiles for select constituents in the borehole water samples. The profiles show high levels of molybdenum in discrete strata both near the water table and at depth across from the screened interval in the Los Alamos County drinking water well PM-3. Molybdenum was used to control corrosion in the TA-3 power plant cooling tower after the use of hexavalent chromium was stopped. A large volume of molybdenum-contaminated wastewater was discharged to Sandia Canyon.

The EPA does not have a drinking water standard for molybdenum. However, a 2004 EPA guidance recommends levels not to exceed 50 ug/L or 50 parts per billion (ppb) for molybdenum. Figure 3-1 shows that the levels of molybdenum measured in the strata near the water table are greater than 200 ug/L and the levels of molybdenum measured in the strata across from the well screen in drinking water well PM-3 are greater than 80 ug/L. The molybdenum analyses on the water samples produced from the two boreholes were important information for the identification of the depth intervals to install the screens in wells R-35a and R-35b.

Hexavalent chromium levels were also measured on water samples produced from the two boreholes. However, the levels of hexavalent chromium were never greater than background values expected to be present in the regional aquifer, which are less than 10 ppb compared to the EPA drinking water standard of 100 parts per billion. The highest known levels of hexavalent chromium in the LANL plume are greater than 400 ppb. The real-time analyses of a suite of selected analytes on the *in situ* formation water produced from the air rotary boreholes is important information to guide decisions on the installation of monitoring wells. The collection of *in-situ* formation water is only possible when the drilling is with the dry air-rotary reverse circulation casing advance drilling method with the use of only air as a drilling fluid.

The successful drilling of LANL monitoring wells R-35a and R-35b with the dry air rotary casing advance drilling method requires revision of the NAS prepublication copy. The prepublication copy of the NAS report must be revised with a discussion of the successful use of the dry air-rotary casing advance drilling method for the installation of the two R-35 characterization/monitoring wells that were recently installed into the regional aquifer to investigate the nature and extent of groundwater contamination traveling to supply well PM-3, a very important drinking water well for Los Alamos County.

For the two new monitoring wells, the drilling into the regional aquifer was only with the use of air as a drilling fluid. The drilling into the regional aquifer was without any organic drilling fluids, organic drilling foams, or bentonite clay drilling muds. The R-35 wells are the first LANL characterization/monitoring wells installed in the regional aquifer with drilling methods that prevented the invasion of the screened intervals with the above listed drilling additives that have well known properties to prevent the detection of many radioactive and hazardous contaminants that are produced by nuclear weapons research and production activities at the Los Alamos National Laboratory.

The prepublication copy of the NAS report has a brief discussion of the plans to drill well R-35 with the casing advance drilling method. However, the discussion is inaccurate and needs to be revised with a detailed description of the successful application of the dry air rotary reverse circulation casing advance drilling method for the installation of the two wells. The discussion in the NAS report was predicated on the position that the casing advance drilling method was risky but the drilling method may be successful because of the known characteristics of the hydrogeologic setting at the location of the two wells. In fact, just the opposite is true. The unstable geologic formations at the location of the two wells caused the collapse and loss of drilling equipment in two boreholes where the attempt was made to drill with the mud-rotary open hole drilling method *i.e.,* LANL wells R-4 and R-8. The dry air-rotary reverse circulation casing advance drilling method is the best drilling method for every hydrogeologic setting at the Los Alamos National Laboratory and it is important for the NAS Final Report to recognize the superiority of this drilling method.

The casing advance drilling method was not responsible for casing abandoned in the boreholes at some LANL wells. The prepublication copy of the NAS report makes the statement that "Broxton (2006) lists a total of over 2600 feet of stuck drill pipe abandoned in place in 8 R-wells" (page 81). This statement is a serious mistake because it gives the reader the impression that the casing advance drilling method is too risky and, therefore, LANL had to use drilling methods that invaded the screened intervals with drilling fluids that have well known properties to mask the detection of many hazardous and radionuclide contaminants produced by nuclear weapons research and production. Below, we have explained why the stuck drill pipe was abandoned for other reasons than from using air rotary casing advance drilling methods. The three R-wells are R-9, R-12 and R-16.

The abandonment of the drill casing was never because of a problem with the casing advance drilling method but was always because of other factors including the over-sized collars on the retractable drill casings that increased the danger for the casing to become stuck, the failure to use powerful casing jacks for retraction of the "stuck" casing, and often because of mistakes in the drilling and well construction activities. The stuck casing never prevented the planned installation of any LANL characterization well. LANL characterization well R-16 was the only well where the stuck casing blocked the use of the uppermost screen in the multiple-screen well with four screened intervals.

Stuck casing in well R-16 is due to drilling mistakes. The first attempt to drill well R-16 was with open hole drilling methods using bentonite clay drilling mud to hold the borehole open. The bentonite clay drilling mud could not stabilize the borehole from collapse so the air-rotary casing advance drilling method was used as a "last resort" to install drill casing in the unstable borehole (LANL well R-16 completion Report, LA-UR-03-1841, June 2003). The drill casing became stuck in well R-16 because a single dimension of casing with over-size casing collars was drilled from land surface to a total depth of 729 feet and this was too great a distance to drill with one dimension of drill casing into unstable strata. The LANL drill casings had threaded connectors on the end of each 10-ft or 20-ft section of drill casing that were a larger diameter than the diameter of the casing. The larger size of the threaded collars served as "catch points" that greatly increased the risk of the casing becoming stuck in the boreholes. The standard industry practice is to use drill casing with a smooth outside wall dimension and no catch points.

In addition, the standard industry practice is to use powerful hydraulic jacks for retraction of drill casings from boreholes. The LANL well R-16 completion report does not demonstrate that the powerful jacks were used to retract the drill casing. Instead, the attempt to retract the drill casing was probably only with the markedly less hydraulic "pull back" power of the drill rig alone.

The claim by the LANL scientists that the stuck casing in well R-16 is because the casing advance drilling method is too risky is disingenuous because the characterization well drilled near well R-16 to replace the blocked screen was also drilled with the casing advance drilling method (LANL well R-16r completion report, Kleinfelder Project No. 40436, February 2006). The new borehole was drilled into the same unstable strata with three strings of smooth outside-wall telescoped drill casings and the casings did not become stuck in the borehole. The new borehole was drilled with the casing advance drilling method because the drilling history at well R-16 was proof that the unstable geologic formations could not be drilled with the mud-rotary drilling methods.

It is a serious mistake that the LANL scientists and the DOE managers do not mention the successful and necessary use of the casing advance drilling methods for the installation of many of the LANL characterization wells. The casing advance drilling method was often used as a "last resort" because of the failure of the open-hole mud-rotary drilling methods. Instead, the focus of LANL/DOE is on presenting the claim that the casing advance drilling methods are too risky and, therefore, it is necessary to invade the screened intervals in the LANL characterization wells and monitoring wells with drilling additives that mask the detection of many potential contaminants of concern.

<u>Casing abandoned in well R-9 because of well construction mistakes</u>. Well R-9 is an example of where the drill casing was not stuck in the borehole. Instead, mistakes in the backfilling of the well are responsible for the abandonment of 952 feet of drill casing. From page 70 of the LANL Well R-9 Completion Report:

> During well-construction operations, the 8-in. well casing was successfully pulled back in increments while annular materials were placed around the well with a tremie line. The 8.62-in. casing was completely removed from the borehole and the annular materials were installed to the bottom of the 10.75-in. drill casing. However, when attempts were made to pull back on the 10.75-in. drill casing, it was discovered that the 5-in. well casing had become locked to the drill casing. Attempts to decouple the 5-in. well casing from the 10.75-in. drill casing were unsuccessful. Because further attempts to pull back on the 10.75-in. drill casing might cause severe damage to the well completion string, a decision was made to cement in place the 10.75-in. casing and the two other remaining drill casings. LANL report LA-13742-MS, May 2001.

Thus, the abandonment of 952 feet of drill casing in well R-9 was because of mistakes in well construction and not because the casing was stuck in the borehole.

<u>Stuck drill casing in well R-12 because of the long period between drilling and well construction</u>. There was a 20-month lag period between the drilling activities that installed the 14-in, casing in the borehole and the attempt to retract the casing during construction of the characterization well. This long period of time increased the danger for the casing to become stuck in the borehole. In addition, there is no information in the LANL well R-12 completion report that shows hydraulic jacks were used in the attempt to remove the "stuck" casing. The available information indicates that the attempt to retract the stuck casing was limited to the much lower hydraulic "pull back"

power of the drill rig alone. The only discussion of the "stuck" casing in well R-12 is as follows on page 58 of the well R-12 completion report:

> Well construction was conducted from January 11, 2000, to January 21, 2000. At total depth the R-12 borehole contained three telescoped drill casings with diameters of 14 in., 11.75 in., and 9.625 in. The drill casings were retracted as annular backfill materials were emplaced around the well casing. The 14-in. drill casing could not be retracted from its original landed depth of 450 ft and was grouted in place in the borehole. LANL report LA-13822-MS, May 2001.

There is no discussion that hydraulic jacks were used in an attempt to retract the 14-in. drill casing. In fact, it is unlikely that hydraulic jacks were used because the powerful jacks would have either retracted all or part of the stuck casing because the jacks have the power to cause the casing to separate at a threaded connector.

The inaccurate and biased reporting in the NAS prepublication copy. The discussion above for wells R-9, R-12, and R-16 is proof that the casing advance drilling method was not responsible for the decisions to abandon drill casing at the three wells. The discussion above was provided to the NAS committee in the report by Gilkeson, R.H. 2007 titled *"Case History Study of LANL Characterization Wells Installed in Boreholes Drilled With the Air Rotary Casing Advance Drilling Method."* This case history report contains a detailed description of the reasons that caused the abandonment of the drill casing in each LANL characterization well where casing was abandoned. The case history report presented excerpts from the LANL published reports to show that the abandoned casing was always because of mistakes in the drilling and well construction. The information presented in the Gilkeson 2007 case history report was factual and without bias.

The casing advance drilling method was never responsible for the casing abandoned in any borehole. The reference section of the prepublication copy of the NAS Report lists the case history report by Gilkeson (2007). Nevertheless, the NAS committee is demonstrating bias in defending the unsupported position of the LANL scientists that the casing advance drilling method was too risky, and that there was no alternative but to use drilling methods that invaded the screened intervals of the LANL monitoring wells with drilling agents that have well known properties to mask the detection of the LANL contaminants produced by nuclear weapons research and production.

Prepublication copy of NAS report recommends for LANL to install monitoring wells with drilling methods that only use air or water. The NAS committee makes the following recommendation in the NAS prepublication copy:

> ***Recommendation:*** *LANL should design and install new monitoring wells with the following attributes:*
> - *A borehole drilled through the monitoring zone without the introduction of drilling muds or additives (i.e., use air or water),*
> - *One screened interval that targets a single saturated zone, and*
> - *A carefully planned design (length and depth) of the well screen, which is confirmed with information collected in the drilling process.* p. 98.

The NAS Final Report needs to recognize the importance of the air rotary reverse circulation casing advance drilling method for the installation of the LANL monitoring wells. This drilling method has the capability to drill to a great depth into the regional aquifer and through the monitoring zones using only air as a drilling fluid. The use of only air as a drilling fluid provides for the collection of profiles of *in situ* water quality data as a function of depth drilled. As illustrated below in Figure 3-1, the profiles of selected constituents such as molybdenum are important for the carefully planned design (length and depth) of the well screen.

The NAS prepublication report misrepresents the evolution of the LANL drilling methods for the installation of characterization/monitoring wells. It is a serious mistake for the NAS committee to describe the 10-year failure of the LANL scientists and DOE managers to install reliable monitoring wells as follows in the "Concluding Comments on Well Construction":

> The changes and evolution of LANL's drilling program are in keeping with the development of any major scientific undertaking; indeed such evolution is essential. One cannot know all the answers at the outset and learns as the program progresses." p. 91.

The NAS committee is mistaken to describe LANL's drilling program as a major scientific undertaking. The 10-year program has not produced any advances in drilling technology for the installation of characterization/monitoring wells. There was no evolution over the 10-year period in the ability to install wells that produced reliable and representative data for either hydrologic properties or water quality. Over the 10-year period, the LANL scientists and DOE managers always used drilling methods that invaded the screened intervals with water-based drilling additives that have well known properties to lower the measured permeability of the screened intervals and to mask the detection of many of the LANL contaminants in the water produced from the screened intervals.

The evolution of the LANL drilling program was only a concern to lower the cost for each well and to meet the schedule for well installation that was required by the New Mexico Environment Department (NMED). LANL/DOE continued to use drilling fluids that masked the detection of many hazardous and radionuclide contaminants because the NMED approved these drilling practices.

The prepublication copy of the NAS report describes the drilling history to install characterization wells at LANL as follows:

> Broxton (2006) and Nylander (2006) describe efforts by LANL, the Department of Energy (DOE), and their drilling contractors to install the approximately 1000-feet-deep wells into the regional aquifer (R-wells) required by the Hydrogeologic Workplan. Air and/or water were found to be inadequate as drilling fluids due largely to the depth to be drilled and the instability of some formations to be drilled through, although procedural errors have also

> been cited (Gilkeson, 2007). Lack of lubrication and the tendency of the boreholes to collapse resulted in slow progress and instances of stuck drill pipe and bits. Broxton (2006) lists a total of over 2600 feet of stuck drill pipe abandoned in place in 8 R-wells. As a result of these experiences, more traditional fluids—municipal water with organic chemical additives (EZ Mud® and Quik Foam®)—were used in most of the 34 R-wells. In eight of the R-wells, bentonite mud was used as the drilling fluid for at least part of the well depth (Table B-3, LANL 2005). p. 81.

It is imperative for the NAS committee to revise the prepublication copy to recognize the ability of the air-rotary reverse circulation casing advance drilling method for drilling through the vadose zone and deep into the regional aquifer with only air as a drilling fluid. The recent success in the casing advance drilling of the deep boreholes for wells R-35a and R-35b is proof that the casing advance drilling methods are not risky and that air alone is capable of drilling through the vadose zone and deep into the regional aquifer.

The success of using only air for drilling casing advance boreholes at LANL was described in Gilkeson (2007), including a detailed explanation that the casing advanced drilling method was not responsible for any of the 2600 feet of "stuck" drill pipe. The NAS committee paid too little attention to the Gilkeson case history report. The above paragraph in the prepublication copy of the NAS report is another example of the NAS committee bias to the opinions of the LANL scientists and DOE managers without making an effort to fully study the facts.

Figure 3-1. Profiles of water chemistry in boreholes for LANL monitoring wells R-35a and R-35b. Source: LANL documents on file with NMED.

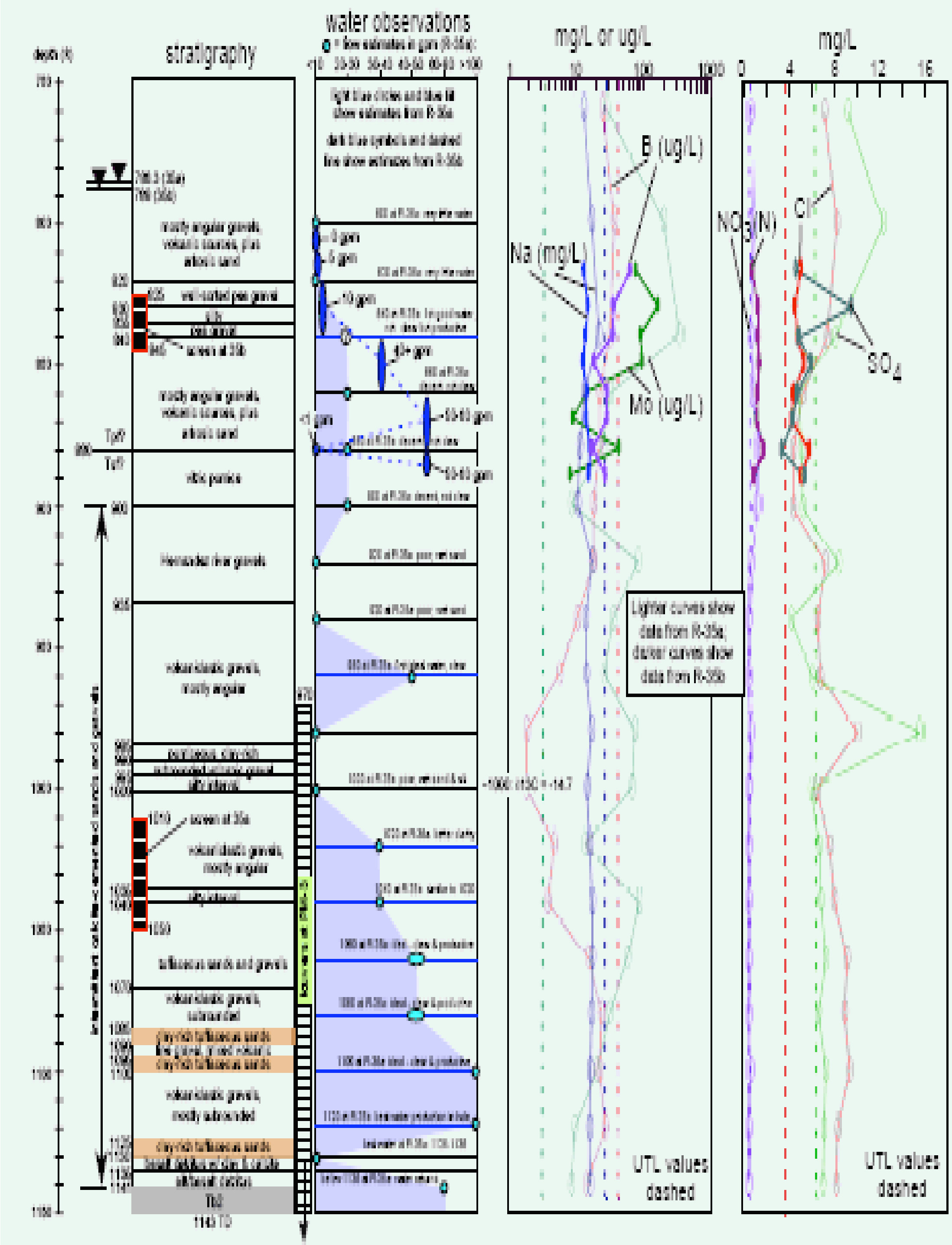

Figure 2. Stratigraphy, water observations, and groundwater chemistry for selected analytes in samples collected in boreholes R-35a and R-35b.