June 7, 2006

John E. Kieling, Program Manager
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Bldg. 1
Santa Fe, New Mexico 87505-6303

Re: Recommendations re: Sandia National Laboratories' Mixed Waste Landfill Permit Modification - Corrective Measure Implementation Plan (CMIP) and Fate and Transport model (FTM) for the Mixed Waste Landfill.

Dear Mr. Kieling:

Attached are recommendations complied by Paul Robinson, Research Director for the Southwest Research and Information Center, on behalf of Citizen Action New Mexico re: Sandia National Laboratories' Corrective Measure Implementation Plan (CMIP) and Fate and Transport model (FTM) for the Mixed Waste Landfill.

For your convenience we have also attached recommendations submitted to the NMED under this comment period by Robert H. Gilkeson citing deficiencies in the construction of the monitoring wells and sampling methods currently used to detect contaminants at the Mixed Waste Landfill.

We look forward to your responses to our comments. If you have any questions please feel free to contact me at: (505) 262-1862. Thank you for your consideration.

Sincerely,

Sue Dayton, Director
Citizen Action New Mexico
(505) 262-1862

RECOMMENDATIONS

Sandia National Laboratories'
Corrective Measure Implementation Plan (CMIP)
Fate and Transport model (FTM) for the Mixed Waste Landfill (MWL)

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June 7, 2006

Citizen Action Recommendations
CMIP/FTM
Mixed Waste Landfill
Sandia National Laboratories

Citizen Action New Mexico submits the following recommendations based on new information available to the New Mexico Environment Department (NMED) since the Sandia National Laboratories' Mixed Waste Landfill Permit Modification was approved.

The recommendations are based on new information from comments submitted by members of the public, the Corrective Measures implementation Plan (CMIP) and Fate and Transport model (FTM) for the Mixed Waste Landfill (MWL), and information presented at the Technical Discussion Public Meeting convened by the NMED on May 25, 2006:

I. General:

A) NMED defer final approval of Mixed Waste Landfill Corrective Measure Implementation Plan (CMIP) pending review of a remedy based on new information in Fate and Transport Model (FTM) and additional information provided in response to NMED queries.

B) NMED revise its MWL "Permit Modification" to require submittal, review, and approval of a Long-term Monitoring and Maintenance Plan (LMMP) on a schedule parallel to the schedule for the remaining portions of the CMIP rather than deferring the submittal of the LMMP until the 180 days following completion of the construction of the corrective measure as may be approved in the future.

These recommendations are based on information presented in the CMIP, FTM, public comments and the Technical Discussion Public Meeting of May 25, 2006, to demonstrate that the effectiveness of the CMIP is dependent on the implementation of the Long-term Monitoring and Maintenance Plan (LMMP) associated with the CMIP as installed and operated.

In the CMIP, SNL/DOE provided substantial information regarding critical portions of the needed LMMP including trigger levels and moisture monitoring systems.

The LMMP should include, but not be limited to:

1. Bio-monitoring program including establishment of bio-monitoring triggers at a significant increase over background to establish baseline and identify bio-accumulation, if any, in plant, animal and insects species in and around the MWL for as long as the waste remains in place. This program would include the identification of specific

species to be monitored, frequency of sampling, and type of contaminates to be monitored (radiological, volatile organic compounds (VOCs), and heavy metals).

2. Require SNL/DOE to establish and maintain site access controls and use restrictions as identified in the CMS and Administrative Order on Consent Based immediately.

3. Vadose zone monitoring of VOCs, moisture and an appropriate suite of radionuclides and metals to verify model outputs; establishment of a statistically defensible baseline; and consideration of continuous monitoring.

4. Reinstalled monitoring wells before any cover is installed to insure that drilling equipment does not damage the evapotranspirative cover for the MWL.

C) NMED require replacement of the existing set of monitoring wells and acquire a comprehensive suite of data from the replacements wells based on the analysis of MWL construction and sampling data recommended by R. H. Gilkeson and provided to NMED as comments and recommendations regarding the MWL CMIP and FTM.

Citizen Action recommends that the ground water monitoring wells at the MWL be replaced with wells that meet regulatory standards including RCRA standards capable of meeting applicable data quality objectives and providing reliable and verifiable water quality and soil column data.

Citizen Action recommends that NMED conduct an independent analysis of the effectiveness of the monitoring wells to identify the occurrence of VOCs and other constituents of concern including those modeled in the FTM.

The monitoring well replacements are needed due to the defects in well construction and completion and the generation of unreliable data about water quality below the MWL. The replacement wells are needed to:

1. Conduct lawfully adequate characterization of soil column and upper most aquifer;
2. Provide accurate and verifiable groundwater sampling data including appropriate trigger levels; and
3. Refine and enhance the FTM model.

D) NMED require a revised set of geophysical surveys of the MWL to update and enhance the Phase 2 data on to provide detailed information about the shape, distribution and content of containers in the MWL, the distribution of metals and other materials in landfill, and otherwise expand knowledge of inventory. This updated geophysical baseline should include replication of geophysical investigations in the RFI Phase 2 Report with contemporary equipment and analytic capabilities as well as conduct of additional geophysical analyses including, but not limited to sonar, ground penetrating radar, and magnetic resonance.

II. Specific Recommendations:

A) Full disclosure of FTM model input data;

B) A revised and expanded FTM to address the range of parameters associated with "model uncertainties/sensitivities" – including vadose zone profile (Kd), half-life (degradation), inventory of VOCs, as identified at FTM p. 57;

C) The implementation of a subsurface sampling program to identify distribution of VOCs detected in the MWL RFI Phase 2 Report to verify and/or refine FTM model results, applying including appropriate QA/QC methods including split sampling with NMED incorporating duplicates and blank samples to verify analytic accuracy;

D) Establishment of trigger levels for agency and public notification and initiating responsive action at values 50% - 100% above background and/or 50% above detection limit for VOCs identified in 1993-4 and technogenic radionuclides, and an appropriate suite of metals and naturally-occurring radionuclides;

E) Establishment of a shallow (less than 50 foot depth) subsurface monitoring program in the vadose zone for detection of VOCs as part of long-term a maintenance and monitoring plan and apply triggers at those sites;

F) An enhanced version of the FTM be run for the *full range* of VOCs identified in soil in the MWL RFI Phase 2 Report including, but not limited to dichloro-difluoromethane; trichloroethene; 1,1,1-trichlorethane (TCA), toluene, ethylbenzene, xylene, 1,1,2-tri-chloro-trifluoroethane, dichloroethyne, acetone, isopropyl ether, 1,1-dichloroethene and styrene. The MWL RFI Phase 2 Report identifies dichloro-difluoromethane concentrations of 29,000 ppb at 10 feet and 21,500 ppb at 30 feet at Fir 4.5 – 16 and Fig. 4.5-22, which are 4 – 5 times higher than the concentrations of PCE detected at those depths in the same report;

G) The enhanced FTM realizations include considerations of VOC concentrations 100x and 1000x the concentrations identified in soil the MWL RFI Phase 2 Report;

H) Identification, compilation and review of container deterioration data applicable to containers identified at or likely to have been disposed of at the MWL including information from other SNL, Lockheed, and DOE sites to determine container patterns applicable to the MWL;

I) Identification and submittal to NMED and review other models of VOC movement conducted by Sandia for other waste sites at SNL including, but not limited to the Chemical Waste Landfill, Liquid Waste Disposal System, and Lurance Canyon sites located at SNL.

III. CMIP Recommendations

A) Locate run-off and run-on collection and diversion canals/swale away from the perimeter of cover system to manage flows from peak precipitation events - 25 to 50 meters;

B) Include an erosion resistant layer (armor) to reduce wind erosion effects;

C) Identify specific vegetative cover standards for determination of re-vegetation success including, but not limited to, species diversity, plant survival, and ground cover parameters.

Assessment That the Monitoring Wells Installed at the Sandia Mixed Waste Landfill do not Meet the Requirements of the RCRA Statute Subpart F, the NMED Consent Order, or DOE Orders for Selection of Remedy or for Long-Term Compliance Monitoring, Final Version. 06-05-06 by

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Executive Summary. The strategy to leave chemical and radioactive waste at the Sandia mixed waste landfill and to assure protection of the regional aquifer by long-term monitoring of the existing set of monitoring wells is unacceptable because of the poor quality of the water samples produced from the wells. There are many important factors for why the wells do not meet the regulatory requirements for detection monitoring:

- Drilling additives with well known chemical properties to mask the detection of contamination were allowed to invade the strata that surround the wells.
- The drilling additives lowered the permeability of the strata surrounding the wells so that the wells produce stagnant water that was in contact for a long period of time with the strata affected by the drilling additives.
- The wells are sampled with procedures that strip from the water the volatile contaminants that are known to be released from the landfill (e.g., PCE).
- The wells are sampled with procedures that expose the water to oxygen and therefore, many metal and radioactive contaminants known to be disposed of at the landfill are hidden from being detected.
- The wells are not installed in the aquifer strata with high permeability – the strata where the highest levels of contamination are expected and the strata that are fast pathways for horizontal travel of contaminated groundwater over great distance.
- The wells are not installed in the unsaturated strata beneath the landfill to monitor the levels of toxic volatile contaminants (e.g., PCE) and tritium that are released over time from the landfill.

Because of the above factors, the existing network of monitoring wells at the Sandia mixed waste landfill do not meet the requirements of the RCRA Statute, the NMED Sandia Consent Order, or the DOE Orders for the detection of contamination released from the waste buried in the landfill. The monitoring wells do not provide the scientifically sound and legally defensible data that are required to identify the best long-term remedy for the mixed waste landfill.

The current strategy to cover the waste disposed of at the mixed waste landfill with an engineered earthen cover is not supported by the spurious data from the monitoring wells. The final remedy for the Sandia mixed waste landfill must wait until a network of monitoring wells are installed that produce reliable data on the presence or absence of contamination in soil air and in groundwater now and in the future. A reliable network of monitoring wells must be installed before the installation of an engineered earthen cover because the heavy weight of drilling equipment will do irreparable damage to the earthen cover.

The failure of Sandia National Laboratory, the Department of Energy, and the New Mexico Environment Department to install the needed network of monitoring wells that are in compliance with Federal and State Regulations and that provide accurate data for the remedy is a serious issue that requires formal investigation and reconciliation.

Assessment That the Monitoring Wells Installed at the Sandia Mixed Waste Landfill do not Meet the Requirements of the RCRA Statute Subpart F, the NMED Consent Order, or DOE Orders for Selection of Remedy or for Long-Term Compliance Monitoring, Final Version. 06-03-06 by

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Overview: The proposed Corrective Measure for the mixed waste landfill at the Sandia National Laboratory is not to remove the radioactive and chemical waste that are a danger to the groundwater resource, but instead, only to cover the landfill with an engineered earthen cover. The strategy to leave buried waste at the Sandia mixed waste landfill and to assure protection of the regional aquifer by long-term monitoring of the existing set of monitoring wells is unacceptable because of the poor quality of the water samples produced from the existing wells. A fundamental factor for the assessment of poor water quality is that the wells are purged dry and the water samples are collected after slow recharge, often over a period of seven days.

The collection of water samples after the wells are purged dry is unacceptable because of aeration and oxidation of the water that trickles into the wells, and therefore, a loss of many contaminants from the water and especially volatile solvents. One of the parameters for compliance monitoring is perchloroethylene (PCE), a volatile solvent contaminant that will be stripped from the groundwater that recharges into the wells after they are purged dry. PCE is present at very high levels as vapor in the vadose zone beneath the mixed waste landfill. The PCE vapor is 5.83 times heavier than air and over time the PCE may travel down through the vadose zone to contaminate groundwater.

Because of health concerns, the Environmental Protection Agency has set the Drinking Water Standard for PCE at a Maximum Contaminant Level (MCL) of 5 ug/L (5 parts per billion). In addition, because of the danger to health, the EPA has set a Maximum Contaminant Level Goal of ZERO for the presence of PCE in groundwater. A level of 0.8 ppb PCE in drinking water is the estimated one in a million incremental cancer risk. The loss of volatiles such as PCE from monitoring wells that are purged dry is a concern of RCRA Subpart F (see page B.2), the NMED Consent Order (see page B.5) and DOE Order 435.1 that requires monitoring wells at the Sandia mixed waste landfill to meet the requirements of RCRA Subpart F (see page B.7).

A fundamental requirement of RCRA Subpart F is for monitoring wells to be installed in the geologic strata that have a sufficient permeability to provide a continuous flow of groundwater with a minimum of drawdown of the water level in the well during the collection of groundwater samples. It is essential for the monitoring wells at the mixed waste landfill to provide a continuous flow of water for monitoring of sensitive water parameters with a closed flow-through cell with the collection of water samples after the sensitive parameters stabilize.

Furthermore, a fundamental requirement of Subpart F is for monitoring wells to be installed in the aquifer strata with high permeability that are present beneath a RCRA disposal facility. The geologic strata in the regional aquifer beneath the mixed waste landfill are heterogeneous and include strata with markedly different permeability. Presently, monitoring wells are not installed in the aquifer strata with high permeability beneath the landfill. The strata with high permeability are the fast pathways for the horizontal travel of contaminated groundwater from beneath the disposal site to the drinking water wells.

From *Applied Hydrogeology* by Fetter (1994): "Heterogeneities in the aquifer can cause the pattern of the solute movement to vary from what one might expect in homogeneous beds. Because flowing groundwater always follows the most permeable pathways, those pathways will also have the most contaminant."

An important reason for the low permeability of the strata that surround the screened intervals in many of the mixed waste landfill monitoring wells is that drilling additives were allowed to invade the strata. The effects of drilling additives to lower the permeability of screened intervals in monitoring wells are well known and are described in Appendix A. It is also possible that some of the well screens are installed in strata with low natural permeability. The importance for monitoring wells to be installed in pristine environments with open hydraulic communication with the aquifer strata of high permeability is described in the EPA Report that is summarized in Article A-12 in Appendix A.

The available information that are summarized in this report show that none of the seven (7) monitoring wells installed at the mixed waste landfill produce water samples that are representative of the *in situ* groundwater. The corrective measures decision to leave buried waste permanently disposed of in the landfill that are a danger to the precious water resource requires accurate contaminant data now and in the future from a network of monitoring wells.

It is a curious fact that the NMED has not enforced the requirements of the RCRA Statute or the NMED Consent Order that require monitoring wells at the mixed waste landfill to provide representative groundwater samples (see the summary of the RCRA Statute and the Consent Order in Appendix B). There is an immediate need to replace most (and perhaps all) of the monitoring wells at the Sandia mixed waste landfill with wells that are installed with drilling methods that prevent the aquifer strata from being invaded with any drilling additives. The new wells must be installed before an earthen cover is deployed over the mixed waste landfill because the weight of the drilling equipment will cause irreparable damage to the engineered earthen cover. There is also a need to install wells in the vadose zone beneath the mixed waste landfill for monitoring the concentrations of volatile contaminants in the soil gas. The monitoring wells in the vadose zone are required by DOE Order 450.1 for early identification of the release of contamination from the mixed waste landfill.

The locations of the monitoring wells at the mixed waste landfill are shown on Figure 1. The mud rotary drilling method was used for the boreholes of monitoring wells MWL-MW2, MWL-MW3, and MWL-BW1. This drilling method invaded the aquifer strata that surround the screened intervals of the three wells with large quantities of bentonite clay drilling mud, and perhaps also with organic drilling additives. The effects of bentonite clay and organic drilling additives to plug the permeability of aquifer strata and to prevent monitoring wells from providing representative water samples are well known in the technical literature and are summarized in Appendixes A and B.

MWL-MW1. The air rotary drilling method was used to drill an open borehole for the well. Drilling open boreholes with the air rotary method requires the use of organic drilling additives to stabilize the open borehole from collapse. The organic drilling additives that invaded the strata surrounding the well screen are a fuel for a bloom of microbes that are always naturally present. The microbial processes cause chemical reactions that deposit coatings of large volume iron precipitates on the aquifer strata that surround the well screen. The iron coatings lower the permeability of the strata and have chemical properties for removing many contaminants from the groundwater produced from the wells (see Articles A-4 to A-12 in Appendix A).

The lithologic record for well MW1 describe strata in the screened interval that would be expected to provide a continuous flow of water to the well. The seven day interval between the purging and the collection of water samples is unacceptable and is direct evidence that the strata are plugged. The water that recharged the well and was collected for the analytical suite had a turbidity slightly higher than the recommended upper limit of 5 NTUs in the RCRA guidance. The elevated turbidity may be responsible for the large difference between total iron and dissolved iron. However, the microbial processes greatly increase the level of colloidal iron in the groundwater and the high level of colloidal iron is probably the cause of both the high turbidity and the high level of total iron.

In addition, nickel is at an anomalous high level in the water produced from the well. The nickel may have been leached from the stainless steel well screen. Nevertheless, the high nickel values are evidence that the water produced from the well is from a stagnant zone surrounding the well screen and is not representative of the groundwater in the aquifer. The drilling and construction record for MWL-MW1 should be reviewed to determine if redevelopment and rehabilitation of this well is warranted or if it is necessary to replace the well.

MWL-MW2, MWL-MW3, and MWL-BW1. The three wells were drilled with the conventional mud rotary drilling method that allowed the invasion of the screened intervals with bentonite clay drilling mud and possibly with organic drilling additives. The effects of the bentonite clay and the organic additives to mask the detection of contamination is a concern for the monitoring wells installed at the Los Alamos National Laboratory (LANL). See Appendix A with particular attention to reports A-4 and A-5 by the EPA and the DOE IG for the mud rotary monitoring wells at LANL. For the contaminants of concern at the Sandia mixed waste landfill, the RCRA Statute, the NMED Consent Order, and the DOE regulations caution against allowing monitoring wells to be invaded with drilling additives (see Appendix B). The use of the mud rotary method for construction of the monitoring wells at the mixed waste landfill was a mistake and the wells shall be replaced.

MWL-MW4. The angle borehole for this well was drilled with the dry sonic method. Nevertheless, the one day interval between purging and sampling is unacceptable. In addition, the chemical data show that the water produced from the well has a negative Eh and is possibly anaerobic instead of the high positive Eh and aerobic chemistry of the background groundwater at well BW1. For well MW4, the measurements that show dissolved oxygen in the water with negative Eh are in conflict and show the need to improve the methods that are used for measuring these sensitive water parameters. The trend in Eh and dissolved oxygen measurements show that the necessary amount of groundwater was not purged from the well before samples were collected for the analytical suite. The drilling and construction record for MWL-MW4 should be reviewed to determine if redevelopment and rehabilitation of this well is warranted.

Well MW4 has two screened intervals with each screen having a length of 20 feet. The rehabilitation of MW4 shall include installation of a low-flow submersible pump between two inflatable packers to restrict the interval of aquifer strata that produce water from the well. A minimum requirement is for the well to produce a continuous flow of water for monitoring of sensitive parameters with a flow-through cell and with collection of water samples for the analytical suite after the sensitive parameters stabilize.

<u>MWL-MW5 and MWL-MW6</u>. The air rotary casing hammer (ARCH) drilling method was used for the construction of the two wells. The ARCH method advances steel drill casing to stabilize the borehole. The drill casing is retracted from the borehole during the construction of the well. However, the low values of Eh and dissolved oxygen in the water produced from the two wells are indicators that organic drilling additives have invaded the aquifer strata during the drilling with the ARCH method. The use of organic drilling additives for drilling with the ARCH method is routine but not necessary.

For the water produced from well MW5, the Eh and dissolved oxygen levels are much lower than the levels measured in the background groundwater. Furthermore, the water produced from MW6 has a negative Eh and a low level of dissolved oxygen. The negative Eh and presence of dissolved oxygen do not occur together in groundwater and show the need to improve the measurement procedures with continuous monitoring using a closed flow-through cell. For the two wells, the purging and sampling was on the same day, but page 15 of the SAND Report states that -"The monitoring wells were purged to dryness, allowed to recover, and then sampled -." This is an unacceptable sampling procedure.

The anomalously low Eh and low dissolved oxygen levels in the water produced from the two wells is probably because of invasion of the screened intervals with organic drilling additives. An additional indication that well MW5 does not produce representative water is that the concentrations of iron and manganese are much higher than the concentrations measured in the background well MWL-BW1.

The elevated iron and manganese levels in well MW5 may be due to chemical processes from the organic drilling additives. As explained above, the chemical processes will create iron coatings on the aquifer strata that have enhanced properties to remove contaminants of concern for the compliance monitoring from the groundwater produced from well MW5. The coatings also lower the permeability of the strata that surround the well screen. The drilling and construction records for MWL-MW5 and MWL-MW6 should be reviewed to decide if attempts to redevelop the two wells are warranted. The wells shall be replaced If organic drilling additives or bentonite clay additives were allowed to invade the screened intervals.

Zinc in groundwater as a natural analogue to trace metal contaminants. Zinc is a trace metal that naturally occurs in groundwater. The chemical properties of zinc are directly comparable to the properties of many of the trace metal and radioactive contaminants that are disposed of in the Sandia mixed waste landfill (LANL *Well Screen Analysis Report* - Report LA-UR-05-8615, November, 2005). The very low levels of dissolved zinc in the groundwater produced from all of the monitoring wells at the Sandia mixed waste landfill are evidence that the drilling additives have formed a reactive contaminant capture barrier in the strata that surround the well screens. The chemical data show that the barrier is actively removing zinc from the groundwater produced from the wells. The barrier will also mask the detection in groundwater of many of the radionuclide contaminants and trace metal contaminants disposed of in the mixed waste landfill.

The zinc data for water samples collected from the mixed waste landfill monitoring wells in April 2005 are summarized below. The NMED Approved Background Value for total zinc and dissolved zinc is 260 ug/L (parts per billion).

Monitoring Well No.	Total Zinc[1] (ug/L)	Dissolved Zinc[1] (ug/L)
MW1	12.7	5.13 J[2]
MW2	24.5	8.86 J
MW3	48.4	6.58 J
MW4	23	NA[3]
MW5	17.3	NA
MW6	2.68 J	NA (not greater than 2.68[4])
BW1	22.2	NA

[1] Zinc values are from SAND Report (SAND 2006-0391)
[2] J = estimated value near detection limit of analytical method
[3] NA = water sample was not analyzed for dissolved zinc
[4] The dissolved zinc value will not be greater than the total zinc value

Note that the total zinc concentrations measured in the seven monitoring wells are over an order of magnitude lower than the NMED approved natural background concentration of total zinc in groundwater. Of more importance are the very low levels of dissolved zinc in the groundwater produced from the monitoring wells.

The very low dissolved zinc levels are evidence that the wells are surrounded by a reactive contaminant capture barrier that prevents the wells from producing representative water samples

1). for the *in situ* groundwater chemistry, and
2). for the presence of contamination from waste released from the mixed waste landfill.

The low levels of dissolved zinc and the low permeability of the strata surrounding the monitoring wells are evidence of the need to replace the wells.

<u>Summary.</u> The monitoring wells installed at the Sandia mixed waste landfill do not meet the requirements of the RCRA Statute Subpart F for characterization of the release of contaminants from the mixed waste landfill to the regional aquifer. In addition, the wells do not meet the requirements for long-term RCRA compliance monitoring. Furthermore, the monitoring wells do not meet the requirements of the NMED Consent Order for the Sandia National Laboratory. The analytical data collected over the years from the monitoring wells are not scientifically sound and legally defensible. The decision to leave the buried waste in the mixed waste landfill is not supported by the spurious data from the network of monitoring wells. There is an immediate need to replace the wells with new monitoring wells that maintain a pristine environment in the aquifer strata with sufficient permeability to provide a continuous flow of groundwater to the wells.

Minimum requirements for the necessary Corrective Measures at the Sandia mixed waste landfill include

1). accurate data on the groundwater chemistry of the regional aquifer,
2). accurate knowledge of the presence or absence of contaminants in the precious water resource, and
3). a network of monitoring wells in the vadose zone and in the regional aquifer for early identification of the release of contamination from the mixed waste landfill at the present time and in the future.

The failure of the NMED to enforce the RCRA Statute and the NMED Consent Order for characterizing the danger of the Sandia Mixed Waste Landfill to the contamination of the valuable groundwater resource is a serious issue that requires a formal investigation by Ron Curry, the Secretary of the New Mexico Environment Department, and by Governor Richardson.

The unacceptable record of performance of the Sandia National Laboratory, the Department of Energy, and the New Mexico Environment Department to protect the precious water resource show the pressing need for an independent company to perform a validation and verification of all activities to study the Sandia mixed waste landfill. The independent company shall be responsible to the Stakeholders, and to EPA Region 6, the Federal Authority for oversight on compliance with the RCRA Statute. The company shall perform all work to redevelop, rehabilitate, and install new monitoring wells at the mixed waste landfill. The company shall install multiple-port monitoring wells in the vadose zone below the mixed waste landfill to depth profile the concentrations of volatile contaminants in the soil air. The company shall use proper methods to collect water and air samples from the network of wells.

The company shall investigate if the hydrostratigraphy beneath the mixed waste landfill is sufficiently characterized. The characterization of the hydrostratigraphy shall include the depth and thickness of the aquifer strata with sufficient permeability to provide large supplies of groundwater. The installation of monitoring wells near the water table and at greater depth in the highly permeable aquifer strata are a requirement of RCRA Subpart F for compliance monitoring of the impact of the mixed waste landfill on the groundwater resource. The installation of multiple-port wells for profiling solvent and tritium contamination in the soil air below the mixed waste landfill is a requirement of DOE Order 450.1 for the early detection of the mobile contaminants before they reach the groundwater resource.

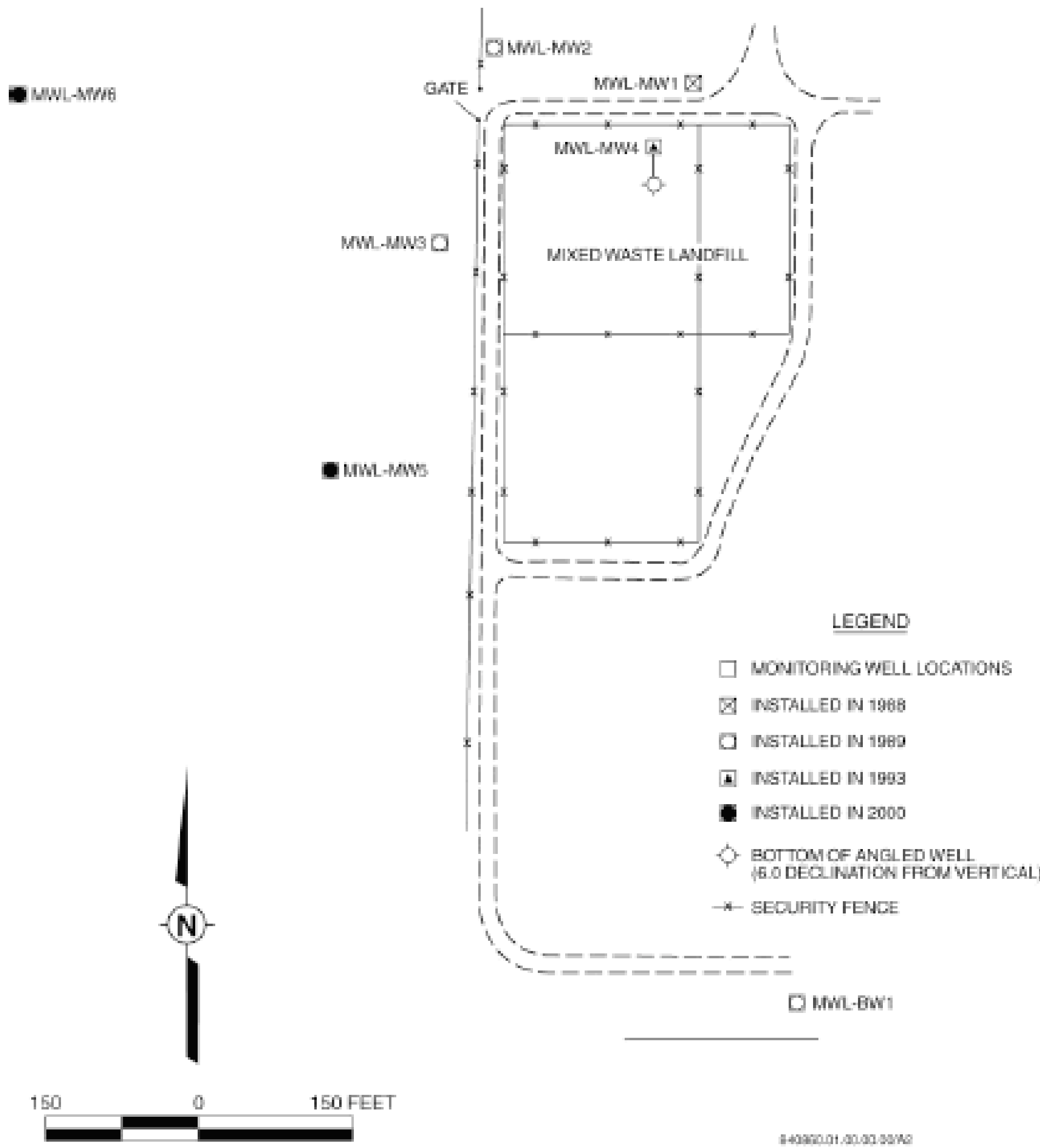

Figure 1. Map of the 2.6 Acre Sandia Mixed Waste Landfill
The 6 Monitoring Wells are MWL-MW1 to -MW6
The 1 Background Well is MWL-BW1

Figure from SAND REPORT(SAND 2006-0391)

Page 8. Assessment of Sandia Mixed Waste Landfill Monitoring Wells

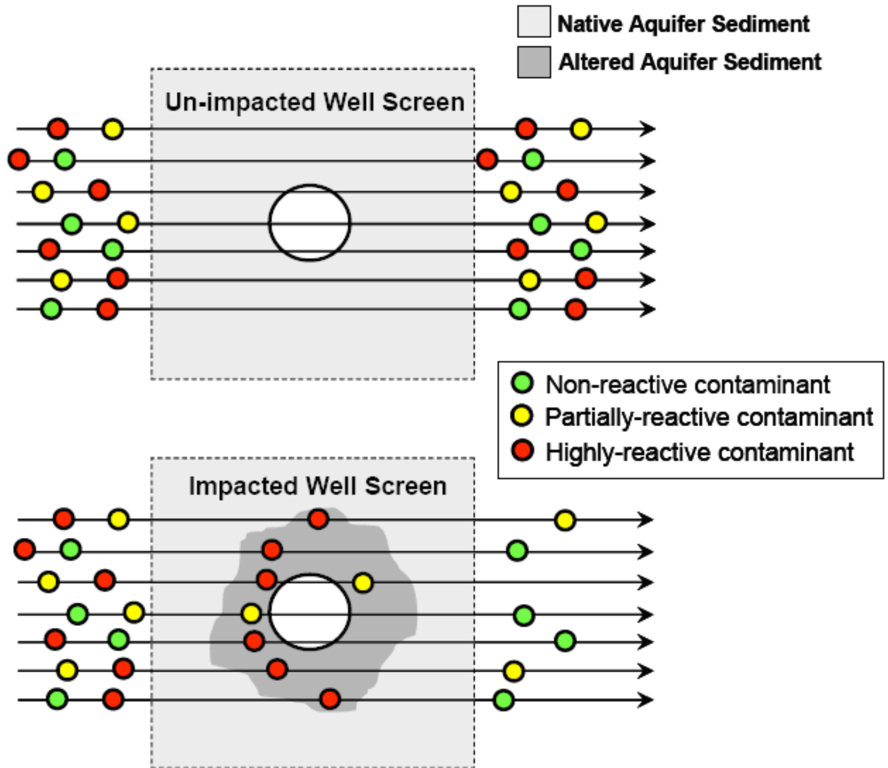

Figure 2. Comparison of an un-impacted well screen constructed to maintain a pristine environment in the aquifer strata surrounding the screened interval and an impacted well screen where drilling additives have developed a reactive contaminant capture barrier that removes contaminants from the water produced from the well (figure from EPA Report –"*LANL Characterization Well Construction Practices",* February 10, 2006 – see Article A-4 in Appendix A).

The figure only addresses the chemical properties of the barrier and not the properties of the barrier to lower the permeability of the aquifer strata and therefore, create a zone of stagnant groundwater. Because of the stagnant zone, the water produced from the impacted well screens is non-representative for all contaminants.

- Examples on non-reactive chemical contaminants are chloride and tritium.
- Examples of partially-reactive chemical contaminants are nitrate and perchlorate.
- Examples of highly-reactive chemical contaminants are volatile solvents, trace metals, and most radionuclide contaminants.

Appendix A. **A.1**

Technical literature with reasons for <u>not</u> installing monitoring wells in strata that are invaded with organic drilling additives or bentonite clay drilling muds

Article A-1: The text book **Aqueous *Environmental Chemistry*** by Langmuir (1997) describes the preferential adsorption of trace contaminants by bentonite clay drilling muds as follows:

> "Adsorption (onto bentonite clay) of a dissolved ionic species is always part of an (ion) exchange reaction that involves a competing ionic species. The desorbing species creates the vacant site to be

occupied by the adsorbing one. As the trace metal (or radioactive contaminant) level drops relative to that of a competing major ion, adsorption of the trace species is increasingly favored relative to competing major species."

Article A-2: The text book ***Aquatic Chemistry*** by Stumm and Morgan (1996) describes the preferential adsorption of trace contaminants by bentonite clay as follows:

"The sorption of alkaline and earth-alkaline cations [e.g., strontium-90] on expandable three-layer clays [e.g., bentonite clays] can usually be interpreted as stoichiometric exchange of interlayer ions (ion exchange). To understand binding of trace heavy metals [e.g., also the trace radioactive contaminants such as plutonium and americium] on clays, one needs to consider – in addition to ion exchange – the surface complex formation on end–standing functional OH groups. Three layer silicates (e.g., bentonite clays) contain on the crystal edges (broken bonds) end-standing OH groups which can interact with [remove from groundwater] metal ions [and many radionuclide contaminants]."

Articles A-1 and A-2 are important because they describe the preferential removal from groundwater of many trace radionuclide contaminants and trace metal contaminants by the bentonite clay drilling muds that have invaded the aquifer strata surrounding the screened intervals in many of the monitoring wells at the Sandia Mixed Waste Landfill.. The preferential properties of the bentonite clay to remove many contaminants from groundwater will not become exhausted during the scheduled life for the monitoring wells.

Article A-3: The Los Alamos National Laboratory (LANL) established a team of experts known as the External Advisory Group (EAG) to review activities to install a network of monitoring wells beneath the Laboratory facility. The EAG Semi-Annual Report (EAG, Dec. 23, 1999) lists 17 disadvantages for installing monitoring wells in boreholes that were drilled with the mud rotary method. The EAG report contains the following summary statements concerning use of the mud rotary drilling method:

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

"The artificial entrainment of bentonite clay drilling muds in the pore space around a monitoring well is clearly not desirable. This is because these materials can remove from solution the very constituents that need to be monitored by the well. <u>This is a significant concern for LANL since radionuclides are known to be adsorbed by these clays</u>. That the drilling mud, i.e., bentonite, penetrates into the aquifer strata is not disputed. It is reasonable to assume that fairly extensive intrusion of the bentonite into the aquifer strata can be expected. It is argued that well development, via high-flow pumping, using surge blocks, etc. is sufficient to remove blockage and create adequate flow through the well screen when a well has been drilled with mud. This is generally true. However, sufficient water flow is not the only consideration here. It is extremely unlikely that such well development techniques can remove the extruded bentonite sufficiently to assure that residual clay materials are not present in the pore space around the wells and serving as an adsorptive barrier to contaminant detection and quantification. Unfortunately, if no contamination is detected then there is simply no way (without drilling another well by a different technique) to determine whether the contaminant is truly absent at this point or whether it is being adsorbed by residual drilling fluids."

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

The caution of the EAG against the mud rotary drilling method for the LANL monitoring wells also apply to monitoring wells installed for the Sandia Mixed Waste Landfill. Unfortunately, after the caution of the EAG, the mud rotary drilling method was used for the installation of many of the LANL monitoring wells – See Articles A-4 and A-5.

A.3

Article A-4: The EPA National Risk Management Research Laboratory published a report in February, 2006 about the adverse impact of drilling additives on the quality of data from the monitoring wells installed at the Los Alamos National Laboratory

Excerpts from the EPA Report:

"Most of the hydrogeologic characterization wells at LANL appear to have been installed using drilling additives that have the potential to impact the quality of data obtained from the affected well screens. Some of these impacts have been documented in various LANL publications. A systematic study to identify impacted screens based on aqueous chemistry has recently been performed (LANL, 2005c) and will be reviewed under separate cover."

"In general, it is likely that many of these screens may not produce representative samples for constituents that strongly sorb to clays or whose fate in the environment is sensitive to changes in redox conditions for some period of time. In particular, the constituents of concern that may be most affected by the residual drilling additives are radionuclides (*e.g.*, isotopes of americium, cerium, plutonium, radium, strontium, uranium), many stable metal cations, and organic compounds that may be degraded in the impacted environment near the well screen."

"Predictions of the time frames for the impacted intervals to return to natural conditions are uncertain. The time frame for this continuing impact to the representativeness of groundwater samples may be years to decades."

"It is also likely that the inability to fully remove the additives which were used during drilling has reduced the hydraulic conductivity of many of the impacted screened zones."

"Due to the difficulty in assessing the damage that may be caused by the presence of residual drilling additives in the screened zone of a well, it is recommended that the need for continued use of additives within the screened interval of monitoring wells be reassessed."

"The following recommendations for improvement during the drilling and construction of future monitoring wells may allow installation of wells that provide the most representative samples possible for all of the contaminants of concern at LANL. It is noted that many of these techniques are successfully used at the Idaho National Laboratory (INL) to avoid the use of drilling additives, other than water to control heaving, in the screened zone. Although the drilling conditions at no two sites are identical, similar problems, such as heaving materials, consolidated and unconsolidated formations, and depths in excess of 1000 ft are also encountered at INL and successfully drilled using techniques similar to those described below."

"Strive to drill boreholes using no bentonite or organic additives within screened intervals. Additives may be used in intervals above the target monitoring zone if telescoping casing constructions are used and the hole is adequately cleaned before drilling the final footage within the interval to be screened. Targeting of monitoring intervals prior to drilling should be possible at locations where data from the existing characterization wells are available."

"At locations determined to be critical to the detection monitoring program, consider replacement of wells that were drilled using bentonite or that exhibit impacts due to organic additives with wells installed without additives in the screened zones, if needed to meet the DQOs for that monitoring location."

Excerpts from the EPA Report: (continued)

"The path for resolution of issues concerning the impacts of drilling additives on the quality of ground-water samples should include identification of all well screens impacted by drilling additives, specification of the corrective actions to be taken, and field studies performed to verify these evaluations."

"Based on the uncertainty in characterizing the condition of aquifer materials adjacent to the well screens and the potentially long time frames that some impacts may last, installation of replacement wells at critical locations should also be considered."

"With respect to screens where bentonite-based additives were used, it is possible that even trace amounts of residual bentonite that remain following development may render groundwater samples non-representative for highly sorbing constituents. This situation would be difficult to accurately characterize. Therefore, the quality of samples for constituents such as isotopes of americium, cerium, plutonium, and radium obtained from these screens will likely remain uncertain even after re-development."

"With respect to screened intervals where organic additives were used, ... it is unlikely that the new mineral phases formed during biodegradation of the organic materials would be fully removed during redevelopment."

"Relative to addressing the question of whether ground-water samples are representative of the undisturbed aquifer chemistry, water quality data alone provide an unreliable indication of whether there is sustained impact to sediment sorption characteristics. The use of more direct methods [*e.g., costly investigations that involve drilling new boreholes to collect sediment samples]* would be necessary to determine the extent of mineralogical changes to aquifer materials following the return of oxidizing conditions near the well screen."

Article A-5: The Office of the Inspector General of the Department of Energy wrote a report about the bentonite clay drilling mud and organic drilling additives that were allowed to invade the screened intervals in monitoring wells installed at the Los Alamos National Laboratory – Report DOE/IG-0703, September 2005.

Excerpt from the report:

- "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."

Article A-6: "*DRILLING – The Manual of Methods, Applications and Management*" by The Australian Drilling Industry Training Committee Limited (1996).

From page 480 of the Drilling Manual:

"Drilling fluids, if used, must be carefully chosen to avoid contamination or alteration of final water [chemistry of groundwater produced from monitoring wells] or soil chemistry [chemistry of aquifer strata],"

From page 480 of the Drilling Manual:

"When metals or radionuclides are the target compounds, bentonite muds must be avoided. They have cation-exchange properties, and bind up these constituents. In this case, synthetic polymers may be a better choice. Biodegradable muds may also be used; but they must be completely removed to the trace level; otherwise they promote bio-fouling, which also alters groundwater quality."

From page 472 of the Drilling Manual:

"Causes of biofouling plugging of well screens: Microbial oxidation and precipitation of Fe, Mn, and S, with associated growth and slime production. Usually associated with simultaneous chemical encrustation and corrosion. Associated problem: water quality degradation. Includes, but not always, "iron bacteria". Biofouling plugging causes reduced specific capacity and efficiency, reduced yield, and even complete well production loss."

The geochemical data in the Sandia Mixed Waste Landfill Annual Groundwater Monitoring Report April 2005 show that the water produced from monitoring wells MW-4 and MW-6 are anaerobic and the water produced from monitoring wells MW-2 and MW-5 have an unreasonably low level of Eh and dissolved oxygen compared to the levels measured in the background well. The anomalous chemistry of water produced from the wells may be caused by the invasion of the strata with drilling additives. It is also possible that the anomalous chemistry may be the result of contamination from the mixed waste landfill. A lesser possibility is that the anaerobic groundwater is the natural chemistry of water in the confining bed strata. The naturally aerobic background chemistry of groundwater in the permeable strata in the regional aquifer have high Eh and high dissolved oxygen.

Article A-7: "*Handbook of Ground Water Development*" by Roscoe Moss (1990).

From page 211 of the Handbook:

"Because iron and sulfur bacteria are ubiquitous, - care should be taken in drilling and casing and screen installation so as not to introduce gross organic contamination into the aquifer."

From page 371 of the Handbook:

"Excessive growth of filamentous iron bacteria results in gelatinous slimes that may seriously reduce water yield from wells. This problem is more likely to occur in a well that is inactive or intermittently operated."

A.6

Article A-8: "*Groundwater and Wells, Second Edition*" by Fletcher Driscoll (1986), published by Johnson Screens, St. Paul, Minnesota.

From page 455:

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

From page 456:

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

Article A.9: *"Aqueous Environmental Geochemistry"*, by Donald Langmuir, 1997 by Prentice-Hall, Inc., Upper Saddle River, New Jersey.

From page 436:

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

From page 462:

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

From Page 538:

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

The concentration of total and dissolved iron in water samples produced from the Sandia mixed waste monitoring wells are markedly higher than the concentration measured in the background well. The cause of the high concentrations in the monitoring wells may be the result of drilling additives or contamination from the mixed waste landfill. The high levels of iron in the water samples is direct proof that the water produced from the monitoring wells is not representative of the natural groundwater in the permeable strata in the regional aquifer.

Article A-10: The ASTM (1990) article is ASTM Standard D 5092 – *Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers*. The ASTM article presents the following guidance for drilling methods and well development:

> "Whenever feasible, drilling procedures should be utilized that do not require the introduction of water or liquid fluid into the borehole. When the use of drilling fluids is unavoidable, the selected fluid should have as little impact as possible on the water samples for the constituents of interest. In addition, care should be taken to remove as much drilling fluid as possible from the well and the aquifer during the well development process."

> "Well development should be continued until representative water, free of the drilling fluids, cuttings, or other materials introduced during well construction is obtained. Representative water is <u>assumed</u> to have been obtained when pH, temperature, and specific conductivity readings stabilize and the water is visually clear of suspended solids."

The ASTM guidance for successful well development does not guarantee that all or even most of the drilling fluids are removed from the aquifer strata that are in contact with groundwater samples that are collected from the monitoring wells for contaminant analyses. The small diameter of the Sandia monitoring wells, the great depth of the wells, the short screen length, the small slot size of the screen openings, and the small size of the filter pack sediments that surround the well screen are factors that prevent removal of most of the bentonite clay muds and drilling fluids that are entrained into the aquifer strata.

Article A-11: The article by Gibb, J.P., and K.V.B. Jennings. 1987, "How Drilling Fluids and Grouting Materials Affect the integrity of Ground Water Samples from Monitoring Wells. *Ground Water monitoring Review* 7(1): 33. describes how drilling fluids and grouting materials affect the integrity of groundwater samples from monitoring wells. The article has the following discussion concerning the drilling of boreholes for monitoring wells with the mud rotary method using drilling fluids and/or bentonite clay muds:

> "Rotary drilling methods using bentonite or organic based drilling fluids present serious problems in the construction of monitoring wells. Wells constructed with these drilling methods are seldom capable of providing accurate hydrologic or chemical data for a wide variety of inorganic and organic constituents. - - The amount of drilling fluids lost into formations or deposits (aquifer strata) is directly proportional to their hydraulic conductivity."

> "In geologic environments where drilling fluids are a necessity, inorganic clay muds are preferred over those containing organic materials. The introduction of substrates for microbial activity can seriously impact the integrity of water samples."

> "In addition to the migration of drilling fluids into the subsurface materials, monitoring wells normally are constructed in the borehole while it is still filled with the drilling fluid. The casing, screen, and gravel pack materials are placed directly into the drilling fluid. The gravel pack materials often become suspended in the drilling fluid making it extremely difficult to determine where the gravel pack materials terminate and the overlying well seal begins. It is almost impossible to document the "as built condition" of monitoring wells constructed using rotary drilling methods and drilling fluids."

> "Breaking down the mud cake and removal of all drilling fluids introduced during the drilling and construction process is extremely difficult. Groundwater velocities required to remove drilling fluids, and the colloidal size particles associated with

them from the aquifer materials usually cannot be created during development of small diameter monitoring wells."

"The potential consequences of using drilling fluids (fluids and muds) should be obvious. The use of drilling fluids and muds should be curtailed whenever possible. Migration of bentonite or even "clean water" into the aquifer materials disturbs the subsurface environment and creates chemical and biological conditions
that have the potential for altering water quality in the immediate vicinity of the well and the area impregnated. Due to the limited area of influence experienced during the development of monitoring wells, drilling fluids seldom are removed to the extent that they will not cause "well trauma". ("well trauma" means the monitoring well provides groundwater samples with a chemistry that is not representative of the aquifer. Water samples from the monitoring wells at the Sandia mixed waste landfill may exhibit "well trauma". The chemical data is not sufficient for assessment of "well trauma".)

"Similarly, the improper placement of well sealing materials often results in these materials being in the flow path to the well or in such close proximity that they also chemically interfere with the quality of water collected from the well". (See the
above discussion on the difficulty of installing monitoring wells in boreholes that are filled with drilling fluids. The well sealing materials for the LANL monitoring wells are bentonite clay that has properties to remove radionuclide contaminants
from groundwater.) The inability to measure in situ groundwater quality conditions prevents field documentation or measurement of these types of chemical interferences. The sparsity of field documentation or evidence should not be used as an excuse to overshadow common sense and laboratory evidence that clearly indicates the potential for chemical interference from drilling fluids and grout materials."

"Experience has shown that drilling muds not effectively removed from the well bore opposite the screen and gravel pack will interfere with the chemical and biological quality of samples from those wells."

A.9

The features of the Sandia monitoring wells at the mixed waste landfill that prevent the recovery of most of the drilling fluids that have invaded the aquifer strata where screens are installed include 1). because of the great depth to the water table of the regional aquifer, the mud rotary drilling method operated as a powerful injection pump for invasion of the bentonite clay into the strata that surround the well screens, 2). the great depth of the monitoring wells limits the pumping energy for development, 3). the small inside diameter for well casing of 4.5 inches limits the size (power) of submersible pumps, 4). the short length of the well screens, 5). the small spacing of 0.01 inch for the slots on the well screens, and 6). the medium-grained sand in the filter pack that surrounds the well screens. Factors 2 through 6 restrict the energy for recovering the drilling fluids compared to the much greater energy of the mud rotary drilling method for invading the strata with the drilling additives.

Article A-12: The article by. Puls, R.W., and M. J. Barcelona, 1989. *Groundwater Sampling for Metals Analyses,* Report Number EPA/540/4-89/001. U.S. Environmental Protection Agency, Ada, Oklahoma, has the following recommendations for the construction and development of monitoring wells:

"The disturbance of the subsurface environment as a result of well construction and sampling procedures presents serious obstacles to the interpretation of ground-water quality results. The impact of improper well construction and sampling techniques can permanently bias the usefulness and integrity of wells as sampling points."

"If no alternative to the use of drilling muds or fluids exists, these materials must be removed from the well bore and adjacent formations by careful well development."

"It should be recognized, however, that the well must first provide a representative hydraulic connection to the geologic formation of interest. Without the assurance of this hydraulic integrity, the water chemistry information cannot be interpreted in relation to the dynamics of the flow system or the transport of chemical constituents."

"Maintenance of the hydraulic performance of monitoring wells and the connection of wells to the zones of greatest hydraulic conductivity, where contaminant transport is most probable, should take equal importance to the collection of representative water quality data."

The monitoring wells installed at the Sandia Mixed Waste Landfill do not meet the important requirement of being in open hydraulic connection to the strata with the greatest hydraulic conductivity (i.e., permeability). The monitoring wells are either plugged by the bentonite clay drilling fluids or they are installed in "confining bed" strata with very low permeability. Both situations are unacceptable for long-term monitoring. A minimum requirement is that the monitoring wells produce a continuous flow of groundwater with minimum drawdown during the collection of water samples.

Appendix B: **B.1**

The regulatory requirements of USEPA RCRA, NMED Consent Order, and DOE Orders for the installation of monitoring wells at the Sandia Mixed Waste Landfill

- **Regulatory requirements of the RCRA Statute**

The NMED Sandia National Laboratory Consent Order, the DOE Orders, and the RCRA Statute require that the Sandia monitoring wells installed at the mixed waste landfill shall meet the requirements of a RCRA-compliant monitoring well as described in the US Environmental Protection Agency (EPA) document "RCRA Groundwater Monitoring: Draft Technical Guidance," November, 1992, EPA/530-R-93-001.

This EPA RCRA document (known as the EPA RCRA Manual, 1992) has the following concerns for installation of monitoring wells in boreholes drilled with the mud rotary method and the invasion of aquifer strata with drilling additives.

Concern 1:

"While there are hydrogeologic conditions where mud rotary drilling is the best option (e.g., where it is extremely difficult to maintain a stable borehole), mud rotary creates a high potential for affecting aquifer characteristics and ground-water quality. If the mud rotary method is used, the drilling mud(s) should not affect the chemistry of ground-water samples." (page 6-12)

Concern 2:

"Some organic polymers and compounds provide an environment for bacterial growth, which reduces the reliability of sampling results." (page 6-12)

The bentonite clay drilling muds that were used in the boreholes for the Sandia mixed waste landfill monitoring wells have a large affect on the chemistry of groundwater samples for many radionuclide and chemical contaminants of concern for long-term monitoring. In addition, the anaerobic chemistry of water samples produced from some wells may be due to organic drilling additives. The use of organic additives should be investigated.

Concern 3:

> "The ability of a well development method to remove clays from the sides of the borehole should be considered, because clays retained in the borehole may alter the chemical composition of groundwater in the well." (page 6-50)

The great depth and physical design of the Sandia monitoring wells are obstacles to the removal of the large volume of bentonite clay that has invaded the aquifer strata (See Article A-11 and discussion on page A.7).

B.2

Concern 4:

> "Drilling should be performed in a manner that preserves the natural properties of the subsurface materials." (page 6-2)

For many of the Sandia mixed waste landfill monitoring wells, the invasion of the aquifer strata with bentonite clay drilling mud and perhaps organic drilling additives has caused a great change to the natural properties of the aquifer strata; a lowering of the permeability and an increase of the chemical properties for removing contaminants from groundwater.

Concern 5:

> "Drilling fluids, drilling fluid additives, or lubricants that impact the analysis of hazardous constituents in groundwater samples should not be used." (page 6-2)

Sandia has used drilling methods that have invaded the aquifer strata with drilling fluids that impact the analysis of hazardous and radioactive constituents in groundwater samples collected from the wells. The drilling fluids include bentonite clay drilling muds. The use of organic drilling additives should be investigated as the cause of anaerobic water chemistry at some wells.

Concern in the EPA RCRA Manual for purging monitoring wells to dryness:

"Wells also should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur. A low purge rate also will reduce the possibility of stripping VOCs from the water, and will reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions. The owner/operator should ensure that purging does not cause formation water to cascade down the sides of the well screen. At no time should a well be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated; water should be purged from the well at a rate that does not cause recharge water to be excessively agitated. Laboratory experiments have shown that unless cascading is prevented, up to 70 percent of the volatiles present could be lost before sampling." (page 7-8)

The routine practice of purging the Sandia monitoring wells to dryness is unacceptable in general and specifically because of one of the indicator parameters for the long-term monitoring is the volatile contaminant PCE.
The purging to dryness causes aeration of the recharge water and therefore, an unacceptable loss of volatiles. The purging record in the Sandia Mixed Waste Landfill Annual Groundwater Monitoring Report April 2005 (SAND 2006-0391) show that the loss of volatiles will occur in all of the monitoring wells including well MW-4 that is installed in a borehole drilled on an angle below the mixed waste landfill.

B.3

- **Regulatory requirements of the NMED Sandia Consent Order**

The requirements of NMED for monitoring wells at the Sandia Mixed Waste Landfill are presented in the NMED Sandia National Laboratory Order dated April 29, 2004.

From pages 63 to 64 of the NMED Sandia Consent Order:

VIII. GROUNDWATER MONITORING WELLS

VIII.A. DRILLING, DESIGN, AND CONSTRUCTION

A variety of methods are available for drilling monitoring wells and piezometers. While the selection of the drilling procedure is usually based on the site-specific geologic conditions, the following issues shall also be considered.

1. Drilling shall be performed in a manner that minimizes impacts to the natural properties of the subsurface materials;
2. Contamination and cross-contamination of groundwater and aquifer materials during drilling shall be prevented;
3. The drilling method shall allow for the collection of representative samples of rock and unconsolidated sediments and soil, as applicable;
4. The drilling method shall allow the Respondents to determine when the appropriate location for the screened interval has been encountered;
5. The drilling method shall allow for the proper placement of the filter pack and annular sealants;
6. The drilling method shall allow for the collection of representative groundwater samples and water level data. Drilling fluids (including air) shall be used only when minimal impact to the surrounding formation and groundwater can be ensured.

The selection of the specific drilling procedure will usually depend on site-specific geologic conditions. Justification for the method selected must be provided to the Department in writing (normally in a work plan or sampling and analysis plan) that will be subject to approval by the Department.

Groundwater monitoring wells and piezometers must be designed and constructed in a manner that will yield high quality, representative samples. Each well or piezometer must be constructed such that it will last the duration of the planned monitoring need (i.e., last long enough to gather enough samples for purposes of establishing concentration trends for Contaminants or potential Contaminants; determining if releases from SWMUs or AOCs will impact groundwater; monitoring post VCA, VCM, or corrective measure activities to ensure efficacy; and monitoring for post-closure care). In the event of a well or piezometer failure, or if a well or piezometer is any way no longer usable for its intended purpose, it must be replaced with an equivalent well or piezometer. In constructing a well or piezometer, Respondents shall ensure that the well or
piezometer will not serve as a conduit for Contaminants to migrate between different zones of saturation. The design and construction of groundwater monitoring wells and piezometers shall comply with the guidelines established in EPA guidance, including, but not limited to:

- U.S. EPA, *RCRA Groundwater Monitoring: Draft Technical Guidance*, EPA/530-R-93-001, November, 1992; (the EPA RCRA Manual)

- 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, 1

VIII.B. WELL DEVELOPMENT

Each monitoring well shall be developed to create an effective filter pack around the well screen, correct damage to the formation caused by drilling, remove fine particles from the formation near the borehole, and assist in restoring the water quality of the saturated zone in the vicinity of the well to that prior to well installation. Development of wells is important to ensure the collection of representative groundwater samples.

From pages 66 to 67 of the NMED Sandia Consent Order:

IX. GROUNDWATER

IX.A. SAMPLING

Groundwater samples shall initially be obtained from monitoring wells between 10 to 30 days after completion of well development. Groundwater monitoring and sampling shall be conducted at an interval approved in writing by the Department after the initial sampling event or in accordance with the frequency specified in Section XI, Table XI-1, or in accordance with work plans or sampling and analysis plans approved in writing by the Department. The Respondents shall sample all saturated zones screened to allow entry of groundwater into a monitoring well during each sampling event unless otherwise approved in writing by the Department. All requests for variances from the groundwater sampling schedule shall be submitted to the Department, in writing, 30 days prior to the start of scheduled monitoring and sampling events. If a variance is approved, the Department will state so in writing. When a saturated zone is encountered in an
exploratory boring that was not intended to be completed as a monitoring well, Respondents shall install a properly constructed groundwater monitoring well in the boring or next to the boring that encountered groundwater. In such cases, samples shall be collected and analyzed for the constituents of concern appropriate to the purpose of the borehole. Water samples shall be analyzed for physical and chemical parameters as determined in work plans or sampling and analysis plans or other plans and shall be completed by schedules approved by the Department. Sampling shall be conducted in accordance with a written and approved plan or in accordance with the EPA Technical Enforcement Guidance Document (U.S. EPA, *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1, Sept. 1986).

Sampling and Analysis Plans shall, at a minimum, include the following elements of discussion.

1. Water level measurements;

2. Sampling equipment / pump type;
3. Purge requirements;
4. Filtration;
5. Preservation and holding times;
6. Containers;
7. Sequence of sample fractions;
8. Field quality control (QC) samples;
9. Laboratory QC samples;
10. Labeling containers;
11. Analytical requests;
12. Chain of custody;
13. Handling/shipping;
14. Field parameters:
   • pH, temp, specific conductance;
   • turbidity, dissolved oxygen;
15. Decontamination procedures;
16. Report format;
17. Schedules and frequency of sampling;
18. Report due date;
19. Instrument calibration methods;
20. Health and safety.

IX.B. WELL PURGING

Stagnant well water in each monitoring well shall be purged by removing groundwater prior to sampling to ensure that fresh formation water is being sampled. Micro-purging (or no-purge) methods shall not be employed. Well purging shall be conducted in accordance with the Department's position paper *"Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring*" (Oct. 30, 2001), or in accordance with the EPA technical enforcement guidance document

(EPA, RCRA *Groundwater Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1 (Sept. 1986)). **From the Oct. 30, 2001 NMED Position Paper –**

[8]For wells with insufficient recharge during sustained pumping where stabilization of indicator parameters cannot be achieved, samples shall be collected in the following manner (using a properly selected pump): collect indicator parameters, when the well purges dry the sampler shall note so in the log book and include the total volume of water removed, once the well is allowed to recover the sample shall be collected. Indicator parameters should be collected from the well prior to sample collection. If the well purges dry for four consecutive quarters or one year, the use of the well as a compliance monitoring point will need to be re-evaluated.

The monitoring wells at the Sandia Mixed Waste Landfill do not meet the requirements under the RCRA Statute or the NMED Consent Order for compliance monitoring. The wells require replacement with wells that do not purge dry. The replacement wells shall be drilled with methods that prevent the invasion of the screened intervals with any organic drilling additives or bentonite clay drilling muds. The wells shall produce a continuous flow of groundwater for monitoring sensitive parameters (e.g., Eh, dissolved oxygen, pH, temperature, and specific conductance with a closed flow-through cell.

B.6

❖ **Regulatory Requirements of the United States Department of Energy**

The U.S. Department of Energy (DOE) is a regulatory agency and the activities of the LANL Hydrogeologic Workplan are required to be in compliance with DOE ORDERS 450.1, 435.1 and 5400.5. It is important to note that the DOE ORDERS also require the activities of the Hydrogeologic Workplan to be conducted in compliance with the technical requirements of RCRA.

- DOE ORDER 450.1 - Approved: 1-15-03, Review Date: 1-15-05, Chg 1: 1-24-05

SUBJECT: ENVIRONMENTAL PROTECTION PROGRAM

1. OBJECTIVES. To implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by Department of Energy (DOE) operations and by which DOE cost effectively meets or exceeds compliance with applicable environmental; public health; and resource protection laws, regulations, and DOE requirements. This objective must be accomplished by implementing Environmental Management Systems (EMSs) at DOE sites. An EMS is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. These EMSs must be part of Integrated Safety Management Systems (ISMSs) established pursuant to DOE P 450.4, Safety Management System Policy, dated 10-15-96.

4. REQUIREMENTS.

a. General Requirements. All DOE elements must ensure that site ISMSs include an EMS that does the following:

(1) Provides for the systematic planning, integrated execution, and evaluation of programs for—

(a) public health and environmental protection,

(b) pollution prevention (P2), and

(c) compliance with applicable environmental protection requirements.

(4) 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.

(14) Conduct environmental monitoring, as appropriate, to support the site's ISMS, to detect, characterize, and respond to releases from DOE activities; assess impacts; estimate dispersal patterns in the environment; characterize the pathways of exposure to members of the public; characterize the exposures and doses to individuals, to the population; and to evaluate the potential impacts to the biota in the vicinity of the DOE activity.

B.7

- DOE ORDER 435.1

I. 1.E.(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.

Discussion:

The potential additional risks posed by mixed radioactive waste due to the hazardous constituents involved, and the complexities of managing mixed radioactive waste, have been recognized for years. This requirement acknowledges the regulation of the hazardous constituents of mixed radioactive wastes in accordance with the Resource Conservation and Recovery Act (RCRA), as amended or in accordance with state hazardous waste regulations promulgated under RCRA authority. Each of the waste type chapters in DOE M 435.1-1 contains additional requirements for mixed radioactive wastes. Guidance for those additional requirements (DOE M 435.1-1, Sections II.C, III.B, and IV.B.(1)) should be consulted to find discussions on management of radioactive mixed waste under DOE O 435.1. Also, implementation guidance on the Department's management of mixed low-level waste is in the guidance on the Complex-Wide Low-Level Waste Management Program requirement, DOE M 435.1-1, Section IV.C.

The objectives of DOE Order 435.1 are to ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment:

- Mixed Transuranic Radioactive Waste. Mixed transuranic waste that is disposed of at Sandia shall be managed in accordance with the requirements of RCRA and DOE Order 435.1.

- Mixed Low-Level Radioactive Waste. Mixed low-level waste that is disposed of at Sandia shall be managed in accordance with the requirements of RCRA and DOE Order 435.1.

- Low-Level Radioactive Waste . At Sandia, each operational or non-operational low-level radioactive waste treatment, storage, and disposal facility shall be monitored by an environmental monitoring program that conforms with DOE 5484.1 and, at a minimum, meet the requirements of paragraph 3K(2) through 3K(4) in DOE Order 435.1:

- 3K(2) The environmental monitoring program shall be designed to include measuring and evaluating releases, migration of radionuclides, disposal unit subsidence, and changes in disposal facility and disposal site parameters which may affect long-term performance.

- 3K(3) Based on the characteristics of the facility being monitored, the environmental program may include, but not necessarily be limited to, monitoring surface soil, air, surface water, and, in the subsurface, soil and water, both in the saturated and the unsaturated zones. The site-specific "performance assessment and composite analysis shall be used to determine the media, locations, radionuclides, and other substances to be monitored.

- 3K(4) The monitoring program shall be capable of detecting changing trends in performance sufficiently in advance to allow application of any necessary corrective actions prior to exceeding performance objectives.

• DOE ORDER 5400.5
  The Objectives of DOE ORDER 5400.5 are Radiation Protection of the Public and the Environment.

- Protecting the Public. It is DOE's objective to operate its facilities and conduct its' activities so that radiation exposures to members of the public are maintained within the limits established in this Order and to control radioactive contamination through the management of real and personal property. It is also a DOE operative that potential exposures to members of the public be as far below the limits as is reasonably achievable (ALARA) and that DOE facilities have the capabilities, consistent with the types of operations conducted, consistent with the types of operations conducted, to monitoring routine and non-routine releases and to assess doses to members of the public.

- Protecting the Environment. In addition to providing protection to members of the public, it is DOE's objective to protect the environment from radioactive contamination to the extent practical.

From DOE Order 5400.5 Concerning Monitoring and Surveillance

- It is the intent of DOE that the monitoring and surveillance programs for the DOE activities, facilities, and locations be of <u>high quality</u>.

- Drinking Water Pathway Only. All DOE Sources of Radionuclides. It is the policy of DOE to provide a level of protection for persons consuming water from a public drinking water supply operated by the DOE, either directly of through a DOE contractor, that is equivalent to that provided to the public by the public community drinking water standards of 40 CFR Part 141. These systems shall not cause persons consuming the water to receive an effective dose equivalent greater than 4 mrem (0.04 mSv) in a year.