Properties of the Stainless Steel Screens in the LANL Characterization Wells to Prevent the Detection of Radionuclide and Hazardous Waste Contamination in Groundwater
by
Robert H. Gilkeson, Registered Geologist
Revision 1, May 6, 2008

Abstract. During the past ten years, more than fifty "characterization wells" with more that 100 screened intervals were installed at the Los Alamos National Laboratory (LANL) for characterization of the hydrogeologic setting below LANL and to produce water samples from perched zones of saturation and from the sole source regional aquifer. The LANL characterization wells were intended to meet the requirements of the Resource Conservation and Recovery Act (RCRA), the Department of Energy (DOE) Orders and the New Mexico Environment Department (NMED) Consent Order as monitoring wells, but practically all of the wells fail to be usable for that purpose.

All of the LANL characterization wells installed into the regional aquifer and into the deep perched zones of saturation are constructed with Type 304 stainless steel well screens and casing. Laboratory research over the past twenty years has determined stainless steel well screens and casing have strong sorption properties for masking or preventing the detection of many RCRA trace metals, and especially the DOE trace metal radionuclide contaminants in the water samples produced from the wells. The DOE trace metal radionuclide contaminants that are quantitatively removed from groundwater by stainless steel include isotopes of plutonium, americium, neptunium, cesium, cobalt, etc.

Research at the Nevada Test Site determined that uncorroded 304 stainless steel has strong properties to sorb cesium-137 and cobalt-60 from groundwater. Other research has determined the strong sorption properties of uncorroded stainless steel for many RCRA trace metals. However, corrosion greatly increases the properties of the 304 stainless steel for sorption of RCRA trace metals and the DOE trace metal radionuclides. Research has determined that the high levels of dissolved oxygen in the natural groundwater below LANL will cause corrosion of type 304 stainless steel after only a few months. Research has also determined that the thousands of welds on the wire-wrap LANL well screens facilitate corrosion. A LANL report documents the onset of corrosion in five of the LANL characterization wells and the New Mexico Environment Department (NMED) has ordered replacement of two of the wells. Unfortunately, DOE/LANL continue to install new monitoring wells with the stainless steel screens.

The greatest removal of the LANL contaminants will occur in the no-purge water samples collected from the majority of the LANL characterization wells. The no-purge Westbay^{R} sampling systems collect stagnant water samples that were in contact with the stainless steel screens for a very long period of time. Also, in addition, the screened intervals in the LANL characterization wells were invaded with organic drilling fluids and bentonite clay muds that have well know properties in the scientific literature to prevent the wells from producing reliable and representative water samples for the detection of RCRA trace metals and the DOE trace metal radionuclide contaminants.

Besides the stainless steel screens and the drilling fluids, there are many other factors that prevent the network of LANL monitoring wells - i.e., the LANL characterization wells and the 50-year old LANL "test wells" from producing water samples that are reliable and representative for the detection of the contamination produced by the LANL mission in nuclear weapons research and manufacture.

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Properties of the Stainless Steel Screens in the LANL Characterization Wells to Prevent the Detection of Radionuclide and Hazardous Waste Contamination in Groundwater

- By Robert H. Gilkeson, Registered Geologist , Revision-1, May 6, 2008.

1.0. Introduction - Summary of the mistakes that prevent the LANL characterization wells from being reliable to detect groundwater contamination. During the past ten years, more than fifty (50) "characterization wells" were installed at the Los Alamos National Laboratory (LANL or the Laboratory) for characterization of the hydrogeologic setting below the Pajarito Plateau and to produce water samples from perched zones of saturation and from the sole source regional aquifer. The LANL characterization wells were intended to meet the requirements of the Resource Conservation and Recovery Act (RCRA), the Department of Energy (DOE) Orders and the New Mexico Environment Department (NMED) Consent Order [1] as monitoring wells, but practically all of the wells fail to be usable for that purpose.

This report presents the findings in the scientific literature that the Type 304 stainless steel well screens installed in the LANL characterization wells have properties to prevent the wells from producing water samples that are reliable and representative for the detection of many of the LANL contaminants of concern.

There are many factors that prevent the characterization wells from producing water samples that are reliable and representative for the detection of groundwater contamination from the past, present or future LANL operations in research and manufacture of nuclear weapons. Some of the factors are summarized below:

- 1). The wells are not installed at important locations.
- 2). The wells are installed too far away from the LANL legacy waste dumpsites.
- 3). The well screens are installed in geologic formations with low permeability where groundwater contamination is not likely to be present.
- 4). The screens are not installed in the aquifer zones where groundwater contamination is most likely to be present.
- 5). Many screens provide dilution and masking of groundwater contamination because they are too long.
- 6). A LANL report [2] published in 2007 shows that no-purge sampling methods are used to collect samples of stagnant groundwater from 54 of the 80 screened intervals in the network of LANL characterization wells.
- 7). The chemical properties of the pristine and corroded stainless steel screens will prevent the detection of many LANL trace metal and radionuclide contaminants.
- 8). The chemical properties of the new mineralogy introduced into the screened intervals by the organic drilling fluids and bentonite clay muds will prevent the detection of many LANL contaminants of concern including the RCRA trace metals and the DOE trace metal radionuclides.
- 9). The water quality data from the old LANL "test wells" have never been reliable for the detection of contamination because of a). the chemical properties of the corroded iron screens, b). dilution of contamination by the very long screens, c). invasion of the screens in two of the old test wells with drilling muds, and d). many of the old test wells were not at appropriate locations. The old test wells are still used as the primary monitoring wells for the detection of contamination from a highly contaminated experimental area (MDA AB at TA-49) where a very large inventory of plutonium wastes are buried in unlined shafts.

Drilling methods prevent detection of contamination. A major factor is that all of the characterization wells studied in the LANL report [2] (80 screens) were drilled with fluid-assisted methods that invaded the screened intervals with water-based organic drilling additives and in many cases also with bentonite clay drilling muds. The organic additives and bentonite clay have formed a new mineralogy in the screened intervals with well known properties [3,4,5,6,7] to prevent the detection of many RCRA regulated trace metal contaminants, and especially the DOE regulated trace metal radionuclide contaminants that include isotopes of plutonium, americium, neptunium, curium, cesium, cobalt, etc. Large inventories of these RCRA wastes and DOE radionuclide contaminants are buried in many of the legacy waste dump sites located across the 40-square mile Laboratory facility. Also, long reaches of sediments within the canyons are contaminated with the RCRA wastes and the DOE radionuclides because of releases of liquid wastes to the canyons over the decades of time from the 1940s up to the present.

Stainless steel screens prevent detection of contamination. A second major factor is the stainless steel screens in all of the characterization wells that were installed into the regional aquifer and in practically all of the wells that were installed in the perched zones of saturation. The screens are made of a metal alloy (Type 304 stainless steel) with well known properties to prevent the detection of many RCRA trace metal contaminants and especially the DOE trace metal radionuclide contaminants that are listed above.

In addition, the stainless steel screens corrode in the groundwater below LANL and the corroded screens have even stronger properties to prevent the detection of the DOE radionuclides and many of the LANL RCRA contaminants. The LANL *Well Screen Analysis Report-Revision 2* [2] (WSAR-2) presents findings that the corrosion is now present in five of the screens in the LANL characterization wells. Because of the corrosion, the New Mexico Environment Department (NMED) has ordered DOE/LANL to install two new monitoring wells to replace the two corroded screens in multiple-screen monitoring well R-25. The activities to repair the damaged well caused abrasion of screens #1 and #2 in well R-25.

This report presents the findings in the scientific literature that the Type 304 stainless steel well screens installed in the LANL characterization wells have properties to prevent the wells from producing water samples that are reliable and representative for the detection of many RCRA trace metals and especially the DOE trace metal radionuclide contaminants. These contaminants are a concern for groundwater contamination below the large number of legacy waste dumps and below the canyons that received large discharges of liquid wastes over decades of time.

The Northern New Mexico Citizens' Advisory Board (CAB) held a public forum on April 16, 2008 for DOE/LANL to describe progress on the characterization of the danger of the large 63-acre legacy waste dumpsite known as Material Disposal Area G (MDA G) to contaminate the sole-source drinking water aquifer. The locations of MDA G, MDA L, MDA J and MDA H in Technical Area 54 (TA-54) are displayed on Figure 1. The figure also shows the locations of the seven LANL characterization wells that were installed into the regional aquifer. Missing from the figure is well R-16r that is located 20 feet north of well R-16 because of a drilling mistake that blocked the uppermost screen in well R-16.

None of the seven wells produce reliable and representative water samples for the detection of contamination from the four MDAs. The only well located close to any of the

MDAs is well R-22 at a distance of 500 feet from MDA G. Wells R-16r, R-21 and R-22 were drilled with fluid-assisted drilling methods that invaded the screened intervals with organic additives. Wells R-16, R-20, R-23 and R-32 were drilled with the mud-rotary method that invaded the screened intervals with drilling muds that contained both organic additives and bentonite clay.

The well development methods were not capable of removing the organic additives and clay muds from any of the screened intervals. The organic additives and the bentonite clay have well known properties to prevent the detection of many RCRA hazardous waste contaminants of concern in the water samples produced from the seven characterization wells and especially to prevent the detection of the DOE trace metal radionuclide contaminants.

All of the screens in the seven wells are Type 304 stainless steel. Wells R-16r, R-21 and R-23 have a single screen and are equipped with electric submersible pumps that will allow purging large amounts of groundwater before samples are collected. However, the study of the water quality data show that the three wells are not sufficiently purged in order to collect reliable and representative water samples for detection of many of the contaminants of concern for the MDAs in TA-54. The water quality data are evidence that the three wells are not reliable for the detection of the RCRA trace metals and the DOE trace metal radionuclide contaminants (see discussion of wells R-16r, R-21 and R-23 in Section 11.2.). Figure 2 shows the as-built construction of single-screen well R-23.

Wells R-16 and R-22 are multiple-screen wells that use the Westbay^{R} no-purge sampling systems for the collection of water samples. Figure 3 shows the as-built construction of well R-22. The Westbay^{R} system produces stagnant water samples that were in contact for a long period of time with the stainless steel screens and with the zone surrounding the screens that was impacted by the drilling additives. The no-purge water samples produced from the Westbay^{R} systems are not reliable for the detection of many contaminants of concern from the MDAs in TA-54 and certainly are not reliable for accurate detection of RCRA trace metals and the DOE trace metal radionuclides (see the discussion of the no-purge sampling methods in Section 11.1).

Figure 1 shows that Well R-22 is the only characterization well that is located close to any of the MDAs. A large suite of DOE radionuclide and RCRA hazardous waste contaminants were detected in the water samples produced from well R-22 and this contamination is proof that MDA G has contaminated the groundwater in the sole source regional aquifer. Exhibit R-22 describes the radionuclide and hazardous waste contaminants detected in the water samples produced from well R-22.

The WSAR-2 identified the onset of corrosion in screen #1 in well R-22. Screen #1 is installed in the first zone of permeable strata below the water table and this zone is crucial for investigation of contamination at the present time and for long-term monitoring. However, because of a). the organic drilling additives, b). the stainless steel screen and c). the Westbay^{R} no-purge water samples, screen #1 has never produced reliable and representative water quality data.

Nevertheless, the NMED has not ordered DOE/LANL to install a new monitoring well to meet compliance with the RCRA requirement to produce reliable and representative water samples from the "uppermost aquifer" below MDA G. RCRA defines the "uppermost aquifer" as the first zone of permeable strata below the water table. In fact, the NMED has not required DOE/LANL to be in compliance with the requirements of RCRA for a reliable network of monitoring wells at either MDA G, MDA H or MDA L.

Wells R-20 and R-32 are multiple-screen wells where the WSAR-2 identified that the bentonite clay muds and the Westbay no-purge sampling systems prevented the screened intervals from producing reliable and representative water samples. The NMED ordered DOE/LANL to rehabilitate the two wells but these efforts were unsuccessful. The NMED report [3] that ordered DOE/LANL to rehabilitate the two wells was a mistake and a misspending of money that should have been used to install new monitoring wells (The author is preparing a report about the failure of the attempt to rehabilitate the two wells).

2.0. <u>The NMED has not enforced the requirements in the NMED Consent Order for the materials that may be used for casings and screens in the LANL monitoring wells</u>. The LANL characterization wells and the old LANL test wells do not meet the requirements in the NMED Consent Order [1] for well construction materials that may be used in monitoring wells. The section in the Consent Order that describes the requirements for well construction materials is pasted below:

> "X.C.1 Well Construction Materials
> Well construction materials shall be selected based on the goals and objectives of the proposed monitoring program and the geologic conditions at the site. When selecting well construction materials, the primary concern shall be selecting materials that will not contribute foreign constituents or remove contaminants from the groundwater. Other factors to be considered include the tensile strength, compressive strength, and collapse strength of the materials; length of time the monitoring well will be in service; and the material's resistance to chemical and microbiological corrosion" (p. 193).
>
> "The design and construction of groundwater monitoring wells shall comply with the guidelines established in various EPA RCRA guidance, including, but not limited to:
> - U.S. EPA, *RCRA Groundwater Monitoring: Draft Technical Guidance*, EPA/530-R-93-001, November, 1992 [EPA RCRA Manual, 1992];
> - U.S. EPA, *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1, September, 1986; and
> - Aller, L., Bennett, T.W., Hackett, G., Petty, R.J., Lehr, J.H., Sedoris, H., Nielsen, D.M., and Denne, J.E., *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*, EPA 600/4-89/034, 1989 [Aller et al., 1989]." (p. 189).

- Aller et al. (1989)[6] present findings that stainless steel casing and screens are unsuitable materials for the LANL monitoring wells. The disadvantages presented in Aller et al. are pasted below:

> "Disadvantages of stainless steel well casing and screen materials:
> - May corrode under some geochemical and microbiological conditions;

- May sorb cations and anions;
- May contribute metal ions (iron, chromium, nickel, manganese) to groundwater samples;
- High weight per unit length; and
- Type 304 and Type 316 stainless steel are unsuitable for use when monitoring for inorganic constituents."

- The EPA RCRA Manual (1992) [7] presents findings that Type 304 stainless steel casing and screens are unsuitable for the LANL monitoring wells. The disadvantages presented in the EPA RCRA Manual are pasted below:

"Monitoring well casings and screens should be resistant to chemical and microbiological corrosion and degradation in contaminated and uncontaminated waters. Metallic casing and screen materials are subject to corrosion, and thermoplastic casing and screen materials are subject to chemical degradation by solvents. The extent to which these processes occur depends on water quality within the formation and changing chemical conditions such as fluctuations between oxidizing and reducing conditions. Casing materials should be chosen with a knowledge of existing and anticipated ground-water chemistry." (p. 6-23 - 6-24).

"The presence of corrosion products represents a high potential for the alteration of ground-water sample chemical quality. The surfaces where corrosion occurs also present potential sites for a variety of chemical reactions and adsorption. These surface interactions can cause significant changes in dissolved metal or organic compounds in ground-water samples." (p. 6-30).

"Monitoring well casing and screen materials should not chemically alter ground-water samples as a result of their sorbing, desorbing, or leaching analytes, especially with respect to the analytes of concern. If a casing material sorbs selected constituents from the ground water, those constituents either will not be present in any water quality sample or the concentration of constituents will be reduced." (p. 6-24).

- The EPA RCRA Manual describes the properties of water chemistry that cause corrosion of stainless steel well casings and screens. From page 6-29 in the Manual:

"High dissolved oxygen content -- if dissolved oxygen content exceeds 2 milligrams per liter, corrosive water is indicated;

Presence of hydrogen sulfide (H_2S) -- presence of H_2S in quantities as low as 1 milligram per liter can cause severe corrosion."

The requirements in the Consent Order make Type 304 stainless steel screens and casings unacceptable for the LANL monitoring wells because

- 1). the stainless steel leaches and adds nickel, chromium and iron to the groundwater,
- 2). the stainless steel has well known properties to remove trace metal contaminants, and especially trace metal radionuclide contaminants from groundwater, and
- 3). the stainless steel screens and casings will corrode in the natural highly oxidizing

groundwater below the Pajarito Plateau. In addition, the organic drilling additives caused highly anaerobic groundwater to be present at many screened intervals on a temporary basis. The stainless steel screens will corrode in the anaerobic groundwater.

In summary, the NMED has not enforced the requirements in the Consent Order for DOE/LANL to use casing and screen materials for the LANL monitoring wells that would not

- 1). contribute foreign constituents to groundwater,
- 2). remove contaminants from the groundwater and
- 3). that were resistant to corrosion.

The organic drilling fluids temporarily caused a strongly anaerobic water chemistry for many of the LANL characterization wells and the presence of H_2S. However, the natural groundwater chemistry is highly oxidizing with dissolved oxygen concentrations far above the 2 milligrams per liter (2 mg/L) concentration that indicates corrosion. For example, Tables 1, 2 and 3 show that the dissolved oxygen concentrations measured in the water samples produced from wells R-16r, R-21 and R-23 range to maximum values of 5.2, 5.1 and 6.47 mg/L, respectively. Figure 1 shows the three wells are miles apart. The dissolved oxygen content in the three wells are evidence that the natural water chemistry in the regional aquifer below the Pajarito Plateau will corrode stainless steel well screens and casing.

The water quality data show that stainless steel screens and casings should not be used in the LANL monitoring wells because the highly oxidizing groundwater will corrode the stainless steel and prevent the collection of reliable and representative water samples. Nevertheless, despite the requirements in the Consent Order that prohibit stainless steel well screens, the NMED continues to approve of the compromised water quality data collected from the stainless steel screens and to approve of stainless steel screens in the installation of new LANL monitoring wells, even when the new wells are ordered by NMED because of the corrosion of the stainless steel screens.

3.0. <u>Chemical properties of uncorroded Type 304 stainless steel well screens to prevent detection of trace metals in groundwater</u>. Corrosion specialists have identified that the key to corrosion protection of stainless steel screens is the formation of a passive film on the surfaces of the stainless steel and the long-term condition of this film. Studies with x-ray photon electron spectroscopy and Auger Electron Spectroscopy have analyzed the properties of the passive film. Castle and Clayton (1977)[9] measured the films to have a thickness of 1.5 to 3 nanometers and that the films are composed of oxides and hydroxides of Cr^{+3}, Fe^{+2} and Fe^{+5}. Ferreira and Dawson (1985)[10] have found the film may grow in stages; at low potentials the film consists mainly of chromium, whereas at high potentials, iron predominates. Okamoto (1973)[11] determined that surface films on stainless steel are composed primarily of chromium at a potential of 0 to 2 volts. He characterized the film as a hydrated oxide film having a gel-like structure.

The very strong properties of the gel-like films of oxides and hydroxides of iron and manganese to adsorb the RCRA trace metals and DOE trace metal radionuclide contaminants from groundwater are described by Langmuir (1997) [3], Stumm and Morgan (1996) [4], and Hem (1970) [5].

Driscoll (1986)[12] described the fragile nature of the passive films and that abrasive silt- and sand-sized particles passing through a well screen during well development and well rehabilitation activities may irreparably damage the film, leading to enhanced corrosion rates. Aggressive rehabilitation activities were performed in many of the LANL characterization wells.

4.0. <u>Sorption properties of uncorroded stainless steel well screens to remove RCRA trace metals and DOE trace metal radionuclides from groundwater</u>. Laboratory studies were performed by Hewitt (1992)[13] to measure the removal (sorption) of metals from groundwater by uncorroded Type 304 stainless steel well materials. The studies were on 5.0 cm diameter monitoring well casing that was cut into rings with a length of 2 cm.

The casing rings were placed in containers filled with groundwater that had low dissolved oxygen because of purging the water with nitrogen. The periods for immersion of the stainless steel rings and the concentration of dissolved oxygen measured in the water in the containers were as follows: (2 hr / 1.8 mg/L), (8 hr / 1.6 mg/L), (24 hr / 0.8 mg/L), and (72 hr / 0.3 mg/L).

The trace metals tested were cadmium, chromium, copper and lead. The uncorroded Type 304 stainless steel exhibited strong properties for sorption of all four trace metals from the groundwater and the removal of the metals from the groundwater was detected after immersion of the casing rings for only 2 hrs.

The Hewitt paper [13] also studied the sorption properties of the two commonly used plastic materials for monitoring well screens and casings - polytetrafluorethylene (PTFE) and rigid polyvinylchloride (PVC). The findings in the Hewitt paper for the three well construction materials were as follows:

> "Ranking the materials based on their ability to sorb the metals studied shows that PTFE < PVC < SS 316 << SS 304." (p. 134).
>
> "If only metal analytes are of concern, PTFE is the best material for groundwater monitoring wells with respect to material inertness. Groundwater samples analyzed for trace metals would be more suspect if taken from wells constructed with stainless steel than if taken from wells made of either PVC or PTFE." (p.134).

The findings in Hewitt (1992) [13] are strong evidence that <u>all</u> of the groundwater samples collected from the LANL characterization wells and especially samples collected with the Westbay[R] no-purge methods are not reliable for the measurement of the strongly sorbing DOE trace metal radionuclide contaminants and for most RCRA trace metals.

5.0. <u>Research by DOE determined that uncorroded Type 304 stainless steel well casing and screens mask the detection of radionuclide contamination in groundwater</u>. A 1996 journal article [14] presents findings from research at the DOE Nevada Test site for the sorption of the radionuclides cesium-137 (monovalent cations) and cobalt-57 (divalent cations) on well casing and screens made of Type 304 stainless steel. The groundwater used in the experiments was oxidizing with a sodium bicarbonate chemistry. The groundwater was spiked with trace levels (less than 1 ug/L) of cesium-137 and cobalt-57 that were purchased as chloride salts in dilute hydrochloric acid. The coupons of uncorroded stainless steel were placed in contact with the spiked groundwater in glass

containers for periods of time ranging from two hours to three weeks. The stainless steel showed no signs of corrosion during the time of this experiment.
The research [14] found that Type 304 stainless steel screens had strong properties for sorption of both cobalt-57 and cesium-137 with strongest sorption of cobalt-57:

> "The cesium-137 solution concentration fell to about 65 percent of its initial value by one day of contact, then stabilized for the remainder of the experiment. The stainless steel sorbed cobalt-57 during the entire three week period, apparently competing effectively with the walls of the glass container. [t]he cobalt-57 concentration rapidly decreased and remained lower than it was in the control throughout the experiment." (p.165)

The limited research at the Nevada Test Site is evidence that all of the LANL characterization wells with Type 304 stainless steel screens will mask and possibly completely prevent the detection of groundwater contaminated with the strongly sorbing radionuclide contaminants including isotopes of plutonium, americium, neptunium, curium, cesium, cobalt, etc. The greatest effect of the stainless steel screens to prevent the detection of the radionuclides will be in the large number of multiple-screen characterization wells where stagnant water samples are collected with the Westbay[R] no-purge sampling systems. This is because the Westbay[R] system produces water samples that were in contact with the stainless steel screens for a long period of time.

6.0. <u>The design of the LANL stainless steel well screens enhances corrosion</u>. All of the stainless steel screens in the LANL characterization wells (more than 100 screens) are a design with horizontal coils of stainless steel wire wrapped around and welded to vertical stainless steel rods. The rods are welded to end caps at the top and bottom of the screens. On Figure 1, the screens in wells R-16, R-16r, R-20, R-22, R-23 and R-32 are a pipe-based design. In this design, the rods are also welded to a stainless steel casing that is installed inside the rods to increase the strength of the well screen. Figure 4 is a schematic of the pipe-based screen design and illustrates the thousands of welds in each of the LANL well screens. There are widely reported observations in the scientific literature [15,16] that the welds are preferred locations for the onset of corrosion of stainless steel screens. This corrosion will occur because of the differences in galvanic electrical properties between the welds and the stainless steel. In addition, the corrosion is enhanced by the large populations of aerobic and anaerobic microbes that preferentially grow at the locations of the welds [15]. The organic drilling fluids were metabolites for production of very large populations of microbes in the zone surrounding the well screens. Research by DOE [17] has determined that the microbes not only increase the corrosion but the colonies of bacteria that are attached to the screens also sorb and accumulate the trace metal radionuclide contaminants.

7.0. <u>Leaching and sorption of trace metals from corroded Type 304 stainless steel well screens</u>. Hewitt (1994)[16] studied the leaching and sorption properties of corroded Type 304 and Type 316 stainless steel well screens that were placed into sealed flow chambers made of glass with a constant flow of groundwater through the chambers while avoiding atmospheric exposure. The flow chambers were located within 1 meter of the well head. The well screens placed inside the flow chambers were a rod-based wire wrap design with a diameter of 2 inches and a length of 17 inches. The flow chambers were used to simulate the common practice of purging wells screens before collection of water samples. The flow rate of the groundwater through the chambers was held constant for a residence time of the water in the chambers of one-half hour. To study the sorption properties of the corroded screens, the groundwater was spiked with trace concentrations of lead (Pb^{2+}) and cadmium (Cd^{2+}). Samples were collected for the analytical suite after 5, 6, 7, 8, 9, and 10 chamber flushes.

Corrosion was formed on uncorroded Type 304 and Type 316 stainless steel screens by submerging the screens in stagnant groundwater for a period of 130 days. The dissolved oxygen concentration in the stagnant water is not given in the paper. After the period of 130 days, approximately 20 % of the surfaces of the Type 304 screen was corroded. The corrosion was centered on the welds that attached the coils of wire to the rods and to the end caps. The corrosion caused the formation of rust on the surfaces of the screen that were precipitates of ferrous hydroxide and hydrated ferric oxide. Hewitt (1994) [16] described the properties of the precipitates as follows:

> "Furthermore, with the development of iron oxide coatings, new surfaces were generated that provided large and active exchange sites for the sorption of metals from solution. The experiment provided strong evidence for the occurrence of this loss [i.e., sorption] mechanism, since both Pb^{2+} and Cd^{2+} were sorbed from the solution as the groundwater passed through chambers with the corroded stainless screens." (p. 93 - 94).

The geochemistry text book of Langmuir (1997) [3] describes the very strong properties of ferrous hydroxide and hydrated ferric oxide for the sorption of the actinide radionuclide contaminants from groundwater. The actinide radionuclides include the isotopes of plutonium and americium that are present in the LANL wastes.

- Results of leaching studies on stainless steel screens. The water flushed from the flow chambers contained concentrations of nickel and chromium that leached from the corroded well screens. After five flushes, the measured concentrations of chromium and nickel leached from the corroded Type 304 stainless steel screen were 9.9 and 92 ug/L, respectively (Hewitt 1994[16], p. 93).

- Studies on PVC and PTFE well screens. Hewitt (1994)[16] also used the flow cells to study sorption and leaching properties of rigid PVC and PTFE well screens. The conclusions in the Hewitt paper are the following:

> "Common stainless steel well screens significantly affect solution metal concentrations under dynamic conditions consistent with typical groundwater sampling protocol. The magnitude of the influence appears directly correlated with the presence of corrosion products on stainless steel screens, and concentrations of Nickel (and perhaps chromium) could approach those that would affect regulatory compliance. Along with leaching, surface corrosion also causes significant sorption losses for metals such as Pb and Cd. Only PVC and PTFE, which showed no influence or diminished influences in comparison to the stainless steel screens, should be recommended for construction of wells intended for monitoring metals in groundwater. No significant sorption of TCE was observed for dynamic conditions that limited the exposure between any of the casing materials and groundwater to eight hours or less." (p. 94).

8.0. <u>LANL *Well Screen Analysis Report-Revision 2* [2] (WSAR-2) identifies five of the LANL characterization wells to have corroded stainless steel well screens</u>. The LANL WSAR-2 identified the onset of corrosion in 5 discrete screened intervals in the network of LANL characterization wells. The position of DOE/LANL is that corrosion of the stainless steel screens is responsible for the high concentrations of chromium and nickel that are measured in the water samples produced from screen #1 and #2 in the multiple-screen well R-25. However, in a report [8] dated April 5, 2007, the NMED described the claim of DOE/LANL that screen corrosion was responsible for the high levels of chromium and nickel as "speculation". The NMED ordered installation of two new single-screen monitoring wells at locations close to well R-25 with the screens targeting equivalent intervals to screen #1 and #2 in well R-25.

The five screened intervals that the LANL WSAR-2 identified to show signs of corrosion are listed below:

• LANL Well	year installed	evidence of corrosion
- Well CdV-16-2(i)r	July 2005	high total/dissolved iron ratio
- Well R-19 Screen 7	April 2000	high total/dissolved iron ratio, high total/dissolved chromium ratio
- Well R-22 Screen 1	October 2000	high total/dissolved chromium ratio
- Well R-25 Screen 1	July 1999	high total/dissolved iron ratio, high total/dissolved chromium ratio *(also high dissolved nickel concentrations***)*
- Well R-25 Screen 2	July 1999	high total/dissolved chromium ratio, high dissolved nickel concentrations*

***** The high dissolved nickel concentrations may be due to groundwater contamination in the perched zone at the location of well R-25. This contamination is discussed below. The nickel, chromium, RDX, HMX and turbidity measured in water samples produced from well R-25 screen #1 by the Westbay no-purge sampling system are in the table below:

<u>Analyses on water samples from Well #25 - Screen #1</u>

sample date	**nickel (ug/L) filtered / unfiltered**	**chromium (ug/L) filtered / unfiltered**	**RDX (ug/L) unfiltered**	**HMX (ug/L) unfiltered**	**Turbidity (NTU)**
- 08-07-02	**[A]NA / 812, 809 *[B]**	**NA / 30.7, 18.2***	**58.6 / 58.6***	**9.1 / 7.8***	**11**
- 12-11-03	**NA / 1060, 1060***	**NA / 23, 23***	**56.5 / 74.1***	**9.1 / 14***	**10**
- 09-01-04	**NA / 1720, 1670***	**NA / 44.8, 42***	**44.6 / 41.4***	**7.3 / 7.4***	**22**
- 08-02-05	**723 / 742**	**6.2 / 153**	**52.2 / NA**	**9.1 / NA**	**9.1**

[A]NA = a filtered water sample was not analyzed for the listed constituent
***[B] = asterisk indicates analysis on duplicate sample**

The high concentrations of chromium in the unfiltered samples with an increase in measured concentrations over time compared to the low concentration of dissolved chromium in the sample collected on 08-02-05 may be evidence of corrosion of the stainless steel screen. However, the very high concentrations of nickel in all of the water samples and the dominance of dissolved nickel in the sample collected on 08-02-05 (and probably also in the earlier samples) are not expected from corrosion. The high concentrations of dissolved nickel measured in groundwater samples produced from both screen #1 and #2 in well R-25 are probably from nickel contamination in the plume of contaminated groundwater in the perched zone of saturation at well R-25. The table shows the concentrations of the high explosives contaminants RDX and HMX that were measured in the water samples.

LANL well R-25 was installed in 1999. The plan of DOE/LANL to use Type 304 stainless steel screens in the new wells is a mistake because the screens will corrode over a period of only a few years according to the position of DOE/LANL that corrosion is responsible for the very high levels of nickel measured in August of 2002 in the water samples produced from screen #2 in well R-25. The contaminants of concern for the perched zone of saturation in the region of Well R-25 are trace metals and high explosives. DOE/LANL should investigate installing monitoring wells with non-metallic screens for the two new wells installed to replace the corroded screens in well R-25.

9.0. <u>Study of PVC casings and screens for measurements of high explosive contaminants</u>. A research paper by Parker and Jenkins (1986)[18] presented findings from a study of the ability of PVC well casings and screens to produce water samples that were reliable and representative for the detection of high explosive contaminants in groundwater. The study did not identify any substances leached from the rigid PVC casing that interfered with the reversed-phase HPLC analysis of low concentrations of the high explosive contaminants HMX, RDX, TNT and DNT. The leaching studies were performed for a period of 25 days.

Sorption studies performed for a period of 80 days measured very little sorption by rigid PVC for HMX, RDX, and DNT, but significant sorption for TNT. However, sorption tests were also conducted for periods of 25 days for a variety of different groundwater chemistries by varying the pH, dissolved oxygen content, and salinity. The 25-day tests measured no significant sorption by PVC for HMX, RDX, and DNT, and a slight decline for TNT exposed to PVC. The decline in TNT is not assigned to sorption by the PVC casing but to increased microbial degradation in the presence of PVC. Parker and Jenkins (1986)[18] present the following conclusions:

> "Since the purging of stagnant water from the well prior to sampling should ensure a relatively short contact time between the sample and the well casing, the degree of loss exhibited in these experiments should not limit the use of PVC for this application.
>
> Long-term leaching studies using local groundwater with two different brands of PVC casing indicated that nothing was leached at sufficient concentrations to interfere with reversed-phase HPLC analysis for low levels of TNT, RDX, HMX or DNT in groundwater.
>
> Therefore, the authors conclude that the use of PVC well casings is acceptable for groundwater monitoring for low levels of these munitions." (p. 97).

The available information indicates the two new monitoring wells that are installed to replace the corroded screens in well R-25 should be constructed with PVC casing and screens in the perched zones of saturation. A suitable steel may be used for the riser casing from above the perched zone of saturation to land surface.

10. NMED requires Sandia National Laboratories Albuquerque Facility to replace the stainless steel monitoring wells at the Sandia Mixed Waste Landfill with wells that have PVC screens and casing. The NMED is aware that the Type 304 stainless steel well screens installed at LANL will corrode and prevent detection of the LANL contaminants because of the corrosion that has occurred with the same type of stainless steel well screens at the Sandia Mixed Waste Landfill (MWL). In letters[19,20] dated June 19 and July 7, 2007, the NMED has ordered replacement of the monitoring wells with corroded stainless steel well screens at the Sandia MWL dump with new monitoring wells that have nonmetallic well screens and casing made of the plastic polyvinylchloride (PVC). The wells that require replacement because of corroded screens were installed in 1988 and 1999. The historical water quality data show the stainless steel screens in the MWL wells were corroded after being installed for a period of ten years. Of course, as described in Section 5.0 and 6.0, even the uncorroded stainless steel screens had properties to prevent the detection of groundwater contamination due to releases from the wastes buried in the Sandia MWL dump.

11.0. The NMED has not enforced the requirements in the NMED Consent Order for carefully purging wells before the collection of water samples.

11.1. Failure to sufficiently purge the LANL multiple-screen characterization wells. The NMED approved of the Westbay[R] no-purge water sampling equipment that was installed in the large number of exorbitantly expensive LANL multiple-screen characterization wells. The Westbay[R] systems collected stagnant water samples that were in contact for a long period of time with the stainless steel screens and with the new mineralogy produced by the organic drilling additives and bentonite clay muds. The NMED continues to approve of the no-purge sampling methods up to the present time even after the water quality data from the Westbay[R] sampling systems were proof by year 2001 of the need to actively pump water from each screened interval.

The NMED has not enforced the requirement in the NMED Consent Order for carefully purging wells before the collection of water samples. The pertinent sections from the NMED Consent Order [1] are pasted below:

- "IX.B.2.i.i. Well Purging. All zones in each monitoring well shall be purged by removing groundwater prior to sampling and 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 in writing."
- "IX.B.2.i.ii. Groundwater Sample Collection. Groundwater samples shall be obtained from each well after a sufficient amount of water has been removed from the well casing to ensure that the sample is representative of formation water" [emphasis supplied].

The no-purge sampling methods used in the majority of the LANL characterization wells do not meet the rigorous purging requirements described in the Consent Order. The Consent Order requires LANL to collect water samples from the network of characterization wells on an annual basis with analytical results presented in the *Interim Facility-Wide Groundwater Monitoring Plan.* However, in the network of characterization wells that are sampled to meet the requirement of the Consent Order, more that fifty (50) of the screened intervals are sampled with the no-purge methods that the Consent Order prohibits.

The information presented in this report about the properties of the stainless steel screens to mask the detection of many of the LANL contaminants is proof that the collection of no-purge water samples is a practice that must stop. NMED is being irresponsible for not enforcing the requirement in Section IX.B.2.i.i. in the Consent Order that

> "All zones in each monitoring well shall be purged by removing groundwater prior to sampling and in order to ensure that formation water is being sampled."

The National Academy of Sciences (NAS) Final Report [21] on the LANL Groundwater Protection Practices described the importance to purge sufficient water from each LANL well before collecting water samples:

- "Application of proper purging techniques in both well development and groundwater sampling is necessary for collection of representative groundwater samples, especially in the regional aquifer. The most trustworthy sampling technique includes purging three or more well volumes from the monitoring well before sample collection." p.56

Despite the NAS finding, the NMED is still not enforcing the requirement of the Consent Order to properly purge the LANL wells to ensure that the samples are representative of formation water. Of course, purging very large quantities of water from the LANL characterization wells may not improve the ability of the wells to produce *in situ* formation water. In addition, the purging does not address the many other factors (see the list of factors in section 1.0) that prevent practically all of the LANL characterization wells from producing the data needed for decisions in the Consent Order and from meeting the requirements for reliable long-term monitoring wells.

11.2. <u>Failure to sufficiently purge the LANL single-screen characterization wells</u>. The study of trends in the water quality data for water samples collected from the three single-screen characterization wells R-16r, R-21 and R-23 is proof that DOE/LANL are not purging a sufficient amount of water from many of the single-screen wells to ensure that the water samples are technically defensible as being reliable and representative of formation water. The poor reliability of the water quality data for the single-screen wells R-16r, R-21 and R-23 are demonstrated by the summary data presented in Tables 1, 2 and 3. The poor quality of the water samples produced from the three single-screen wells even after purging is further proof that the no-purge water samples collected with the Westbay no-purge sampling systems from the multiple-screen characterization wells are not technically defensible as being reliable and representative of the in situ formation water.

The trends displayed in Tables 1, 2, and 3 are proof that the statistical scheme used in the LANL WSAR-2 is <u>not credible</u> to assess that any discrete screen in the entire network of LANL characterization wells produces technically defensible water samples for the detection of the LANL contaminants of concern. There is no technical basis for the claim in Table 6-4 in the LANL WSAR-2 that wells R-16r, R-21 and R-23 produce water samples that are technically defensible for detection of all of the LANL contaminants of concern including the RCRA trace metals and the DOE trace metal radionuclide contaminants.

The fact that the three wells do not produce water samples that are technically defensible for the detection of the RCRA trace metals and the DOE trace metal radionuclide contaminants is proven by the trend analyses of the data presented in Tables 1, 2, and 3. The tables present the trends in the analytical results for selected dissolved constituents from the first water samples to the most recent. The selected constituents occur naturally in the regional aquifer and the measured concentrations should show very little change from the first sample to the most recent. In fact, the data for the three wells show little change from the first to the most recent samples for the dissolved concentrations of strontium and chloride but very large declines over time for many trace metals that occur naturally in the groundwater.

All three wells show a large decline for the measured dissolved concentrations of the naturally occurring trace metals zinc, barium, molybdenum and boron in the groundwater samples collected from the three wells. The water samples from well R-16r also show a large decline in the measured concentrations of dissolved vanadium and the water samples from well R-23 also show a large decline in the measured concentrations of dissolved nickel. The removal of the trace metals from the water samples is because of 1). the sorptive properties of the new mineralogy in the screened interval that was formed by the drilling fluids, and 2). the sorptive properties of the stainless steel screens.

The declines in measured concentrations of the trace metals are summarized below for each well. For comparison, the measured variations of dissolved concentration of strontium and chloride are also presented.

- **Well R-16r**
- **Dissolved zinc declines by 86% from 57 ug/L to 7.8 ug/L**
- **Dissolved barium declines by 80% from 340 ug/L to 67.3 ug/L**
- **Dissolved vanadium declines by > 80% from 11 ug/L to < 2 ug/L (not detected)**
- **Dissolved molybdenum declines by > 65% from 5.6 ug/L to < 2 ug/L (not detected)**
- **Dissolved boron declines by >80% from 83 ug/L to ~16.5 ug/L**

- **Dissolved chloride concentrations show little change in an overall range from 2.24 to 2.4 mg/L - a variation of 6%.**
- **Dissolved strontium concentrations vary from 156 to 199 ug/L (20% variation) but do not show a declining trend.**

- **Well R-21**
- **Dissolved zinc declines by > 75% from 7.8 ug/L to < 2 ug/L (not detected)**
- **Dissolved barium declines by 18% from 16.1 ug/L to 13.3 ug/L**
- **Dissolved molybdenum declines by > 50% from 3.85 ug/L to < 2 ug/L (not detected)**
- **Dissolved boron declines by 26% from 15.9 ug/L to 11.7 ug/L.**

- **Dissolved chloride concentrations show little change in an overall range from 1.75 to 1.96 mg/L - a variation of 10%.**
- **Dissolved strontium concentrations show little change in an overall range from 44 to 45.8 ug/L - a variation of 4%.**

- Well R-23

- Dissolved zinc declines by > 95% from 30 ug/L to < 2 ug/L (not detected)
- Dissolved barium declines by 53% from 47 ug/L to 21.8 ug/L
- Dissolved molybdenum declines by > 50 % from 3.1 ug/L to < 2 ug/L (not detected)
- Dissolved boron declines by 53% from 29 ug/L to 13.7 ug/L
- Dissolved nickel declines by 73% from 2.6 ug/L to ~0.7 ug/L

- Dissolved chloride concentrations show little change in an overall range from 3.52 to 4 mg/L - a variation of 10%.
- Dissolved strontium concentrations decline from 88 ug/L in an early sample to 76 ug/L in the most recent - a decline of 13%.
- High total nitrate plus nitrite concentrations are evidence of a contaminant plume at the location of well R-23. The values range up to 1,510 ug/L compared to the background value of 330 ug/L.

The large declines in the measured concentration of the naturally occurring trace metals in the water samples produces from wells R-16r, R-21, and R-23 are proof that a sufficient volume of water is not purged from any of the three wells and all of the water quality data are not technically defensible to prove that the groundwater in the regional aquifer is not contaminated with RCRA trace metals or with the DOE trace metal radionuclide contaminants including the isotopes of plutonium, americium, cobalt, cesium, etc. that are a concern for the buried wastes in MDA G, MDA H, and MDA L.

The failure of the three wells to produce reliable water samples is a combination of the stainless steel screens and the new mineralogy formed in the screened intervals by the organic drilling fluids and also bentonite clay for well R-23. A field study is necessary to investigate if purging large quantities of water from the three wells can improve the ability of the wells to produce reliable and representative water samples. The study should include continuously pumping the wells for a period of possibly longer than 15 days with collection of water samples on a time schedule for analysis of selected constituents including the RCRA metals and the DOE trace metal radionuclides.

The nitrate contamination measured in the water samples produced from well R-23 is a special concern that requires installation of a cluster of new monitoring wells at the location of well R-23 to characterize the nature and extent of the contamination that is present in the plume. The factors that prevent well R-23 from producing reliable and representative water samples include

- 1). the Type 304 stainless steel screen,
- 2). the large quantity of organic drilling additives and bentonite clay muds that were allowed to invade the screened interval,
- 3). the hydraulic force of the mud-rotary drilling method for invading the screened interval with the bentonite clay muds was orders of magnitude greater than the hydraulic force available to the development methods for removing the drilling additives,
- 4). the restrictive design of the pipe-based stainless steel screen in well R-23 (see Figure 4) is another factor that prevents the well development procedures from being able to recover the drilling muds, and
- 5). The 57-ft length of the well screen (see Figure 3) will cause dilution of contamination that is present in a discrete zone over the length of the screen. The

screen is installed across the water table and dilution of contamination at the water table is ensured because the intake for the submersible pump is located at the bottom of the screen. The position of RCRA[7] and the NMED Consent Order[1] is that screen length should not exceed 10 feet.

12.0. <u>NMED approved technically flawed LANL report to assess reliability of LANL characterization wells</u>. In the report - *Well Screen Analysis Report-Revision 2* [2] (WSAR-2), LANL has developed a badly flawed scheme to use only "snapshots" of the water quality data from the characterization wells to make an assessment for the ability of the discrete screened intervals to produce reliable and representative water samples. The reports by the NAS [21] and the EPA[22,23,24] described why the statistical scheme in the WSAR-2 cannot identify if any LANL well produces reliable and representative water samples.

The NAS Final Report [21] described why the scheme in the LANL *Well Screen Analysis Reports* was not credible to determine that the LANL monitoring wells would detect the LANL contaminants:

- "Evidence about the conditions prevalent around the screens in the compromised wells is indirect—relying on plausible but unproven chemical interactions, general literature data, analyses of surrogates, and apparent trends in sampling data that may not be statistically valid." p. 60

In 2005, prior to the study by the National Academy of Sciences (NAS), the Northern New Mexico Citizens Advisory Board (the CAB) asked the EPA Kerr Laboratory to review the original version of the WSAR. The EPA findings were published in three reports[22,23,24]. Excerpts from the February 2006 EPA report [24] are pasted below:

- "In general, the criteria used to evaluate the representativeness of ground-water samples from well screens installed under the hydrogeologic characterization program still fail to consider impacts that may be present following biodegradation of residual organic drilling additives and the return of oxidizing conditions." p.1
- "The changes in aquifer mineralogy resulting from iron- and sulfate-reducing conditions established by biodegradation of organic drilling additives can significantly alter the sorption characteristics for reactive site contaminants. The changes in aquifer sorption properties and, therefore, reactive contaminant movement to impacted well screens will not be adequately reflected by the LANL criteria." p. 1-2
- "The well screen assessment only utilizes data from the most recent sampling rounds. Examination of trends [from the first to the most recent water samples] provides another line of evidence regarding the condition of impacted well screens and should be formally included in these evaluations." p.3.

- The CAB has asked the EPA Kerr Laboratory to review the latest version of the LANL report (the WSAR-2). That review will be conducted this summer.

Despite the findings by the NAS and EPA, in a letter [25] dated May 25, 2007, the NMED approved of the scheme in the WSAR-2 for the purpose to monitor the progress of the impacted screens to clean up and produce reliable and representative water samples for the detection of hazardous wastes. However, It is important to note that the NMED approval letter expressed uncertainty for the assessment by the WSAR-2, with special uncertainty for the DOE trace metal radionuclide contaminants. An excerpt from the NMED approval letter is pasted below:

> "NMED notes that the conclusions obtained in the Report were derived mainly from analysis of extent data in the literature, possibly under conditions different from the Los Alamos National Laboratory's site (the site). The absence of critical site-specific data, such as adsorption properties, reaction kinetics and microbial activities, implies that there would be uncertainties and limitations in using the methodology developed in the Report to assess the quality of groundwater samples collected from monitoring wells installed at this site. NMED is especially concerned about the uncertainty with respect to monitoring certain potential contaminants of concern, such as the highly adsorptive radionuclides. NMED therefore suggests that the Permittees consider conducting proper laboratory and field studies to address the uncertainty regarding whether or not the monitoring wells installed as the monitoring network are capable of providing reliable data to monitor potential releases of the highly adsorptive radionuclides from operation of the Laboratory to groundwater."

The above statement alone in the approval letter is proof that the NMED has made a mistake to approve of the LANL WSAR-2. In addition, the information presented in this report is proof that the statistical scheme in the LANL WSAR-2 is not credible to assess the impact of stainless steel screens or the new mineralogy produced by the drilling fluids on the water quality produced from the LANL characterization wells.

NMED should order DOE/LANL to retract the LANL Well Screen Analysis Report - Revision 2 and instruct the LANL scientists to not revise the report because the statistical study of only water quality data is not sufficient to identify if any of the LANL characterization wells produce reliable and representative water samples.

NMED should order DOE/LANL to install a new network of monitoring wells

- 1). with drilling methods that do not invade the screened intervals with any organic drilling additives or bentonite clay muds, and
- 2). with nonmetallic well screens because stainless steel screens have properties to prevent the detection of many LANL contaminants and especially the RCRA trace metals and the DOE trace metal radionuclides.

In addition, the new network of monitoring wells is required because of the factors listed in Section 1.0. of this report.

NMED should modify the schedule in the NMED Consent Order because the existing network of LANL characterization wells and old test wells do not provide the data that is necessary to support decisions on corrective action for the contaminated canyons or the legacy waste dumps referred to as Material Disposal Areas (MDAs).

Contact Robert H. Gilkeson with questions or comment.

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Table 1. Water quality data from LANL characterization well R-16r.
Well R-16r has a single-screen with an electric submersible pump.

- Well No. - R-16r	Zinc ug/L F / T	Ba ug/L F	Sr ug/L F	Cr ug/L F	V ug/L F	Mo ug/L F	B ug/L F	Ni ug/L F	Cl mg/L F	D.O. mg/L T
10-17-05	57 / NA	340	170	3.8	11	2.5	83	< 10U	2.39	?
12-19-05	< 5.5 J / < 6.9 J	76.6	192	9.6	5.6	5.6	< 10U	2 J	2.38	4.33
03-08-06	< 7.1 J / < 11	69.5	189	10.3	3.5	3.5	20 J	1.5 J	2.3	3.22
03-08-06*	< 7.6 J / < 7.6 J	70.7	191	10.8	3.1	3.1	19.1J	1.6 J	2.3	
05-24-06	< 9.3 J / < 12.3 J	71.1	192	11.9	2.7J	2.7	19.4J	1.6 J	2.38	4.38
08-17-06	< 7.6 J / < 10 J	58.3	160	9.9	2.1J	2.1	17.7J	2.3	2.35	4.49
08-17-06*	< 7.2 J / < 11.2	55.1	152	9.2	< 2U	< 2U	14.9J	1.9 J	2.35	
11-01-06	12.7 / 12.5	70.1	196	13.4	< 2U	< 2U	21	2.1	2.4	3.22
03-14-07	< 11.8 / < 13.7	71.6	199	12.8	< 2U	< 4.6J	19.9J	2.1	2.36	4.92
03-14-07*	< 11.6 / < 12.6	68.3	190	12.3	< 2U	< 2.1J	18.7J	2.8	2.32	
06-13-07	56.9? / 11.2	66.6	192	12.1	2.2J	2.2J	19.5J	2.7	2.34	5.2
06-13-07*	9.7 / 10.9	68.1	196	12.7	2.4J	2.4J	18.8J	1.9 J	2.27	
08-20-07	7.8 / 10.5	67.3	189	11.9	< 2U	< 2U	16.5J	1.9 J	2.24	4.6

Ba = barium, Sr = strontium, Cr = total chromium, V = vanadium, Mo = molybdenum,
B = boron, Ni = nickel, Cl = chloride, D.O. = dissolved oxygen,
ug/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
F = analyses on filtered water sample
T = analyses on unfiltered water sample
NA = not analyzed
U = constituent was not detected with the limit of detection the listed < value.
* = analytical results for duplicate sample
J = estimated value

- Trends over time for water samples produced from well R-16r

- Dissolved zinc declines by 86% from 57 ug/L to 7.8 ug/L

- Dissolved barium declines by 80% from 340 ug/L to 67.3 ug/L

- Dissolved vanadium declines by > 80% from 11 ug/L to < 2 ug/L (not detected)

- Dissolved molybdenum declines by > 65% from 5.6 ug/L to < 2 ug/L (not detected)

- Dissolved boron declines by >80% from 83 ug/L to ~16.5 ug/L

- Dissolved chloride concentrations show little change in an overall range from 2.24 to 2.4 mg/L - a variation of 6%.

- Dissolved strontium concentrations vary from 156 to 199 ug/L (20% variation) but do not show a declining trend.

Table 2. Water quality data from LANL characterization well R-21.
Well R-21 has a single-screen with an electric submersible pump.

- R-21 Sample Date	Zinc ug/L F / T	Ba ug/L F	Sr ug/L F	Cr ug/L F	V ug/L F	Mo ug/L F	B ug/L F	Ni ug/L F	Cl mg/L F	D.O. mg/L T
03-31-04	7.58 / 5.81	15.6	45.1	1.78J	5.28	3.85	10.1	< 0.69U	1.98	?
03-31-04*	4.42 / 5.51	16.1	45.5	1.92J	5.16	3.83	7.95	0.861J	1.94	
06-30-04	7.81 / 16	15	45.8	2.36 B	5.03	2.7	< 17.9	< 0.69U	1.92	3.9
09-23-04	< 2.8J/< 3.5J	14.9	45.8	< 3.9J	4.5	2.2	12.4	< 1.8 J	1.75	
12-14-04	7.4 / 7.8	14.1	45.6	3 J	5	2.1	< 20.8	< 0.69U	1.88	4.8
06-06-05	< 2.9 J/< 3J	14.7	45.4	2.4 J	5.3	3.1	15.9	0.47J	1.76	4.33
06-06-05*	< 2 U /< 2.3J	14	44.3	1.6 J	< 5.1	< 2 U	12.3	0.58J	1.74	
07-07-06	< 3J /< 3.6J	14.1	44	3.1	5.3	3.1J	15.3	0.59J	1.86	4.32
11-06-06	< 2.7J/< 3.6J	14.1	45.6	3.6	6.4	3 J	15.9	0.57J	1.95	3.98
11-06-06*	< 5.6J/< 4.2J	13.5	44.7	2.7 J	5.3	3.7J	13	0.56J	1.96	
03-15-07	< 2.7J/<4.7J	13.7	45.4	3.5	< 5.7	< 2U	11.6	0.54J	1.89	4.43
06-13-07	6.5 J / 2.3 J	13.1	45.1	3.1	5.1	< 2U	12.3	< 0.5U	1.85	5.1
08-20-07	< 2 U / < 2 U	13.3	45.4	< 4.9	5.5	< 2U	11.7	0.61J	1.82	5

Ba = barium, Sr = strontium, Cr = total chromium, V = vanadium, Mo = molybdenum,
B = boron, Ni = nickel, Cl = chloride, D.O. = dissolved oxygen,
ug/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
F = analyses on filtered water sample
T = analyses on unfiltered water sample
NA = not analyzed
B = reported value was obtained from a reading that was less than the Contract Required Detection Limit (CRDL) but greater than or equal to the Instrument Detection Limit (IDL).
U = constituent was not detected with the limit of detection the listed < value.
*** = analytical results for duplicate sample**
J = estimated value

- Trends over time in water samples produced from well R-21

- **Dissolved zinc declines by > 75% from 7.8 ug/L to < 2 ug/L (not detected)**
- **Dissolved barium declines by 18% from 16.1 ug/L to 13.3 ug/L**
- **Dissolved molybdenum declines by > 50% from 3.85 ug/L to < 2 ug/L (not detected)**
- **Dissolved boron declines by 26% from 15.9 ug/L to 11.7 ug/L.**

- **Dissolved chloride concentrations show little change in an overall range from 1.75 to 1.96 mg/L - a variation of 10%.**
- **Dissolved strontium concentrations show little change in an overall range from 44 to 45.8 ug/L - a variation of 4%.**

Table 3. Water quality data from LANL characterization well R-23.
Well R-23 has a single-screen with an electric submersible pump

- R-23 Sample Date	Zinc ug/L F / T	Ba ug/L F	Sr ug/L F	N ug/L F / T	Mo ug/L F	B ug/L F	Ni ug/L F	Cl mg/L F	D.O. mg/L T
10-17-02	1 / NA	47	NA	470 / NA	3.1	29	2.6	3.72	?
12-17-03	1.13B/<0.883U	37.8	85.4	520 / 460	1.68	13.2	1.28	3.52	0.9
03-23-04	30.5 / 22.6	30	88	650 /880	1.51	9.85	< 0.69 U	3.87	?
03-23-04*	29.3 / 23.6	30.7	86.4	650 /860	1.56	10.8	< 0.69 U	3.86	
06-29-04	12 / 10.5	29.1	85.2	940 / 970	1.66	< 19.9	< 0.69 U	4	3.9
06-29-04*	11.3 / 10.4	29.5	87.1	960 /960	1.68	17.4	< 0.69 U	3.96	
09-24-04	< 5.5 / < 5 J	28.5	83.8	1360 / 1380	1.4	18.7	< 1.7 J	3.74.	3
07-14-05	18.4 / < 11	26.8	81.9	1020 / NA	< 2 U	15.2	1.4 J	3.95	3.6
07-14-05*	16.1 / < 12.3	26.8	81.6	1030 / 1380	< 2 U	11.1	1 J	3.67	
08-15-06	2.5 J / 3.7 J	24.6	79.9	1360 / 1470	< 2 U	15.6	< 0.5 U	3.64	6.09
08-15-06*	< 2 U / 2.6 J	24.7	80.4	1380 / 1550	< 2 U	14.5	< 0.5 U	3.67	
12-18-06	< 2.2 J / 40.1	21.6	73.6	1340 / 1270	< 2 U	11.6	< 2.5 U	3.75	6.47
12-18-06*	< 2 U / < 3 J	23.9	81.6	1290 / 1470	< 2 U	11.8	< 2.5 U	3.73	
03-19-07	< 2.8 J / < 5.8 J	23.6	80.5	1060 / NA	< 2 U	13	0.53 J	3.6	4.38
03-19-07*	< 3 J / < 5.2 J	24	80.4	948 / NA	< 2 U	12.8	0.57 J	3.67	
06-25-07	< 2 U / < 2 U	23.9	82.1	1310 / NA	< 2 U	14.9	0.55 J	3.78	5.1
06-25-07*	< 2 U / < 2 U	24	83	1360 / NA	< 2 U	15	< 0.5 U	3.82	
09-06-07	< 2 U / < 2 U	23	80.3	1230 / NA	< 2 U	14.4	0.72 J	3.59	4.1
09-06-07*	< 2 U / < 2 U	21.8	76	1340 / NA	< 3.5J	13.7	0.7 J	3.64	

Ba = barium, Sr = strontium, N = nitrate + nitrite, Mo = molybdenum, B = boron,
Ni = nickel, Cl = chloride, D.O. = dissolved oxygen,
ug/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
F = analyses on filtered water sample
T = analyses on unfiltered water sample
NA = not analyzed
U = constituent was not detected with the limit of detection the listed < value.
*** = analytical results for duplicate sample**
J = estimated value

- Trends over time in water samples procuced from well R-23

- **Dissolved zinc declines by > 95% from 30 ug/L to < 2 ug/L (not detected)**
- **Dissolved barium declines by 53% from 47 ug/L to 21.8 ug/L**
- **Dissolved molybdenum declines by > 50 % from 3.1 ug/L to < 2 ug/L (not detected)**
- **Dissolved boron declines by 53% from 29 ug/L to 13.7 ug/L**
- **Dissolved nickel declines by 73% from 2.6 ug/L to ~0.7 ug/L**

- **Dissolved chloride concentrations show little change in an overall range from 3.52 to 4 mg/L - a variation of 10%.**
- **Dissolved strontium concentrations decline from 88 ug/L in an early sample to 76 ug/L in the most recent - a decline of 13%.**
- **High total nitrate plus nitrite concentrations are evidence of a contaminant plume at the location of well R-23. The values range up to 1,510 ug/L compared to the background value of 330 ug/L.**

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Exhibit R-22. <u>Mistakes in the Well Installation and Collection of Water Samples at LANL Characterization Well R-22 in Technical Area 54</u>. Well R-22 was installed to monitor groundwater contamination below MDA G, a 63-acre radioactive and hazardous waste disposal site where burial of radioactive waste, hazardous waste, and mixed waste (radioactive waste with a component of hazardous waste) started in 1957 and continued to 1986. At MDA G, the wastes were buried in unlined pits, trenches, and shafts. The disposal of low-level radioactive waste continued from 1986 to the present time in unlined trenches and shafts that are described as located in Area G. See Figure 1 for the location of well R-22 and MDA G / Area G. Figure 3 is the as-built construction of multiple-screen well R-22.

<u>MDA G is a RCRA Regulated Unit</u>. The Resource Conservation and Recovery Act (RCRA) identifies MDA G as a RCRA "regulated unit" because hazardous wastes were disposed of at MDA G after July 26, 1982. RCRA requires a network of monitoring wells at MDA G that meet the requirements in 40 CFR §§264.91 through 264.100 (the set of regulations are referred to as RCRA §264 Subpart F).

The recent LANL report "*Technical Area 54 Well Evaluation and Network Recommendations, Revision 1"* (LA-UR-07-6436 October 2007) (TA-54 workplan) describes the groundwater monitoring required under RCRA for MDA G as follows:

> "The following requirements from 40 CFR 264.90 - 99, Subpart F apply to permitted units or regulated units that received waste after July 26, 1982. The regulations apply throughout the active life of the units and the closure and post-closure period if the units are not "clean-closed" under RCRA. <u>The groundwater-monitoring network and facility process must be able to detect, evaluate, and respond to releases of hazardous waste or hazardous waste constituents into the uppermost aquifer</u>" [emphasis supplied]. p. 6.

DOE/LANL have never been in compliance with the groundwater monitoring requirements of RCRA §264 Subpart F for MDA G and the proposed network of monitoring wells in the above cited LANL TA-54 workplan <u>still fail</u> to meet the RCRA requirements for a network of monitoring wells that are "able to detect, evaluate, and respond to releases of hazardous waste of hazardous waste constituents into the uppermost aquifer."

A major reason for this failure is that the LANL TA-54 workplan does not acknowledge the RCRA hazardous waste contaminants that were detected in the water samples produced from well R-22, and accordingly, the Compliance Monitoring Program in RCRA §264.99 is required for the monitoring well network at MDA G. The radionuclide and hazardous contaminants detected in well R-22 are summarized in Table R-22 -2.

A second reason is that the TA-54 workplan does not recognize that the aquifer zone sampled by screen #1 in well R-22 is the "uppermost aquifer" that RCRA requires to be carefully monitored for the detection of contamination. The TA-54 workplan acknowledged that screen #1 cannot be rehabilitated but then made the mistake to use screen #2 and screen #3 in well R-22 to monitor groundwater contamination from MDA G. This plan is unacceptable because screen #2 is installed in an unproductive zone of basalt that RCRA identifies as a confining bed. Screen #3 is located too deep below the water table and also is installed in an unproductive zone. The low permeability (saturated hydraulic conductivity or Ksat) of the formations surrounding screen #1 and #2 are documented by injection tests performed in the screened intervals.

The geologic record from drilling the R-22 borehole and the Schlumberger[R] borehole geophysics provide important information that identifies the zones where monitoring well screens must be installed. The available information shows that screen #2 and #3 in well R-22 are installed in zones with very low Ksat where groundwater contamination is not expected to be present. The drilling and borehole geophysics record is summarized in Table R-22 -1.

Table R-22 -1. Drilling and Borehole Geophysics Record for Well R-22

- Cerros del Rio Basalt **-**190 to 1173 feet below ground surface (ft bgs)

- 883 ft bgs - water table for the regional aquifer
- 893 to 903 ft - no recovery of drill cuttings and Schlumberger borehole geophysics identifies this zone as a fast pathway in fractured basalt. This zone is the "uppermost aquifer" that RCRA Subpart F requires to be monitored for groundwater contamination. Screen #1 is installed across this zone but has never produced reliable and representative water samples.
- 928 to 958 ft - massive basalt with no mention of fractures. This 30-ft thick layer of basalt is the upper layer of a 90-ft thick confining bed that may be important to prevent downward flow of contamination in groundwater below MDA G.
- Screen #2 is installed from 947 to 989 ft bgs and does not meet requirements of RCRA Subpart F because of 42-ft length and the screen is installed within a thick confining bed in basalt of low permeability as shown by very low measured value for Ksat of 0.04 ft/day.
- 973 to 1018 ft - 45-ft thick layer of massive basalt with no mention of fractures
- 1038 to 1063 ft - 25-ft thick layer of fractured basalt and scoria, drilling record and Schlumberger geophysics identify this interval as a fast pathway with permeability >50 ft/day that are not monitored. RCRA Subpart F requires this zone to be monitored for groundwater contamination.
- 1088 to 1133 ft - 45-ft thick interval with no returns of drill cuttings, drilling record and Schlumberger geophysics identify this interval as a fast pathway in basalt strata with permeability >50 ft/day. Well R-22 does not monitor this zone.

- Puye Sediments 1173 to 1338 ft bgs

- 1188 to 1191 ft - gravel with coarse sand, 1191 to 1237 ft - no recovery of drill cuttings, drilling record is proof of 50-ft thick layer of fast pathway river gravels and cobbles with Ksat >50 ft/day. Well R-22 does not monitor this zone.
- 1273 to 1278 ft, very fine silty sand to pebble gravel, the poorly sorted fine-grained sediments have a low Ksat of 0.32 ft/day measured by a LANL injection test.
- Screen #3 is installed in the depth interval of 1272.2 to 1278.9 ft bgs and is worthless for detecting contamination because of 1). the great depth of 385 ft below the water table, 2). the low permeability of the screened interval, and 3). the contamination of the screened interval by the organic drilling additives and by the bentonite/cement grout that invaded the screened interval because of a mistake in well construction.

RCRA 40 CFR §260.10 has the following definitions that apply to the network of monitoring wells that RCRA §264 Subpart F requires for MDA G:

- *Uppermost aquifer* means the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary.
- *Aquifer* means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of ground water to wells or springs.
- *Confined aquifer* means an aquifer bounded above and below by impermeable beds or by beds of distinctly lower permeability than that of the aquifer itself; an aquifer containing confined ground water.

RCRA §264 Subpart F requires DOE/LANL to replace well R-22 with a cluster of new monitoring wells; one well with a screen placed in the productive aquifer zone at screen #1 in well R-22 - i.e., the "uppermost aquifer" under RCRA and a second well with a screen installed in the first productive zone located below the ~90-ft thick confining bed in the basalt. The new monitoring wells should be located west of well R-22 as close as possible to the eastern boundary of MDA G.

LANL installed characterization well R-22 for monitoring the groundwater from beneath MDA G/Area G that is traveling eastward along poorly understood flow paths toward the Rio Grande and possibly to the San Ildefonso Pueblo and to the Buckman well field, an important water supply for Santa Fe. Below is a summary of the contaminants detected in water samples produced from well R-22 that are published in two LANL reports.

- LANL Well R-22 Completion Report (LA-13893-MS, February 2002).
- LANL Well R-22 Geochemistry Report (LA-13986-MS, September 2002).

Table R-22 -2. Contaminants detected in water samples collected from well R-22

- *tritium (109 picocuries per liter (pCi/L)), - sample collected at the water table
- *technetium-99 (4.3 and 4.9 pCi/L),
- *pentachlorophenol (6.2 micrograms per liter (ug/L)),
- *chloroform (0.94 ug/L),
- *phenol (19 and 32 ug/L),
- *4-methylphenol (44 to 210 ug/L),
- *2-butanone (6.9 to 8.9 ug/L),
- *diethylphthalate (1.3 ug/L),
- benzoic acid (3 to 12.5 ug/L),
- butyl benzyl phthalate (9.8 ug/L),
- toluene (0.2 to 0.76 ug/L),
- methylene chloride (0.62 and 2.2 ug/L),
- bis(2-ethylhexyl)phthalate (1.0 and 3.9 ug/L),
- several substituted benzene compounds including
  isopropylbenzene (0.16 to 0.54 ug/L), and
  1,4-dichlorobenzene (0.16 to 0.23 ug/L).

• Mobile Contaminants. Tritium, technetium-99, and the six chemical contaminants with asterisks in the above list are highly mobile in groundwater. The tritium level of 109 pCi/L was measured in the water sample collected at the water table during drilling of the borehole with water-based drilling fluids. The drill water diluted the actual level of tritium contamination at the water table below MDA G. The six chemical contaminants are commonly found in groundwater beneath hazardous waste landfills studied by the Superfund activities of EPA.

A LANL report – (LA-UR-04-6777, September 2004) recognizes the contamination detected in the water samples produced from well R-22 as follows:

> "Thirty-one volatile and semi-volatile organic compounds have also been detected in water from well R-22. Only two of these, pentachlorophenol (1 detection, 6.2 ppb, MCL = 1 ppb) and benzo(a)pyrene (2 detections, 0.24 ppb, MCL = 0.2 ppb) were present at concentrations above the MCL. Monitoring for organic compounds at well R-22 will continue." [MCL means Maximum Contaminant Level allowed in the EPA Drinking Water Standards].

The large number of hazardous contaminants repeatedly measured in the water samples produced from well R-22 are identified by RCRA §264.98 as "statistically significant evidence of contamination." This contamination requires the Compliance Monitoring Program of §264.99 for MDA G. The depth of the contaminated groundwater below MDA G is not known because of the mistakes in the drilling and installation of well R-22. The drilling of an open borehole allowed the contamination near the top of the regional aquifer to flow down the open borehole. The tritium contamination that is still detected in screen #5 in well R-22 is relict contamination from the downward flow of contaminated groundwater in the open borehole.

The 90-ft thick zone of massive basalt in well R-22 at a short distance below the water table is a confining bed at the location of well R-22 and the confining bed may be an important control to limit the downward travel of groundwater contamination below MDA G. The top of the basalt confining bed is at a distance of 55-ft below the water table. It is very important to investigate the lateral presence of this confining bed below MDA G. This investigation requires the location of monitoring wells and deep boreholes drilled through the confining bed at several locations inside MDA G.

The requirement of RCRA §264 Subpart F to locate monitoring wells within MDA G is described in §264.97 - General Groundwater Monitoring Requirements:

> §264.97(a)(3) - The ground-water monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths to yield ground-water samples from the uppermost aquifer that allow for the detection of contamination when hazardous waste or hazardous constituents have migrated from the waste management area to the uppermost aquifer [The early detection of groundwater contamination requires that monitoring wells are located within MDA G].
>
> §264.97(d) - The ground-water monitoring program must include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide a reliable indication of ground-water quality <u>below the waste management area</u> [i.e., below MDA G and because of the large size of the legacy waste dump, this requirement is only met by locating monitoring wells within MDA G.]

<u>Direction and speed of travel of groundwater in the fast pathway strata below and away from MDAs G, H and L is not known</u>. DOE/LANL has not met the RCRA requirement for annual measurement of the direction and speed of groundwater travel beneath and

away from MDA G. The Detection and Compliance Monitoring Programs of RCRA require LANL to determine the groundwater flow rate and direction in the uppermost aquifer at least annually. From the pertinent parts of RCRA §264 Subpart F:

- §264.98 Detection monitoring program. §264.98(e) The owner or operator must determine the ground-water flow rate and direction in the uppermost aquifer at least annually.
- §264.99 Compliance monitoring program. §264.99(e) The owner or operator must determine the ground-water flow rate and direction in the uppermost aquifer at least annually.

The network of monitoring wells installed at MDA G and site-wide at LANL do not meet the requirements of DOE Order 450.1. ENVIRONMENTAL PROTECTION PROGRAM.

- DOE Order 450.1 requires DOE/LANL to have a groundwater monitoring program at MDA G and site-wide at LANL to accomplish the following:
    - the monitoring program "meets or exceeds compliance with applicable environmental; public health; and resource protection laws, regulations, and DOE requirements" (Section 1, DOE Order 450.1).
    - the monitoring program provides for "implementation of a site-wide approach for groundwater protection" (Section 4.b.(1).(c)., DOE Order 450.1).
    - the monitoring program will "Ensure the early identification of, and appropriate response to, potential adverse environmental impacts associated with DOE operations, including, as appropriate, preoperational characterization and assessment, and effluent and surveillance monitoring" (Section 4.b.(4)., DOE Order 450.1).

This Exhibit and the Report by R.H. Gilkeson - *Properties of the Stainless Steel Screens in the LANL Characterization Wells to Prevent the Detection of Radionuclide and Hazardous Waste Contamination in Groundwater* - Revision 1, May 6, 2008, are proof that DOE/LANL are not in compliance with DOE Order 450.1 for groundwater monitoring at MDA G and site-wide at LANL. After all, DOE Order 450.1 requires compliance with applicable environmental laws including RCRA §264 Subpart F.

DOE is self-regulating for DOE radionuclide contaminants in groundwater and the stainless steel screens in the large network of LANL characterization wells have well known properties (by DOE's own research) to prevent the detection of the DOE trace metal radionuclide contaminants (i.e., isotopes of plutonium, americium, neptunium, cesium, curium, etc.).

Report by the DOE Inspector General

- In September 2005, the DOE IG published a report titled *"Characterization Wells at Los Alamos National Laboratory"* Report DOE/IG-0703. Pertinent excerpts from the report are pasted below:

> "Muds and other drilling fluids that remained in certain wells after construction created a chemical environment that could mask the presence of radionuclide contamination and compromise the reliability of groundwater contamination data" (p.2).

– The DOE IG Report described the requirement of DOE Order 450.1 for a site-wide network of reliable monitoring wells at the Los Alamos National Laboratory by December 31, 2005:

- "The current requirements for a groundwater surveillance monitoring program are found in DOE Order 450.1, "Environmental Protection Program," which LANL has until December 31, 2005, to implement. As LANL works to meet this deadline, we believe that the Laboratory should, as the Hydrogeologic Workplan [characterization] wells are converted to monitoring wells, ensure that monitoring data are reliable. We also believe that particular attention should be given to well development and purging methods, the quality of radionuclide data, and any qualifications on that data" (p.2).

The network of monitoring wells sitewide at LANL and at MDA G are <u>not</u> in compliance with either RCRA or DOE Order 450.1. This was the finding presented in the 2007 Final Report of the National Academy of Sciences (NAS) titled - "Plans and Practices for Groundwater Protection at the Los Alamos National Laboratory." Findings in the NAS Final Report are pasted below:

– "Many if not all of the wells drilled into the regional aquifer under the [LANL] Hydrogeologic Workplan appear to be compromised in their ability to produce water samples that are representative of ambient groundwater for the purpose of monitoring." (p.49)

– "During this study the committee was presented a good deal of information indicating that <u>most or all wells into the regional aquifer at LANL (R-wells) are flawed for the purpose of monitoring</u>. The committee did not disagree, but rather found a <u>lack of basic scientific knowledge</u> that could help ensure future success. Evidence about the conditions prevalent around the screens in the compromised wells is indirect—relying on plausible but unproven chemical interactions, general literature data, analyses of surrogates, <u>and apparent trends in sampling data that may not be statistically valid</u> [emphasis added]." (p.60)

– **"** 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.61)

<u>The network of monitoring wells installed at MDA G / Area G do not meet the requirements of DOE Order 435.1. RADIOACTIVE WASTE MANAGEMENT</u>.

- DOE Order 435.1 has the following requirements in Section 4:

4. REQUIREMENTS.

- b. Radioactive waste shall be managed to:
  (2) Protect the environment.
  (4) Comply with applicable Federal, State, and local laws and regulations.
- c. All radioactive waste shall be managed in accordance with the requirements in DOE M 435.1-1, *Radioactive Waste Management Manual*.

- DOE Order M 435.1-1 has the following requirements:

- 1). "E. Requirements of Other Regulations and DOE Directives:
  - (10) **Mixed Waste**. Radioactive waste that contains both source, special nuclear, or by-product material subject to the *Atomic Energy Act of 1954*, as amended, and a hazardous component is also subject to the *Resource Conservation and Recovery Act* (RCRA), as amended."
- 2). "F. Field Element Managers are responsible for:
  - (15) **Disposal**. Ensuring radioactive waste is disposed in a manner that protects the public, workers, and the environment and in accordance with a radioactive waste management basis. Conducting performance assessment and composite analysis maintenance.
  - (16) **Monitoring**. Ensuring monitoring is conducted for all radioactive waste management facilities as required. Ensuring that disposal facilities are monitored, as appropriate, for compliance with conditions of the disposal authorization statement."
- 3). "Chapter IV. Low-Level Waste Requirements.

  - B. <u>Management of Specific Wastes</u>.

    (1) **Mixed Low-Level Waste**. Low-level waste determined to contain both source, special nuclear, or byproduct material subject to the *Atomic Energy Act of 1954*, as amended, and a hazardous component subject to the *Resource Conservation and Recovery Act* (RCRA), as amended, shall be managed in accordance with the requirements of RCRA and DOE O 435.1, *Radioactive Waste Management*, and this Manual.

  - P. <u>Disposal</u>. Low-level waste disposal facilities shall meet the following requirements.

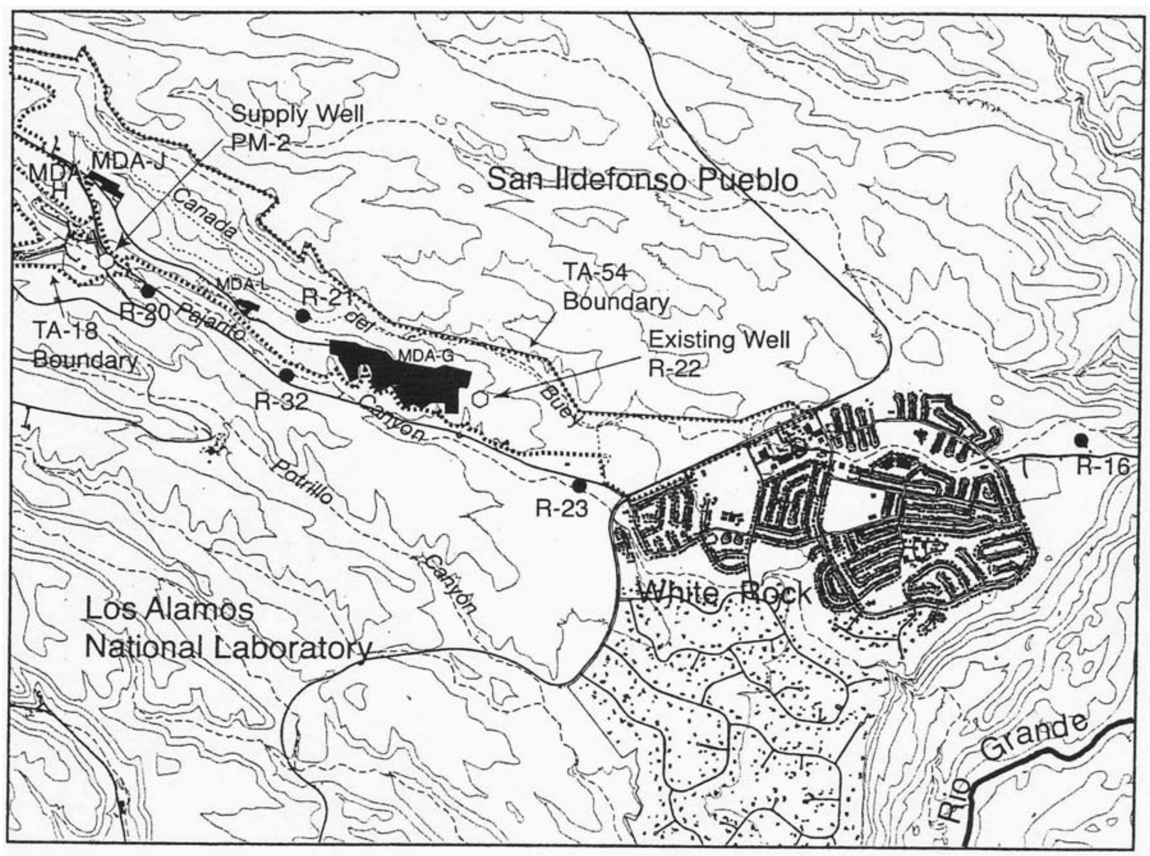
    (4) **Performance Assessment and Composite Analysis Maintenance**. The performance assessment and composite analysis shall be maintained to evaluate changes that could affect the performance, design, and operating bases for the facility. Performance assessment and composite analysis maintenance shall include the conduct of research, field studies, and monitoring needed to address uncertainties or gaps in existing data.

DOE/LANL are not in compliance with the requirements of DOE Order 435.1 for a network of monitoring wells at MDA G / Area G that meet the requirements of RCRA for monitoring the nature and extent of groundwater contamination at the present time and in the future.

The characterization wells installed surrounding MDA G / Area G over the past ten years have identified uncertainties and gaps in existing data. Important new information is the DOE radionuclide contaminants and RCRA hazardous wastes that were detected in the groundwater samples collected from well R-22 (see Table R-22-2).

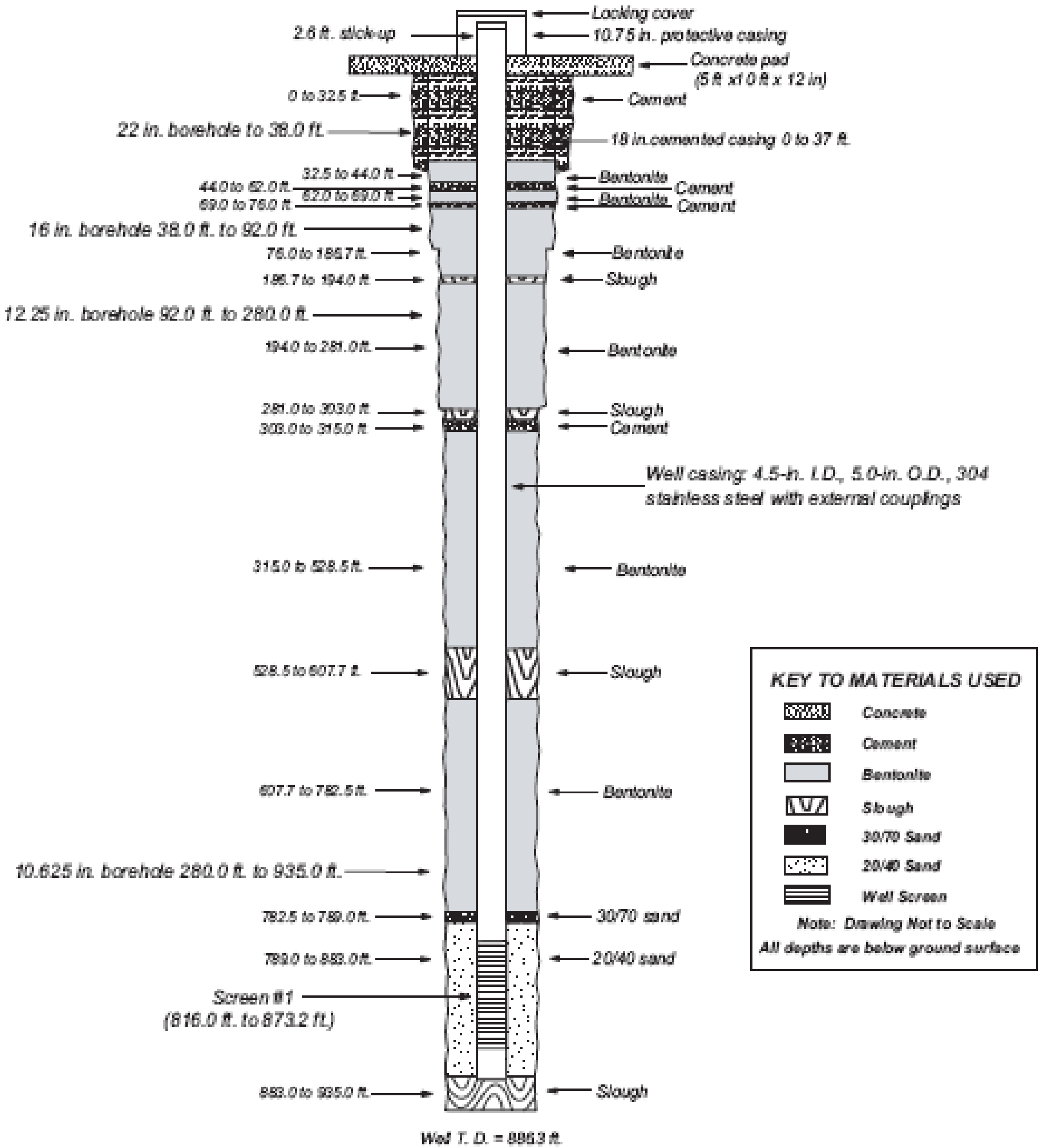
DOE/LANL have failed to do the research and field studies that are required by DOE Order 435.1 to characterize the nature and extent of groundwater contamination below MDA G / Area G and to determine the safety for continued disposal of low-level radioactive waste in unlined pits and trenches at Area G.

Figure 1. MDA G, MDA L, MDA J and MDA H at TA-54. The direction of groundwater flow at the water table of the regional aquifer is from west to east toward the Rio Grande. The LANL characterization wells installed into the regional aquifer (from west to east on the figure) are R-20, R-32, R-21, R-22, R-23, and R-16. Well R-16r is located approximately 20 feet north of well R-16.



Scale 0 1/4 1/2 3/4 1 2 miles

Figure 2. The as-built construction of LANL characterization well R-23.

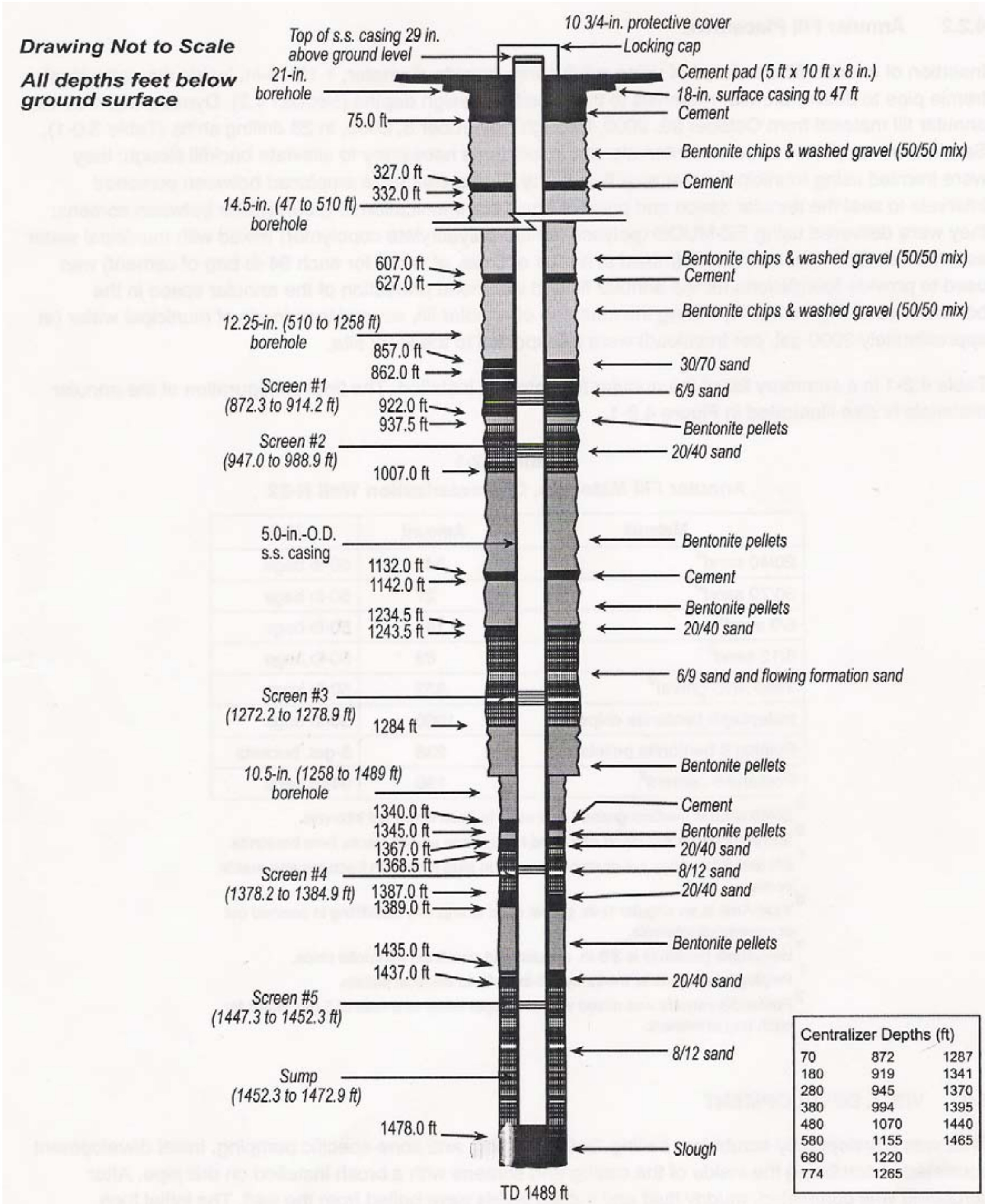


Note: **1. The screen interval lists the footage of the pipe perforations, not the top and bottom of screen joints.**

2. Pipe-based screen: 4.5-in. I.D., 5.563-in. O.D. 304 stainless steel with s.s. wire wrap: 0.010-in. slot.

Source for Figure 2: LANL Characterization Well R-23 Completion Report, (LA-UR-03-2059, June 2003.)

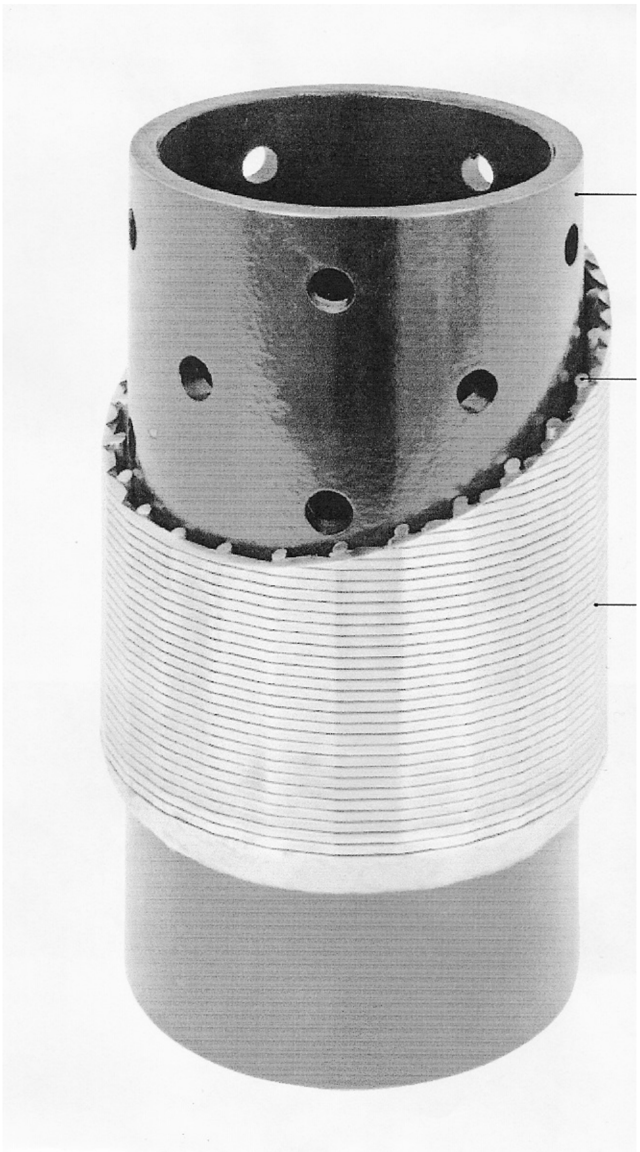
Figure 3. The as-built construction of LANL characterization well R-22.



Note: 1. The screen interval lists the footage of the pipe perforations, not the top and bottom of screen joints.
2. Pipe-based screen: 4.5-in. I.D., 5.563-in. O.D. 304 stainless steel with s.s. wire wrap: 0.010-in. slot.

Source for Figure 3: LANL Characterization Well R-22 Completion Report, (LA-13893-MS, February 2002).

Figure 4. Schematic of the pipe-based wire-wrap stainless steel well screens installed in many of the LANL characterization wells.



The set of drill holes through the base pipe are only 5% of the surface area of the stainless steel screen.

Type 304 stainless steel rods are welded to the base pipe and to each wrap of the wire-wrap screen.

The coils of Type 304 stainless steel wire are wrapped around the base pipe with an opening between each coil of typically one-hundreth of an inch (0.010 inch).

The constrictive design of the pipe-based screens prevents efforts at well rehabilitation from even cleaning residual drilling additives and clays from the wire wraps of the well screens. Deep cleaning of the new mineralogy produced by the drilling additives from the filter pack that surrounds the well screen and from the zone surrounding the borehole is not feasible.