The Los Alamos National Laboratory *Groundwater Background Investigation Report - Revision 3* Does Not Provide Useful Information on the Background Water Quality in the Regional Aquifer

- by Robert H. Gilkeson, Registered Geologist on September 19, 2009
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Executive Summary. The Los Alamos National Laboratory (LANL) *Groundwater Background Investigation Report - Revision 3* (GBIR-3) was a requirement in the New Mexico Environment Department (NMED) LANL Consent Order. The purpose of the GBIR-3 was to provide background concentrations for naturally occurring metals and general chemistry parameters in groundwater below LANL. However, LANL does not have the required network of monitoring wells to provide knowledge of the background groundwater chemistry.

For the regional aquifer, the GBIR-3 used inappropriate sources for the background groundwater chemistry that included 1). the deep Los Alamos County drinking water wells, 2). springs located miles from LANL, and 3). three of the LANL monitoring wells that were impacted by the organic drilling fluids that were allowed to invade the wells.

The mineralogy of the rocks and sediments control the background chemistry of the groundwater in the regional aquifer. However, the springs and the drinking water wells produce groundwater from rock formations that have a different mineralogy than the sediments and rock formations where the LANL monitoring wells are installed. The comparison of water quality data from the two new monitoring wells (R-35a and R-35b) that were installed as sentry wells for the deep drinking water well PM-3 show the important control of the mineralogy of the sediments at the locations of the wells on the background chemistry of the groundwater produced from the three wells.

The GBIR-3 did not provide useful background water quality data for the assessment of the impact of organic drilling additives and bentonite clay drilling muds on the ability of the LANL monitoring wells to produce reliable and representative water samples for the detection of LANL contaminants. Nevertheless, the LANL scientists used the GBIR-3 for that purpose in the most recent revision of the LANL *Well Screen Analysis Report.* The use of inappropriate background water quality data is one of several reasons for the Department of Energy to order LANL to retract the *Well Screen Analysis Report.*

The GBIR-3 does not replace the requirement for the installation of background water quality monitoring wells at many locations across LANL. The installation of background wells at locations close to the LANL waste disposal sites are a requirement of the Resource Conservation and Recovery Act (RCRA). However, the NMED has not enforced the requirement of RCRA for networks of monitoring wells and background wells at the LANL waste disposal sites known as MDA G, MDA H and MDA L.

The GBIR-3 does not provide the required knowledge of background chemistry of groundwater that is required for wise decisions in the NMED Consent Order. The NMED Hazardous Waste Bureau (HWB) has not enforced the requirements in the Consent Order for DOE to install monitoring wells at LANL that provide reliable and representative water samples for detection of LANL contaminants. There is an inconsistent practice by the NMED HWB for the protection of groundwater at LANL and at the Sandia National Laboratories in Albuquerque.

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Comment on the Failure of the Los Alamos National Laboratory *Groundwater Background Investigation Report - Revision 3* to Provide Useful Information on the Background Water Quality in the Regional Aquifer

- Comment by Robert H. Gilkeson, Registered Geologist on January 5, 2009
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1. Introduction. The Los Alamos National Laboratory (LANL) *Groundwater Background Investigation Report - Revision 3* (GBIR-3) published in May of 2007 was a requirement in the New Mexico Environment Department (NMED) Order on Consent that was signed into law on March 1, 2005. The pertinent excerpt from the Consent Order is pasted below:

> "IV.A.3.d. Background Investigation
> The Respondents shall determine the background concentrations for naturally occurring metals and general chemistry parameters in alluvial, intermediate, and regional groundwater. Within 180 days after the effective date of this Consent Order, the Respondents shall submit to the Department for review and written approval a Groundwater Background Investigation Report to determine Facility background concentrations for naturally occurring metals in groundwater at or near the Facility [emphasis added]. The background investigation shall state the background concentration for each metal and the general chemistry parameters, and state the bases for selecting each such concentration" [page 41].

The requirement by the NMED for LANL to submit the groundwater background report within 180 days after the effective date of the Consent Order was a mistake because the network of monitoring wells to determine the background concentrations for naturally occurring metals and general chemistry parameters in the groundwater in the regional aquifer below LANL did not exist in 2005 and ***still*** do not exist in 2009.

In addition, a report on background water quality "at or near the facility" could not replace the need for the installation of background monitoring wells at locations close to the discrete LANL waste disposal sites. The background water quality monitoring wells are a requirement of the federal environmental law known as the Resource Conservation and Recovery Act (RCRA). Accurate background water quality data from monitoring wells located close to the LANL waste disposal sites are essential for the investigation and long-term monitoring of groundwater contamination from the disposal sites.

This report is primarily concerned about the failure of the LANL *Groundwater Background Investigation Report - Revision 3* (GBIR-3) to produce the required background water quality data for the regional aquifer for the following purposes:

- 1). The GBIR-3 did not provide the required knowledge of the background concentrations for naturally occurring metals and general chemistry parameters in the groundwater below the LANL waste disposal sites.

- 2). The GBIR-3 did not provide the data that was required to support the findings presented in the LANL *Well Screen Analysis Report - Revision 2* (WSAR-2). The WSAR-2 was a study of the ability of the LANL monitoring wells (80 discrete screened intervals) that were invaded with organic and/or bentonite clay drilling additives to produce reliable and representative water samples.

- 3). The GBIR-3 did not provide the background water quality data that is required by the NMED Consent Order for informed decisions on corrective action.

- 4). The GBIR-3 did not provide the background data that is required by RCRA for investigation and long-term monitoring of groundwater contamination from LANL operations. A background water quality report can not replace the requirement under RCRA to install background water quality monitoring wells close to the LANL waste disposal sites at locations that are hydraulically upgradient from the buried wastes.

- The NMED Hazardous Waste Bureau (HWB) made a mistake to approve of the GBIR-3 as providing the required knowledge of background water quality for decisions in the LANL Consent Order. The failure of the NMED HWB to recognize that the GBIR-3 did not provide the required background water quality data is a serious problem.

2. <u>The sparse and inappropriate sources of data for the regional aquifer that were used in the LANL GBIR-3</u>. For the regional aquifer, the GBIR-3 presents water quality data from the following twenty one (21) sources: eight drinking water supply wells, three LANL contaminant detection monitoring wells and ten springs. The locations of the wells and springs are displayed on Figure 1.

- Drinking water wells G-1A, G-2A, G-3A, G-4A, G-5A, PM-2, PM-4, and PM-5.
- LANL contaminant detection monitoring wells R-1, R-13, and R-21.
- Springs 1, 5B, 6, 6A, 8A, 9, 9A, 9B, Ancho Spring, and Sacred Spring. Ancho and Sacred Spring are not displayed on Figure 1. Ancho Spring is located in Ancho Canyon approximately 1/2 mile northwest of Spring 6. Sacred Spring is located approximately 2 1/2 miles north of Spring 1.

<u>None</u> of the twenty one sources listed above produced water quality data that meet the following requirements:

- 1). The background concentrations in the GBIR-3 did not provide the data that were needed for the statistical study in the LANL WSAR-2 report. This failure is discussed below in Section 5 on page 9 of this report.

- 2). The NMED Consent Order relied on the LANL WSAR-2 report to determine the ability of the large network of badly compromised LANL monitoring wells to produce reliable and representative water samples. However, one reason the findings in the WSAR-2 are not credible was because they were based on the inappropriate background water quality data presented in the GBIR-3.

- 3). The DOE has not met the requirements in RCRA for a network of contaminant detection monitoring wells and background water quality monitoring wells to produce accurate knowledge of groundwater contamination from the large number of waste disposal sites at many locations across LANL.

3.0. <u>The mistake in using the springs and the deep drinking water wells as a source for the background water quality data in the GBIR-3</u>. The cross-sections in Figures 2 through 7 display the complex stratigraphy in the regional aquifer beneath the Pajarito Plateau. The mineralogy of the discrete rock formations have a strong control on the natural background chemistry of the groundwater produced from the monitoring wells installed in the rock formations. The cross-sections show the great changes that occur laterally and vertically in the rock formations in the upper part of the regional aquifer below LANL.

The cross-sections show that the springs and the drinking water wells produce groundwater from the deep rock formation described as the Santa Fe Group Sands. However, the cross-sections show that the network of LANL monitoring wells produce water from rock formations with a different mineralogy that are located above the Santa Fe Group Sands. The fact that practically all of the water quality data in the GBIR-3 were collected from drinking water wells and springs that produced water samples from the Santa Fe Group Sands is an important reason the report is <u>not credible</u> for the background water quality at the locations of the LANL monitoring wells.

3.1. <u>The mistake in using the springs that discharge from the regional aquifer as a source for the background water quality data in the GBIR-3</u>. Figure 1 shows that the springs are located along the Rio Grande and miles from the contaminant sources at LANL. The cross-sections in Figures 2 through 4 show that the springs discharge groundwater from the Santa Fe Group Sands. For comparison, the cross-sections in Figures 2 through 7 show that the LANL monitoring wells produce groundwater from rock formations that are above the Santa Fe Group Sands. The groundwater quality data from the springs are not representative of the background water quality for the naturally occurring metals and general chemistry parameters in the rock formations at the locations of the LANL monitoring wells.

3.2. <u>The mistake in using the deep drinking water wells as a source for the background water quality data in the GBIR-3</u>. The locations of the eight Los Alamos County drinking water wells are displayed on Figure 1. The wells are G-1A, G-2A, G-3A, G-4A, G-5A, PM-2, PM-4, and PM-5. The wells have screens that are greater than 1,000 feet long with the top of the screens at distances greater than 100 feet below the water table and often greater than 200 feet below the water table. The five G-series wells are located in the Guaje Canyon well field a distance greater than two miles north of LANL. The cross-sections in Figures 5 through 7 show that the G-series wells produce groundwater from the deep Santa Fe Group Sands. Figure 7 shows that the drinking water well PM-5 also produces groundwater from the deep Santa Fe Group Sands.

The dominant control of the mineralogy of the rock formation in the sampling zone of the LANL monitoring wells on the natural background chemistry of groundwater is illustrated by the large differences in background water quality in the groundwater produced from the LANL monitoring wells R-35a and R-35b and the drinking water well PM-3. The close locations of the three wells are shown on Figure 8.

Monitoring wells R-35a and R-35b were installed as sentry wells for the deep drinking water well PM-3. The two monitoring wells were installed with casing advance drilling methods that prevented the invasion of any organic or bentonite clay drilling fluids into the screened intervals. However, a mistake during the construction of well R-35a caused the screened interval in the well to be invaded with the bentonite clay grout that was used to seal the annulus between the well casing and the borehole wall. As described below, the bentonite clay has prevented well R-35a from producing reliable and representative water samples for background water quality and for the detection of groundwater contamination from LANL sources.

Well R-35a is the deeper of the two sentry wells and was completed with a well screen in the depth interval corresponding to the top of the screen in drinking water well PM-3. Well R-35b was completed with a screen near the top of the regional aquifer. The depth of the two wells is summarized below:

- The water table of the regional aquifer is at ~ 787 feet below ground surface (ft bgs).
- The R-35b screened interval = 825 to 848 ft bgs or ~ 40 ft below the water table.
- The R-35a screened interval = 1013 to 1062 ft bgs or ~ 230 ft below the water table.

The zinc, barium and strontium concentrations in the groundwater samples produced from the three wells are summarized below in Table 1. Table 2 compares the concentrations measured in the three wells to the background values for zinc, barium and strontium that were published in the GBIR-3.

Table 1. Comparison of the water quality data produced from three wells installed at different depths into the regional aquifer.

- The close locations of wells R-35b, R-35a and PM-3 are displayed on Figure 8.
- Monitoring well R-35b - screened interval near the water table

Sampling Date	Zinc (ug/L) Filtered	Zinc (ug/L) Unfiltered	Barium (ug/L) Filtered	Barium (ug/L) Unfiltered	Strontium (ug/L) Filtered	Strontium (ug/L) Unfiltered
08-29-07	59.9	105	31	31.9	75.3	76.8
11-10-07	63.4	105	31.6	32.4	75.1	74.5
02-07-08	51.7	86.9	32.7	32	70.2	68.9
05-13-08	50.3	54.8	36.1	35.6	67.5	66.2
08-12-08	41.9	51.5	35.3	37.6	64.2	64.3

- Monitoring well R-35a - screened interval across the top of the screen in well PM-3

Sampling Date	Zinc (ug/L) Filtered	Zinc (ug/L) Unfiltered	Barium (ug/L) Filtered	Barium (ug/L) Unfiltered	Strontium (ug/L) Filtered	Strontium (ug/L) Unfiltered
08-30-07	185	364	299	300	162	162
11-10-07	36.4	44	312	321	163	168
02-21-08	26.8	29.2	340	315	174	162
05-13-08	2.4 J	5.3 J	319	321	164	165
08-12-08	5.2 J	9.6 J	338	335	165	164

- Drinking water well PM -3

Sampling Date	Zinc (ug/L) Filtered	Zinc (ug/L) Unfiltered	Barium (ug/L) Filtered	Barium (ug/L) Unfiltered	Strontium (ug/L) Filtered	Strontium (ug/L) Unfiltered
05-20-04	N.A.	13.8	N.A.	49.5	N.A.	120
05-18-05	N.A.	7.2 J	N.A.	50.9	N.A.	125
01-19-06	6.32 J	5.6 J	54.3	53.5	129	130
05-24-06	N.A.	7.3 J	N.A.	50.8	N.A.	125
05-16-07	N.A.	2 J	N.A.	50	N.A.	122

- ug/L = micrograms per liter or parts per billion
- J identifies that the listed concentration is an estimated value.
- NA means the constituent was not analyzed in a filtered water sample

Table 2. Comparison of the water quality data produced from the three wells in Table 1 to the background water quality data in the LANL *Groundwater Background Investigation Report Revision-3* (GBIR-3).

- **Zinc** (filtered)	median (ug/L)	minimum (ug/L)	maximum (ug/L)	Range Factor
- GBIR-3	1.9	< 2	41.1	> 20 times
- R-35b	53.4	41.9	63.4	1.5 times (decrease)
- R-35a	51.2	2.4 J	185	77 times (decrease)
- PM-3 (unfiltered)	7.3	2 J	13.8	7 times (decrease)

- **Barium** (filtered)	median (ug/L)	minimum (ug/L)	maximum (ug/L)	Range Factor
- GBIR-3	21	4.68	69.2	15 times
- R-35b	33.3	31	36.1	1.16 times (increase)
- R-35a	321.6	299	340	1.14 times (increase)
- PM-3 (unfiltered)	50.9	49.5	53.5	no overall change

- **Strontium** (filtered)	median (ug/L)	minimum (ug/L)	maximum (ug/L)	Range Factor
- GBIR-3	55.5	44.88	179.8	4 times
- R-35b	70.5	64.2	75.3	1.17 times (decrease)
- R-35a	165.6	162	174	no overall change
- PM-3 (unfiltered)	124.2	120	130	no overall change

- The three wells show large differences in the measured concentrations of dissolved zinc, barium and strontium because of the properties of the mineralogy of the rock formations in the sampling zones of the wells.

- The zinc values measured in wells R-35a and R-35b are much higher than the background values published in the GBIR-3 and also much higher than the values measured in the deep drinking water well PM-3.

- The barium values measured in well R-35a are five times higher than the maximum value for barium in the GBIR-3. The barium values measured in well R-35a are also much higher than the values measured in wells R-35b and PM-3. The possibility that the high barium values measured in well R-35a are from LANL contamination should be investigated.

- For successive sampling events, the groundwater samples should show a change of not greater than approximately 10% in the measured concentrations for the dissolved constituents. There also should be little or no overall change in the dissolved concentrations through the years of measurement. In Table 1, there is little change for barium and strontium. However, the large decline in dissolved zinc concentrations measured in the groundwater samples produced from well R-35a is an issue that must be investigated.

- In Table 1, the large decline over time in the dissolved zinc measured in the groundwater produced from well R-35a is probably because of the bentonite clay grout that invaded the screened interval. The bentonite clay has strong adsorption properties to remove zinc and many of the LANL contaminants from the groundwater samples produced from well R-35a. The large decline in zinc indicates that well R-35a is not reliable for background water quality data for natural metals. In addition, the zinc data indicate that well R-35a is also not reliable to detect many LANL contaminants. The need to replace well R-35a should be investigated.

- In Table 1, there are many factors that may be responsible for the change in zinc concentrations measured in drinking water well PM-3 including 1). the very long length of the well screen, 2). corrosion of the well screen and well piping, 3). the period of time the well was pumped before collecting the water samples, and 4). practically all of the analytical results are for unfiltered samples. There are many reasons the water quality data from the drinking water wells are not reliable for accurate knowledge of the background concentrations of zinc and other trace metals in the discrete formations in the regional aquifer.

4. <u>The mistake in using the three contaminant detection monitoring wells R-1, R-13 and R-21 as sources for the background water quality data in the GBIR-3</u>. The use of the water quality data from the three contaminant detection monitoring wells R-1, R-13 and R-21 as representative of background water quality for naturally occurring metals was a mistake in the GBIR-3 because of the drilling methods. The three wells were drilled with methods that invaded the screened intervals with organic drilling fluids and -foams that have well known properties to form a new mineralogy in the sampling zones with strong properties to remove the naturally occurring metals from the water samples produced from the wells. The NMED recognized the importance to use chemicals to destroy the organic drilling additives in order to prevent the microbial processes that would form a new mineralogy with a reactive chemistry in the screened interval. The pertinent excerpt from the NMED Consent Order is pasted below:

> - "[o]rganic polymer drilling muds have been observed to facilitate bacterial growth, which reduces the reliability of sampling results. If polymer emulsions are to be used in the drilling program at the Facility, polymer dispersion agents shall be used at the completion of the drilling program to remove the polymers from the boreholes. For example, if EZ Mud® is used as a drilling additive, a dispersant (e.g., BARAFOS® or five percent sodium hypochlorite) shall be used to disperse and chemically breakdown the polymer prior to developing and sampling the well." [page 191]

EZ Mud® was allowed to invade the screened intervals in wells R-1, R-13 and R-21. *<u>However, the NMED did not enforce the requirement in the Consent Order for LANL to use chemicals to disperse and chemically breakdown the organic drilling additives prior to developing and sampling the wells</u>*. Figure 9 displays the new mineralogy (i.e., reactive chemistry) that was formed in the zone surrounding the well screens by the bacterial processes that thrived on the organic drilling additives. The new mineralogy was described in the NMED Notice of Disapproval (NOD) that was issued on September 18, 2006 for the LANL *Well Screen Analysis Report;*

> - "The presence of residual drilling fluids may not only turn groundwater from aerobic into anaerobic water, but also cause composition changes in aquifer solid materials [i.e., the mineralogy] adjacent to well screens. For example, the availability

of organic compounds contained in drilling fluids likely stimulates sequential microbial metabolism, including iron and sulfate reduction. As a result, it is likely that iron sulfides are produced as precipitates, thereby enhancing the reactivity of the aquifer solids adjacent to impacted screens. It has been well-documented that iron sulfides are able to reductively transform organics such as chlorinated solvents, and some oxidizing metals and ions (e.g., hexavalent chromium, perchlorate, nitrate). In addition, the change of mineralogical compositions may also increase the adsorption capability of aquifer materials adjacent to impacted screens. Thus, water samples collected from impacted screens where aerobic conditions have been re-established after rehabilitation may still produce biased concentrations for certain contaminants [and naturally occurring trace metals] in comparison to formation water" [emphasis added]. [page 2 in the NMED NOD]

The organic drilling fluids have caused a new reactive chemistry in the zone where groundwater is produced from the LANL monitoring wells R-1, R-13 and R-21. The zone of reactive chemistry is displayed in Figure 9. The new chemistry prevents the wells from producing reliable and representative water samples for the background concentrations of the naturally occurring metals.

Zinc is an example of a naturally occurring metal that is often present in groundwater in the regional aquifer. The dissolved concentrations of zinc in the groundwater produced from a monitoring well that provides reliable and representative water samples will show little change between successive sampling events. However, a time-series analysis of the groundwater samples produced from the LANL monitoring wells R-1, R-13 and R-21 show a large decline in dissolved zinc. The concentrations of dissolved zinc in the water samples collected from each well are summarized below.

- Dissolved zinc in the groundwater samples produced from well R-1

Sample No. & Date	**Dissolved Zinc (ug/L)** [B]
1). 11-03	**1.4**
2). 05-19-05	**7.6 J** [C]
3). 09-05 / 09-05 [A]	**2.7 J / N.D.** [D]
4). 11-05	**N.D.**
5). 01-06	**N.D.**
6). 07-06 / 07-06 [A]	**5.1 J / 3.9 J**
7). 10-06 / 10-06 [A]	**2.3 J / N.D.**
8). 03-07	**3.3 J**
9). 06-07 / 06-07 [A]	**2.1 J / 6.6 J**
10). 08-07	**3.5 J**
11). 11-07 / 11-07 [A]	**2.7 J / 3.5 J**
12). 02-08 / 02-08 [A]	**2.6 J / 3.1 J**
13). 05-20-08	**N.D.**
14). 08-15-08	**3.5 J**

- **[A] 09-05 / 09-05 [A] denotes analysis on a duplicate filtered sample.**
- **[B] (ug/L) = micrograms per liter or parts per billion.**
- **[C] J denotes an estimated concentration.**
- **[D] N.D. denotes that dissolved zinc was not detected in the water sample at an analytical method detection limit of 2 ug/L.**

For well R-1, the time-series analysis shows a decline in dissolved zinc concentrations from 7.6 ug/L for the May of 2005 sample to not detected in the samples collected in November of 2005, January of 2006, and May of 2008. A zinc concentration of 3.5 ug/L was measured in a water sample collected in August of 2008. The time-series data show a minimum decline of greater than 55%. The time series data show the presence of a new reactive chemistry that is efficiently removing zinc from the groundwater produced from well R-1. Well R-1 does not produce reliable and representative water samples for the background concentration of zinc and other naturally occurring trace metals in the regional aquifer at the location of the well.

Well R-1 is in Mortandad Canyon at an important location for monitoring contamination in a permeable zone that is present a short distance below the water table of the regional aquifer. However, the screen in well R-1 was installed in a confining bed of clayey sediments that is located below the permeable zone. The misplaced screen in well R-1 in the clayey sediments is another reason the well does not produce the required background water quality data.

In addition, the new reactive mineralogy from the organic drilling additives and the misplaced screen are reasons that well R-1 is not reliable to detect LANL contaminants in the regional aquifer.

- Dissolved zinc in the groundwater samples produced from well R-13

Sample No. & Date	**Dissolved Zinc (ug/L)** [B]
1). 10-31-01	**N.A.** [E]
2). 04-18-02	**5.53**
3). 07-03-02	**5.78**
4). 10-02	**3.5**
5). 01-03	**N.D.** [D]
6). 05-03	**N.D.**
7). 12-03	**1.5 J**
8). 02-06	**N.D.**
9). 07-06	**3 J** [C]
10). 10-06	**2.3 J**
11). 02-07	**4 J**
12). 06-07	**N.D.**
13). 08-07	**N.D.**
14). 11-07	**2.7 J**
15). 02-08	**12.1**
16). 05-08 / 05-08 [A]	**N.D. / N.D.**
17). 08-08 / 08-08 [A]	**N.D. / N.D.**

- [A] **05-08 / 05-08** [A] **denotes analysis on a duplicate filtered sample.**
- [B] **(ug/L) = micrograms per liter or parts per billion.**
- [C] **J denotes an estimated concentration.**
- [D] **N.D. denotes that dissolved zinc was not detected in the water sample at an analytical method detection limit of 2 ug/L.**
- [E] **N.A. denotes a water sample was not analyzed**

The construction and development of well R-13 was completed by October of 2001 but the first water sample was collected 6 months later in April of 2002. The time-series analysis shows a decline in dissolved zinc concentrations from 5.78 ug/L for a sample collected in July of 2002 to not detected on many of the later sampling dates beginning in January of 2003 and including the samples collected in May and August of 2008 - a minimum decline of greater than 65%. The time series data show the presence of a new reactive chemistry that is efficiently removing zinc from the groundwater produced from well R-13. Well R-13 does not produce reliable and representative water samples for the background concentration of zinc and the other naturally occurring trace metals in the regional aquifer at the location of the well.

Well R-13 is in Mortandad Canyon at an important location for monitoring contamination in a permeable zone that is a short distance below the water table of the regional aquifer. However, the screen in well R-13 was installed 125 feet below the water table and below clayey sediments that are confining beds. In addition, a mistake during the construction of well R-13 invaded the screened interval with bentonite clay. The misplaced screen, the organic drilling additives and the contamination of the screened interval with bentonite clay are all reasons that well R-13 does not produce the required background water quality data.

In addition, the new reactive mineralogy from the organic drilling additives and the bentonite clay and the misplaced screen are reasons that well R-13 is not reliable to detect LANL contaminants in the regional aquifer.

- Dissolved zinc in the groundwater samples produced from well R-21

Sample No. & Date - - - - - - 1). 12-02 2). 03-04 / 03-04 [A] 3). 06-30-04 4). 09-04 5). 12-04
Dissolved Zinc (ug/L) [B] N.A. [E] 7.58 / 4.42 7.81 2.8 J 7.4
6). 06-05 / 06-05 [A] 7). 07-06 8). 11-06 / 11-06 [A] 9). 03-07 10). 06-07 11). 08-07
2.9 J [C] / N.D. [D] 3 J 2.7 J / 5.6 J 2.7 J 6.5 J N.D.
12). 11-07 13). 02-08 14). 05-08 / 05-08 [F] 15). 08-08 / 08-08 [F]
N.D. N.D. 4.4 J / N.D.T [G] 4.2 J / 3 J T [G]

- **[A] 03-04 / 03-04 [A] denotes analysis on a duplicate filtered sample.**
- **[B] (ug/L) = micrograms per liter or parts per billion.**
- **[C] J denotes an estimated concentration.**
- **[D] N.D. denotes that dissolved zinc was not detected in the water sample at an analytical method detection limit of 2 ug/L.**
- **[E] N.A. denotes that a water sample was not analyzed.**
- **[F] 03-06 / 03-06 [F] denotes analyses on a pair of filtered and unfiltered samples.**
- **[G] 4.2 J / 3 J T [G] T denotes analysis on an unfiltered sample.**

The construction and development of well R-21 was completed by December of 2002 but the first water sample was collected 15 months later in March of 2004. The time-series analysis shows a decline in dissolved zinc concentrations from 7.8 ug/L for a sample collected in June of 2004 to not detected in five of the sampling events from June of 2005 to May of 2008 - a minimum decline of greater than 75%. The time series data show the presence of a new reactive chemistry that is efficiently removing zinc from the groundwater produced from well R-21. Well R-21 does not produce reliable and representative water samples for the background concentration of zinc and other naturally occurring trace metals in the regional aquifer at the location of the well.

Well R-21 is in Canada del Buey at an important location for monitoring contamination near the water table of the regional aquifer. However, the screen in well R-21 was installed 90 feet below the water table; a distance too great for the detection of the groundwater contamination that may be present near the water table.

The new reactive mineralogy from the organic drilling additives and the misplaced screen are reasons that well R-21 is not reliable to detect LANL contaminants in the regional aquifer.

- In summary, the water quality data from the LANL monitoring wells R-1, R-13 and R-21 do not produce accurate background concentrations for naturally occurring metals because organic drilling additives were allowed to invade the screened intervals. In addition, the three wells do not meet the requirement in RCRA for knowledge of the background water quality (or the presence of LANL contaminants) in the first productive aquifer zone that is located near the water table of the regional aquifer. The three wells do not produce the required knowledge for wise decisions in the NMED Consent Order.

5. The inappropriate water quality data in the LANL GBIR-3 were used to assess the ability of the LANL monitoring wells to produce reliable and representative water samples. LANL used drilling methods that allowed organic polymer drilling fluids and/or organic foams to invade approximately 100 of the screened intervals in the large network of LANL monitoring wells. Many of the screened intervals were also invaded with bentonite clay. The impacted wells were installed in intermediate zones and in the regional aquifer. *The NMED HWB approved the use of the inappropriate drilling methods that invaded the screened intervals with a new reactive chemistry.*

The organic fluids and -foams and the bentonite clay established a new mineralogy (i.e., reactive chemistry) in the screened intervals with strong properties to prevent the wells from producing water samples that were reliable and representative for the detection of many of the LANL contaminants. The new mineralogy also greatly reduced the permeability of the zone surrounding the well screens which created a stagnant zone where the groundwater was in contact for a long period of time with the new reactive chemistry. The majority of the LANL monitoring wells produce water samples from the stagnant zones surrounding the well screens. The stagnant zone that surrounds the impacted well screens is displayed on Figure 9.

The LANL *Well Screen Analysis Report - Revision 2* (WSAR-2), was a statistical assessment of the ability of eighty (80) of the impacted screened intervals to produce reliable and representative water samples. However, the statistical study was not credible because it compared water quality data from the impacted wells to the inappropriate background water quality data that was published in the LANL GBIR-2 report. The only change from the GBIR-2 to the GBIR-3 is that the GBIR-3 did not use the water quality data from LANL monitoring well R-18 because the groundwater was contaminated with high explosives and did not represent background water quality.

In fact, the LANL scientists were aware that the background water quality data published in the LANL GBIR reports did not meet the requirements for the assessment scheme that was used in the WSAR-2. The pertinent excerpts from the WSAR-2 are pasted below:

> **"2.3 Background Groundwater Chemistry**
> The evaluation process used in this report compares selected geochemical indicators for each individual screen against the range of background concentrations [presented in the LANL background water quality report] that are assumed [emphasis added] to encompass predrilling conditions at that screen. Water-quality data that fall outside the range, and that cannot be attributed to the presence of a contaminant plume may then be identified as potentially unreliable or not representative of predrilling conditions**"** [page 6].
>
> **"**The ideal approach to determining representative water quality would be to compare water-chemistry data for each screen against background concentrations specific to the formation lithology [i.e., mineralogy] in which the screen is located. However, this level of distinction for background groundwater chemistry does not exist and is unlikely to ever exist at this level of detail [emphasis added]. Consequently, in this report, the range of background concentrations is limited to that defined in the “Groundwater Background Investigation Report, Revision 2” (LANL 2007, 094856) for the regional aquifer and perched intermediate zones**"** (page 6).

The statistical assessment in the WSAR-2 required accurate knowledge of the background concentrations for the groundwater in the formations where the impacted screens were installed. However, the fact that the LANL scientists knowingly used inappropriate background data in the WSAR-2 report is one of the mistakes that prevented the findings presented in the WSAR-2 from being credible.

The record shows that the NMED Hazardous Waste Bureau (HWB) has not required the Department of Energy (DOE) to install the network of monitoring wells and background water quality wells at LANL that are required for
1). wise decisions on corrective action in the NMED Consent Order and
2). long-term monitoring for the detection of groundwater contamination from LANL operations.

The required action is for the NMED HWB to order the DOE to retract both the LANL *Groundwater Background Investigation Report - Revision 3* and the LANL *Well Screen Analysis Report - Revision 2* with no opportunity for revision because both reports are not credible and the required data to make the reports credible does not exist. Both reports prevent accurate knowledge of the ability of the LANL monitoring wells to produce reliable and representative water samples. In addition, the two reports prevent identification of the emerging emergency for groundwater contamination of the regional aquifer because of the poor management practices by the DOE for the large inventory of LANL wastes discharged to wet canyon landscapes and buried in unlined pits, trenches and shafts at many unmonitored or poorly monitored disposal sites.

6. <u>The NMED HWB has not enforced the requirement in RCRA for the DOE to install background water quality monitoring wells at the LANL waste disposal sites</u>. Figure 10 shows the network of monitoring wells that are intended for providing information on groundwater contamination below the three waste disposal sites in LANL Technical Area 54 (TA-54). The three waste disposal sites from west to east on Figure 10 are MDA H, MDA L and MDA G. MDA G is a large 63-acre waste disposal site compared to the small 0.6-acre MDA H.

The three disposal sites (MDA G, MDA H and MDA L) are "regulated units" under RCRA because the three sites buried RCRA hazardous waste after July 26, 1982. RCRA requires networks of point of compliance monitoring wells installed as close as possible to the downgradient boundary at each of the three waste disposal sites and monitoring wells for background water quality installed at appropriate locations upgradient of the disposal sites.

The RCRA requirements for networks of monitoring wells at RCRA regulated unit waste disposal sites are published in 40 CFR §§264.91 through 264.100. §264.97 describes the general groundwater monitoring requirements for regulated units including monitoring wells for background water quality. The pertinent excerpts from §264.97 are pasted below:

- (a) 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:
    - (1) Represent the quality of background ground water that has not been affected by leakage from a regulated unit;
    - (2) Represent the quality of ground water passing the point of compliance.

- (3) Allow for the detection of contamination when hazardous waste or hazardous constituents have migrated from the waste management area to the uppermost aquifer.

- (g) In detection monitoring or where appropriate in compliance monitoring, data on each hazardous constituent specified in the permit will be collected from background wells and wells at the compliance point(s).

- RCRA defines the "uppermost aquifer" as the first permeable zone below the water table of the regional aquifer, and the deeper permeable zones.

The NMED HWB has not enforced the requirement in the LANL Consent Order for the LANL monitoring wells to comply with the EPA RCRA guidance. The pertinent excerpt from page 189 of the Consent Order is pasted below:

> 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 [known as the EPA RCRA Manual].

The EPA RCRA Manual describes the networks of monitoring wells that are required at the RCRA "regulated unit" waste disposal sites. Pertinent excerpts from the EPA report are pasted below:

> "5.1.3 Placement of Background (Upgradient) Monitoring Wells
> The ground-water monitoring well system must allow for the detection of contamination when hazardous waste or hazardous constituents have migrated from the waste management area to the uppermost aquifer. A sufficient number of background wells must be installed at appropriate locations and depths to yield ground-water samples from the uppermost aquifer that represent the quality of background water that has not been affected by leakage from a regulated unit." [page 5-10]
>
> "Background and point of compliance [monitoring] wells must be screened in the same hydrostratigraphic position to allow collection of comparable ground-water quality data." [page 5-10]
>
> "To establish background ground-water quality, it is necessary to establish ground-water flow direction(s) and to place wells hydraulically upgradient of the waste management area." [page 5-10]
>
> "Background wells should be located far enough from waste management units to avoid contamination by the units. In the event that background wells become contaminated by a release from the waste management unit(s), new background wells that will not be affected by the release should be installed." [page 5-12]

Figure 11 is a schematic map from the EPA RCRA Manual that shows the networks of monitoring wells that are required at RCRA regulated unit waste disposal sites. Comparison of Figure 11 to Figure 10 shows that the planned networks of monitoring wells at MDA G, MDA H and MDA L do not meet the requirements of RCRA, and accordingly, the networks also do not meet the requirements in the NMED LANL Consent Order. There are no monitoring wells for background water quality and there are no contaminant detection monitoring wells installed along the hydraulic downgradient boundary of the three waste disposal sites.

- Nevertheless, the NMED HWB approved of the deficient network of monitoring wells proposed by LANL on Figure 10 for MDA G, MDA H and MDA L. The network of monitoring wells at MDA G, MDA H and MDA L do not meet the requirements of RCRA. Furthermore, the network of monitoring wells do not provide the knowledge needed for wise decisions in the NMED Consent Order.

7. The inconsistent requirements of the NMED HWB for groundwater protection practices at LANL and at Sandia National Laboratories in Albuquerque. Figure 12 shows the NMED requirements for the network of monitoring wells at the Sandia National Laboratories Mixed Waste Landfill (Sandia MWL dump) in Albuquerque, New Mexico. The 2.6 acre MWL dump has a similar waste disposal history to MDAs G, H and L. Wastes were buried in unlined trenches and pits at the Sandia MWL dump from 1959 through 1988. The NMED has approved a plan to leave the buried wastes at the MWL dump below a dirt cover.

The direction of groundwater flow at the water table below the Sandia MWL dump is to the west-southwest. For the long-term monitoring at the 2.6 acre MWL dump, Figure 12 shows that the NMED requires three downgradient "point of compliance" monitoring wells at locations immediately along the western boundary of the dump, two monitoring wells a distance to the west of the dump, one monitoring well installed inside the dump and one upgradient monitoring well for background water quality.

As at the Sandia MWL dump, the NMED HWB should require a similar design for the networks of contaminant detection monitoring wells and background water quality wells at MDA G, MDA H, MDA L, and the other legacy waste disposal sites at LANL including MDA AB at TA-49, MDA C and TA-50 and the waste disposal sites at TA-21. In addition, the 65-acre size of MDA G requires the installation of monitoring wells at appropriate locations inside MDA G near the unlined trenches and shafts. If there is resistance to installing monitoring wells inside MDA G, then an alternative method for gaining the required knowledge on groundwater contamination would be to install angled monitoring wells below MDA G. The angled wells would be located south of MDA G in Pajarito Canyon and north of MDA G in Canada del Buey.

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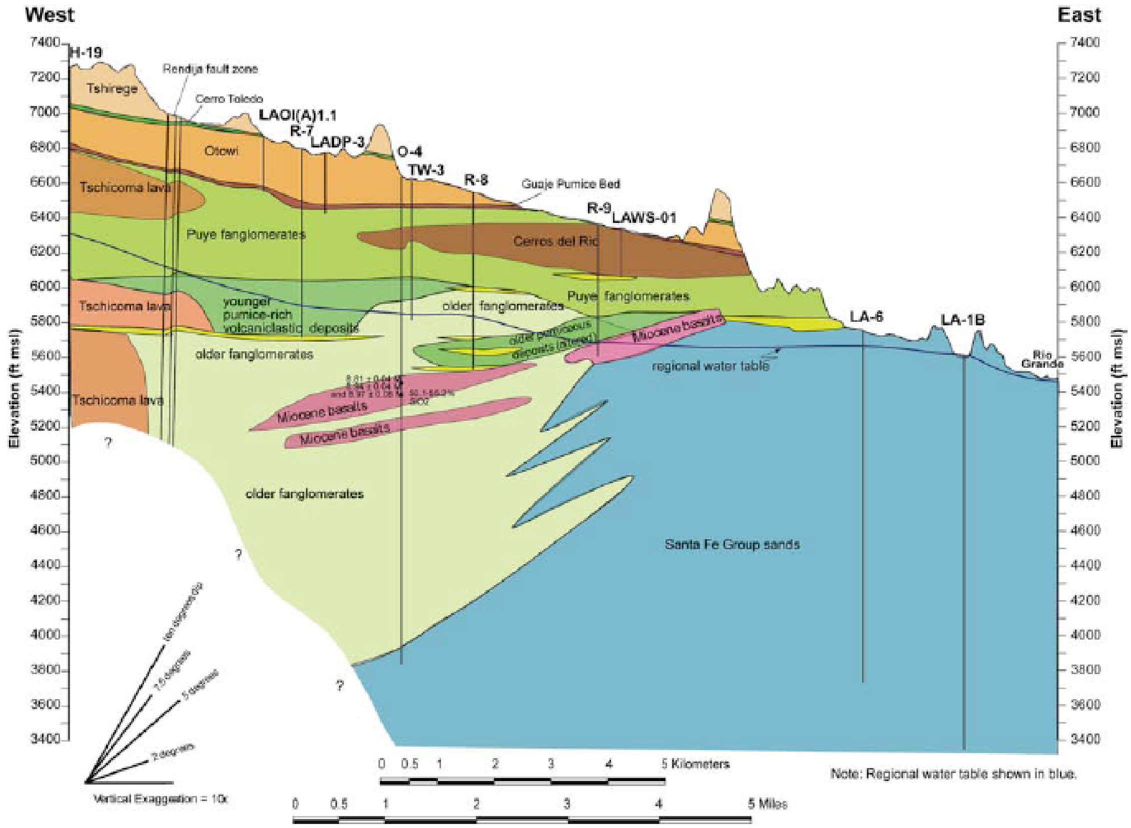
Figure 1. Map showing wells and Rio Grande springs

- On the map, the direction of groundwater flow in the regional aquifer below the Los Alamos National Laboratory is from west to east to the Rio Grande

Source: LANL *Well Screen Analysis Report - Revision 2.*

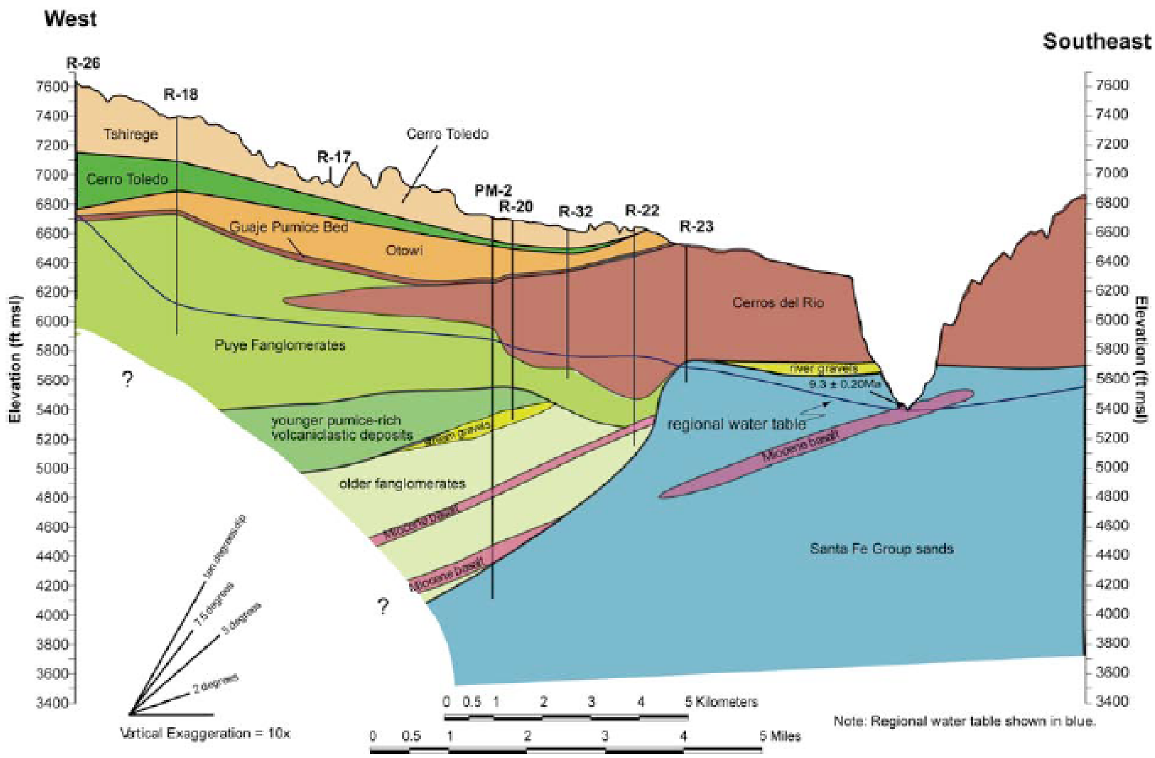
Figure 2. Conceptual west-east cross-section for Los Alamos Canyon in the northern region of the laboratory. The water table of the regional aquifer is shown with the blue line.



Source: LANL *Hydrogeologic Synthesis Report*, December 2005

- **The locations of the wells on the cross-section are displayed on Figure 1.**
- **From west to east on the cross-section -**
  - **The Los Alamos County drinking water well is O-4. LA-6 and LA-1B are abandoned drinking water wells.**
  - **The LANL monitoring wells in the regional aquifer are R-7, old test well TW-3. R-8 and R-9.**

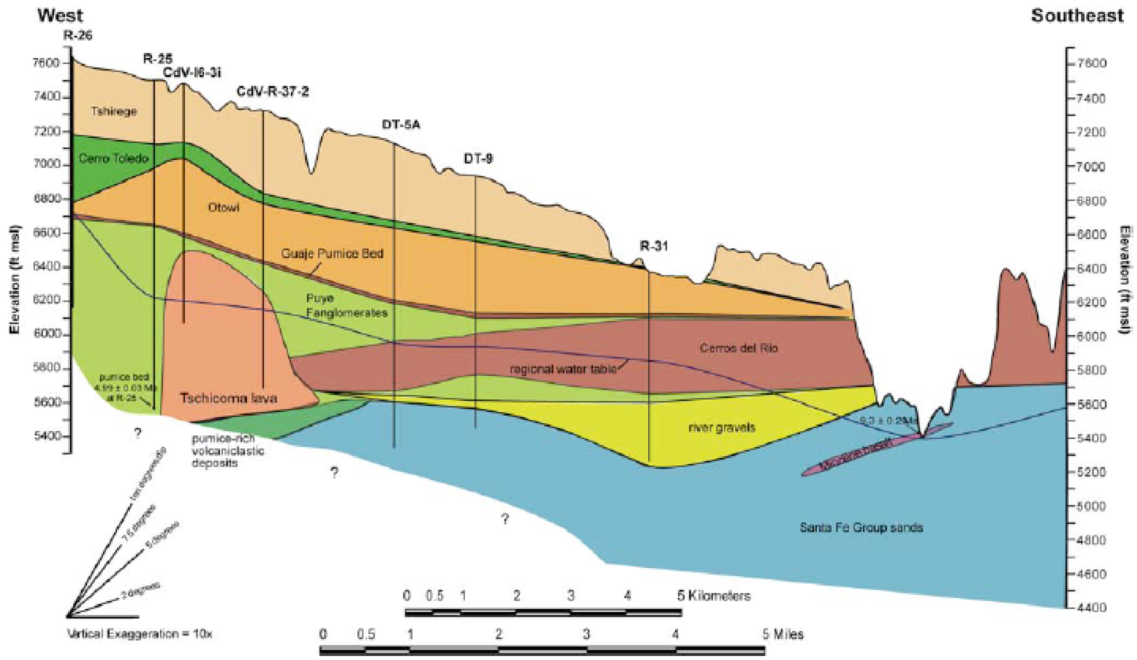
Figure 3. Conceptual west-southeast cross-section for Pajarito Canyon in the central region of the laboratory. The water table of the regional aquifer is shown with the blue line.



Source: LANL *Hydrogeologic Synthesis Report*, December 2005

- **The locations of the wells on the cross-section are displayed on Figure 1.**
- **From west to southeast on the cross-section -**
  - **The Los Alamos County drinking water well is PM-2.**
  - **The LANL monitoring wells in the regional aquifer are R-26, R-18, R-17, R-20, R-32, R-22 and R-23.**

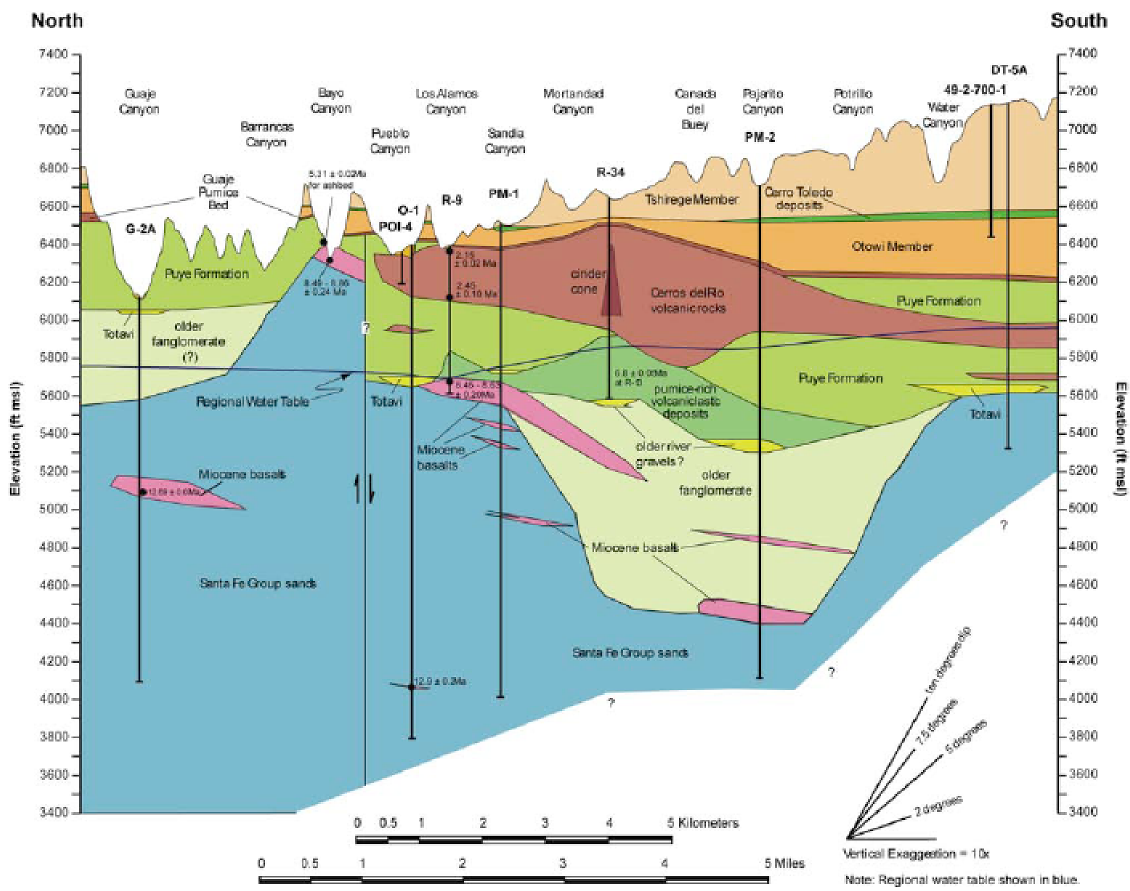
Figure 4. Conceptual west-east cross-section for Water Canyon in the southern region of the Laboratory. The water table of the regional aquifer is shown with the blue line.



Source: LANL *Hydrogeologic Synthesis Report*, December 2005

- **The locations of the wells on the cross-section are displayed on Figure 1.**
- **From west to southeast on the cross-section -**
  - **There are no Los Alamos County drinking water wells on the section.**
  - **The LANL monitoring wells in the regional aquifer are R-26, R-25, CdV-16-3i, CdV-R-37-2, old test well DT-5A, old test well DT-9 and R-31.**

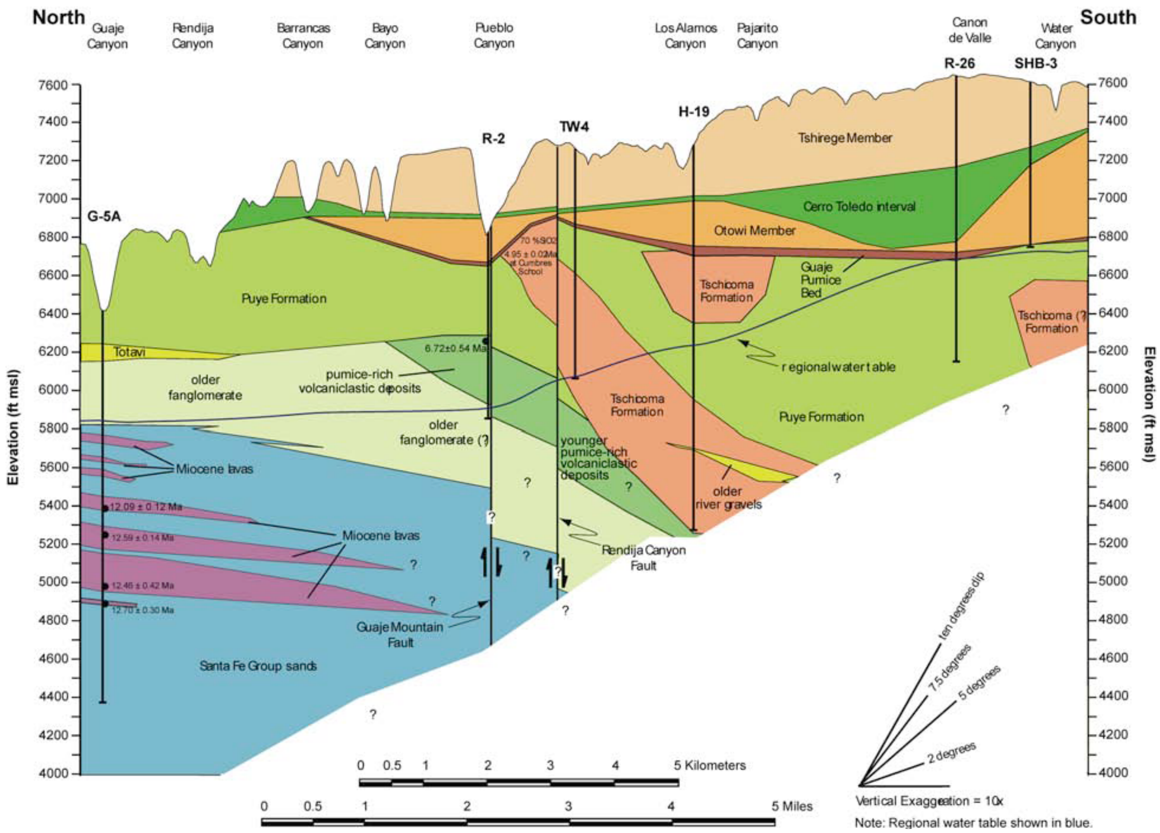
Figure 5. Conceptual northeast-southwest cross-section from the Guaje Canyon well G-2A north of the laboratory through the central part of the laboratory to Water Canyon and Technical Area 49 at the southern boundary. The water table of the regional aquifer is shown with the blue line.



Source: LANL *Hydrogeologic Synthesis Report*, December 2005

- **The locations of the wells on the cross-section are displayed on Figure 1.**
- **From north to south on the cross-section -**
  - **The Los Alamos County drinking water wells are G-2A, O-1, PM-1 and PM-2.**
  - **The LANL monitoring wells in the regional aquifer are R-9, R-34 and old test well DT-5A.**

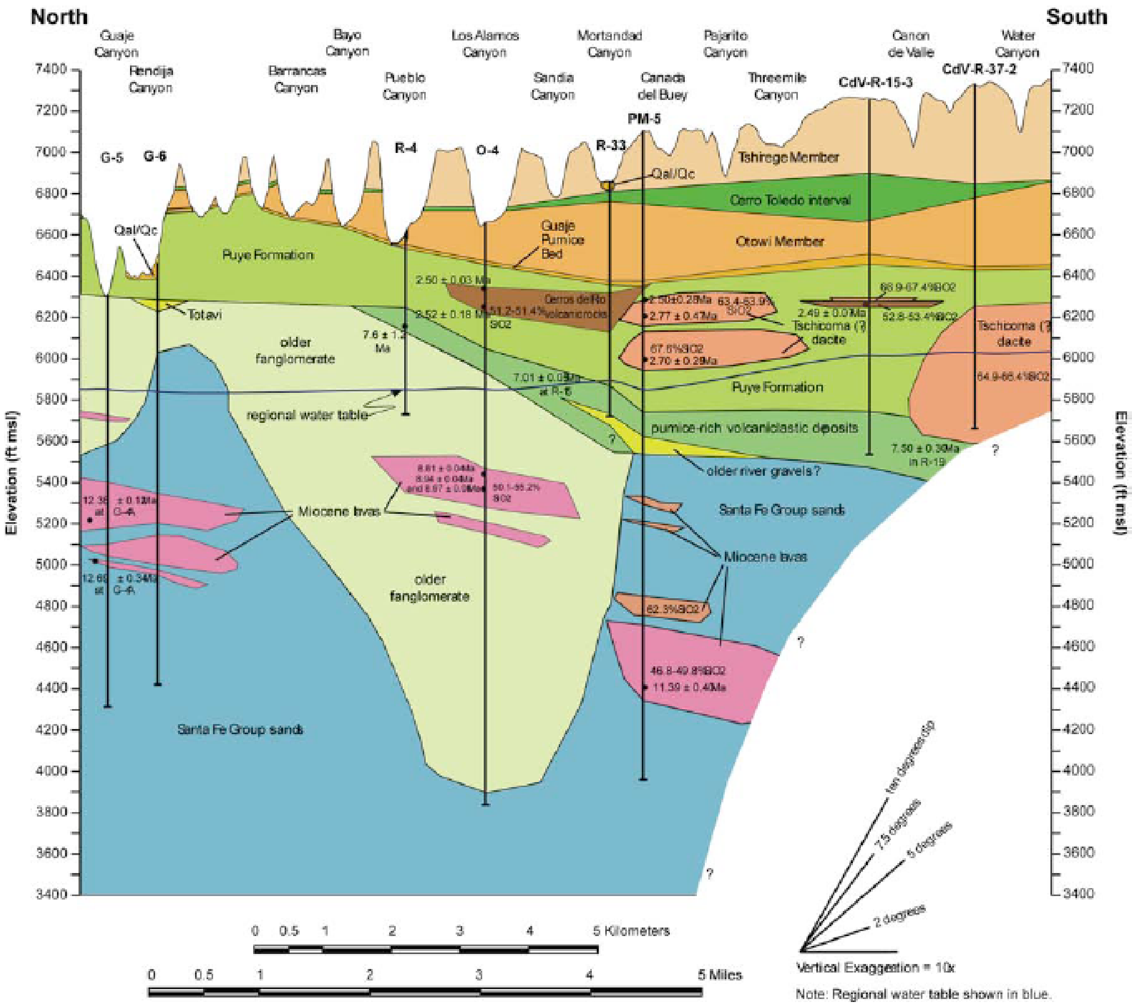
Figure 6. Conceptual north-south cross-section from the Guaje Canyon well G-5A north of the laboratory across the western part of the laboratory. The water table of the regional aquifer is shown with the blue line.



Source: LANL *Hydrogeologic Synthesis Report*, December 2005

- **The locations of the wells on the cross-section are displayed on Figure 1.**
- **From north to south on the cross-section -**
  - **The Los Alamos County drinking water well is G-5A.**
  - **The LANL monitoring wells in the regional aquifer are R-2, old test well TW-4 and R-26.**

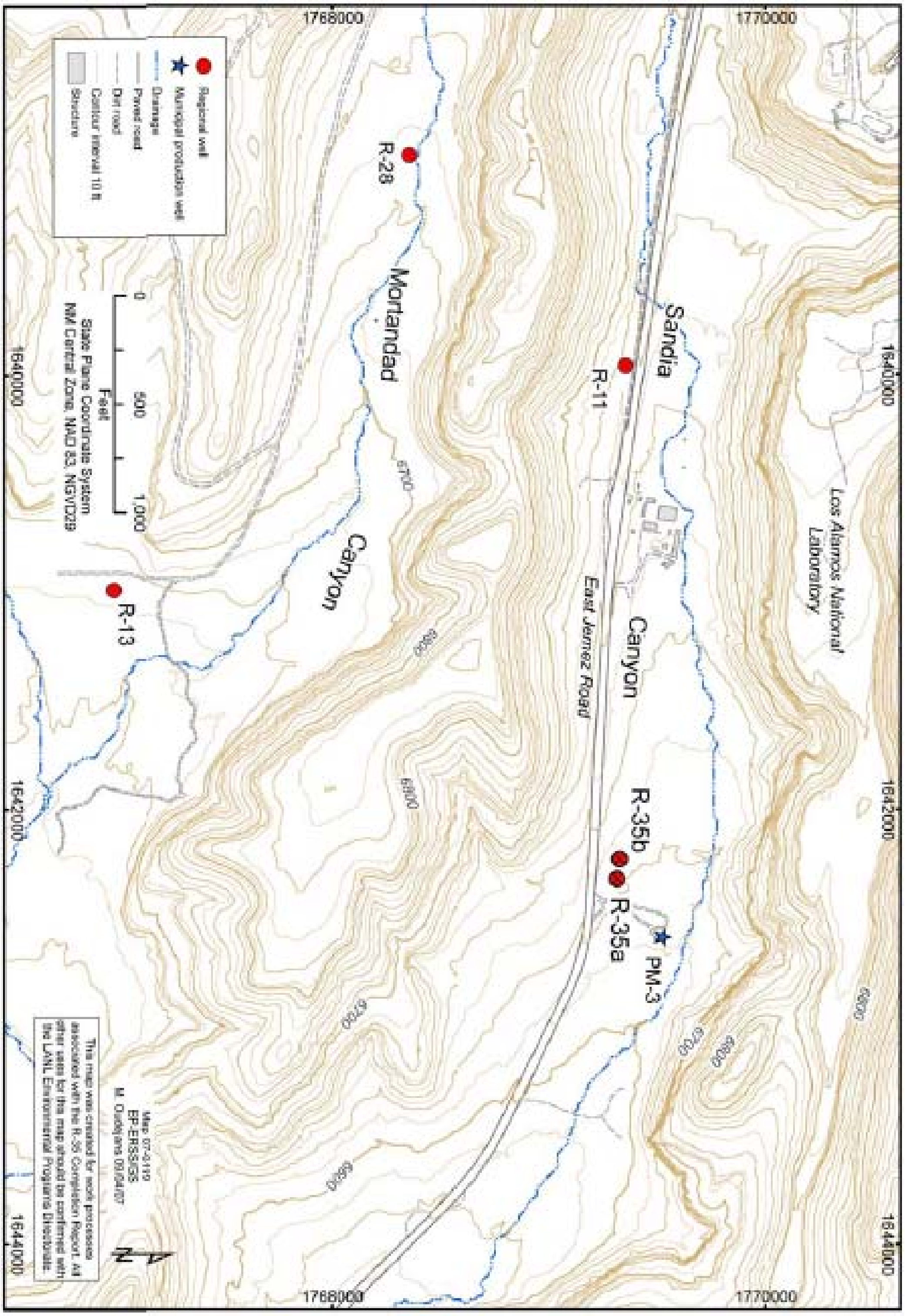
Figure 7. Conceptual north-south cross-section from the Guaje Canyon wells G-5 and G-6 north of the laboratory across the central part of the laboratory. Wells G-5 and G-6 are located approximately 1/2 mile southeast of well G-5a. The water table of the regional aquifer is shown with the blue line.



Source: LANL *Hydrogeologic Synthesis Report*, December 2005

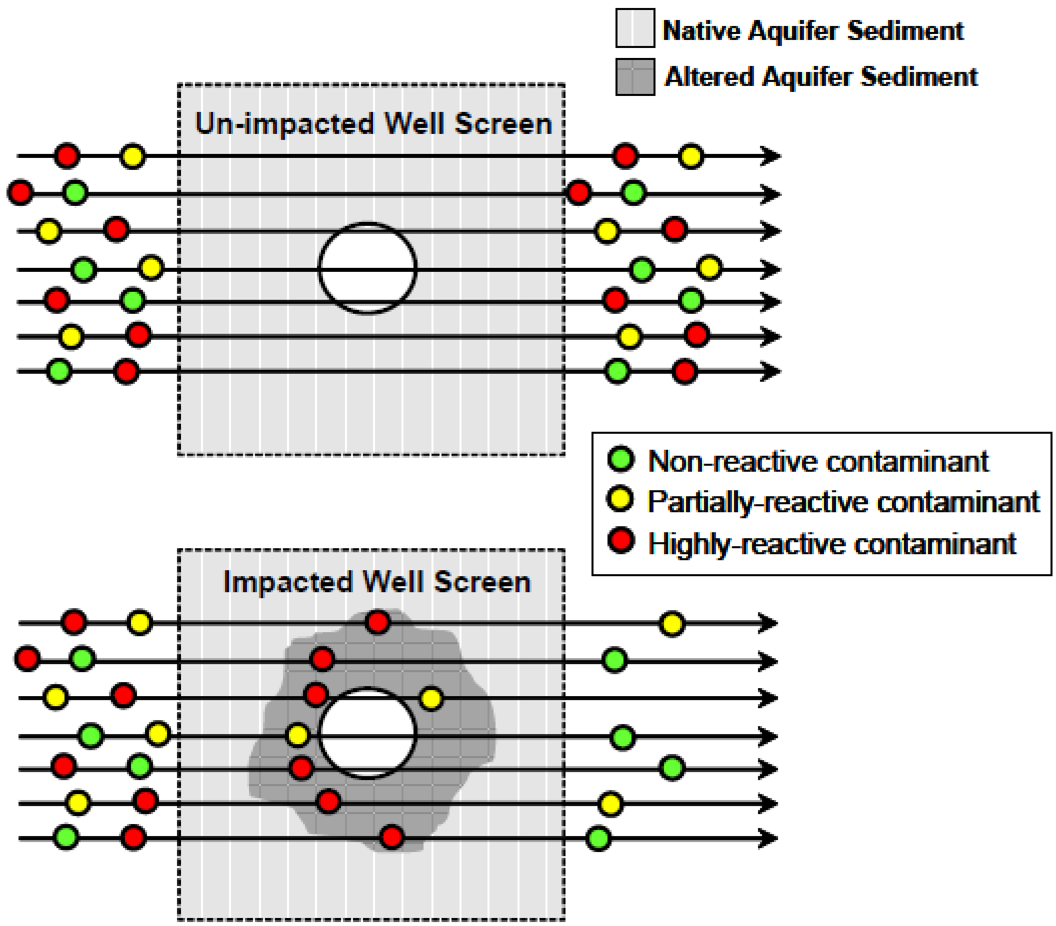
- **The locations of the wells on the cross-section are displayed on Figure 1.**
- **From north to south on the cross-section -**
  - **The Los Alamos County drinking water wells are G-5, G-6, O-4 and PM-5**
  - **The LANL monitoring wells in the regional aquifer are R-4, R-33, CdV-R-15-3 and CdV-R-37-2.**

Figure 8. The close locations of regional aquifer monitoring wells R-35a and R-35b to Los Alamos County drinking water supply well PM-3.



Source: Completion Report for Regional Aquifer Wells R-35a and R-35b. LANL report LA-UR-07-5324, September 2007.

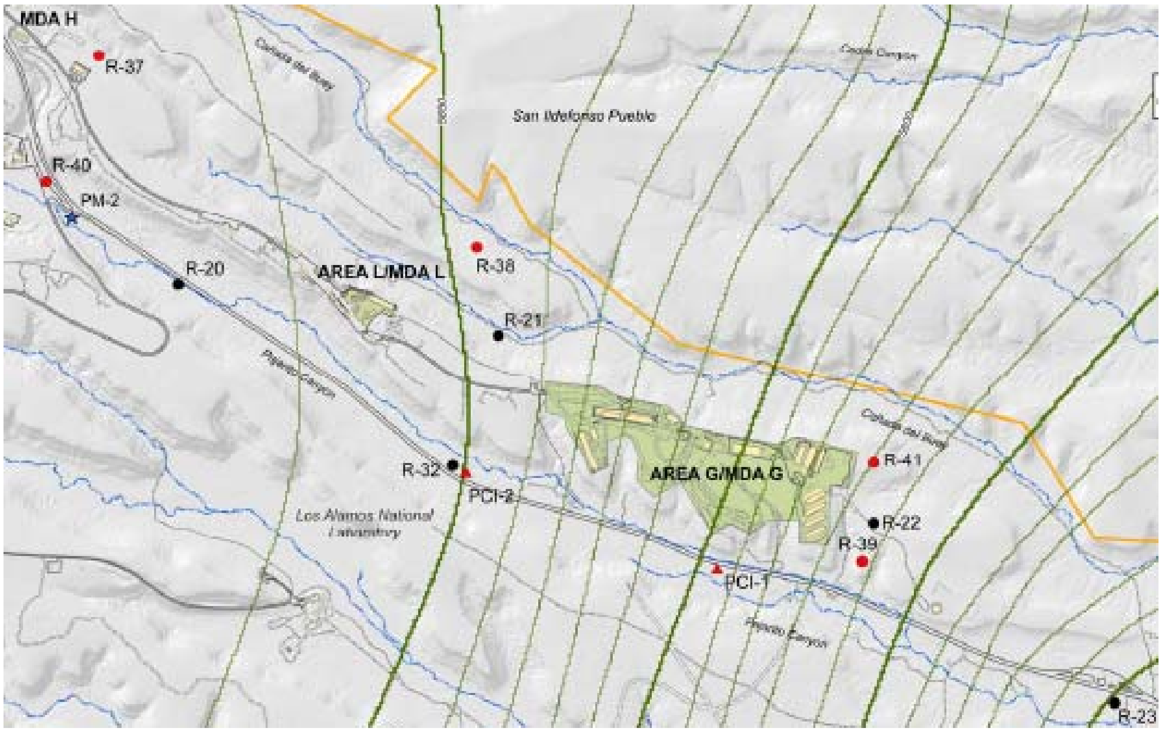
Figure 9. Conceptual schematic illustrating differential transport behavior of contaminants within the impacted zone adjacent to a well screen influenced by biodegradation of organic-based drilling fluids.



Source: Final Report of the EPA Kerr Laboratory on the LANL Monitoring Well Construction Practices, February 10, 2006.

- **Tritium and chloride are examples of Non-reactive Contaminants.**
- **Uranium and chromium may be examples of Partially-reactive Contaminants.**
- **The LANL radioactive contaminants plutonium, americium and cesium are examples of Highly-reactive contaminants.**
- **Zinc is an example of a naturally occurring trace metal that is highly reactive.**

Figure 10. Location of the RCRA "Regulated Unit" waste disposal sites MDA H, MDA L and MDA G atop Mesita del Buey at LANL Technical Area 54

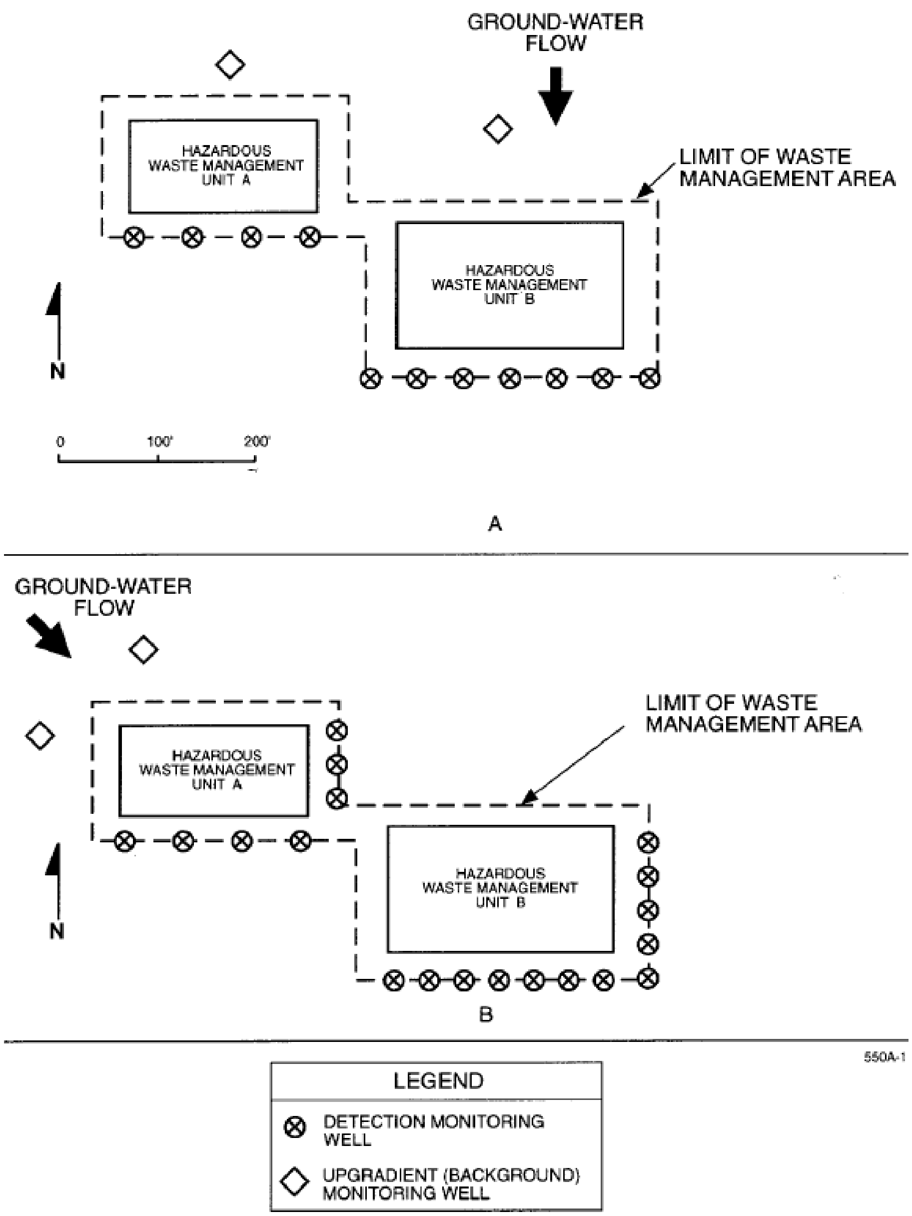


Scale 0--------------------2000 feet

- **Existing monitoring wells in the regional aquifer are shown as black dots**
- **Proposed monitoring wells in the regional aquifer are shown as red dots**

Source: ***TA-54 Well Evaluation and Network Recommendations, Revision 1***

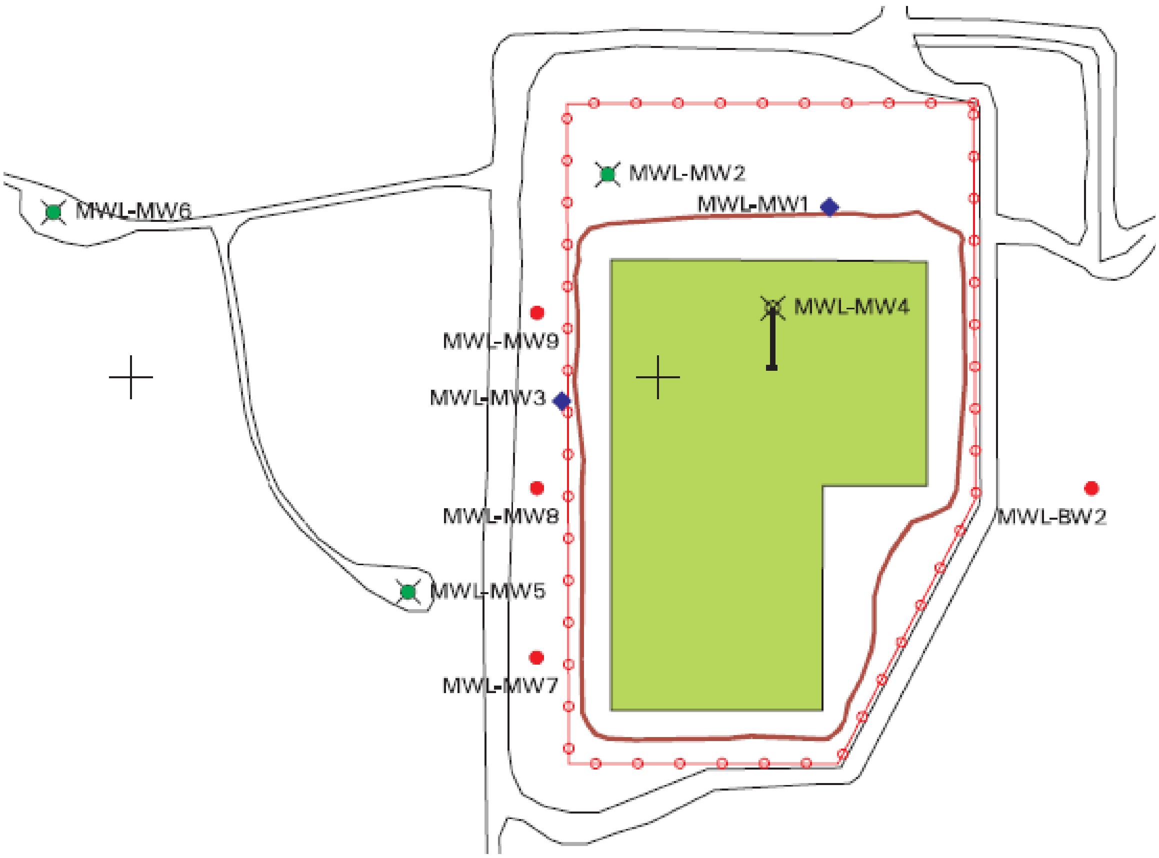
Figure 11. The RCRA requirements for networks of monitoring wells at hazardous waste disposal sites. Background water quality monitoring wells are required to be installed at locations hydraulically upgradient of each disposal site.



DOWNGRADIENT WELLS IMMEDIATELY ADJACENT TO THE HAZARDOUS WASTE MANAGEMENT AREA LIMITS

Source: US EPA *RCRA GROUND-WATER MONITORING: DRAFT TECHNICAL GUIDANCE (The EPA Groundwater Manual),* November, 1992

Figure 12. The NMED requirements for the network of monitoring wells at the Sandia National Laboratories Mixed Waste Landfill in Albuquerque, New Mexico.



Scale 0------------------------200 feet

Source: Sandia National Laboratories *Long-Term Monitoring and Maintenance Plan* for the Mixed Waste Landfill, September 2007.

- The down-gradient detection monitoring wells required for the long-term monitoring program are MWL-MW5, -MW6, -MW7, -MW8 and -MW9.

- Well MWL-MW4 is a detection monitoring well installed inside the Mixed Waste Landfill to monitor groundwater contamination below an unlined trench.

- Well MWL-BW-2 is the background water quality well that is located hydraulically upgradient of the Mixed Waste Landfill.

- The 2.6 acre Mixed Waste Landfill was in operation from 1959 through 1988. The hazardous and mixed waste are buried in unlined pits and trenches. The NMED has approved a plan to leave the wastes buried below a dirt cover.