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General ~~Report~~

memorandum

Risk Reduction & Environmental Stewardship (RRES)
Groundwater Protection Program (RS-GPP, MS M992)

To/MS: Distribution Charles Nylander
From/MS: Charles Nylander, RRES-GPP, MS M992
Phone/Fax: 7-0808/5-4747
Symbol: RRES-GPP-04-0023
Date: May 26, 2004

SUBJECT: MINUTES FROM THE GROUNDWATER PROTECTION PROGRAM QUARTERLY MEETINGS HELD JANUARY 28 AND APRIL 12, 2004

Enclosed please find the minutes from Los Alamos National Laboratory (LANL) Groundwater Protection Program Quarterly Meetings held January 28 and April 12, 2004. The meeting minutes include a written summary of the presentations and discussions and copies of the presentation materials. Also enclosed is the Master Publication List of the Groundwater Protection Program. This list includes published documents that describe work resulting from the Groundwater Protection Program.

These minutes are being sent to you because you received a copy of the Laboratory's Hydrogeologic Workplan or because you attended a quarterly meeting and were added to the distribution list. If you are not interested in continuing to receive meeting minutes, please contact Kelly Bitner at 505-884-8455 or bitner@neptuneinc,org.

Please review these minutes for accuracy. If you identify substantive changes that should be made, please submit your comments to me in writing or via e-mail at nylander@lanl.gov.

CN/KB/th

Enclosure:

1. Quarterly minutes from January 28, 2004 meeting
2. Presentations from January 28, 2004: Status of Wells (T. Whitacre); Groundwater Protection Program Monthly Screening for Constituents for Concern (P. Longmire and A. Groffman); Los Alamos and Pueblo Groundwater Investigation Work Plan Addendum (P. Longmire); Hydrogeologic Conceptual Model (B. Robinson); DP Canyon Tracer Study (A. Groffman); Hydrogeologic Workplan Final Report (B. Robinson)
3. Quarterly minutes from April 12 meeting
4. Presentations from April 12 meeting: Status of Wells (T. Whitacre); Water Quality Sampling Results (P. Longmire); Overview of Hydrologic Testing Results (S. McLin); FY04 Planned Work (C. Nylander); Update on Monitoring Results for the Permeable Reactive Barrier (P. Longmire); Low-Level Perchlorate Analyses by LC/MS/MS (B. Turney); Introduction to Meteorology and Air Quality at Los Alamos (J. Dewart) (attached to this e-mail)
5. Master publication list

13854

Cy(w/enc:)
M. Manzanares, NNMCAB, (2 copies)
H. Daneman
R. Carpenter, City of Santa Fe
J. Arends, CCNS
K. Agogino, EPD, DOE/AL, Albuquerque, NM 87116
D. Youngberg, DOE/HQ/DP-13, Germantown, MD
T. Longo, DOE/HQ/EM-45, Germantown, MD
E. Anderson, EAG, Sciences International Inc., Alexandria, VA
R. Charles, EAG, Ranchester, WY
R. Powell, EAG, Powell & Associates, Las Vegas, NV
J. Powers, EAG, Murray, UT
J. Powers, EAG, Bloomington, MN
D. Schafer, EAG, Stillwater, MN
C. McLane, EAG, Princeton, NJ
P. Davis, Envirologic Inc
R. Mayer, EPA, Dallas, TX
L. King, EPA, Dallas, Tx
M. Everett, Kleinfelder, Inc.,
T. Glasco, Los Alamos County, Los Alamos, NM
P. Padilla, Los Alamos County, Los Alamos, NM
M. Bates, Los Alamos Study Group
K. Bitner, Neptune & Co., Albuquerque, NM
K. Hull, Neptune & Co., Albuquerque, NM
J. T. Grubesic, Assistant Attorney General
L. Lovejoy, NM Atty Genl Ofc.
J. Bearzi, NMED/HRMB, Santa Fe, NM
J. Young, NMED/HRMB, Santa Fe, NM
M. Leavitt, NMED/GWQB, Santa Fe, NM
D. McQuillan, NMED/GWQB, Santa Fe, NM
C. Frischkorn, NMED/GWQB, Santa Fe, NM
J. Davis, NMED/SWQB, Santa Fe NM
J. Parker, NMED/DOE/OB, Santa Fe, NM
D. Antoni, NMED Secretary, Santa Fe, NM
P. Ritzma, NMED Deptury Secretary, Santa Fe, NM
G. Lewis, NMED/HRMB, Santa Fe, NM
C. Cooper, NMED/HWB
V. Maranville, NMED/HWB
C. Abeyta, NMED/HWB
C. Ash, NMTC, Santa Fe
B. Latham, NNMCAB
D. Miotla, NNSA, Germantown, MD, MS C146
B. Jacobs, Bandelier, NM
J. Pecos, Cochiti Pueblo, Cochiti, NM
D. Gonzalez, Cochiti Pueblo
G. Valdo, Pueblo Cochiti

N. Weber, San Ildefonso Pueblo, Santa Fe, NM
J. Chavarria, Santa Clara Pueblo, Espanola, NM
R. Gutierrez, Santa Clara Pueblo, Espanola, NM
D. Duffy, Jemez Pueblo, Jemez, NM
K. Nasser, Revision, Denver, CO
R. Lewis, Schlumberger, Englewood, CO
F. Lauffer, SNL
J. Ahlquist, UC
C. Abeyta, USGS
D. Larrsen, Westbay, N. Vancouver
B. Johnson, Westbay, N. Vancouver
M. Chacon, San Ildefonso Pueblo
J. Kelsey, DB Stephens & Assoc.,
J. Galemore, DB Stephens & Assoc.
C. Mechels
B. Enz, DOE/LASO, MS A316
M. Johansen, DOEOLASO, MS A316
T. Taylor, LAAME, DOE/LASO, MS A316
J. Vozella, DOE/LASO, MS A316
T. Whitacre, DOE/LASO, MS A316
G. Rael, DOE/ABQ, MS A906
J. Holt, ADO, MS A104
D. Erickson, ADWP, MS A106
S. Gibbs, ADO, MS A104
L. Goen, ADO/IF&C, MS F627
P. Sanchez, ADO-IF&C, MS F627
C. Zerkle, ADO-IF&C, MS F627
B. Grimes, CER-30, MS A117
P. Weber, EES-DO, MS D446
G. Valentine, EES-6. MS D462
J. Aldrich, EES-6, MS D462
D. Broxton, EES-6, MS J462
G. Cole, EES-6, MS D462
F. Goff, EES-6, MS D462
D. Hickmott, EES-6, MS D462
P. Longmire, EES-6, MS D469
D. Vaniman, EES-6, MS D462
R. Warren, EES-6, MS D462
W. Carey, EES-6, MS D462
E. Keating, EES-6, MS T003
B. Robinson, EES-6, MS T003
E. Springer, EES-15, MS J495
B. Newman, EES-15, MS J495
A. Gallegos, EES-15, MS J495
C. LaDelfe, EES-11, MS D462
P. Stauffer, EES-6, MS T003
M. Witkowski, EES-DO, MS C306

T. Antan, EES-13, MS M992
C. Echohawk, EES-9, MS C323
S. Baldridge, EES-11, MS D462
A. Lavine, EES-9, MS D462
C. Lewis, EES-9, MS D462
M. Vesselinov, EES-6, MS T003
K. Birdsell, EES-6, MS T003
M. Nilsson, EES-6, MS T003
J. Sisneros, FWO-SEM, MS P908
L. McAtee, HSR-DO, MS K491
S. Kinkead, IM-8, MS M310
P. Reneau, PeakTCI, MS K490
LANL Reading Room, MS A117
R. Hull, LATA, MS M321
S. Maez, LATA, MS M321
D. Woitte, LC-GL, MS A187
P. Wardwell, LC-GL, MS A187
C. Thayer, LC-GL, MS A187
A. Crowder, MK/PMC, MS M327
K. Granzow, NMED/DOE/OB, MS J993
M. Dale, NMED/DOE/OB, MS J993
S. Yanicak, NMED/DOE/OB, MS J993
A. Dorries, RRES-ECR, MS M992
S. Bolivar, RRES-ECR, MS H865
D. Farley, RRES-ECR, MS H865
B. Gallaher, RRES-WQH, MS K497
S. McLin, RRES-WQH, MS K497
K. Mullen, RRES-WQH, MS K497
C. Nylander, RRES-GPP, MS M992
S. Rae, RRES-WQH, MS K497
D. Rogers, RRES-WQH, MS K497
B. Turney, RRES-WQH, MS K497
S. Veenis, RRES-WQH, MS K497
B. Beers, RRES-WQH, MS K497
A. Barr, RRES-SWRC, MS K498
C. Bare, RRES-ECO, MS M887, (3 copies)
P. Schumann, RRES-R, MS M992
B. Ramsey, RRES-DO, MS J591
D. Stavert, RRES-EP, MS J591
K. Hargis, RRES-DO, MS J591
J. McCann, RRES- WQH, MS M992
P. Gomez, RRES-WQH, MS K497
N. Tapia, RRES-WQH, MS K497
H. Granzow, RRES-GPP, MS M992
A. Lee, RRES-R, MS M992
R. Vocke, RRES-DO, MS J591
L. Maassen, RRES-R, MS M992

D. McInroy, RRES-R, MS M992
D. Hollis, RRES-EA, MS M992
S. Pearson, RRES-GPP, MS M992
N. Quintana, RRES-R, MS M992
R. Koch, SAIC, MS J521
RPF, MS M707 (ER2004-0290)
RRES-RS, MS M992
RRES-GPP File, MS M992
IM-5, MS A150
RPF, MS M707

Los Alamos National Laboratory
Groundwater Protection Program
Quarterly Meeting
January 28, 2004
Minutes

MEETING PURPOSE, ATTENDEES, AND AGENDA

The Los Alamos National Laboratory Groundwater Protection Program met with the New Mexico Environment Department (NMED), the Department of Energy (DOE), and stakeholders on January 28, 2004 for a Quarterly Groundwater Protection Program Meeting. The meeting was held at the Courtyard by Marriott in Santa Fe, New Mexico. Charlie Nylander (Groundwater Protection Program Manager) facilitated the meeting.

The following groups and stakeholders were represented (see List of Participants for specific information):

NMED-Hazardous and Radioactive Materials Bureau
NMED-DOE Oversight Bureau
New Mexico Attorney General
DOE-Los Alamos Site Operations
San Ildefonso Pueblo
Northern New Mexico Citizens Advisory Board
Concerned Citizens for Nuclear Safety
Risk Assessment Corporation
Intera, Inc.
Kleinfelder Inc.
Westbay Instruments
LANL-Groundwater Integration Team (GIT)
City of Santa Fe
County of Los Alamos
DDG & Associates
Albuquerque Journal
Amigos Bravos
Washington Group Incorporated/PMC Technologies
Colorado State University

The purpose of the Quarterly Meeting was to provide NMED, DOE, and stakeholders with information on LANL's groundwater protection efforts and present planned activities for the upcoming fiscal year. The meeting agenda was as follows:

9:00 Introduction and Agenda (C. Nylander)
9:15 Status of Wells (T. Whitacre)
9:45 Water Quality Sampling Results (P. Longmire and A. Groffman)
10:15 Break
10:30 Los Alamos and Pueblo Groundwater Investigation Work Plan Addendum (P. Longmire)
11:00 Hydrogeologic Conceptual Model (B. Robinson)
11:30 DP Canyon Tracer Study (A. Groffman)
12:00 Hydrogeologic Workplan Final Report (B. Robinson)
12:30 Adjourn

Introduction (Charlie Nylander, LANL)
Charlie Nylander welcomed the participants to the Groundwater Protection Program Quarterly Meeting. For the benefit of new participants, the history of the past seven years was reviewed. In 1997 the Lab began the site-wide hydrogeologic characterization. The characterization effort had a seven-year schedule. It included quarterly meetings for NMED, stakeholders, and the public as a way to disseminate information from the effort. The last meeting was popular, attended by close to 100 people. Last quarter, the daytime meeting was followed by a poster

session in the evening that was advertised in the newspaper. We were not able to set up an evening poster session this time, but we plan to continue those as a part of future meetings. Input on the frequency and format of evening poster sessions is requested.

Well Drilling Status Report (Tom Whitacre, DOE)
The technical approach was described at the last quarterly meeting, but the key difference in the approach is that all drilling technology is kept available on-site. This enables us to keep the drilling operations going no matter what conditions are present. Most of the drilling has been done with air rotary with foam. Some mud rotary was used. Casing advance was not needed in any of the boreholes this year. Two rigs have been working all the time. Smaller development rigs are brought in after the drilling is complete. A smaller rig is used for coring the upper sections of the boreholes. There is a separate crew for site preparation.

Perched water detection while drilling has been a concern. Three different techniques have been used to identify perched water. The first technique is a bromide fluid sensor system. Fluid with a known concentration of bromide is included in the drilling fluid. The sensor monitors the concentration of bromide in the returning fluid. If the bromide concentration in the returning fluid is significantly less, it indicates dilution by water, possibly a perched zone. The second technique is to remove the entire drill string every night. The borehole is checked for water before leaving for the night and upon returning in the morning. A rising water level in the borehole indicates accumulation of water. If water accumulation is observed, a sample is collected and sent for screening analysis. The third technique is the installation of temporary piezometers in potential perched zones to allow measurement of water level and collect samples.

Another difference in the technical approach is developing the wells soon after the wells are completed. The development rig is brought in one week to ten days after the well is constructed for development. It seems that the faster that development is started, the better the wells seem to clean up.

Finally, the technical approach to reporting has been changed to make the fact sheets and well completion reports part of the contract deliverables. The fact sheets and completion reports will be submitted to NMED in a more-timely manner.

The wells drilled this year were all cored using dry drilling techniques so that the moisture content profiles could be measured. Open-hole geophysics tools have been run in all boreholes. Cuttings have been collected to log the stratigraphy. The wells that have been drilled this year are:

Well	Location	Total Depth	Completion	Core	Geophysics
R-1	Mortandad Canyon, near Permeable Reactive Barrier	1165 feet	1 screen in regional aquifer	350 feet	Open hole suite
R-2	Pueblo Canyon, LA County property	943 feet	1 screen in regional aquifer	228 feet	Open hole suite
R-4	Pueblo Canyon	844 feet	1 screen in regional	243 feet	Open hole suite

Well	Location	Total Depth	Completion	Core	Geophysics
			aquifer		
R-11	Sandia Canyon, across from PTLA firing ranges	927 feet	1 screen in regional aquifer	224 feet	Open hole geophysics
R-26	Cañon de Valle	1485 feet	2 screens in regional aquifer	250 feet	Open hole suite
R-28	Mortandad Canyon, down from sediment traps	1006 feet	1 screen in regional aquifer	315 feet	Open hole suite
CdV-16-1(i)	Water Canyon, TA-16	680 feet	1 screen, intermediate perched zone	200 feet	Open hole suite
CdV-16-2(i)	TA-16, east of R-25	1063 feet	2 screens	No core	Open hole suite
CdV-16-3(i)	TA-16	1405 feet	No well installed yet	No core	Open hole suite

R-2 on Los Alamos County property required working closely with the County. Recreational visitors pass by the site. Weekly notifications were sent to the County. The County is happy with the communication on this project.

The three TA-16 wells are problematic. They were intended to be intermediate perched groundwater wells installed as part of the TA-16 Corrective Measures Study. The first well (CdV-16-1(i)) is located in Water Canyon, it was completed with one screen in the intermediate perched zone. The second well (CdV-16-2(i)) is located east of R-25. When the borehole reached 960 feet there was water. The down-hole video showed water flowing into the borehole. The borehole was extended to 1063 feet and a second screen was placed in the upper zone. After the winter break the well was checked and there was no water. The down-hole video was used to look at the screens and seals, but everything looked fine. We have consulted experts and showed them the before and after videos. One hypothesis is that the water was coming in from a unit at the bottom of borehole and when the well was constructed that unit was sealed off. We have decided to watch it for a couple of months and then make a decision about what to do about the well. A sample of the water in the borehole before completed was collected and a screening analysis done.

The third well (CdV-16-3(i)) was drilled down to 1405 feet and is dry. The depth is 200 – 300 feet below where the regional water table was projected to be. The video shows no water. A full geophysical suite was run. The rock is dense Tsichoma lava. The current depth is the maximum depth of the equipment. The plan is to monitor the borehole for a couple of months to see if water enters the borehole before making a decision to construct a well or to backfill the borehole.

Well development and testing activity status is:

Well	Development	Hydrotesting	Water Volume Removed
R-1	complete	complete	25,000 gallons

R-2	complete	complete	14,000 gallons
R-4	complete	complete	24,000 gallons
R-11	complete	complete	26,000 gallons
R-26	complete	Next week	37,000 gallons
R-28	complete	Complete	15,000 gallons
CdV-16-1(i)	complete	Next week	5500 gallons

The remaining field work to be accomplished is:

- Complete the hydrotesting in wells R-26 and CdV-16-1(i); expected to be done by Feb. 4
- Install dedicated sampling pumps in R-1, -2, -4, -11, -28, and CdV-16-1(i); expected to be complete by Feb. 4
- Install Westbay equipment in R-26; expected to be done by Feb 4
- Water level detection in CdV-16-2(i) and CdV-16-3(i) – ongoing
- Site restoration at all nine drill sites – water and cuttings are analyzed and then seek NMED approval for discharge. If NMED approves discharge the water is sprinkled at the site or on dirt roads for dust control. Cuttings are used to fill in the pits and spread out at the site. Seed mix is spread over the site. In this way the drill pad is reduced to about half the size.

Status of reporting activities:

Well	Date Completed	Fact Sheet	Well Completion Report
R-1	11/03	Submitted to NMED	Due 4/04
R-2	10/03	Submitted to NMED	Due 3/04
R-4	10/03	Submitted to NMED	Due 3/04
R-11	9/03	Submitted to NMED	Due 2/04
R-26	10/03	Submitted to NMED	Due 3/04
R-28	12/03	Due 2/04	Due 5/04
CdV-16-1(i)	11/03	Due 2/04	Due 5/04
CdV-16-2(i)	12/03	Due 2/04	Due 5/04
CdV-16-3(I)	1/04 (borehole)	Due 3/04	Due 5/04

A single well completion report will be prepared for the three CdV-16 wells.

Well Drilling Status Report Questions, Comments, and Responses

Q: Are you consulting with NMED on the TA-16 wells with no water?
R: Yes, NMED has concurred with the decision to monitor both CdV-16-2(i) and CdV-16-3(i).

Q: Were you able to obtain a static water level in CdV-16-2(i)?
R: There was a rising water level, but it stabilized at 962 feet. The geophysics indicate 100% saturation below 962 feet.

Q: Have you considered neutron logging within the casing?
R: We have considered that, but Schlumberger said that open hole is the best data.

Q: Are there temporary piezometers in place?
R: We are looking at installing dedicated piezometers where the water stays. In some wells the water has dried up. Where the piezometers are in canyons where a work plan has not been

developed, the data from the piezometers will be used in planning the work that needs to be done, including installing intermediate depth wells.

Q: What drilling activities are planned for next year?
R: Additional regional aquifer wells in Mortandad Canyon, on San Ildefonso Pueblo, in Los Alamos and Pueblo canyons. However, the budgets are still being worked out.

Water Quality Sampling Results (Pat Longmire and Armand Groffman, LANL)
Pat Longmire (LANL) presented a conceptual model for adsorption of anions and cations onto hydrogeological media at pH 7. Anions include phosphate, arsenate, chromate, molybdate, arsenite, fluoride, sulfate, uranium (VI), nitrate, nitrite, and perchlorate (weakest adsorbing). Cations include metals (aluminum, barium, beryllium, cadmium, cobalt, mercury, nickel, lead, and zinc) and radionuclides (Am-241, Cs-137, Pu-238, Pu-239,240, Sr-90, U-234,235,238, Tc-99, tritium (weakest adsorbing).

The conceptual model describes how strongly anions and cations are adsorbed when there are different types of rock materials. Silica glass is present in the Bandelier Tuff and in pumice-rich sediments. Silica glass has very limited adsorption for anions but strongly adsorbs cations. Clay minerals (specifically smectite and kaolinite) are present in the Bandelier Tuff, Cerros del Rio basalt, and in the Puye Formation. Where clay minerals are present, they tend to have limited adsorption of anions, but strong adsorption of cations. Iron-manganese oxyhydroxides are present in the Bandelier Tuff, Cerros del Rio basalt, Puye Formation, and the Santa Fe Group. Where iron-manganese oxyhydroxides are present, they have limited adsorption of anions, but strong adsorption of cations. Calcite is present in the Cerros del Rio basalt, in the Puye Formation, and in the Santa Fe Group. Where present, calcite has only moderate adsorption of both anions and cations. High explosive (HE) compounds (TNT, RDX, HMX, and degradation products [2-A-4,6 dinitrotoluene and 4-A-2,6-dinitrotoluene]) are mobile in the subsurface at LANL due to limited adsorption. Biodegradation of TNT and degradation products has been observed.

Only mobile contaminants will make it to the regional aquifer. Anions tend to be mobile, because they do not adsorb on minerals. In Mortandad Canyon at well R-15, there is 2 ppm nitrate in the regional aquifer (from discharges from the TA-50 outfall). Nitrate is seen in the regional aquifer because it is a mobile species. Perchlorate is present in the intermediate perched water and maybe in the regional aquifer. Cations such as barium or strontium interact more strongly with minerals. For example, strontium-90 is up to 50-100 pCi/L in Los Alamos Canyon, but is not seen in the intermediate perched zone or in the regional aquifer. That is because the strontium-90 is being adsorbed and migrates much slower. HE at R-25 in TA-16: TNT and others do not adsorb to the minerals present in the aquifer rock, but they are strongly attracted to solid organic matter. The upper saturated zone at R-25 has HE. The HE is degrading by microbial processes and the degradation products are observed in R-25.

Geochemical modeling using the computer program MINTEQA2 was done to evaluate what species of contaminants should be present in groundwater, given the known geochemical conditions. The results of this simulation resulted in the following:

- 100% of perchlorate in ground water is in the form ClO_4^-
- 100% of nitrate in groundwater is in the form NO_3^-
- 100% of barium in groundwater is in the form Ba^{2+}
- 100% of RDX in groundwater is in the form $C_3H_6N_6O_6^0$
- 100% of the TNT in groundwater is in the form $C_7H_5N_3O_6^0$

In the MINTEQA2 simulation for nitrate and barium, the input concentrations were: Ba (0.010 mg/L), Ca (16.0 mg/L), Mg (5.0 mg/L), Na (15 mg/L), K (3.0 mg/L), Cl (15.6 mg/L), NO_3 (0.10 mg/L), SO_4 (7.99 mg/L) and HCO_3 (61 mg/L, calculated). The pH was 6.71 and the charge balance was –2.39%. Mineral precipitation limits the dissolved concentration of Ba in groundwater. Ba undergoes weak cation exchange with clay minerals and can precipitate as $BaSO_4$ and $BaCO_3$.

Armand Groffman (LANL) talked about the monthly screening of groundwater analytical results. Every month the groundwater data are screened for potential constituents of concern. Data is pulled from the Environmental Restoration Database and the Water Quality Database. Data are reviewed and screened, notable results are reported to DOE. The data are compared to trends in time series plots. The notable results for the first quarter of FY04 are from Mortandad Canyon and Cañon del Valle.

In Mortandad Canyon alluvial water sampled from well MCO-7, the perchlorate was above the screening value. However, this well has had historically elevated perchlorate and the trend shows that the sample taken on 10/20-03 is the lowest since sampling began in the well. The alluvial water in MCO-7 also has slightly elevated nitrate, but lower than water quality standards. The trend shows that the nitrate in the alluvial water dropped below the water quality standard in 2000, and has continued as a decreasing trend.

A different alluvial well in Mortandad Canyon, MCO-4B, has also had historically elevated perchlorate. The sample collected on 10/20/03 had 13 μg/L perchlorate. The time series plot shows that the perchlorate at this well has been rapidly decreasing from a historic high of about 500 μg/L in 1994 to the 13 μg/L measured in October.

In Cañon del Valle, the regional aquifer at well CdV-37-2 has iron and manganese above the secondary standards. The secondary standards are 1000 μg/L for iron and 200 μg/L for manganese. In well CdV-37-2 there are three screens in the regional aquifer. In screen 1 (1200 feet), the iron and manganese are elevated above the secondary standards. In screen 2 (1359 feet), the values of iron and manganese have been decreasing between 2001 and 2003. In screen 3 (1551 feet), both the iron and manganese are cleaning up.

Water Quality Sampling Results Questions, Comments, and Responses

Q: What is meant by the distribution?
R: If the constituent is found in groundwater, how much of it is stable in that form.

Q: What is this information used for?
R: The speciation is consistent with what we observe in transport: negative charges are mobile, positive charge are adsorbed.

Q: How much perchlorate was used up the hill?
R: That has not been estimated yet.

Q: Is the Lab working on that estimate?
R: One way we are working on it is using nitrate to estimate perchlorate. We are also doing interviews with chemists and looking for records.

Q: How much perchlorate was used?
R: In Mortandad from 1963 to present, mass balance calculations have provided a much better estimate of the amount of nitrate released into the canyon.

Q: When was the enhanced treatment for perchlorate added to the TA-50 treatment train?
R: By March 2002 perchlorate was not detectable in the effluent. Even before that there may have been much less perchlorate, but the analytical methods were different and with the higher detection limit, the data may not be comparable.

Q: In the CdV regional aquifer samples, are the analyses for total or dissolved?
R: The analysis is on filtered samples. The variation is probably related to reduction of iron and manganese.

Q: What are the changes in Total Organic Carbon in CdV-27-2? Those changes would indicate microbially-mediated dissolution.
R: We don't know what the TOC is in CdV-37-2, but in R-19, as the TOC decreases, so does the iron and manganese.

Q: Are you seeing a similar decrease in iron and manganese in the other wells?
R: The decrease in iron and manganese is generally true for all the wells. The microbes need an organic carbon source to reduce the iron and manganese.

Q: Drilling the wells introduces carbon, then the microbes use that up, which releases iron and manganese. When the carbon source is all used up, the concentrations of iron and manganese go down?
R: That is the trend in the regional aquifer wells.

Q: In the multiple-screened wells that were drilled with EZMud, do the data reflect that equilibrium has been reached?
R: Generally, there is equilibrium. At CdV-15-1 and CdV-37-2, we see clean up and equilibrium. The more a well is sampled, the cleaner it gets.

Q: Are you confident that the water samples from wells with WESTBAY equipment are representative?
R: For the most part it is. However, it needs to be evaluated on a well-by-well basis. The geochemistry reports completed by Pat Longmire mostly show this same trend. A few have different behavior, but to different hydrologic properties.

Q: Recent wells have had more aggressive pumping during development?
R: Single screen wells clean up better because they can be pumped more. Can collect screening data as they are pumped to determine the progress of the development.

Los Alamos Canyon and Pueblo Canyon Groundwater Work Plan (Pat Longmire, LANL)
The goals of the work plan are:

- Further define the extent of contamination in perched intermediate groundwater at well R-9i and in the regional aquifer at supply well Otowi (O)-1;Evaluate the presence and uncertainties of other contaminants known to have been released in the upper reaches of Los Alamos Canyon and Pueblo Canyon; and

- Evaluate the transport pathways that have resulted in the presence of contaminants in water supply well O-1 and in investigation wells R-9 and R-9i.The history of work plan documents for Los Alamos Canyon and Pueblo Canyon is :
- **Nov 1995:** "Task/Site Work Plan for Operable Unit 1049: Los Alamos Canyon and Pueblo Canyon" was submitted to NMED
- **March 1997:** Notice of Deficiency (NOD) on the submitted work plan
- **April, 1997:** Response to the NOD
- **June 1997:** NMED approved the work plan
- **February, 2002:** "Los Alamos and Pueblo Canyons Work Plan Addendum, Surface Water and Alluvial Groundwater Sampling and Analysis Plan" submitted to NMED
- **May, 2002:** NMED approved the addendum
- **December, 2003**: Groundwater Work Plan Submitted to NMED

The technical objectives of the work plan are:

Groundwater Addendum Objectives	How Addressed
Determine nature and extent of potential contamination within the regional aquifer downstream of the Acid Canyon and Pueblo Canyon confluence in Pueblo Canyon.	R-2 was drilled in October 2003. R-3 is proposed in this work plan addendum to be installed near Otowi-1.
Determine nature and extent of potential contamination within the regional aquifer immediately north of TA-73 in Pueblo Canyon.	R-4 was drilled in August 2003.
Determine nature and extent of contamination within the Cerros del Rio basalt/Puye Formation between wells R-8 and R-9i.	Well LAOI-7, as proposed in this work plan addendum, is located between wells R-8 and R-9i. The information from wells R-8 and R-9 are sufficient for regional aquifer characterization.
Determine background/baseline water chemistry for Los Alamos Canyon and Pueblo Canyon.	Wells R-26 and R-7 serve as background wells for the Laboratory including Los Alamos Canyon and Pueblo Canyon.

The hydrogeologic cross section for Los Alamos Canyon shows alluvium underlain by Bandelier Tuff (Tschirege, Otowi, and Guaje Pumice members). The Bandelier Tuff is underlain by the Puye Formation. Within the Puye Formation is complex mosaic of Cerro del Rio basalts derived from the from the east and dacite lava derived from the west. There is a saturated zone in the alluvium, probably discontinuous. There are intermediate perched zones in the Guaje Pumice (wells LAOI(A) 1.1 and LADP-3) and in the Cerros del Rio basalt (well R-9i). The regional aquifer is in the Puye Formation and has been encountered in O-4, TW-3, R-7, R-8, H-19, and R-9. Proposed wellLAOI-7 should be placed within the zone of saturation in the Cerros del Rio basalt. One option is to place it toward the west, near the contact of the Puye Formation and the alluvium. The second is to place it towards the east where the alluvium overlies the basalt.

The background information on releases in this part of the Lab is:

- Los Alamos Canyon and Pueblo Canyon have received effluents from the Laboratory since the early 1940s discharged from former TA-1, TA-2, TA-21, TA-41, TA-43, and TA-53.
- Effluents have contained contaminants, including nitrate, perchlorate, tritium, cesium-137, strontium-90, americium-241, and several isotopes of uranium and plutonium
- Active outfalls discharging to Los Alamos Canyon and Pueblo Canyon include outfalls at TA-43, TA-53, and the Los Alamos Medical Center.
- Bayo Wastewater Treatment Plant a municipal facility actively discharges treated effluent to Pueblo Canyon.

The water quality information in this area is:

- **R-9i** showed 69.4 to 246 pCi/L tritium in two screens set in perched zones within the Cerros del Rio basalt at depths of 199 and 279 ft**R-7,** has not shown contamination in the regional aquifer. Perched groundwater at 378 ft bgs contained 2.55 to 3.38 pCi/L tritium during characterization sampling
- **R-9** contained 4.84 to 14.68 pCi/L tritium in regional aquifer groundwater at 741 ft. Perched groundwater at 279 ft during the drilling of R-9 contained 0.0484 mg/L dissolved uranium; subsequent sampling well R-9i has shown dissolved concentrations of uranium less than 0.001 mg/L.
- **R-8** borehole water sample contained 16 pCi/L tritium and concentrations of perchlorate were less than 0.004 mg/L using ion chromatography
- **R-2 and R-4** were sampled after development and the analytical results are pending.
- **R-5**, sampled during well development and one characterization round. Tritium and nitrate (as nitrogen) were less than 5 pCi/L and 3 mg/L, respectively, in the regional aquifer.
- **O-1** groundwater samples were collected and analyzed; they contained 1.3 mg/L nitrate (nitrate as nitrogen), 0.00112 to 0.00585 mg/L perchlorate, and 29.06 to 40.23 pCi/L tritium
- **TW-1a and TW-1**, nitrate and tritium have been detected in wells indicating that these wells have experienced recharge from surface water and alluvial and perched intermediate groundwater for several decades

The scope of activities proposed in the work plan is:

- Intermediate well, LAOI-7, located between wells R-8 and R-9, to target the Cerros del Rio basalt. Primary purpose of further characterizing the nature and extent of known contaminants in intermediate perched water.
- Regional aquifer well R-3, located near and upgradient of water supply well O-1 in Pueblo Canyon. The primary purpose of R-3 is to identify the transport pathways that have resulted in the presence of contaminants in O-1.

Intermediate well LAOI-7 specifics:

- Total depth: 300-400 ft
- Collect core samples from surface to core refusal, or a maximum depth of 320 ft, for contaminant, metal, and anion analyses.
- Conduct slug test and/or injection/straddle packer test in the screen completely within the perched zone
- Collect screening water samples during drilling at the top of the perched intermediate groundwater, if encountered.
- Suite and timing of geophysical logging to depend on borehole conditions.Complete well with one screen in the Cerros del Rio basalt or Puye Formation.
- If perched water is encountered in strata above the Cerros del Rio basalt, that water will be collected and analyzed during drilling to determine presence or absence of contamination.
- If perched water is not encountered above or within the Cerros del Rio basalt, the borehole will be extended 100 ft within the underlying Puye Formation immediately beneath the Cerros del Rio basalt to test for presence of perched water.

- If saturation is not encountered, the borehole will be backfilled. Regional Well R-3 specifics:
- Total depth: 1800 ft; penetrate ~ 800 ft below regional water table.
- Collect core samples from surface to core refusal, or a maximum depth 300 ft, for contaminant, metal, and anion analyses
- Conduct slug test, single-step pumping test, or injection/straddle packer test in the screen completely below the regional water table.
- Collect screening water samples during drilling at the top of the regional aquifer
- Suite and timing of geophysical logging to depend on borehole conditions.
- Complete well with up to 3 screens at locations selected based on productive zones in the regional aquifer

Two wells were considered, but were not proposed in the work plan for the following reasons:
Regional Well between R-8 and R-9:

- Based on available sampling results, the regional aquifer presently shows the least amount of impact from Laboratory discharges.
- Dilution and adsorption are active processes, thus a significant variation in water chemistry including contaminant concentrations is not expected to occur within the regional aquifer between wells R-8 and R-9. We do not expect variations because there are not significant chemical gradients and the contaminants are not mobile. If we do see fronts moving through with new data, we will re-evaluate. The chemistry between R-8 and R-9 is remarkably uniform.
- An additional R well probably will not reduce uncertainty in contaminant transport and risk analysis based on groundwater monitoring data collected in Los Alamos Canyon.Background well:
- R-6 was proposed for upper Los Alamos Canyon under the Hydrogeologic Workplan. However, R-26 was recently completed at a location upgradient of Laboratory operations and it will provide high-quality samples for chemical analyses.
- Preliminary results of sampling of well R-26 water indicate background concentrations of analytes are in the expected range. There was low Cl (2 mg/L), and there are no tritium results back yet.
- The construction of well R-26 also provides a technically defensible basis for establishing background conditions for the regional aquifer.
- The regional aquifer in R-7 in Los Alamos Canyon has non detectable tritium (< 3 pCi/L). The alluvium has much higher tritium, so the regional is not showing the impact of Laboratory operations. R-7 can also be used as an up-gradient well.

The schedule for the work is:

- **CY 2005:** Drilling and completing the wells is proposed in this work plan and conducting two quarters of sampling rounds at the wells.
- **June 2006:** An investigation report will be prepared following collection and analysis of environmental data and is currently scheduled for delivery to the NMED by June 16, 2006.

Los Alamos Canyon and Pueblo Canyon Groundwater Work Plan Questions, Comments, and Responses

Q: Was R-7 originally designed to be a background well?
R: R-7 was originally for water quality in the regional and intermediate perched groundwater. It was also to understand the stratigraphy and the extent of the Cerros del Rio basalt. Initially, we did not know what the regional aquifer chemistry would be. But the low values indicate the regional aquifer at R-7 is old water with no mixing with younger water. At the surface it is located down-gradient of Lab facilities, but it represents background conditions for the regional aquifer.

Q: Where is R-26?
R: R-26 is in Cañon del Valle, upgradient of Lab facilities. The chemistry of the perched zone in R-26 matches the springs in the Sierra de los Valles. Water from R-26 will be analyzed for the full suite.

Q: Is R-7 up or down from the Omega West reactor?
R: It is located about one-quarter mile east or down from the reactor. The well was drilled on Los Alamos Canyon because we knew there had been a lot of tritium released in Los Alamos Canyon, as described in the work plan for TA-2 and TA-41. LAOI 1.1 in the intermediate perched zone had low tritium compared to the large releases. That led us to believe that the glass in the Bandelier Tuff had been altered to clay, and the subsequent flow paths are stepwise rather than vertical. The perched water in LAOI 1.1 is recharged from west of the Lab. R-7 is down gradient of TA-2, but based on the low tritium activity, the water in the regional aquifer represents background. There is a geochemistry report available for well R-7.
Q: Has NMED accepted R-7 as a background well?
R: It was just proposed as a background well in this work plan, and the NMED has not responded to the work plan submittal yet.

Q: What about the perched zone in TW-3?
R: R-8 encountered perched water in the Puye Formation, but it drained out and was dry. If there was a perched zone at TW-3, that may have been what R-8 encountered. There was no sample collected, so we don't know. LAOI-7 could serve as the eastern point in the basalt.

Q: This has been a question before, so what is being done?
R: TW-3 could be a sentinel well for water supply well O-4. We have conducted a tracer test in the shallow system to understand how contaminants might be moving, and there is a presentation on that later on the agenda. For tritium, being farther east will get more information on the mass of the plume. For strontium-90, we believe the mass of the contaminant is still in the alluvial system.

C: Water samples from TW-3 had the appearance of iced tea. Believe TW-3 should be plugged and abandoned. The work plan should have included plugging and abandoning TW-3.
R: The color of the water was due to corrosion of the metal casing.

Hydrogeologic Conceptual Model (Bruce Robinson, LANL)

This presentation takes a step back from individual observations and puts together a conceptual picture for how groundwater works. The presentation will summarize the conceptual model for the three zones (alluvial, vadose, and regional aquifer) and what the conceptual model is based on. Then it will discuss the implications of groundwater contamination on the plateau.

Alluvial groundwater flow and transport, using a back-of-the-envelope model calculation:
Order of Magnitude Estimate: Los Alamos Canyon:

Conductivity = 10^{-4} m/s
Gradient = 0.03
Darcy Velocity = $10^{-4} \times 0.03 = 3 \times 10^{-6}$ m/s = 95 m/y
Porosity = 0.3
Transport Velocity = 95/0.3 = 320 m/y

There are some measurements of alluvial groundwater velocity. Purtymun did a tracer test with tritium and chloride in Mortandad Canyon in 1974. These tests resulted in transport velocities

between 620 and 7300 m/y. The model order of magnitude estimate and the measured velocities result in the same conclusion: a mobile contaminant released as a liquid effluent in a canyon will travel down the canyon is a year to a couple of years.

However, not all contaminants are non-adsorbing, many adsorb to rock surfaces. An example is strontium-90 in alluvial groundwater in Los Alamos Canyon. A plot of strontium-90 measurements in alluvial groundwater between 1980 and 2000 shows that the bulk of the strontium-90 has not changed location in 20 years.

Conclusions about alluvial groundwater flow and transport are: transport velocities in the alluvium are expected to be fast for nonsorbing contaminants based on simple calculations, and data from contaminant and tracer migration confirm this result. Sorption reduces transport velocities significantly.
Flow and transport through the vadose zone is much lower in a dry tuff than in a wet canyon.

Order of Magnitude Estimate: Bandelier Tuff, Dry Canyon

- Infiltration Rate = 1 mm/y
- Water Content = 0.1
- Transport Velocity = 1/0.1 = 10 mm/y = 0.01 m/y, or about 10,000 years to traverse 100 m thickness of vadose zone

Order of Magnitude Estimate: Wet Canyon

- Infiltration Rate = 500 mm/y
- Water Content (tuff) = 0.2
- Water Content (Basalt) = 10^{-3}
- Transport Velocity (tuff) = 500/0.2 = 2500 mm/y = 2.5 m/y, or about 40 years to traverse 100 m thickness of vadose zone in tuff
- Transport Velocity (Basalt) = $500/10^{-3} = 5x10^5$ mm/y = 500 m/y, or about 0.2 years to traverse 100 m thickness of vadose zone in basalt

These are the time scales over which transport to the regional aquifer may occur.

Observations of transport in the vadose zone can be found in Mortandad Canyon. The nitrate profiles in MCOBT-4.4 and MCOBT-8.5 would suggest infiltration rates of 100-400 mm/yr. There are lateral pathways, because there is nitrate in the intermediate perched groundwater below the depth shown on these profiles. The nitrate must be getting to the water by traveling laterally, not straight down from the surface.

Another observation of transport through the vadose zone is from the low-head weir site in Los Alamos Canyon. There is percolation through the basalt when water is ponded in the basin behind the weir. Wells were installed to look at transport through the basalt. At this site, tracers were put in the soil of the ponding basin during dry periods. When water is present in the basin, it dissolved the tracer and took it down. A plot of the rise in concentration of tracer associated with storm events and subsequent ponding shows rapid transport.

The conclusion about vadose zone flow and transport is: vadose zone travel times on the order of decades are predicted in wet canyons. Locations where the vadose zone stratigraphy consists of thin Bandelier Tuff and thick basalt have the potential for short travel times to the regional aquifer. Flow and transport in the regional aquifer. We now have more accurate potentiometric maps, which are necessary to know the flow directions. Generally, flow in the regional aquifer is west to east or southeast. Groundwater flow occurs in three dimensions, so there is a vertical component

of flow that is important to know. Generally, the gradients are downward in areas of recharge and upward near the river where the aquifer discharges.

A plot of simulated travel times in the regional aquifer shows that near a water supply well, the travel time is short. However, away from the pumping, the travel time is likely to be long, on the order of 100's of years. The most likely way for a contaminant to get from the surface to the regional aquifer is lateral transport in an alluvial aquifer and infiltration close to a water supply well. Conclusion about regional aquifer flow and transport: travel times from the water table to a point of discharge (the Rio Grande or water supply wells) are predicted to be short if the location is close to the discharge location, but otherwise they are expected to be large.
Contaminant detections in groundwater from the environmental surveillance data in relation to the map of vadose zone travel times shows that the surveillance data are consistent with the conceptual models that have emerged from Hydrogeologic Workplan studies. Well O-1 is where tritium and perchlorate have been detected in the regional aquifer. O-1 is located in an area where the model predicts travel times of 10's or years. That is why contamination of the regional aquifer is seen at O-1 first. At the other water supply wells, the Bandelier Tuff is thicker and there is longer transport time.

Overall conclusions are:
From the perspective of input to groundwater risk assessment studies, the most important potential pathways of concern are:

- Wet canyons with contaminant discharges
- Vadose zone hydrogeologic pathways yielding rapid migration to the regional aquifer are areas with:
  - Thin Bandelier Tuff
  - Basalt pathways
- Contaminant pathways occur close to existing water discharge points (water supply wells, some springs)
- However, transport over long distances in the regional aquifer is not consistent with our current understanding. Transport through basalts and the possibility of preferential transport through sedimentary rocks warrants further study. Transport of sorbing contaminants is likely to be slow.
- The most likely large scale transport (kilometers distance) is via surface and alluvial groundwater.
- Surveillance data are consistent with the conceptual models that have emerged from Hydrogeologic Workplan studies.

Hydrogeologic Conceptual Model Questions, Comments, and Responses

Q: What is the vertical gradient anomaly at R-19?
R: Don't have an answer for that yet. The cross section collapses the north-south data, so the anomaly may be exaggerated, but it is still there.

Q: Are there changes in the potentiometric surface over time?
R: There is dropping associated with water supply wells. There are no large changes over years due to natural processes. The main effect is pumping the water supply wells. The water level declines associated with the wells over 50 years suggests establishment of cones of depression. Near the older pumping centers the decline is on the order of 10's of feet.

Q: Does the map of predicted travel time extend to the Rio Grande?

R: That is a good suggestion. We will check the coverage and see if it can be extended. Travel times near the Rio Grande would be much faster, because the distance to the regional aquifer is much less. Travel times depend on the point at which the contaminant is released. The travel time estimate does not mean much without a source of contaminants.

Q: How would you study preferential transport?
R: Use a tracer study to find the effective porosity.

Q: Have you looked at the vertical gradients in the alluvium?
R: We have looked at the moisture profile and contaminant profile to back out the percolation rate.

DP Canyon Tracer Study (Armand Groffman, LANL)
The tracer study was planned since 1998. The objectives of the study were:

- Understand hydrological behavior of DP Reach-2
- Determine the connection between DP Reach-2 and DP Spring
- Understand how surface/ground water interaction influences tracer movement
- Use results to understand other alluvial systems across the Pajarito Plateau

The tracer study consisted of injecting water containing a known concentration of bromide, and determining the time of arrival of the bromide at wells downstream from the injection site. The amount of time that it takes for bromide to arrive at wells is an estimate of travel time in the alluvial aquifer. The measurement methods used in the study were:

- In*situ* TempHion ion selective electrodes (ISE) deployed in nested wells used to provide continuous data on bromide concentration in groundwater
- Manual sampling of all wells and measurement with Orion ISE in laboratory
- *Isco* automated sampling of surface water and DP-Spring (IC measurement because of low bromide concentrations)

Four types of wells were used in DP Canyon for the study:

1. Transect nested wells to measure bromide concentration. These wells are constructed as three nested screens in the same borehole.
2. Nested piezometer to measure changes in water level. These nests consist of three piezometers in separate boreholes, screened at different depths.
3. Boreholes to determine the extent of alluvial saturation in DP Canyon.
4. Fully-Screened Wells to determine the chemical structure of water. These wells are screened through the entire thickness of the alluvial aquifer.

The bromide was injected over 2.5 hours into a fully-screened well. The objective was to inject the bromide without perturbing the head in the system. Measurements in the nested piezometers showed that the heads were not changed. On day 7 after injection, the bromide plume was largely pooled at the bottom of the alluvial aquifer, probably perched on the weathering rind at the top of the Bandelier Tuff.

By day 137 the plume had moved to the end of reach 2 and the center of mass of the plume was about two-thirds down the length of reach 2. The bromide concentration had decreased from 420 mg/L to 26 mg/L.

Surface water/groundwater exchange was evaluated by:

- Tracking precipitation events
- Measuring channel discharge at a station about 100 feet from the injector well

- Measuring bromide concentration in the surface water
- Estimating seepage velocity measuring the difference in head in three piezometers. If there is a negative value, there is an upward gradient

Under non-precipitation conditions, the water table is below the channel and there is no flow in the channel. After precipitation events, the water table rises and the alluvial aquifer discharges into the stream channel. Any tracer or soluble contaminants in the sediment accompany alluvial water into the channel. The bromide concentration was measured in DP Spring because DP Spring has had measured concentration of contaminants, e.g. strontium-90, over the years and the pathway and travel time was of interest. Both bromide and chloride were measured in the spring. The chloride concentration varies with the amount of runoff from the town (road salt). Bromide was also detected, so there is a connection between Reach 2 and DP Spring.

The conclusions from this study are:

- Tracer has traveled extensively in the channel during and shortly after runoff and infiltration events.
- Ground water surface water exchange appears to facilitate tracer movement close to the channel with diminishing affects away from the channel.
- Supporting evidence includes:
  1. Bromide was detected at DP Spring approximately 30 days after injection.
  2. Bromide concentrations in ground water adjacent to the channel show an almost immediate response to runoff infiltration events.
  3. Hydraulic head and calculated seepage velocities respond to channel flow indicating exchange between surface water and the alluvial aquifer.

DP Canyon Tracer Study Questions, Comments, and Responses

Q: How thick is the alluvium?
R: 13 to 14 feet.

Q: What is the saturated thickness?
R: The saturated thickness is about 4 feet.

Q: Was there any cations measured?
R: Potassium was measured but the data is not presented here.

Q: What is the horizontal distance of reach 2?
R: The exact measurement is not available here, but it is several hundred feet.

Q: Have you calculated a mass balance for the plume?
R: Not yet, but we would like to.

Q: What is the status of the permeable reactive barrier?
R: The Permeable Reactive Barrier (PRB) is a remediation structure in Mortandad. The last time it was sampled was in mid-September. There was so little water in the alluvium that the collected water had to be composited to get enough water for analysis.

Q: Water is supposed to be moving through the PRB, so where is the water? Why is there no quarterly sampling?

R: Because of the drought, the saturation in the alluvium is decreasing. Water has to be there in order for the PRB to work. There is some hope for more water in the spring. Natural evapotranspiration in the canyon is removing water from the alluvial aquifer.

C: Request that a presentation on the PRB be provided at the next meeting.
R: The next meeting will include a presentation on the PRB.

Hydrogeologic Workplan Synthesis Report (Bruce Robinson, LANL)
The synthesis report will include historical studies, data collected under the Hydrogeologic Workplan and other Environmental Restoration projects, and analysis of data from the Hydrogeologic Workplan.

The technical issues, as originally posed by NMED were:

- Individual zones of saturation are not adequately delineated, and "hydraulic interconnection" between them is not understood
- Recharge areas for the regional aquifer and intermediate perched zone not identified; effect of fracture-fault zones on recharge is unknown
- GW flow directions of regional aquifer and intermediate perched zones, as influenced by pumping, are unknown
- Aquifer characteristics cannot be determined without additional monitoring wells; location of wells cannot be addressed adequately without delineation of individual zones of saturation

The Hydrogeologic Workplan addressed questions to respond to the technical issues raised by NMED and to meet programmatic objectives. The questions were:

- Is characterization adequate to determine where GW exists and whether contaminant concentrations exceed regulatory limits or risk levels?
- Is characterization sufficient to establish a detection monitoring program?
- Is characterization sufficient to satisfy conditions of HSWA portion of LANL's RCRA operating permit?

The expected outcomes of the Hydrogeologic Workplan are:

- Refined understanding of hydrogeologic setting (recharge, hydraulic interconnections, flow paths, flow rates, synthesized by modeling)
- Information sufficient to design and implement a detection monitoring program
- Defined areas of existing or potential groundwater contamination, from surface to regional aquifer, with predictions of direction and rates of movement and risk based on modeling

The major report elements are:

- Executive Summary
- Introduction
- Hydrogeology
- Geochemistry
- Contaminant Distributions
- Numerical Models (each section addresses basic model formulation, data sources, model development, and uncertainties)
- Implications of Hydrogeologic Workplan Study Results
- Discussion of Alternate Conceptual Models
- Conclusions

The funding and schedule for the synthesis report are:

- Half of funding is available in FY04
- Report due – March 15, 2005 (assumes funding available next FY to complete)

- High-Level Schedule
  - Annotated outline completed – February 29, 2004
  - All analyses and interpretations completed, September 30, 2004
  - Draft writeup for introductory text and sections for which interpretations are already complete – September 30, 2004
  - Draft writeup for entire report – December 31, 2004
  - Review and publication completed – March 15, 2005
- We welcome NMED and stakeholder input during the preparation and review of this report
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Hydrogeologic Workplan Synthesis Report Questions, Comments, Responses

Q: The program is not complete; the wells are not cleaned out. How can you write a final report? How much money is being spent?
R: Prefer to call it a synthesis report. It will put together what we know, even though we know that new information will come in during and after we prepare the report. In general, we tend to wait too long to write down what we know. The time to do this is now. The funding for the report is $300,000 this fiscal year and another $300,000 next fiscal year. There will continue to be nature-and-extent studies, but the synthesis report will provide the site-wide understanding.

Q: There are several more wells listed in the Hydrogeologic Workplan, are those going to be installed?
R: From here on out, all wells will be under specific work plans. The site-wide evaluation is done and the focus has been shifted to characterizing releases. The driver is no longer the Hydrogeologic Workplan, but the individual work plans. There is no loss in the number of wells, the vehicle has just changed. The report will address what we know as of today. We don't have to work out every well unless there is something revealed that is very different. If the wells serve to confirm what is in the report, the conclusions do not change.

Q: Will the CdV-16 wells be included or where will they be reported?
R: This will not be a well-by-well report, but a synthesis. The CdV wells are part of a CMS and will be reported there, but the results from those wells will be included with the synthesis. An Interim Site-Wide Monitoring Plan will also be done this year, distinct from characterization.

Q: Will the public have the opportunity to review the monitoring plan?
R: The monitoring plan is a state requirement, and it will go through public review consistent with that.

Los Alamos National Laboratory
Groundwater Protection Program
Quarterly Meeting
January 28, 2004
Minutes

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Well Drilling Status Report

January 28, 2004

Tom Whitacre
DOE Project Director

Overview

- Technical Approach
- Drilling Accomplishments
- Well Development and Testing Activities
- Remaining Field Work
- Reporting Activities

Technical Approach

- **Multiple drilling systems and rigs onsite**
  - Air Rotary System
  - Mud Rotary System
  - Casing Advance System
- **Perched water detection**
  - Bromide fluid sensor system
  - Tripping out entire casing string each night
  - Piezometer installation in selected cored boreholes
- **Well developed soon after completion**
- **Reports and Fact Sheets contract deliverables**

Drilling Accomplishments

- **R-1 – Mortandad Canyon – 1165 feet – 1 screen**
  350 feet core – open hole geophysics suite
- **R-2 – Pueblo Canyon - 943 feet - 1 screen**
  228 feet core – open hole geophysics suite
- **R-4 – Pueblo Canyon - 844 feet - 1 screen**
  243 feet core – open hole geophysics suite
- **R-11 – Sandia Canyon – 927 feet - 1 screen**
  224 feet core – open hole geophysics suite
- **R-26 – Canyon de Valle – 1485 feet - 2 screens**
  250 feet core – open hole geophysics suite

Drilling Accomplishments (Con't)

- R-28 – Mortandad Canyon – 1006 feet – 1 screen
  315 feet core – open hole geophysics suite
- CdV-16-1(I) – TA-16 – 680 feet – 1 screen
  200 feet core – open hole geophysics suite
- CdV-16-2(I) – TA-16 – 1063 feet – 2 screens
  no core collected – open hole geophysics suite
- CdV-16-3(I) – TA-16 – 1405 feet – no regional water saturation – no well installed – no core collected - open hole geophysics suite

Well Development and Testing Activities

- R-1 – development and hydrotesting completed about 25,000 gallons removed
- R-2 – development and hydrotesting completed about 14,000 gallons removed
- R-4 – development and hydrotesting completed about 24,000 gallons removed
- R-11 – development and hydrotesting completed about 26,000 gallons removed

Well Development and Testing Activities (Con't)

- R-26 – development completed – awaiting hydrotesting – about 37,000 gallons removed
- R-28 – development and hydrotesting completed about 15,000 gallons removed
- CdV-16-1(I) – development completed – awaiting hydrotesting - about 5500 gallons removed

Remaining Field Work

- Hydrotesting – R-26 and CdV-16-1(I) - 2/04
- Sampling Pump Installation – R-1, R-2, R-4, R-11, R-28, and CdV-16-1(I) – 2/04
- Westbay Installation – R-26 – 2/04
- Water level detection – CdV-16-2(I) and 16-3(I) - ongoing
- Site Restoration – All nine drill sites – 3/04

Reporting Activities

- R-1 – Well completed 11/03
  - Fact Sheet submitted to NMED
  - Well Completion Report due 4/04
- R-2 – Well completed 10/03
  - Fact Sheet submitted to NMED
  - Well Completion Report due 3/04
- R-4 – Well completed 10/03
  - Fact Sheet submitted to NMED
  - Well Completion Report due 3/04

Reporting Activities (Con't)

- R-11 – Well completed 9/03
  - Fact Sheet submitted to NMED
  - Well Completion Report due 2/04
- R-26 – Well completed 10/03
  - Fact Sheet submitted to NMED
  - Well Completion Report due 3/04
- R-28 – Well completed 12/03
  - Fact Sheet due 2/04
  - Well Completion Report due 5/04

Reporting Activities (Con't)

- CdV-16-1(I) – Well completed 11/03
  - Fact Sheet due 2/04
  - Well Completion Report due 5/04
- CdV-16-2(I) – Well completed 12/03
  - Fact Sheet due 2/04
  - Well Completion Report due 5/04
- CdV-16-3(I) – Borehole completed 1/04
  - Fact Sheet due 3/04
  - Well Completion Report due 5/04

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Groundwater Protection Program
Monthly Screening for Constituents of Concern

LA-UR-04-0508

Armand Groffman and Pat Longmire
January 28, 2004

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Groundwater Protection Program
Monthly Screening for Constituents of Concern

- All groundwater sampling activities are reported monthly to the DOE.
- Data are tracked and pulled from the ERDB and WQDB.
- Data are reviewed and screened, and notable results are identified.
- Notable data are compared with historical trends.

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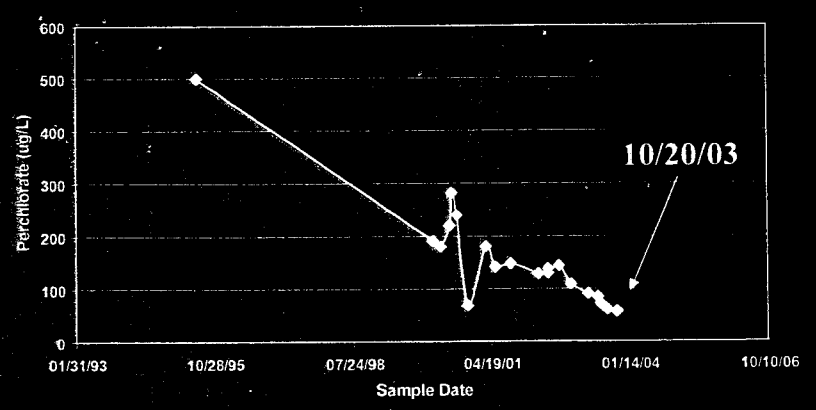
FY04 First Quarter Data

- Notable groundwater data from the first quarter FY04 included locations:
  - MCO-7 and MCO-4B in Mortandad Canyon
  - CdV-37-2 in Canyon de Valle

Mortandad Canyon Alluvial GW Location MCO-7
(historically elevated in perchlorate)



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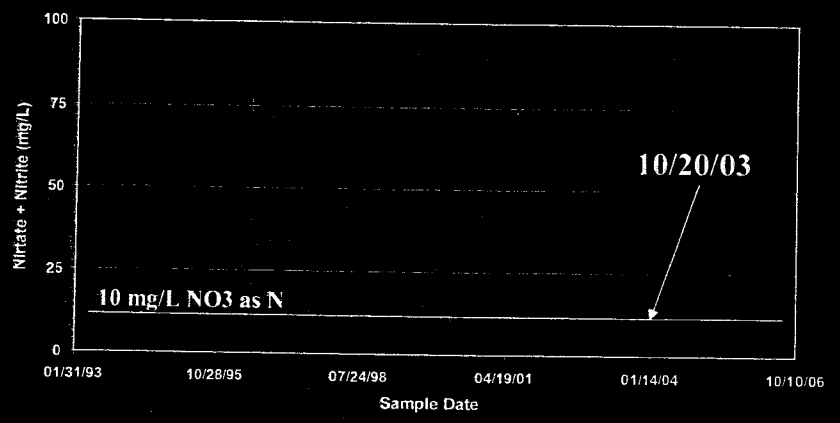
Mortandad Canyon Alluvial GW Location MCO-7

(Nitrate (+NO2) as N is somewhat elevated but below WQ standards)



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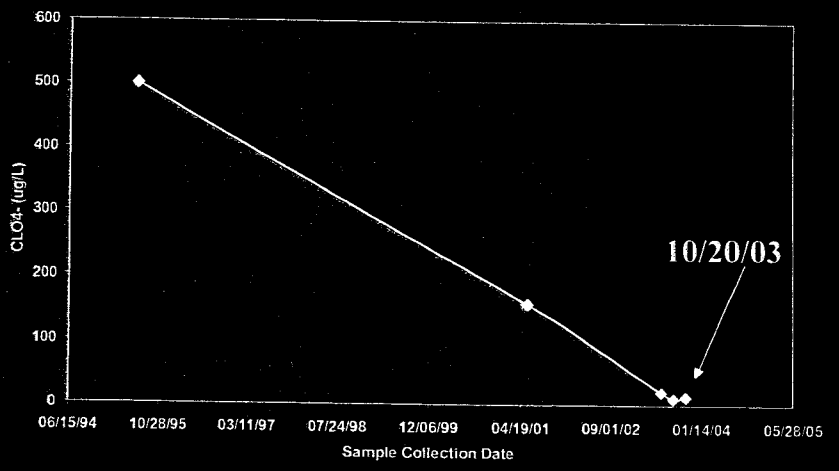
Mortandad Canyon Alluvial GW Location MCO-4B

(historically elevated in perchlorate)



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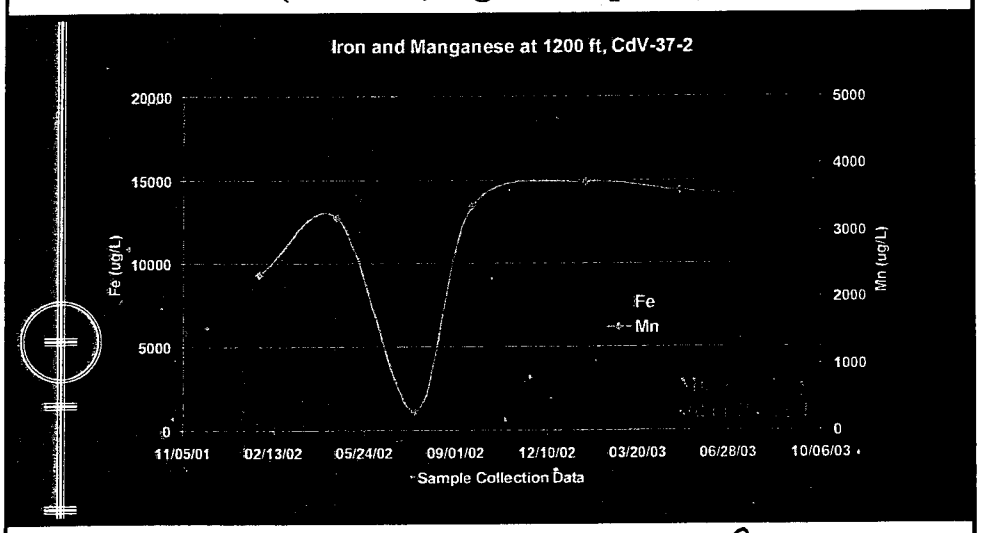
Iron and Manganese at CdV-37-2 (screen-1, regional aquifer)



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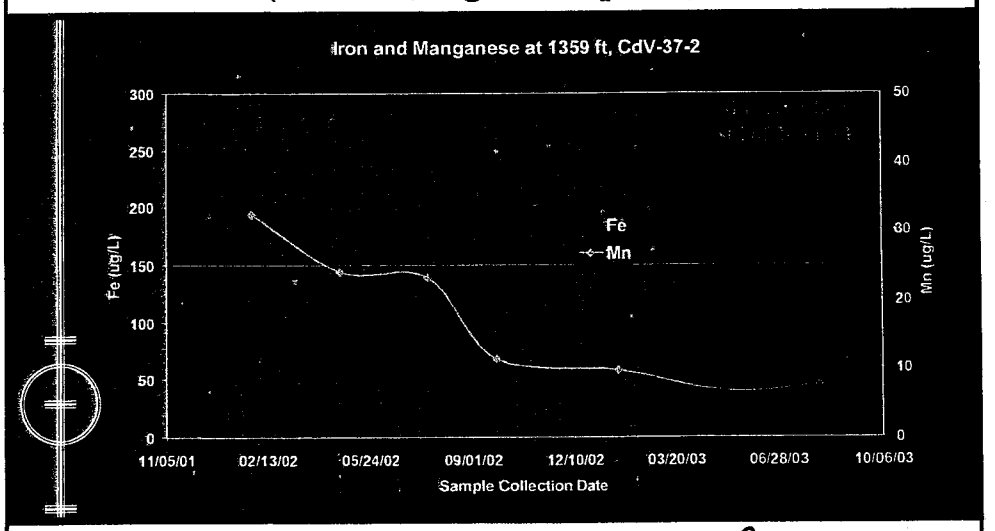
Iron and Manganese at CdV-37-2 (screen-2, regional aquifer)



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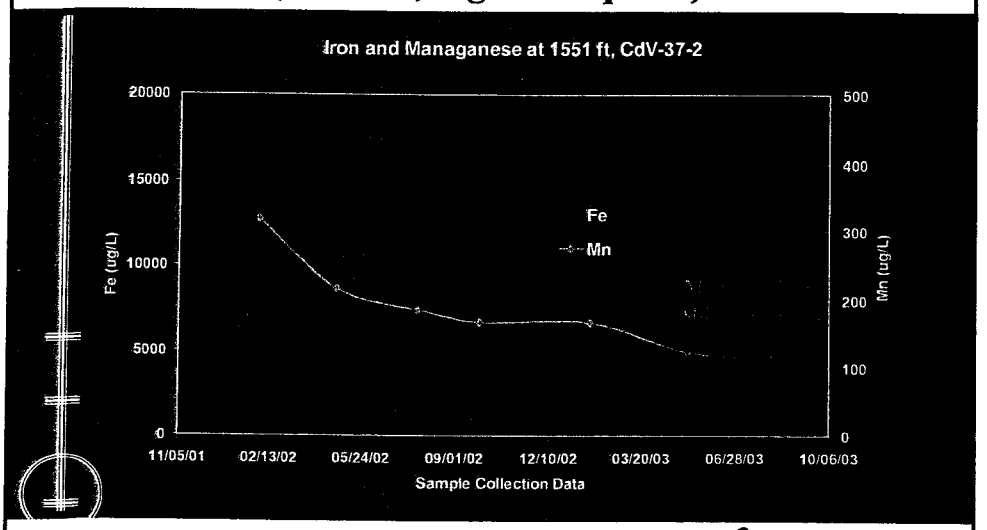
Iron and Manganese at CdV-37-2 (screen-3, regional aquifer)



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Conclusion

Screening of data allows early identification of contaminant mobility

Constituents are tracked in the alluvial, intermediate, and regional systems

Groundwater hydrochemical results are assessed site wide on a monthly basis

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Los Alamos Canyon and Pueblo Canyon Intermediate and Regional Aquifer Groundwater Work Plan

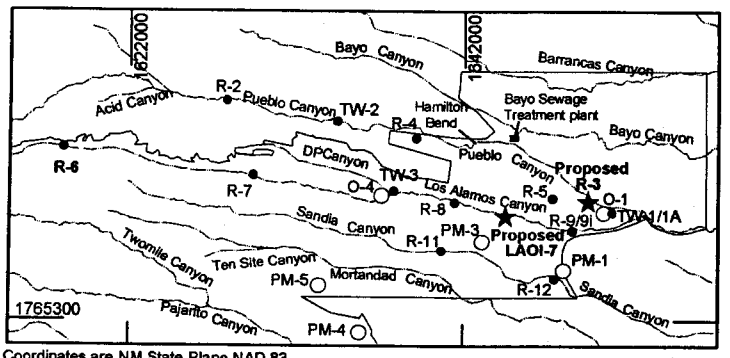
Patrick Longmire and Kelly Bitner

Work Plan Goals

- Further define the extent of contamination in perched intermediate groundwater at well R-9i and in the regional aquifer at supply well Otowi (O)-1;
- Evaluate the presence and uncertainties of other contaminants known to have been released in the upper reaches of Los Alamos Canyon and Pueblo Canyon; and
- Evaluate the transport pathways that have resulted in the presence of contaminants in water supply well O-1 and in investigation wells R-9 and R-9i.

Document Trail

- **Nov 1995:** "Task/Site Work Plan for Operable Unit 1049: Los Alamos Canyon and Pueblo Canyon"
- **March 1997:** Notice of Deficiency (NOD) on the submitted work plan
- **April, 1997:** Response to the NOD
- **June 1997:** NMED approved the work plan
- **February, 2002:** "Los Alamos and Pueblo Canyons Work Plan Addendum, Surface Water and Alluvial Groundwater Sampling and Analysis Plan"
- **May, 2002:** NMED approved the addendum



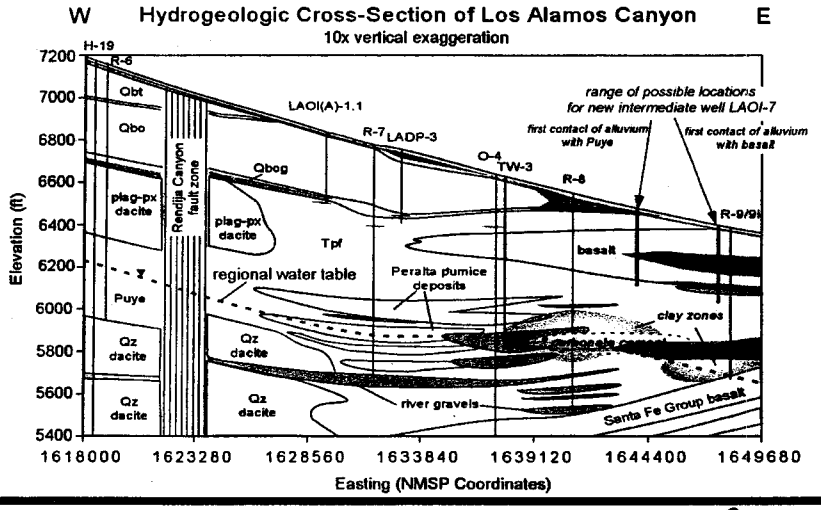
Coordinates are NM State Plane NAD 83

0 0.5 1 2 MILES

- ★ Proposed well
- ○ Water Supply Well
- ▭ Laboratory boundary
- — Canyon drainages
- ● Existing Nearby Test Wells

Technical Objectives

Groundwater Addendum Objectives	How Addressed
Determine nature and extent of potential contamination within the regional aquifer downstream of the Acid Canyon and Pueblo Canyon confluence in Pueblo Canyon.	R-2 was drilled in October 2003. R-3 is proposed in this work plan addendum to be installed near Otowi-1.
Determine nature and extent of potential contamination within the regional aquifer immediately north of TA-73 in Pueblo Canyon.	R-4 was drilled in August 2003.
Determine nature and extent of contamination within the Cerros del Rio basalt/Puye Formation between wells R-8 and R-9i.	Well LAOI-7, as proposed in this work plan addendum, is located between wells R-8 and R-9i. The information from wells R-8 and R-9 are sufficient for regional aquifer characterization.
Determine background/baseline water chemistry for Los Alamos Canyon and Pueblo Canyon.	Wells R-26 and R-7 serve as background wells for the Laboratory including Los Alamos Canyon and Pueblo Canyon.



Background

- Los Alamos Canyon and Pueblo Canyon have received effluents from the Laboratory since the early 1940s discharged from former TA-1, TA-2, TA-21, TA-41, TA-43, and TA-53.
- Effluents have contained contaminants, including nitrate, perchlorate, tritium, cesium-137, strontium-90, americium-241, and several isotopes of uranium and plutonium
- Active outfalls discharging to Los Alamos Canyon and Pueblo Canyon include outfalls at TA-43, TA-53, and the Los Alamos Medical Center.
- Bayo Wastewater Treatment Plant a municipal facility actively discharges treated effluent to Pueblo Canyon.

Perched and Regional Water Quality

- **R-9i** showed 69.4 to 246 pCi/L tritium in two screens set in perched zones within the Cerros del Rio basalt at depths of 199 and 279 ft
- **R-7,** has not shown contamination in the regional aquifer. Perched groundwater at 378 ft bgs contained 2.55 to 3.38 pCi/L tritium during characterization sampling
- **R-9** contained 4.84 to 14.68 pCi/L tritium in regional aquifer groundwater at 741 ft. Perched groundwater at 279 ft during the drilling of R-9 contained 0.0484 mg/L dissolved uranium; subsequent sampling well R-9i has shown dissolved concentrations of uranium less than 0.001 mg/L.

Perched and Regional Water Quality (cont.)

- **R-8** borehole water sample contained 16 pCi/L tritium and concentrations of perchlorate were less than 0.004 mg/L using ion chromatography
- **R-7**, has not shown contamination in the regional aquifer. Perched groundwater at 378 ft bgs contained 2.55 to 3.38 pCi/L tritium during characterization sampling
- **R-2 and R-4** were sampled after development and the analytical results are pending.
- **R-5**, sampled during well development and one characterization round. Tritium and nitrate (as nitrogen) were less than 5 pCi/L and 3 mg/L, respectively, in the regional aquifer.

Perched and Regional Water Quality (cont.)

- **O-1** groundwater samples were collected and analyzed; they contained 1.3 mg/L nitrate (nitrate as nitrogen), 0.00112 to 0.00585 mg/L perchlorate, and 29.06 to 40.23 pCi/L tritium
- **TW-1a and TW-1**, nitrate and tritium have been detected in wells indicating that these wells have experienced recharge from surface water and alluvial and perched intermediate groundwater for several decades

Proposed Scope

- Intermediate well, LAOI-7, located between wells R-8 and R-9, to target the Cerros del Rio basalt. Primary purpose of further characterizing the nature and extent of known contaminants in intermediate perched water.
- Regional aquifer well R-3, located near and upgradient of water supply well O-1 in Pueblo Canyon. The primary purpose of R-3 is to identify the transport pathways that have resulted in the presence of contaminants in O-1.

Intermediate Well LAOI-7

- Total depth: 300-400 ft
- Collect core samples from surface to core refusal, or a maximum depth of 320 ft, for contaminant, metal, and anion analyses.
- Conduct slug test and/or injection/straddle packer test in the screen completely within the perched zone
- Collect screening water samples during drilling at the top of the perched intermediate groundwater, if encountered.
- Suite and timing of geophysical logging to depend on borehole conditions.
- Complete well with one screen in the Cerros del Rio basalt or Puye Formation.

LAOI-7 Caveats

- If perched water is encountered in strata above the Cerros del Rio basalt, that water will be collected and analyzed during drilling to determine presence or absence of contamination.
- If perched water is not encountered above or within the Cerros del Rio basalt, the borehole will be extended 100 ft within the underlying Puye Formation immediately beneath the Cerros del Rio basalt to test for presence of perched water.
- If saturation is not encountered, the borehole will be backfilled.

Regional Aquifer Well R-3

- Total depth: 1800 ft; penetrate ~ 800 ft below regional water table.
- Collect core samples from surface to core refusal, or a maximum depth 300 ft, for contaminant, metal, and anion analyses
- Conduct slug test, single-step pumping test, or injection/straddle packer test in the screen completely below the regional water table.
- Collect screening water samples during drilling at the top of the regional aquifer
- Suite and timing of geophysical logging to depend on borehole conditions.
- Complete well with up to 3 screens at locations selected based on productive zones in the regional aquifer

Considered, but not Proposed

Regional Well between R-8 and R-9:

- Based on available sampling results, the regional aquifer presently shows the least amount of impact from Laboratory discharges.
- Dilution and adsorption are active processes, thus a significant variation in water chemistry including contaminant concentrations is not expected to occur within the regional aquifer between wells R-8 and R-9.
- An additional R well probably will not reduce uncertainty in contaminant transport and risk analysis based on groundwater monitoring data collected in Los Alamos Canyon.

Considered, but not Proposed (cont)

Background well:

- R-6 was proposed for upper Los Alamos Canyon under the Hydrogeologic Workplan. However, R-26 was recently completed at a location upgradient of Laboratory operations and it will provide high-quality samples for chemical analyses.
- Preliminary results of sampling of well R-26 water indicate background concentrations of analytes are in the expected range.
- The construction of well R-26 also provides a technically defensible basis for establishing background conditions for the regional aquifer.

Schedule

- **CY 2005:** Drilling and completing the wells is proposed in this work plan and conducting two quarters of sampling rounds at the wells.
- **June 2006:** An investigation report will be prepared following collection and analysis of environmental data and is currently scheduled for delivery to the NMED by June 16, 2006.

Hydrogeologic Conceptual Model

Bruce Robinson

Groundwater Protection Program Quarterly Meeting
January 28, 2004

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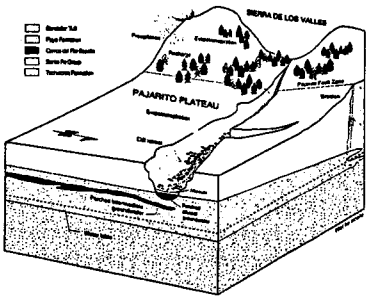
Outline



- Summary of Conceptual Model
  - Alluvial groundwater
  - Vadose Zone
  - Regional Aquifer
- Implications for groundwater contamination on the Plateau

Collaborators: Kay Birdsell, David Broxton, Bruce Gallaher, Steve McLin, Pat Longmire, David Rogers, Bill Stone, David Vaniman, Velimir Vesselinov

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Alluvial Groundwater Flow and Transport

Order of Magnitude Estimate: Los Alamos Canyon:

Conductivity = 10^{-4} m/s

Gradient = 0.03

Darcy Velocity = 10^{-4} x 0.03 = 3 x 10^{-6} m/s = 95 m/y

Porosity = 0.3

Transport Velocity = 95/0.3 = 320 m/y

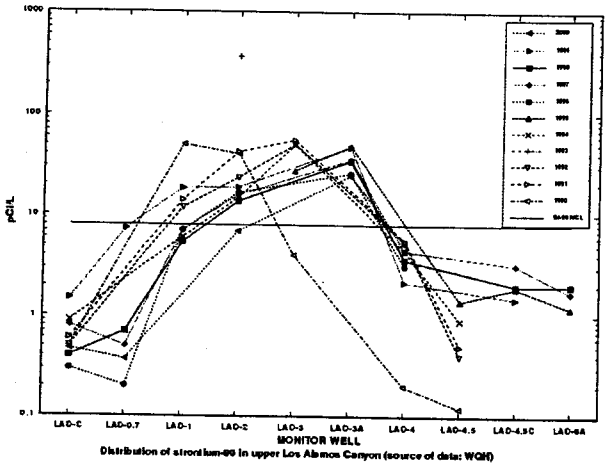
Alluvial Groundwater Flow and Transport

Tritium and Chloride Tracer Test in Mortandad Canyon
Purtymun, 1974, LA-5716-MS

	Distance, m	Tritium		Chloride	
		Transit Time, days	Transport Velocity, m/y	Transit Time, days	Transport Velocity, m/y
MCO-5 to MCO-6	393	20	7300	25	5800
MCO-6 to MCO-7	320	77	1500	63	1900
MCO-7 to MCO-7.5	290	66	1600	52	2000
MCO-7.5 to MCO-8	183	109	620	79	840

Alluvial Groundwater Flow and Transport

Migration of Sr-90 in alluvial groundwater



Distribution of strontium-90 in upper Los Alamos Canyon (source of data: WQH)

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Alluvial Groundwater Flow and Transport

Conclusion: Transport velocities in the alluvium are expected to be fast for nonsorbing contaminants based on simple calculations, and data from contaminant and tracer migration confirm this result. Sorption reduces transport velocities significantly.

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Vadose Zone Flow and Transport

Order of Magnitude Estimate: Bandelier Tuff, Dry Canyon

Infiltration Rate = 1 mm/y
Water Content = 0.1
Transport Velocity = 1/0.1 = 10 mm/y = 0.01 m/y

10,000 years to traverse 100 m thickness of vadose zone

Vadose Zone Flow and Transport

Order of Magnitude Estimate: Wet Canyon

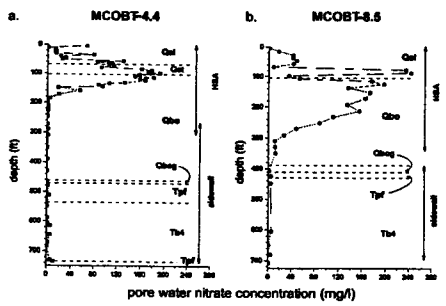
Infiltration Rate = 500 mm/y
Water Content (tuff) = 0.2
Water Content (Basalt) = 10^{-3}
Transport Velocity (tuff) = 500/0.2 = 2500 mm/y = 2.5 m/y
Transport Velocity (Basalt) = $500/10^{-3} = 5x10^5$ mm/y = 500 m/y

40 years to traverse 100 m thickness of vadose zone in tuff
0.2 years to traverse 100 m thickness of vadose zone in Basalt

Vadose Zone Flow and Transport

Wet Canyon, Bandelier Tuff

Conclusion: Moisture profiles and contaminant transport distances are consistent with local downward percolation rates of 100-400 mm/y. However, lateral transport pathways are also evident: intermediate groundwater significantly below the location also contain contaminants. Contaminant front locations are consistent with transport through the rock matrix most of the units of the Bandelier Tuff.



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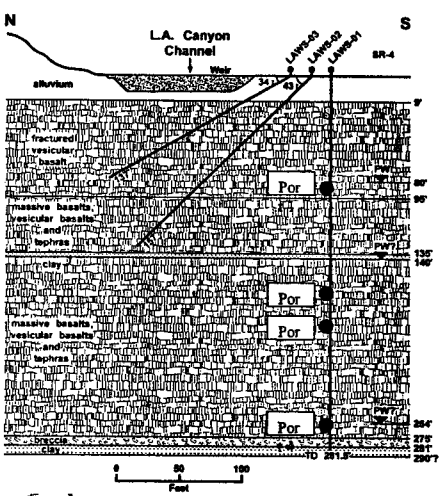
Vadose Zone Flow and Transport

Wet Canyon, Basalt



Low Head Weir in Los Alamos Canyon

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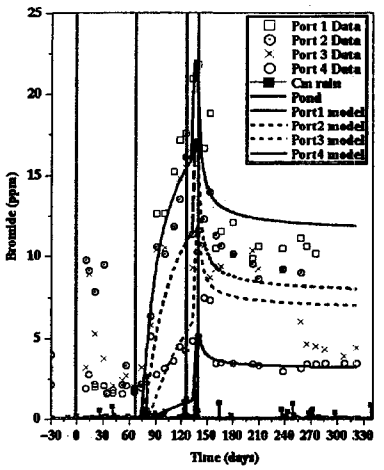
Vadose Zone Flow and Transport

Wet Canyon, Basalt

Conclusion: Water and contaminant transport times through Basalts are short. Regions where Basalts are thick in the vadose zone may be locations where transport to the regional aquifer are most rapid, provided the percolation rates are high enough.



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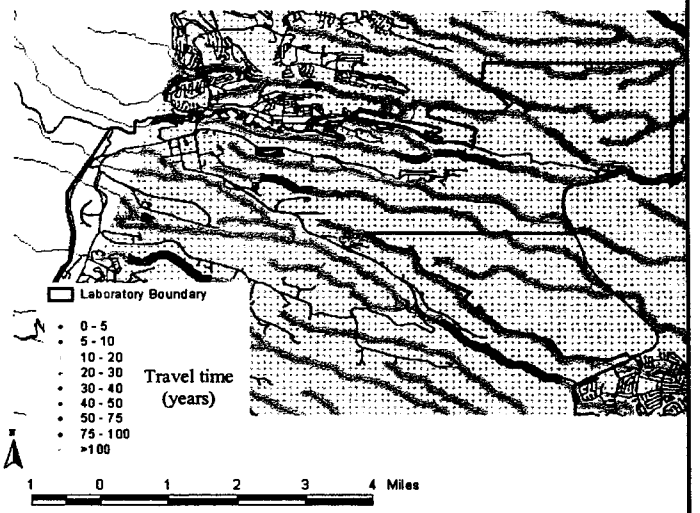
LA-UR-04-2265, Slide 11

Vadose Zone Travel Time Predictions

Conclusion: Vadose zone travel times on the order of decades are predicted in wet canyons. Locations where the vadose zone stratigraphy consists of thin Bandelier tuff and thick Basalt have the potential for short travel times to the regional aquifer.



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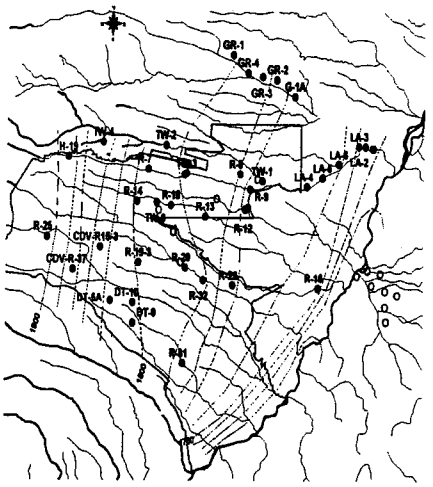
Regional aquifer flow and transport

Potentiometric Data



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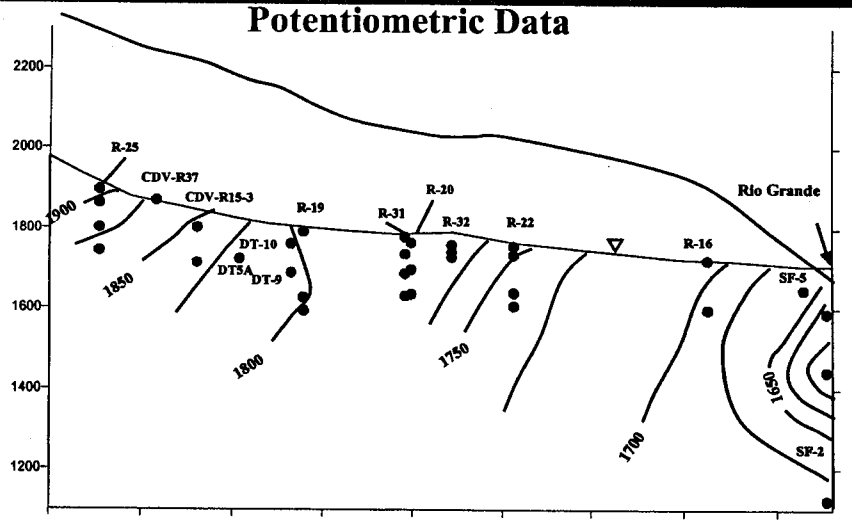
Regional aquifer flow and transport

Potentiometric Data



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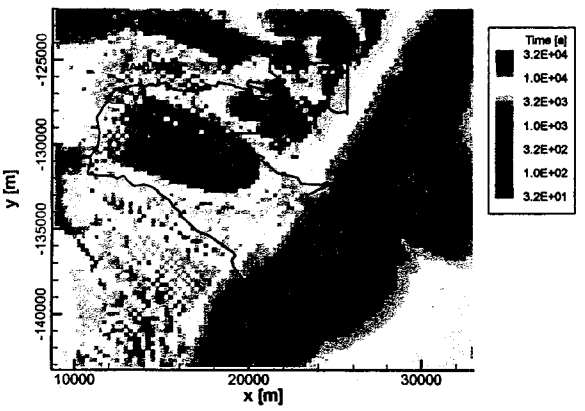
Regional aquifer flow and transport

Travel times and Capture Zones

Conclusion: Travel times from the water table to a point of discharge (the Rio Grande or water supply wells) are predicted to be short if the location is close to the discharge location, but otherwise they are expected to be large.



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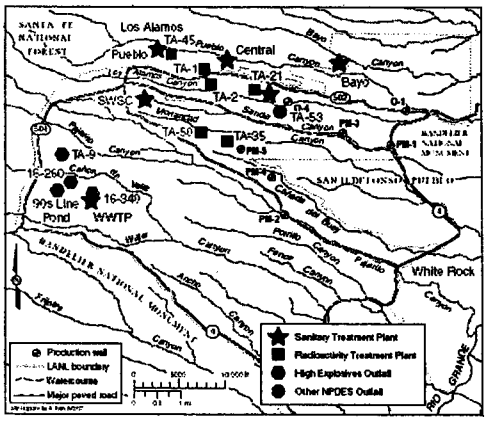
Contaminant Detections

Liquid Effluent Discharge Locations



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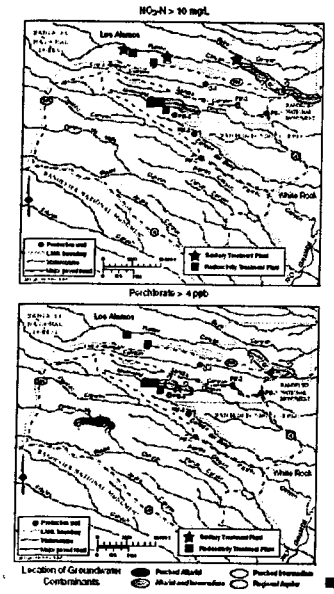
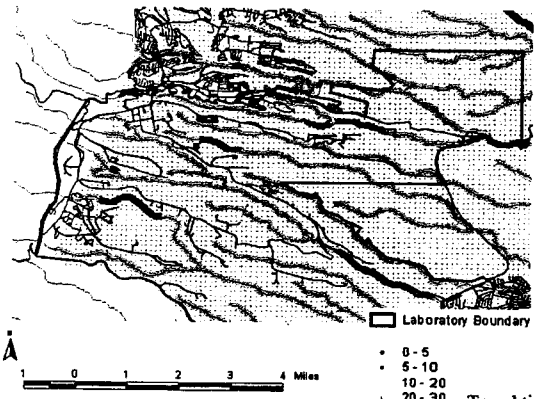
LA-UR-04-2265, Slide 16

Contaminant Detections





Surveillance data are consistent with the conceptual models that have emerged from Hydrogeologic Workplan studies

Conclusions

From the perspective of input to groundwater risk assessment studies, the most important potential pathways of concern are:

- Wet canyons with contaminant discharges
- Vadose zone hydrogeologic pathways yielding rapid migration to the regional aquifer
  - Thin Bandelier Tuff
  - Basalt pathways
- Contaminant pathways that occur close to existing water discharge points
  - Water supply wells
  - Some springs

However, transport over long distances in the regional aquifer is not consistent with our current understanding. Transport through Basalts and the possibility of preferential transport through sedimentary rocks warrants further study. Transport of sorbing contaminants is likely to be slow.

- The most likely large scale transport (kilometers distance) is via surface and alluvial groundwater.
- Surveillance data are consistent with the conceptual models that have emerged from Hydrogeologic Workplan studies.

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DP Canyon Reach-2 Bromide Tracer Study

LA-UR-04-0509

Armand Groffman, Brent Newman, Bob Gray, Danny Katzman, and Valisa Nez

Visualization Images by Bill Schneider (Weston) and Valisa Nez (RRES)

January 28, 2004

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Objectives

- Understand hydrological behavior of DP Reach-2
- Determine the connection between DP Reach-2 and DP Spring
- Understand how surface/ground water interaction influences tracer movement
- Use results to understand other alluvial systems across the Pajarito Plateau

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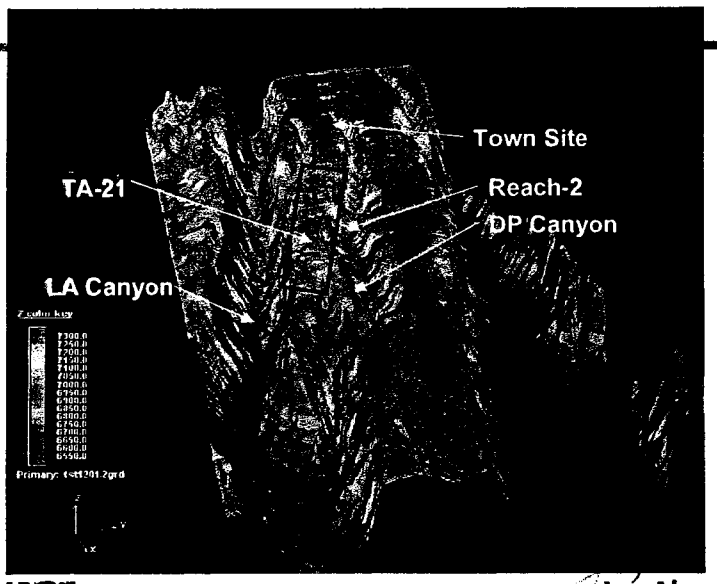
Methods

In situ TempHion ion selective electrodes (ISE) deployed in nested wells (continuous data)

Manual sampling of all wells and measurement with Orion ISE in laboratory

Isco automated sampling of surface water and DP-Spring (IC measurement because of low concentrations)

Digital Elevation Model of TA-21 and DP-Canyon



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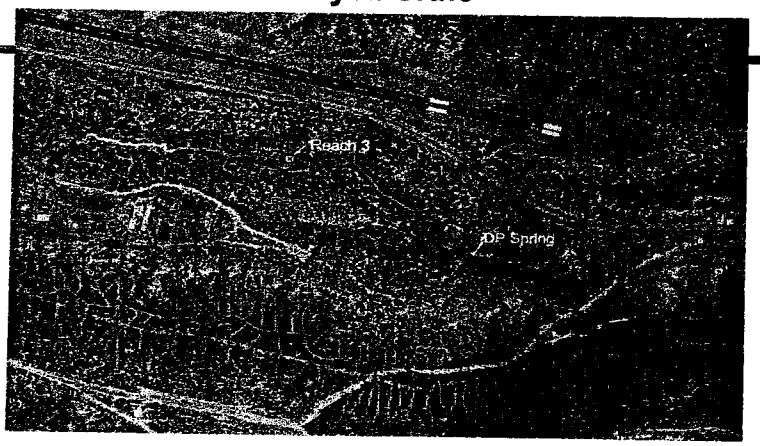
DP Canyon Ortho



0 50 100 Feet

N W E

Reach 3 ISCO
Spring
Channel
Drainage

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DP Canyon Wells - Not Labelled

0 50 100 Feet

N W E S

Well Locations
2 in DNAPL Well
4 in Well
Abandoned Well
Br Base
Lateral Extraction
3-Gradient Piezometer
Spring
Channel

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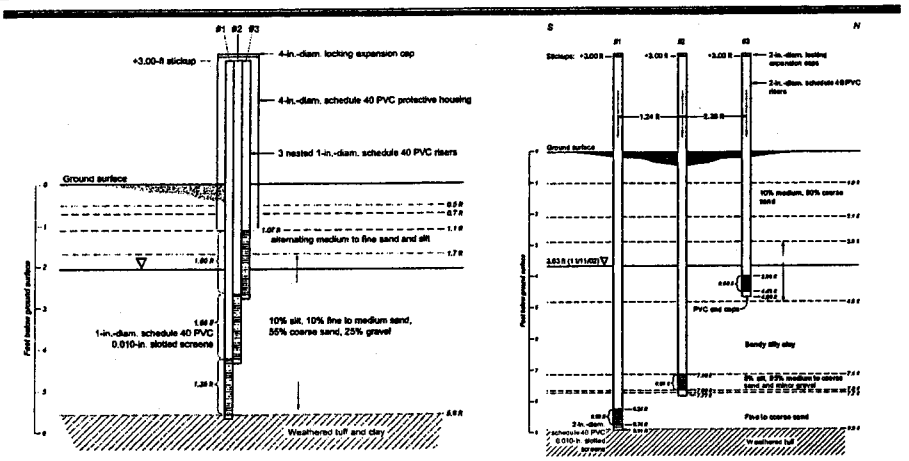
Nested wells to measure bromide

Nested piezometers to measure head



Construction diagram for DPBN nested wells.

Construction diagram for piezometer nest DPPN-4.5N.

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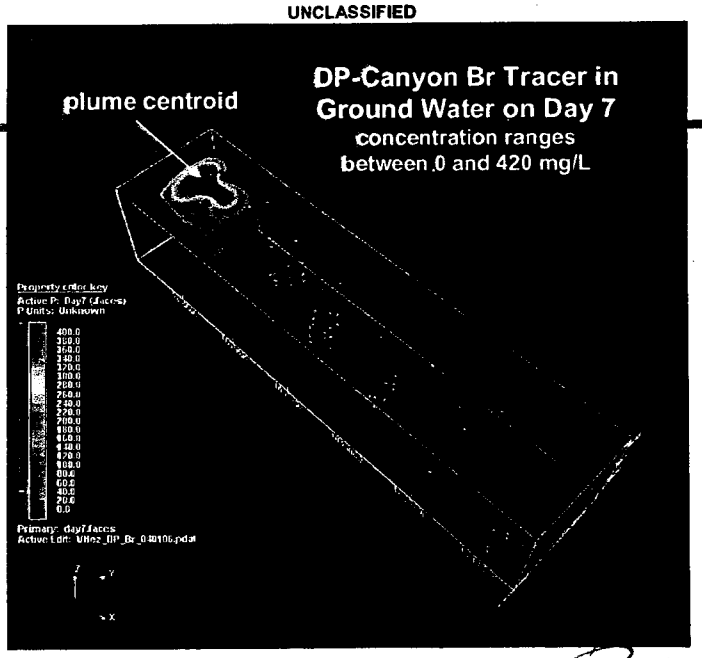

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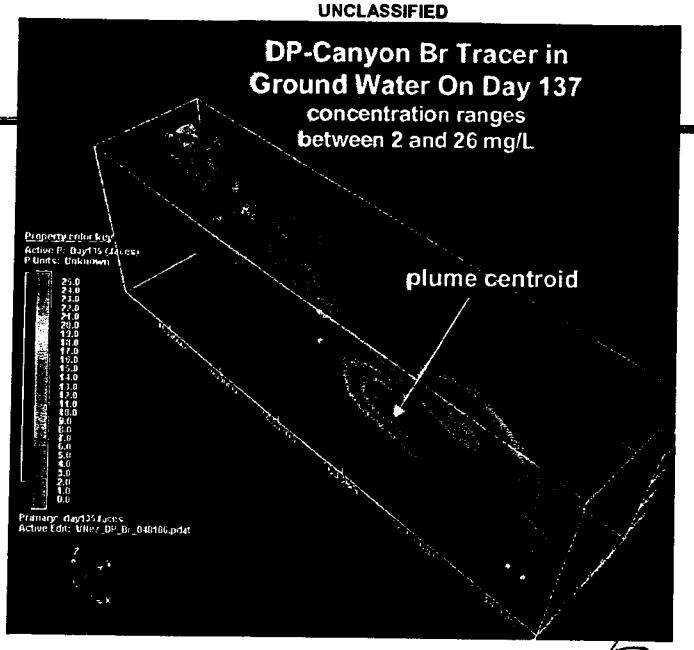

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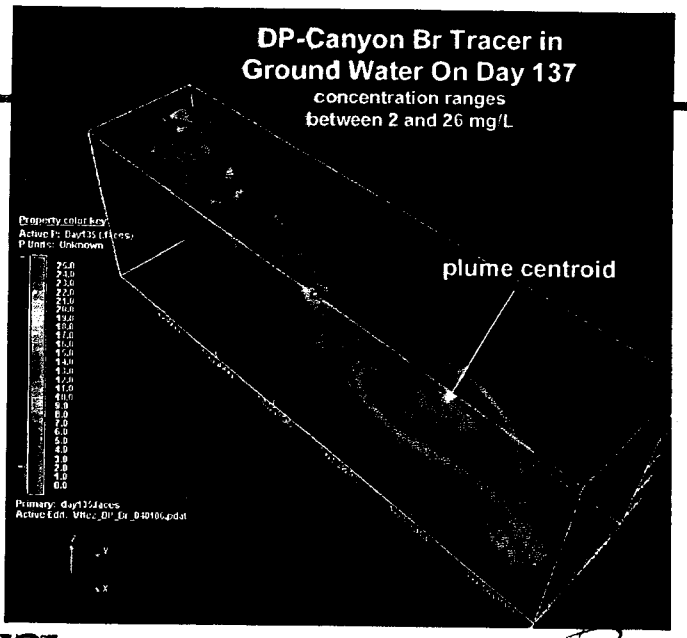

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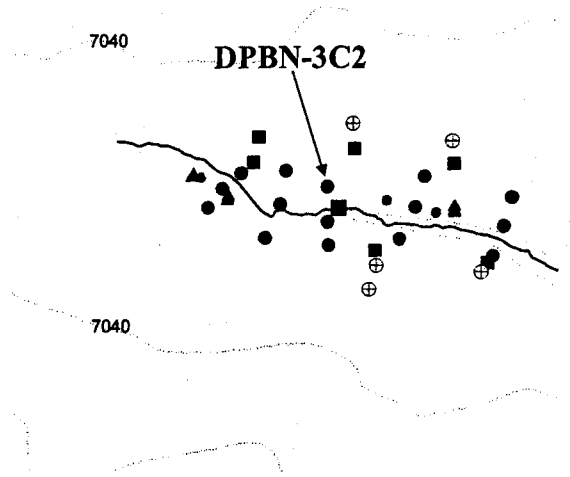
Surface/Ground Water Exchange



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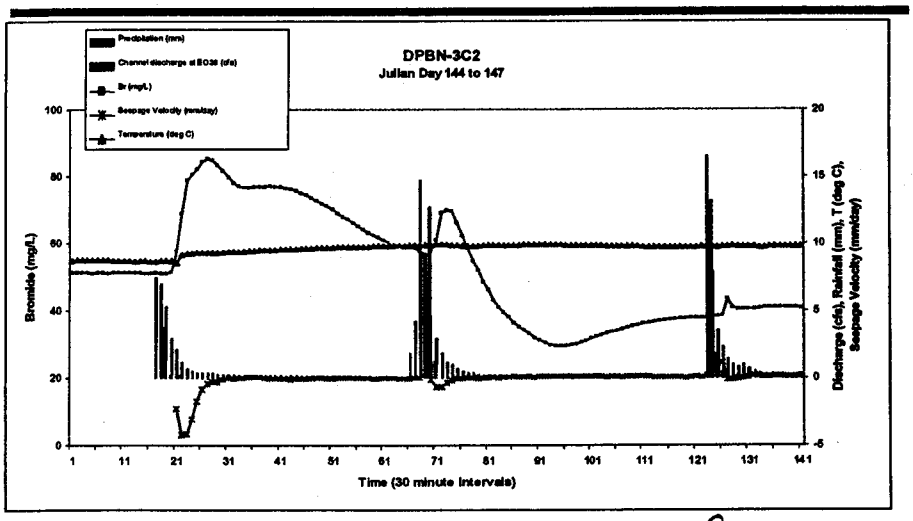
Surface/Ground Water Exchange



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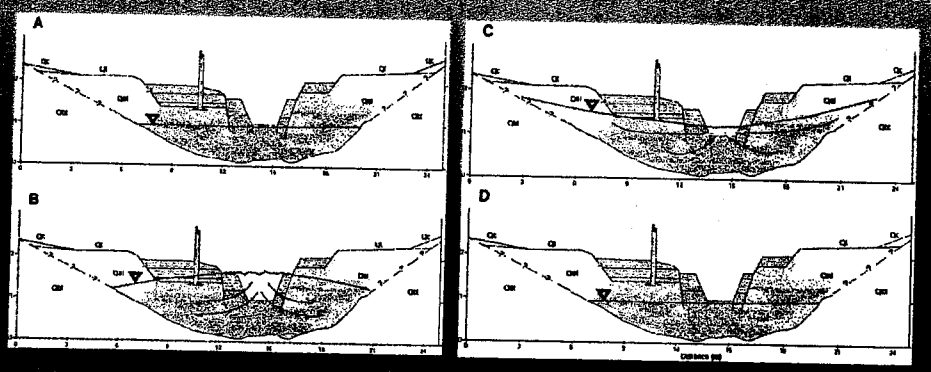
Conceptual Model of Surface/Ground Water Exchange



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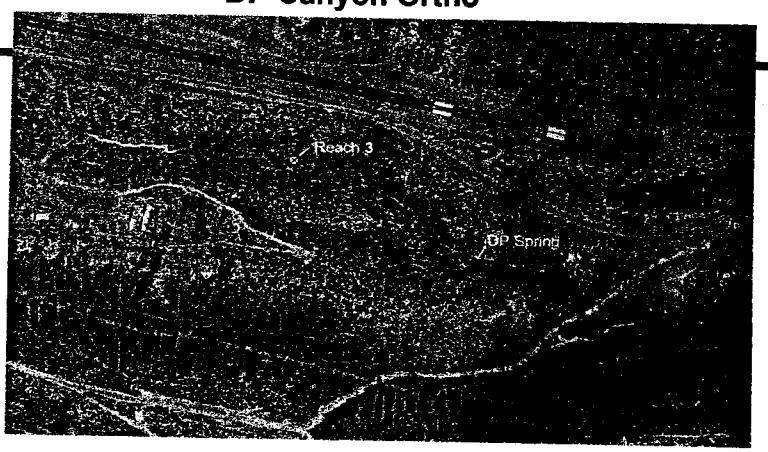
DP Canyon Ortho



0 50 100 Feet

Reach 3 IBCO
Spring
Channel
Drainage

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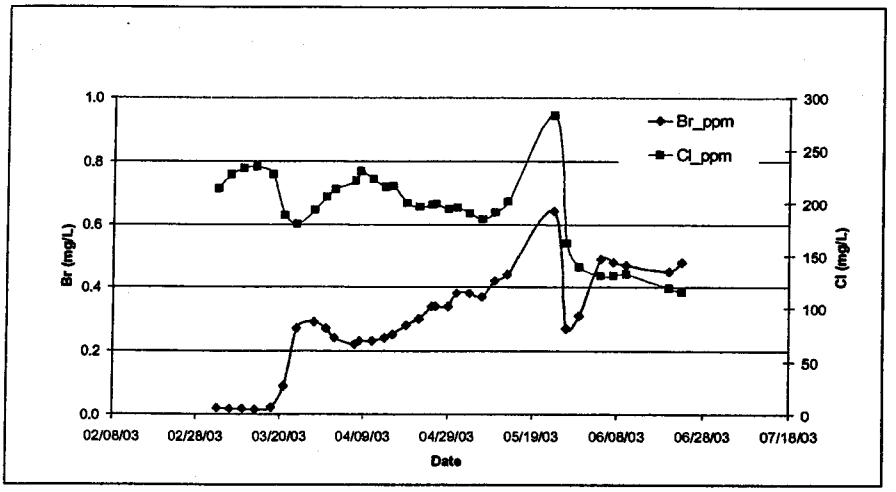
Bromide Tracer in DP-Spring



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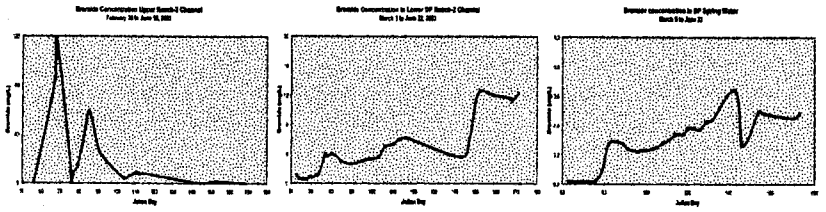
Bromide Tracer in Surface Water

Figure 3. Bromide tracer in surface water. Bromide was collected using using Isco water samplers and measured by ion chrometography. Samples were collected at three collection stations shown in Figures 1.A and 1.B.
Results show that 1) ground/surface water exchange is routing bromide from the aquifer into the channel; 2) bromide concentrations decrease down stream away from the tracer plume due to dilution; 3) it took approximately 30 days after injection for the tracer to travel from the top of reach-2 to DP-Spring.



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Conclusions

- Tracer has traveled extensively in the channel during and shortly after runoff and infiltration events.
- Ground water surface water exchange appears to facilitate tracer movement close to the channel with diminishing affects away from the channel.
- Supporting evidence includes:
  1) Bromide was detected at DP Spring approximately 30 days after injection.
  1) Bromide concentrations in ground water adjacent to the channel show an almost immediate response to runoff infiltration events.
  1) Hydraulic head and calculated seepage velocities respond to channel flow indicating exchange between surface water and the alluvial aquifer.

Hydrogeologic Workplan Final Report

Bruce Robinson

Groundwater Protection Program Quarterly Meeting
January 28, 2004

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LA-UR-04-2265, Slide 19

Hydrogeologic Workplan

Technical Objectives

The following technical issues were identified:

- Individual zones of saturation are not adequately delineated, and "hydraulic interconnection" between them is not understood
- Recharge areas for the regional aquifer and intermediate perched zone not identified; effect of fracture-fault zones on recharge is unknown
- GW flow directions of regional aquifer and intermediate perched zones, as influenced by pumping, are unknown
- Aquifer characteristics cannot be determined without additional monitoring wells; location of wells cannot be addressed adequately without delineation of individual zones of saturation

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LA-UR-04-2265, Slide 20

Hydrogeologic Workplan

Questions Addressed

- Is characterization adequate to determine where GW exists and whether contaminant concentrations exceed regulatory limits or risk levels?
- Is characterization sufficient to establish a detection monitoring program?
- Is characterization sufficient to satisfy conditions of HSWA portion of LANL's RCRA operating permit?

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LA-UR-04-2265, Slide 21

Hydrogeologic Workplan

Outcome of Studies

- Refined understanding of hydrogeologic setting (recharge, hydraulic interconnections, flow paths, flow rates, synthesized by modeling)
- Information sufficient to design and implement a detection monitoring program
- Defined areas of existing or potential groundwater contamination, from surface to regional aquifer, with predictions of direction and rates of movement and risk based on modeling

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LA-UR-04-2265, Slide 22

Report Elements

- Executive Summary
- Introduction
  - Hydrogeologic Workplan drivers
  - Scientific questions addressed by Workplan Activities
  - Approach – integrated program of well drilling, data collection, incorporation of data from other sources, modeling
- Hydrogeology
  - Geologic conceptual model (describes the hydrogeologic information used to define the controls on hydrology)
  - Geologic model description – representative cross sections
  - Connection between geology and hydrologic properties – vadose zone and regional aquifer
  - Alluvial groundwater conceptual model
  - Hydrologic conceptual model, vadose zone (describes the information available that constrains our models of vadose zone flow and transport at the site – moisture and contaminant observations, pore water chemistry)
  - Perched water conceptual model
  - Hydrologic conceptual model, regional aquifer (describes the information available that constrains our models of regional aquifer flow and transport at the site – water budget information, water levels, hydrologic properties, geochemistry, contaminant observations)

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LA-UR-04-2265, Slide 23

Report Elements (cont.)

- Geochemistry
  - Conceptual model (describes what is known about the chemical composition of the GW, and postulates rock-water interactions)
  - Chemical factors affecting contaminant transport – GW chemistry controls on solubility, speciation, and sorption of contaminants
- Contaminant Distributions
  - Contaminant sources
  - Maps of contaminant concentration levels in GW
  - Discussion of concurrence with main elements of conceptual model
  - Outstanding uncertainties
- Numerical Models (each section addresses basic model formulation, data sources, model development, and uncertainties)
  - 3D geologic model
  - Vadose zone flow and transport models – site-wide modeling
  - Regional aquifer flow and transport models – background flow conditions and as influenced by pumping
  - Contaminant transport model predictions – representative canyon and mesa sites

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LA-UR-04-2265, Slide 24

Report Elements (cont.)

- Implications of Hydrogeologic Workplan Study Results
  - Input to design of detection monitoring program
  - Input and uncertainties of parameters in risk assessments
  - Conceptual model uncertainties relevant to monitoring and risk assessment
- Discussion of Alternate Conceptual Models
  - Rapid vadose zone fracture flow and transport to depth
  - Colloid-facilitated transport
  - Perchlorate transport to the Rio Grande
  - Alternate geochemical interpretation of regional aquifer flow path
- Conclusions

Funding and Schedule

- Half of funding is available in FY04
- Report due – March 15, 2005 (assumes funding available next FY to complete)
- High-Level Schedule
  - Annotated outline completed – February 29, 2004
  - All analyses and interpretations completed, September 30, 2004
  - Draft writeup for introductory text and sections for which interpretations are already complete – September 30, 2004
  - Draft writeup for entire report – December 31, 2004
  - Review and publication completed – March 15, 2005

We welcome NMED and stakeholder input during the preparation and review of this report

Los Alamos National Laboratory
Groundwater Protection Program
Quarterly Meeting
April 12, 2004
Minutes

MEETING PURPOSE, ATTENDEES, AND AGENDA

The Los Alamos National Laboratory Groundwater Protection Program met with the New Mexico Environment Department (NMED), the Department of Energy (DOE), and stakeholders on April 12, 2004 for a Quarterly Groundwater Protection Program Meeting. The meeting was held at the Cities of Gold Hotel in Pojoaque, New Mexico. Charlie Nylander (Groundwater Protection Program Manager) facilitated the meeting.

The following groups and stakeholders were represented (see List of Participants for specific information):

NMED-Hazardous and Radioactive Materials Bureau
NMED-DOE Oversight Bureau
DOE-Los Alamos Site Operations
San Ildefonso Pueblo
Northern New Mexico Citizens Advisory Board
Concerned Citizens for Nuclear Safety
Intera, Inc.
Westbay Instruments
LANL-Groundwater Integration Team (GIT)
City of Santa Fe
Daniel B. Stephens and Associates
Albuquerque Journal
Brown and Caldwell
PMC Technologies
NETS, Inc.

The purpose of the Quarterly Meeting was to provide NMED, DOE, and stakeholders with information on LANL's groundwater protection efforts and present planned activities for the upcoming fiscal year. The meeting agenda was as follows:

Introduction and Agenda (C. Nylander)
Status of Wells (T. Whitacre)
Water Quality Sampling Results (P. Longmire)
Overview of Hydrologic Testing Results (S. McLin)
FY04 Planned Work (C. Nylander)
Update on Monitoring Results for the Permeable Reactive Barrier (P. Longmire)
Low-Level Perchlorate Analyses by LC/MS/MS (B. Turney)
Introduction to Meteorology and Air Quality at Los Alamos (J. Dewart)

Introduction (Charlie Nylander, LANL)
Charlie Nylander welcomed the participants to the Groundwater Protection Program Quarterly Meeting. The purpose of the Quarterly Meetings is to provide a status report on recent activities. There will be a poster session from 4:00 to 7:30. Additionally, there will be a presentation on air quality and posters on air quality in the evening session. There will also be posters from other organizations, NMED, North Central New Mexico Economic Development District, and Jemez y Sangre Regional Water Planning. Minutes from the last Quarterly Meeting will be sent out with the minutes from this meeting.

Well Drilling Status Report (Tom Whitacre, DOE)
The wells that have been drilled this year are:

Los Alamos National Laboratory
Groundwater Protection Program
Quarterly Meeting
April 12, 2004
Minutes

Well	Location	Total Depth	Completion	Core	Geophysics
R-1	Mortandad Canyon, near Permeable Reactive Barrier	1165 feet	1 screen in regional aquifer	350 feet	Open hole suite
R-2	Pueblo Canyon, LA County property	943 feet	1 screen in regional aquifer	228 feet	Open hole suite
R-4	Pueblo Canyon	844 feet	1 screen in regional aquifer	243 feet	Open hole suite
R-11	Sandia Canyon, across from PTLA firing ranges	927 feet	1 screen in regional aquifer	224 feet	Open hole geophysics
R-26	Cañon de Valle	1485 feet	2 screens in regional aquifer	250 feet	Open hole suite
R-28	Mortandad Canyon, down from sediment traps	1006 feet	1 screen in regional aquifer	315 feet	Open hole suite
CdV-16-1(i)	Water Canyon, TA-16	680 feet	1 screen, intermediate perched zone	200 feet	Open hole suite
CdV-16-2(i)	TA-16, east of R-25	1063 feet	2 screens	No core	Open hole suite
CdV-16-3(i)	TA-16	1405 feet	No well installed yet	No core	Open hole suite

The three TA-16 wells were described at the last Quarterly Meeting. They were intended to be intermediate perched groundwater wells installed as part of the TA-16 Corrective Measures Study. The first well (CdV-16-1(i)) is located in Water Canyon, it was completed with one screen in the intermediate perched zone. The second well (CdV-16-2(i)) is located east of R-25. When the borehole reached 960 feet there was water. The down-hole video showed water flowing into the borehole. The borehole was extended to 1063 feet and a second screen was placed in the upper zone. After the winter break the well was checked and there was no water. There has been periodic monitoring for water since then and there is about 55 feet of water in the borehole now. The third well (CdV-16-3(i)) was drilled down to 1405 feet and is dry. The depth is 200 – 300 feet below where the regional water table was projected to be. There is still no water in the borehole.

Well development and testing activity status is:

Well	Development	Hydrotesting	Water Volume Removed
R-26	complete	complete	110,000 gallons
R-28	complete	complete	59,000 gallons
CdV-16-1(i)	complete	complete	8,000 gallons

The remaining field work to be accomplished is:

- Sampling pump installation at R-1, R-2, R-4, R-11, R-28, and CdV-16-1(i) will be done between April and May
- Westbay equipment installation in R-26 will be done in April
- Water level detection and monitoring in CdV-16-2(i) and CdV-16-3(i) will continue
- Restoration of all nine drill sites will be accomplished in May. We have approval from NMED to discharge the water using a water truck. We also have approval to dispose of the cuttings in pits on site. The areas will be reseeded.

Status of reporting activities:

Well	Date Completed	Fact Sheet	Well Completion Report
R-1	11/03	Submitted to NMED	Due 4/04
R-2	10/03	Submitted to NMED	Submitted 3/04
R-4	10/03	Submitted to NMED	Submitted 3/04
R-11	9/03	Submitted to NMED	Submitted 3/04
R-26	10/03	Submitted to NMED	Submitted 4/04
R-28	12/03	Submitted to NMED	Due 4/04
CdV-16-1(i)	11/03	Submitted to NMED	Due 5/04
CdV-16-2(i)	12/03	Submitted to NMED	Due 5/04
CdV-16-3(I)	1/04 (borehole)	Submitted to NMED	Due 5/04

A single well completion report will be prepared for the three CdV-16 wells.

Well Drilling Status Report Questions, Comments, and Responses

C: John Young said that he had asked Don Hickmott to take a sample from CdV-16-2(i) and have it analyzed for the presence or absence of HE
R: That sample has been submitted for analysis.

Q: Is the borehole still open?
R: Yes, water is coming in but very slowly.

Q: What is a Westbay string?
R: It is the equipment that goes into the well containing the sampling ports and the mechanisms that function to open and close the sampling ports as required.

C: CCNS would like the well completion reports sent to George Rice.
R: We can do that.

Q: Is there a running reference list?
R: We are in the process of updating the bibliography. The updated bibliography will be distributed with the minutes from this meeting.

Los Alamos National Laboratory
Groundwater Protection Program
Quarterly Meeting
April 12, 2004
Minutes

Q: What is the status of R-11?
R: The contractor was over-drilling it, but had to stop for spotted owl surveys. The over-drilling will begin again, but if they cannot get the casing out, they will abandon the well and start again. Since the contractor got the pump stuck in the well, all of this is at the contractor's expense.

Q: Who will be the contact to find out about water levels the in the peizometers?
R: The Water Quality and Hydrology Group will do the monitoring.

Water Quality Sampling Results (Pat Longmire, LANL)
Pat Longmire (LANL) presented the objectives of the presentation as:

- Present a summary of screening analytical results for perchlorate, nitrate, and tritium at wells R-1, R-2, R-4, R-11, R-26, and R-28. Evaluate influence of Cerro Grande fire on manganese concentrations within alluvial and perched intermediate groundwater in upper Los Alamos Canyon.The approach to sampling wells R-1, R-2, R-4, R-11, R-26, and R-28 was to collect screening groundwater samples were collected during well development after field parameters stabilized. The field parameters include: pH, temperature, turbidity, and specific conductance. The total organic carbon was measured in the laboratory. The analysis of these samples is considered screening level quality, but is expected to be indicative of the water quality that will be measured after the well is completed.Pat Longmire showed a map of the locations of R-1, R-2, R-4, R-11, R-26, and R-28 and the analytical results from screening samples for nitrate, perchlorate, and tritium. These are very mobile contaminants that, when present, are indicative that water from the surface has reached the regional aquifer. The analytical results from the screening samples are:

Well	Canyon	Screening Sample: Nitrate (ppm)	Screening sample: Perchlorate (ppb)	Screening sample: Tritium (pCi/L)
R-1	Mortandad	0.39	Not detected	Not detected
R-2	Pueblo	0.36	0.39	Not detected
R-4	Pueblo	1.39	Not detected	19.5
R-11	Sandia	4.9	0.78	12.8
R-26 Upper screen	Cañon de Valle	0.37	Not detected	Not detected
R-26 Lower screen	Cañon de Valle	0.38	Not detected	Not detected

R-1, R-2, and R-26, are dead with respect to tritium and have baseline perchlorate level, suggesting that there has been no recharge from the surface for at least 60 years. R-26 has the same overall chemistry in both screens. Even though it is near the recharge front, the travel times in the Sierra de los Valles must be long.

The Cerro Grande fire occurred in May 2000. As a result, dissolved organic carbon was added to the groundwater system. The dissolved organic carbon increased the solubility of iron and manganese. Increased amounts of iron and manganese are a good indication of a dissolved organic carbon front moving through the subsurface. The iron and manganese are not moving, the dissolved organic carbon is moving and solubilizing iron and manganese as it goes. To see if these fire-induced groundwater chemistry changes could be used to estimate infiltration rates, we looked at alluvial and intermediate perched water wells in Los Alamos canyon.

A plot shows the dissolved manganese in alluvial groundwater from 1998-2002 in wells going from west to east. Well LAO-B was installed as a background well, it shows increased dissolved manganese after the fire. Further down gradient at LAO-C, the manganese was <2 ppb in 1998, but was up to 1,700 ppb in 2000. As microbes breakdown organic carbon, it solubilizes the manganese. In 2001, the manganese in LAO-C decreased and by 2002 it was near pre-fire levels. Well LAO-1 is about 2000 feet down canyon from LAO-C, and it does not show this effect, probably because there are only 2 samples from the well.

Looking at intermediate perched water in the Guaje Pumice, well LAOI(A)-1.1 shows manganese steadily increasing. There has been only one sample collected from LADP-3, and that is not enough data to track this effect.

The conclusion based on this analysis is that there are possibly interesting trends, but we need more data. The data that are needed are:

- Collect additional groundwater samples from LAO-B, LAO-C, LAO-1, LAOI(A)1.1, and LADP-3.Conduct four rounds of sampling at each well.Analyze groundwater samples for total organic carbon, dissolved organic carbon, manganese, iron, major ion chemistry, and low level tritium. Wells LADP-3 and LAOI(A)-1.1 are both completed in the Guaje Pumice Bed.

Water Quality Sampling Results Questions, Comments, and Responses

C: Measuring the total organic carbon at LANL worked very well because with the quick turn-around, the data could be used to guide the well development.
R: That process did work well.

Q: Were all the samples taken from the same level in the regional aquifer?
R: All of the samples, except the lower screen in R-26, came from within 50 feet of the regional aquifer water table.

Q: Repeat the information on R-26?
R: R-26 was drilled as a background well and based on the screening samples, there are no contaminants. The absence of tritium indicates that recharge in that area takes longer than 60 years to reach the regional aquifer.

Q: Don't we know how much tritium is the result of fall out?
R: There is natural tritium also, but it is decayed out before reaching the R-26 well. Tritium was also produced at the Lab and there are spots with more tritium, such as at R-25.

C: There is a lot of tritium at R-28.
R: Emphasize that these are screening quality values, but clearly shows recent recharge.

Q: R-33 and R-34 are not drilled yet?
R: Correct, drilling can't continue until the owl surveys have been completed and no nesting owls are present in the canyon.

Q: Are there contaminants in the core?
R: The analytical results are being reviewed. The core was sent to the lab. The upper 400 feet was analyzed for nitrogen isotopes and actinides. From an initial look, it appears that contaminants are largely confined to above 400 feet.

Q: Will the analytical results for the core be included in the well completion report?
R: Probably will be in a separate report because getting the data back and interpreting takes longer than is available to go into the well completion report.

Q: How does this new data fit with the conceptual model?
R: Recharge in Mortandad Canyon occurs where the canyon widens out. R-13 is probably background. We are honing in on contaminant distribution. R-11 in Sandia Canyon is consisten with discharge from the plants upstream. Pueblo Canyon data is consistent with O-1 and TW-2. These new data support the conceptual model and are useful for adding details to the model.

Q: Is there data from the Pajarito Canyon wells?
R: We have just started sampling those wells. Screening samples have been collected, and the wells are equilibrating. R-23 is dead with respect to tritium. Nothing stood out in the screening samples.

C: The Oversight Bureau has been collecting samples at LADP-3 and LAOI(A)-1.1 for 3 years now and that data is available.
R: That data will be included in this analysis in the future.

Q: This type of analysis may be a prototype for estimating infiltration rates. Why wouldn't this be applicable to other canyons?
R: The estimated infiltration rate would be a site-specific number, because it represents a combination of lateral and vertical rates, rocks with a specific saturated hydraulic conductivity, the severity of the burn, and the organic acids produced. The approach, could be used in other canyons, but the estimated rate is only good for the specific area in the canyon that you have the data for.

Q: Is the chemistry of the surface water trending back toward pre-fire levels?
R: Did not look at the surface water. .

Q: What are the error bars on these data?
R: They are fairly small.

Q: What causes the dramatic change in LAO-C?
R: Probably the re-precipitation of manganese.

Q: Can this be applied in any canyon?
R: The methodology could be applied anywhere there are sufficient sampling points and pre- and post-fire data. Any estimates of infiltration rate in this canyon cannot be applied to other canyons, because of the number of site-specific factors.

Overview of Hydrologic Testing Results (S. McLin)
Steve McLin (LANL) began by offering the caveat that the new wells discussed by Tom Whitacre earlier are not included in this overview. There were four issues identified in an NMED letter to LANL on August 17, 1995:

- Hydraulic interconnection between saturated geologic units is not understood
- Recharge areas have not been identified
- Influence of municipal water production on ground-water flow directions are unknown
- Aquifer characteristics have not been determined

Hydrologic testing is an important part of resolving these issues. The resolution requires considerations of the following questions:

- How do we best test geologic units for aquifer properties?
- How do we evaluate horizontal and vertical anisotropy?
- Can we test the influence of municipal supply wells?
- Can modeling provide aquifer parameter estimates where testing is not possible?

Conducting multiple-well pumping tests are a way to answer these questions. A multiple-well pumping test is set up to have water pumped out of one well while the water level changes are measured in one or more wells some distance from the pumping well.

The hydraulic conductivity data that we currently have for the Pajarito Plateau is plotted in relation to the geologic unit the measurement was taken in. The plot shows the estimates of hydraulic conductivity range over 8 orders of magnitude. The hydraulic conductivity values used in the regional aquifer model are indicated by the squares on the plot. On the plot, the geologic units that have wider distribution of hydraulic conductivity values are those for which the hydraulic conductivity is not well constrained. Recently the City of Albuquerque did a 58-day pumping test that resulted in transmissivity values 0f 15,000 – 20,000 ft^2/day, which is much larger than on the Pajarito Plateau.

Recent aquifer tests have included:

- Multi-well pumping tests
  - Pumping well – PM-2
  - Observation wells – PM-5, PM-4, R-20, R-32
- Single-well pumping test
  - Pumping well – R-15
- Injection tests
  - Multiple screened wells: R-9i, R-13, R-19, R-22, R-31
  - Single screened wells: R-14, R-16, R-20, R-32

The PM-2 pumping test had an idealized radius of influence shown as a circle. It is idealized because it would only be a circle if the materials were completely homogeneous. The shape is really more elliptical, indicating anisotropy. Wells within the radius of influence that did not show drawdown were too shallow to be effected. A geologic cross section showing the screened intervals in the wells and the regional aquifer water level illustrate why well R-32 did not have drawdown.

The observed drawdown measured in PM-2, R-20, screen 3, PM-4, R-20, screen 2, and PM-5 are plotted against time. The wells experience different amounts of drawdown, as shown on the plot. In a second plot, the drawdonw is plotted against distance from the pumping well. Based on this curve, the transmissivity is 4,184 ft^2/day and the storativity is 0.00045. The storativity is characteristic of a confined aquifer. That is an old-fashioned term and we don't have a confied aquifer, but in this test it reacted as a confined aquifer.

Graphs of water levels in the observation wells lead to the following observations:

- In R-20, if you had only looked at screen 1, you might think there was no drawdown. Water in the production wells comes from deeper down, not right at the water table. There is more resistance to flow in the upper part then in the lower part – this is vertical anisotropy. The best water yields are deeper. There is a vertical component to the gradient. [Note: correction to handout provided at the meeting: it should read "r= 1,225 ft"]

- The response to pumping in R-32 is more subtle, but it could not have been identified if the water level in only the upper screen was measured.

Pumping test data are compared to curves. The data from the PM-2 pumping test fits the Hantush-Jacob Leaky Aquifer curve. This suggests that the units above the pump are providing water to the aquifer. This technique was not originally developed to identify vertical anisotropy, but has been changed to account for partial penetration of the well. This confirms the ratios used for anisotropy. These curves would result in transmissivity of 3686 - 3841 ft^2/day; storativity of 0.00163 – 0.00168, and a vertical anisotropy ratio of 1/100 – 1/1.

Observations from the hydrologic testing program:
- Leaky aquifer behavior across the plateau
- Extensive vertical and horizontal anisotropy
- Influence of complex hydrogeology (e.g. the Miocene trough)
- Pumping influences from municipal supply wells

The observation regarding the Miocene trough comes from the pumping test at PM-3, but no drawdown at PM-2, however, the distance was about the same as between PM-2 and the observation wells in this most recent test.

Conclusions:
- Multiple-well pumping tests reveal complex hydrogeology under Pajarito Plateau
- Multiple-well pumping tests provide estimates for aquifer parameters, including transmissivity, storativity, and anisotropy ratio.
- Single-well and injection tests reveal transmissivity and hydraulic conductivity values for individual geologic units.

Overview of Hydrologic Testing Results Questions, Comments, and Responses

Q: Was the idealized radius of influence circle based on the farthest well that drawdown was measured in?
R: That is correct. However, the cone of depression is not circular.

Q: What would be the zone of maximum yield?
R: A dynamic spinner log was done several years ago in PM-4 and it indicated that the bulk of the water came from the upper 30% of the screened interval.

Q: Would you expect to see drawdown at R-15?
R: The screens at R-20 and R-32 are too short to be effected.

Q: What thickness did you use to calculate storativity?
R: The thickness can vary from about 1000 feet at PM-2 to 500 feet at PM-4. It is an indirect indication of the thickness of the water yielding zone.

Q: Can these data be used to assess recharge?
R: They can. We are collaborating with David Schafer on that. Simplifying assumptions can get leakage, but that leads to idealized conditions, that we are reluctant to use, such as the boundary is not regular. The model can help in assessing and field pumping tests can not answer all the questions.

Q: Is there a better handle on the three-dimensional gradient in the regional aquifer?

R: The model indicates downward flow in the recharge area, flat in the middle and up at discharge. At the Buckman well field there is an upward vertical gradient, but it has been disturbed by pumping. Vertical gradients in R-20 and R-32 are induced by pumping.

Q: What was the pumping rate in the test compared to the pumping rate when the well is being used for water supply?
R: The pumping rate for the test was 1,244 gpm for 26 days and that is the same rate that it is usually pumped at. PM-2 is one of the higher yielding wells on the plateau.

FY04 Planned Work (Charlie Nylander, LANL)
There is a lot of drilling planned for the spring and summer, but the possible presence of nesting spotted owls could hold up the work until summer, pushing the completion over the fiscal year boundary. Spotted owls were observed in Mortandad Canyon, but it is not yet known whether they are transient owls or will stay and nest. If the owls stay and nest, no work can go on in the canyon until late summer.

The planned FY04 field activities includes:

- Install wells in Mortandad Canyon Groundwater Investigation Plan:
    - 7 intermediate wells
    - 2 regional aquifer wells R-33 & R-34 (on San Ildefonso)
- Characterization sampling and analysis of CY 02 and 03 wells
- Hydrologic testing

Planned FY04 non-field activities include:

- Groundwater investigation work plans for Mortandad Canyon and Los Alamos and Pueblo Canyons
- Information Management: still working on putting together Water Quality Database and ER Database into a single system. Currently interviewing vendors. Expect to have chosen a commercially available software product by September.
- Hydrogeologic Synthesis Report: expect to publish this report in March 2005.
- Site-wide monitoring plan: anticipating the Consent Order, the internal monitoring plan has been expanded, based on the Order requirements. A draft of the internal plan will be used to guide sampling in the spring and summer. Getting a head start in managing a much larger monitoring program for the Order.
- Regional aquifer modeling: capture zone analysis, incorporating geochemistry and revised geologic model.
- Geologic Model: Updating the geologic model based on data from the wells installed since the last update.
- Quarterly and Annual Meetings: The next two Quarterly meetings will be held in July and August.
- Groundwater Integration Team meetings and activities

The budget for FY04 totals about $21 million. The budget for FY05 will be larger, but we don't know by how much.

FY04 Planned Work Questions, Comments, and Responses

Q: Does the total budget for FY04 include the release of funds from DOE/HQ?
R: Yes, it does.

Q: When will the funds from ZDOE/HQ be released?

R: Today.

Q: I am concerned that you have $21 million dollars to spend this year but you only have 7 intermediates and 2 regional aquifer wells planned?
R: We are also concerned that the money is coming in so late in the year, which makes it difficult to spend. But we have been chipping away at it and expect to be able to use it on all the planned activities.

Q: How much will it cost to combine the databases? CCNS requests that standards be included in the database.
R: The cost is estimated to cost $1 – 2million. The standards are included in the Water Quality Database now, and they will also be in the combine database.

Q: The Risk Assessment Corporation has developed a database. Has the Lab thought about using the Risk Assessment Corporation database and not reinventing the wheel?
R: The market for commercial off-the-shelf software products is <$0.5 million to some at $10,000 to $20,000. These products are not that expensive. The Risk Assessment Corporation is a one-time-use. The Risk Assessment Corporation and LANL database staff have talked. The Risk Assessment Corporation database is not robust enough for what we need.

Q: Would the new database be able to pull data from the Risk Assessment Corporation database?
R: The Risk Assessment Corporation data is our data. It needs extensive QA before pulling it. After the old data is in the database, then new data could be moved in.

Q: Who is in charge of that?.
R: The Risk Reduction and Environmental Stewardship Division has an Information Management function that will do that.

C: It took 4 years to figure out that you couldn't merge the two databases. Now you are buying new software
R: The two databases work together now. The Risk Reduction and Environmental Stewardship Division wants all media in one database with GIS capabilities.

Q: Is the Groundwater Program paying for all this information management?
R: No.

Q: This sounds like a huge database. The air database is big already. If another 9/11 happens will it take all the data down? How can someone in northern New Mexico find out what they want?
R: The database can be partitioned so that the data remain accessible.

C: CCNS requests that the database be designed for the oldest computer in northern New Mexico that provides public access.
R: We won't close any existing sites until this is up and running.

Q: It will be possible to take down portions and not effect the rest?.
R: Yes, it will be partitioned.

C: Why not upgrade the computers in the public facilities to make data available?

R: The lab has an aggressive program to install used Lab computers in schools and libraries. The new database will be partitioned, but we don't know how the speed issue will be dealt with. The graphics take the longest to download, no matter what. The web page could have standard queries so that your computer is not doing the queries.

C: What is the target date for data migration?
R: October 1 is the target date for having the system installed. There is no date set for data migration. Hope to have a clearer schedule by July. We are concerned about blocking data and will try not to do that.

Update on Monitoring Results for the Permeable Reactive Barrier (Pat Longmire, LANL)
The objectives of the presentation are to: Evaluate hydrologic conditions upgradient, within, and downgradient of the multiple permeable reactive barrier and to present a summary of water chemistry data collected at the multiple permeable reactive barrier. The hydrogeologic setting is in Mortandad Canyon just west of R-1. The site was selected because of the contamination of alluvial groundwater. It is a passive remediation system – the water flows through the barrier and contaminants are removed. The barrier is excavated into the tuff. There are four cells:

- Gravel cell to filter the water and remove colloids
- Apatite cell consisting of phosphate rock from Florida. This cell removes Strontium-90, plutonium, and americium. There rock is naturally coated with an organic layer, which helps to treat nitrate and perchlorate. This was an unexpected but very welcome bonus.
- Organic cell filled with pecan shells and cottonseed meal. This cell reduces nitrate to nitrate gases and perchlorate.
- Limestone cell is the final scrubbing of the water.

Water level measurements were made in June, July, and September. The alluvial water dried up in that time. We had to combine water from the cells in order to get enough of a water sample to analyze. The wells that are immediately down gradient (MCO-4B) and immediately upgradient (PRB-MW-01) also dried up. There has been an increase in saturated thickness after the recent rains. There is a steep hydraulic gradient from west to east in the permeable reactive barrier Saturation in the "alluvial" groundwater upgradient and in vicinity of the permeable reactive barrier occurs primarily in the underlying Bandelier Tuff:MCO-4B: screened 9-29 ft; alluvium 5-19 ft; weathered tuff 19-29 ft; water level: August 1990 = 21.7 ft; April 2004 = 25.8 ft

- MW-01: screened 14-30 ft; alluvium 0-24 ft; weathered tuff 24-30 ft; water level: July 2003 = 25.0 ft; April 2004 = 24.0 ftMW-02: screened 14-29 ft; alluvium 0-27 ft; weathered tuff 27-29 ft; water level: July 2003 = 26.8 ft; April 2004 = 26.2 ft

Comparison of water levels in MW-01 (upgradient) with MW-02 and MW-03 (downgradient) show a significant head decrease (~2-3 ft) downgradient of permeable reactive barrier likely caused by interception and infiltration of groundwater in PRB trench. Added infiltration into the Bandelier Tuff may have increased the depth of saturation in the vicinity of the permeable reactive barrier. The saturated hydraulic conductivity (Ksat) of Tuff is ~10^{-4} cm/sec versus saturated hydraulic conductivity of alluvium is ~10^{-3} cm/sec; when saturation levels rise into alluvium, a preferential flow regime through the alluvium occurs.
The water chemistry from May 2003 to September 2003 measured from four sampling rounds shows the nitrate measured in 2 samples from MCO-4B ranged from 2.6 to 1.6 ppm. The decrease in influent nitrate concentration is due to nitrate treatment in the TA-50 plant. In the barrier cells, the following results were observed:

- Apatite cell: the nitrate level in the apatite cell was low, then increased. This may have been due to the lack of water in the cell. But the denitrification in this cell was an added

bonus due to the organic coating on the phosphate rock. Perchlorate was the same as nitrate. More than 80% of the strontium-90 was removed in the apatite cell.

- Organic bio-barrier cell, the nitrate and perchlorate concentration dropped to less than detection in all samples – 100% removal of nitrate and perchlorate.
- Limestone cell: The strontium-90 dropped, perhaps the remediated water is just now getting to the limestone cell.
- MCO-5: nitrate decreased and then increased, a slower response.

The permeable reactive barrier is working, but it needs to have full saturation.

Update on Monitoring Results for the Permeable Reactive Barrier Questions, Comments, and Responses

Q: How deep are the barrier walls driven in?
R: To the interface of alluvial and Bandelier Tuff. The cells were separated by sheets that were removed after the materials were in place. There is also sheet piling that was driven in at the approach to the barrier that acts as a funnel to get the alluvial water to flow through the barrier.

Q: What is the funnel made of and will the alluvial water react to it?
R: Most of the water does not contact the sheet metal that forms the funnel.

Q: The presence of water in the weathered tuff prior to installing the barrier is known from MCO-4B?
R: Yes, and the 8 wells that were installed prior to installing the permeable reactive barrier.

Q: In the month of September, was the discharge from TA-50 insufficient to support the alluvial groundwater or was it lost to evaporation?
R: About 50% of the recharge in Mortandad Canyon is from the TA-50 discharge. The other 50% is from precipitation and other cooling tower outfalls.

C: MCO-5 has not wetted up, although it has been wet for many years.
R: Don't know when it was measured last. It may have water now.

Q: Is MCO-5 down gradient of the permeable reactive barrier and up gradient from the sediment traps?
R: Yes.

Q: What is the sampling schedule for this summer?
R: We just finished one round, and will try to get three more sampling event before October.

Q: Will there be a rebound effect with higher water levels?
R: There are variable flow rates and saturation in the weathered tuff, which influences what we see at MCO-5. When water levels drop, we see more of the weathered tuff water.

Low-Level Perchlorate Analyses by LC/MS/MS (Bill Turney, LANL)
Bill Turney (LANL) said that EPA specifies that analyses for perchlorate in water be done according to EPA Method 314: "Determination of Perchlorate in Drinking Water Using Ion Chromatography". This method employs conductivity detection. However, conductivity is not specific to perchlorate, so ion chromatography can yield false positive results at concentrations in the low ppb range.

LANL conducted a performance evaluation study of EPA Method 314 Ion Chromatography in October 2001. The results were:

- Method 314 does not produce reliable results in environmental groundwaters at low-ppb levels
- High bias and high false positive rates occurred with real groundwater samples at low-ppb levels
- Consensus was reached between LANL, General Engineering Laboratory, DOE, and NMED-DOE Oversight Bureau that the Method Detection Limit (MDL) = 4 ppb and the Practical Quantitation Limit (PQL) = 12 ppb. This means that at numbers between 14 and 4, we know that perchlorate is present, but it is not possible to quantify how much is present.

A different analytical method, Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS) became available in November 2001. It is more specific to perchlorate than is ion chromatography by Method 314. It has lower detection limits than ion chromatography. The Method Detection Limit = 0.25 ppb and the Practical Quantitation Limit = 0.5 ppb.

LANL conducted a performance evaluation study of the Liquid Chromatography/Mass Spectrometry/Mass Spectrometry method in November 2001. The study was conducted at Acculabs in Golden Colorado. Environmental groundwater samples from three sites were submitted for analysis. The samples were spiked at concentrations of 1, 2, 3, 4, and 5 ppb. With the first set of data Acculabs had a calibration standards discrepancy and an electronics problem that led to reanalysis of the samples. The data from the reanalysis looked good. Spike recovery was used to gauge accuracy in the performance evaluation study. The spike recovery results in the Acculabs performance evaluation study were:

- The recovery control limits were 75% to 125%. These were specified before the samples were submitted.
- The original analysis recoveries were 45% to 563% and no recoveries were within the specified control limits.
- The re-analysis recoveries were 45% to 159% and 80% were within the specified control limits.

Then Acculabs went out of business and closed down. General Engineering Laboratory (GEL) bought a new machine and contracted with the person who was formerly at Acculabs to run it. In May/June 2003, a performance evaluation study was conducted at General Engineering Laboratories, Inc. in Charleston, SC. The Method Detection Limit was reported to be 0.05 ppb and the Practical Quantitation Limit was 0.20 ppb. The performance evaluation study used environmental groundwater samples from 8 sites and de-ionized water. The objectives of the performance evaluation study were:

- Determine if the method works in environmental groundwater samples
- Verify the Method Detection Limit of 0.05 ppb
- Verify the Practical Quantitation Limit of 0.2 ppb
- Determine whether perchlorate is present in the LANL area and in regional groundwater samples

The groundwater samples were spiked by ERA Associates in Denver. The perchlorate spike concentrations were:

- Unspiked: 0 ppb
- Method Detection Limit: 0.05 ppb
- Between the Method Detection Limit and the Practical Quantitation Limit: 0.10 ppb

- Practical Quantitation Limit: 0.02 ppb
- Greater than the Practical Quantitation Limit: 0.5 ppb

Plotting the results of the analysis, shows good performance, except there are some suppression effects at the upper end.

Another check on the quality of the analyses is to look at the isotopic ratio of chlorine. The natural ratio of chlorine 35 to chlorine 37 is 3.066. The plotted data shows a scatter which is probably a problem with tuning the instrument. Isotopes are important in evaluating the quality of the data.

Three different types of columns were tested to clean up the water samples before running the analysis. The Hydrogen-Barium-Barium was selected as the best, but there may be changes to that later on.
Conclusions from the Liquid Chromatography/Mass Spectrometry/Mass Spectrometry performance evaluation at General Engineering Laboratories are:

- QC blank results were all non-detect, which indicates the method is generally free from contamination
- Sample analytical preparation addresses some analytical interferences, but low bias persists
- Chlorine isotopic data demonstrate that such data may provide a useful and accurate means to discriminate false positive signals from perchlorate signals. Performance evaluation study isotopic results have low bias.
- Perchlorate appears to be ubiquitous.
- Effective January 2004, all groundwater samples are analyzed for perchlorate by both EPA Method 314 and Liquid Chromatography/Mass Spectrometry/Mass Spectrometry

2004 analyses of perchlorate in water from Pajarito Mesa (PM) wells by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry resulted in the following:

- PM-1 - 0.42 ppb (2/9/04)
- PM-2 – 0.29 ppb (2/9/04)
- PM-3 – 0.41 ppb (1/28/04
- PM-3 – 0.38 ppb (2/9/04)
- PM-5 – 0.35 ppb (1/28/04)
- PM-5 – 0.30 ppb (2/9/04)

Future directions are to conduct a performance evaluation study with synthetic groundwater in Spring 2004. The purpose is to:

- Evaluate the potential for the Liquid Chromatography/Mass Spectrometry/Mass Spectrometry to generate false positives by the formation of perchlorate from chloride ion or other unidentified means during analysis, possibly by oxidizing the chlorine in water to perchlorate
- Interferences still exist that result in low bias at increasing concentrations. Evaluate matrix suppression effects
-

Low-Level Perchlorate Analyses by LC/MS/MS Questions, Comments, Responses

Q: Is anyone else doing this?
R: Not with Liquid Chromatography/Mass Spectrometry/Mass Spectrometry. The EPA Office of water is looking at other methods, but they need to have an affordable method.

Q: Is perchlorate ubiquitous in other places?
R: Perchlorate has been found to be ubiquitous in other places. One example is the Ogallala Aquifer.

Q: CCNS continues to ask how much perchlorate was used at LANL?
R: I don't know the answer to that question.

Q: How much water would a gallon of perchlorate contaminate?
R: We would need the form of perchlorate and the solubility to calculate that.

Introduction to Meteorology and Air Quality at Los Alamos (Jean Dewart, LANL)
Jean Dewart (LANL) said that last fall the consent agreement was completed. The Air Quality group is looking for the next step in public involvement. Charlie Nylander invited us to see this meeting. We would like to know if people that come to this meeting are interested in hearing about our programs.
A brief overview is:

- Air sampling
- Foodstuffs, biota, and soils monitoring
- All pathways dose assessment
- Meteorology
- Regulatory requirements

Los Alamos National Laboratory
Groundwater Protection Program
Quarterly Meeting
April 12, 2004
Minutes

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Well Drilling Status Report

April 12, 2004

Tom Whitacre
DOE Project Director

Overview

- Drilling Accomplishments
- Well Development and Testing Activities
- Remaining Field Work
- Reporting Activities

Drilling Accomplishments

- R-1 – Mortandad Canyon – 1165 feet – 1 screen
  350 feet core – open hole geophysics suite
- R-2 – Pueblo Canyon - 943 feet - 1 screen
  228 feet core – open hole geophysics suite
- R-4 – Pueblo Canyon - 844 feet - 1 screen
  243 feet core – open hole geophysics suite
- R-11 – Sandia Canyon – 927 feet - 1 screen
  224 feet core – open hole geophysics suite
- R-26 – Canyon de Valle – 1485 feet - 2 screens
  250 feet core – open hole geophysics suite

Drilling Accomplishments (Con't)

- R-28 – Mortandad Canyon – 1006 feet – 1 screen
  315 feet core – open hole geophysics suite
- CdV-16-1(I) – TA-16 – 680 feet – 1 screen
  200 feet core – open hole geophysics suite
- CdV-16-2(I) – TA-16 – 1063 feet – 2 screens
  no core collected – open hole geophysics suite
- CdV-16-3(I) – TA-16 – 1405 feet – no regional water saturation – no well installed – no core collected - open hole geophysics suite

Well Development and Testing Activities

- R-26 – development and hydrotesting completed about 110,000 gallons removed
- R-28 – development and hydrotesting completed about 59,000 gallons removed
- CdV-16-1(I) – development and hydrotesting completed about 8,000 gallons removed

Remaining Field Work

- Sampling Pump Installation – R-1, R-2, R-4, R-11, R-28, and CdV-16-1(I) – 4/04 to 5/04
- Westbay Installation – R-26 – 4/04
- Water level detection – CdV-16-2(I) and 16-3(I) - ongoing
- Site Restoration – All nine drill sites – 5/04

Reporting Activities

- All Fact Sheets submitted to NMED
- R-1 – Well Completion Report due 4/04
- R-2 – Well Completion Report submitted 3/04
- R-4 – Well Completion Report submitted 3/04
- R-11 – Well Completion Report submitted 3/04
- R-26 – Well Completion Report submitted 4/04
- R-28 – Well Completion Report due 4/04
- CdV-16-1(I) – Well Completion Report due 5/04
- CdV-16-2(I) – Well Completion Report due 5/04
- CdV-16-3(I) – Well Completion Report due 5/04

WATER CHEMISTRY RESULTS FOR WELLS R-1, R-2, R-4, R-11, R-26 AND R-28

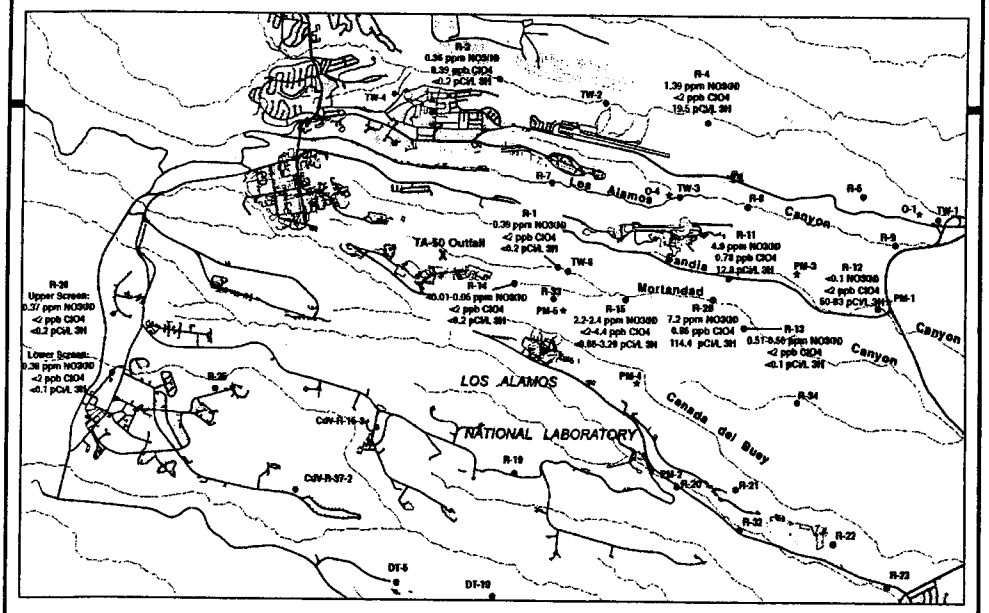
PATRICK LONGMIRE AND DALE COUNCE
EARTH AND ENVIRONMENTAL SCIENCES DIVISION
LOS ALAMOS NATIONAL LABORATORY
APRIL 12, 2004

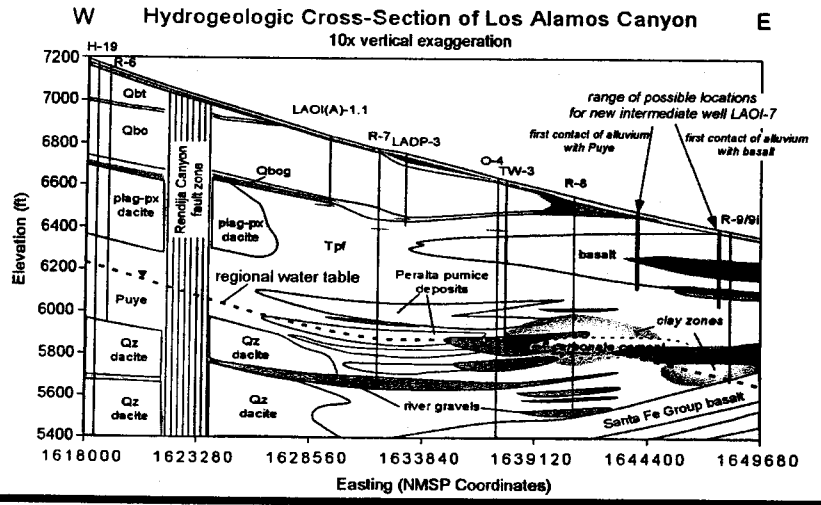
OBJECTIVES OF PRESENTATION

- Present a summary of screening analytical results for perchlorate, nitrate, and tritium at wells R-1, R-2, R-4, R-11, R-26, and R-28.
- Evaluate influence of Cerro Grande fire on manganese concentrations within alluvial and perched intermediate groundwater in upper Los Alamos Canyon.

APPROACH FOR R-WELL SAMPLING

- The screening groundwater samples were collected during well development after field parameters stabilized.
- Field parameters include: pH, temperature, turbidity, and specific conductance.
- Total organic carbon was measured in the laboratory.





LA-UR-04-2387 Groundwater Protection Program Slide 5

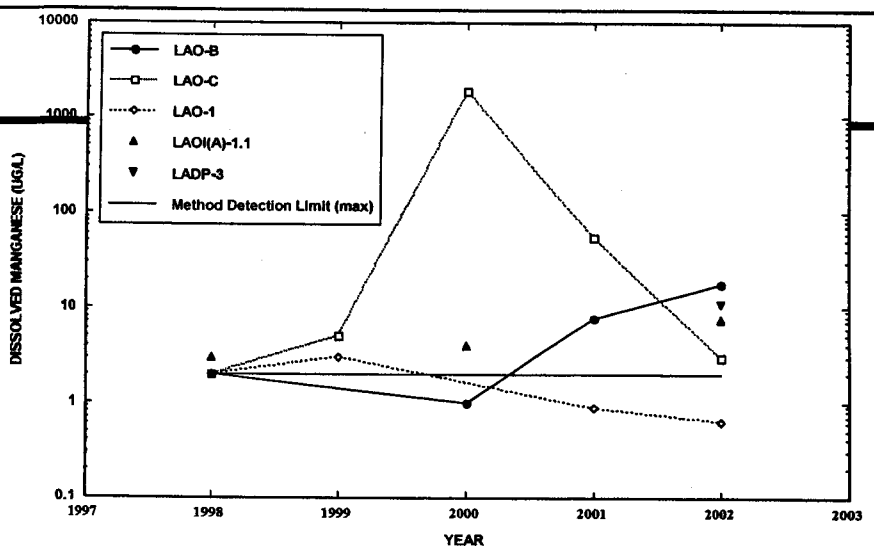


Figure 3. Time versus dissolved manganese concentrations in shallow wells (LAO-B, LAO-C, and LAO-1) and intermediate wells (LAOI(A)-1.1 and LADP-3) in upper Los Alamos Canyon.

LA-UR-04-2387 Groundwater Protection Program Slide 6

ADDITIONAL DATA COLLECTION

- Collect additional groundwater samples from LAO-B, LAO-C, LAO-1, LAOI(A)1.1, and LADP-3.
- Conduct four rounds of sampling at each well.
- Analyze groundwater samples for total organic carbon, dissolved organic carbon, manganese, iron, major ion chemistry, and low level tritium. Wells LADP-3 and LAOI(A)-1.1 are both completed in the Guaje Pumice Bed.

Overview of the Hydrologic Testing Program

Stephen G. McLin
Water Quality and Hydrology Group
April 12, 2004

LA-UR-04-2437

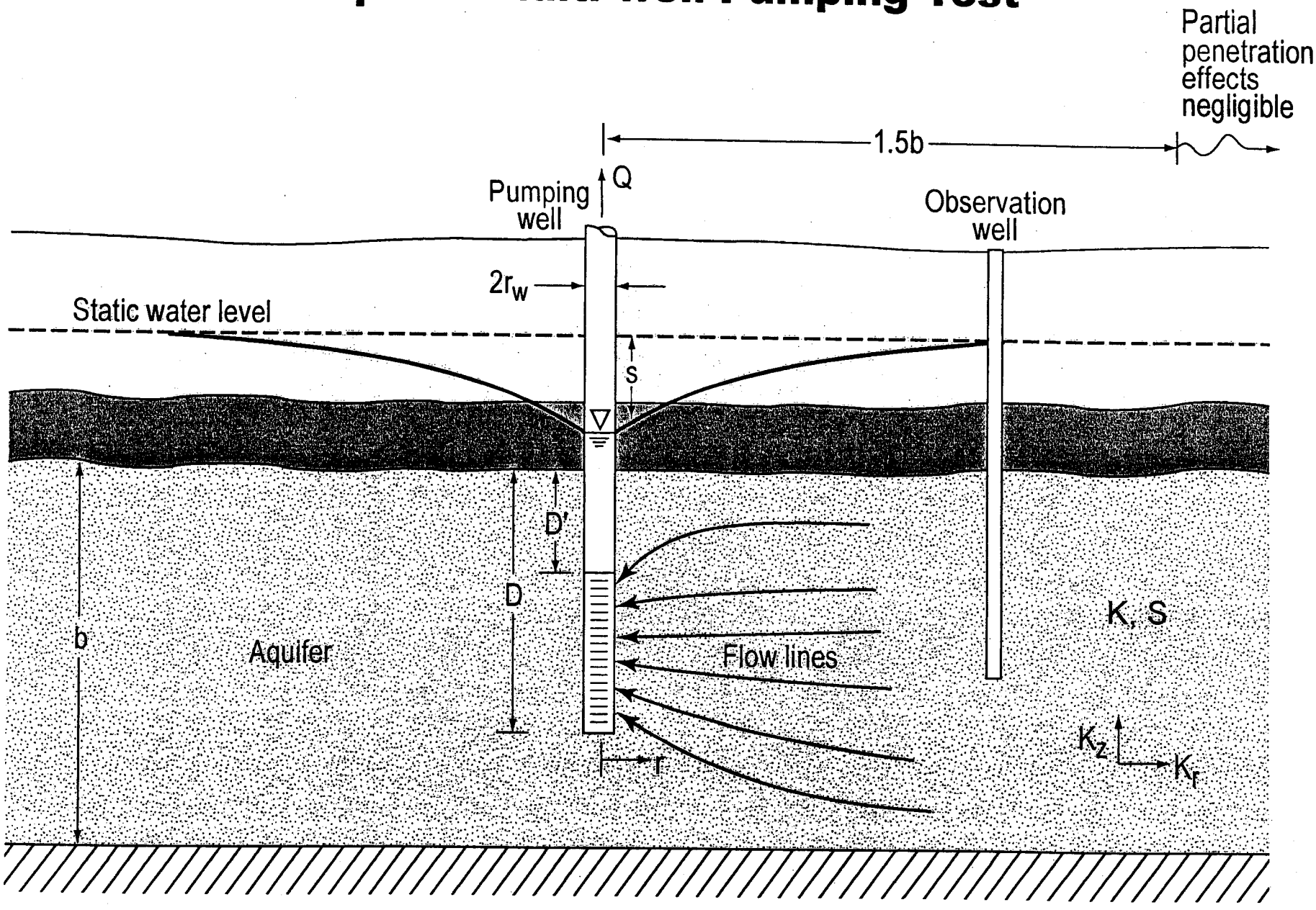
Issues Identified in NMED Letter to LANL on 17 August 1995

- Hydraulic interconnection between saturated geologic units is not understood
- Recharge areas have not been identified
- Influence of municipal water production on ground-water flow directions are unknown
- Aquifer characteristics have not been determined

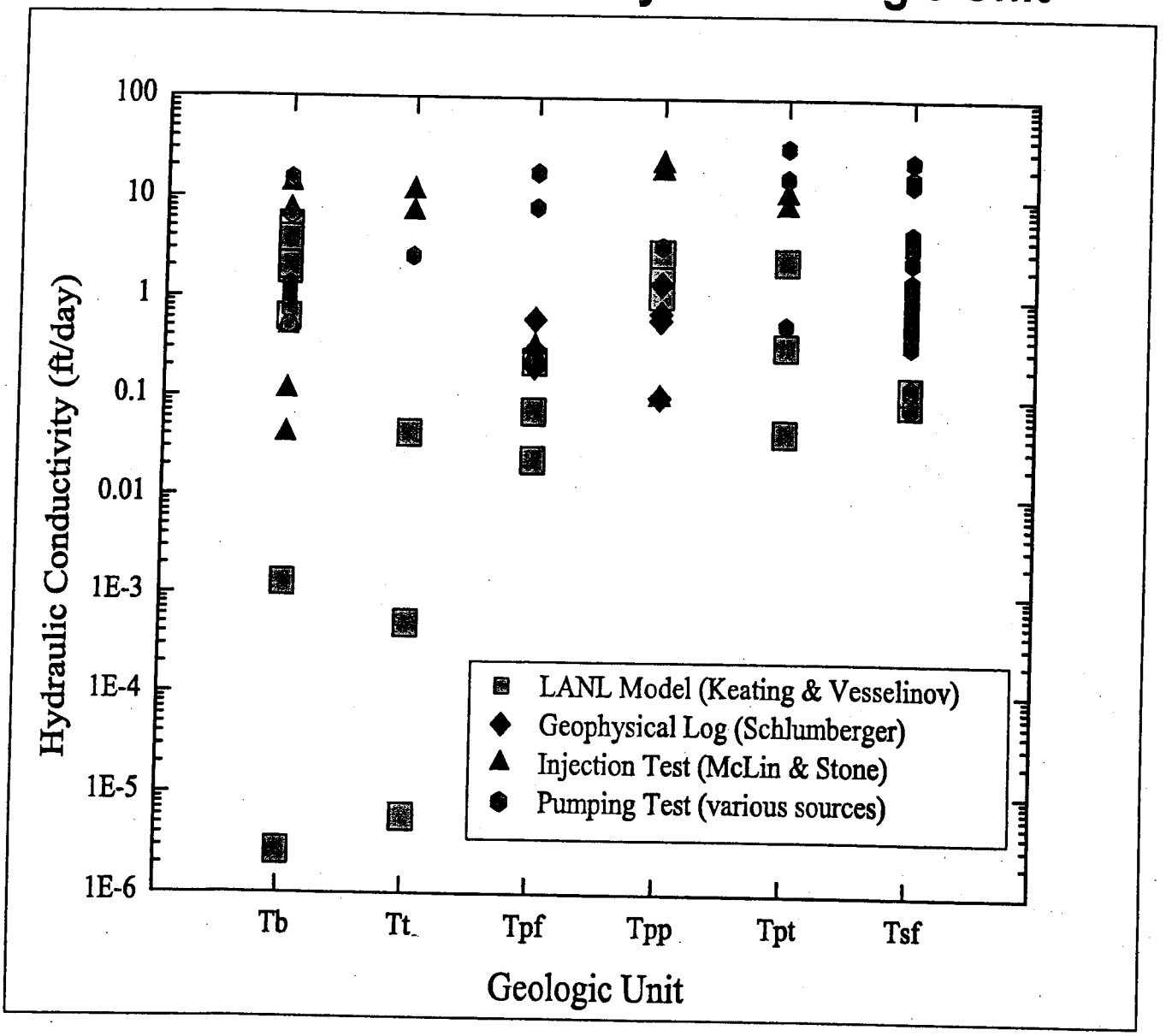
Questions

- How do we best test geologic units for aquifer properties?
- How do we evaluate horizontal and vertical anisotropy?
- Can we test the influence of municipal supply wells?
- Can modeling provide aquifer parameter estimates where testing is not possible?

Example of Multi-well Pumping Test



Hydraulic Conductivity vs. Geologic Unit

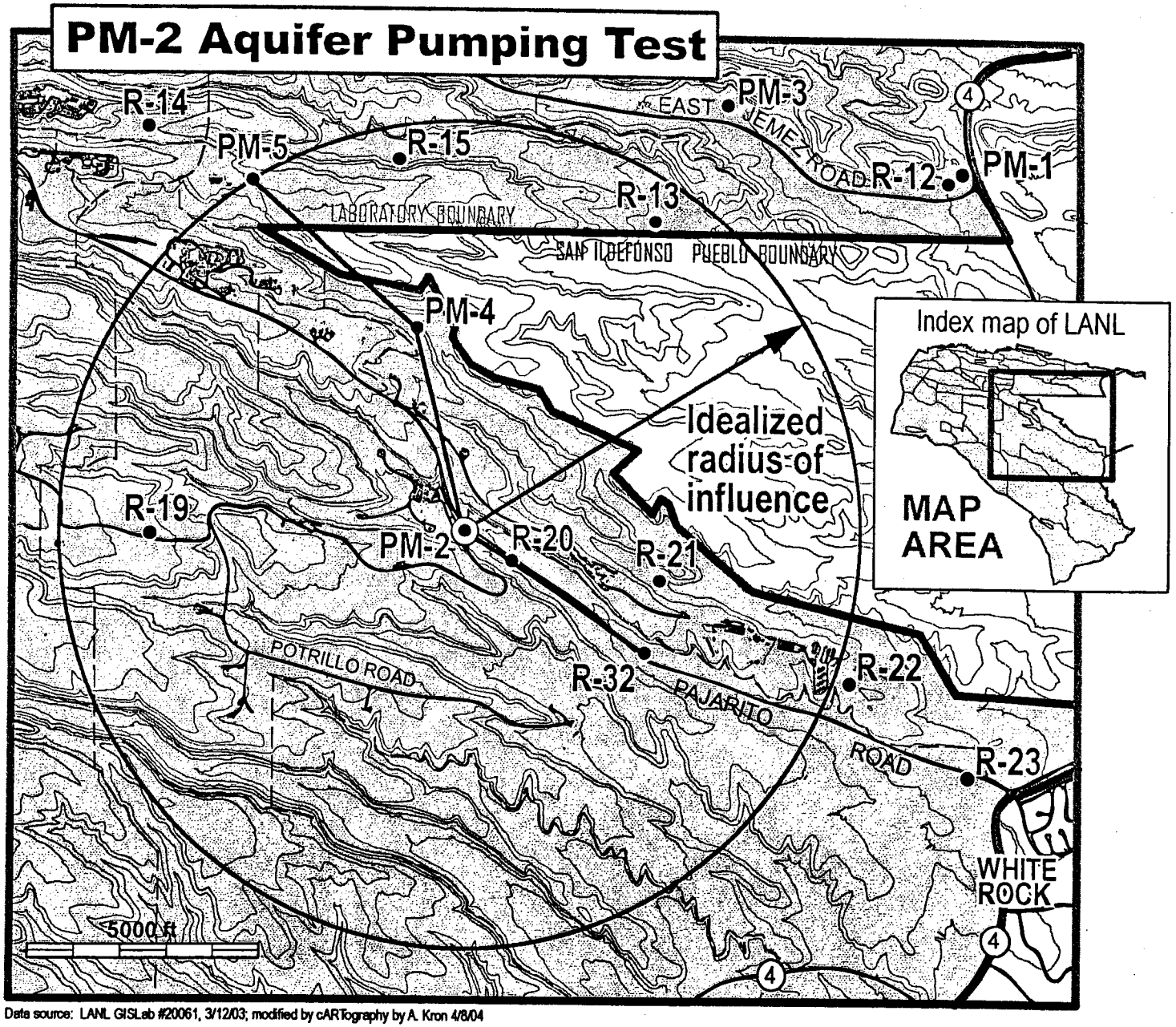


Tb - basalts
Tt - Tschicoma
Tpf - Puye fanglomerate
Tpp - Puye pumiceous
Tpt - Totavi Lentil
Tsf - Santa Fe Group

Description of Some Recent Aquifer Tests

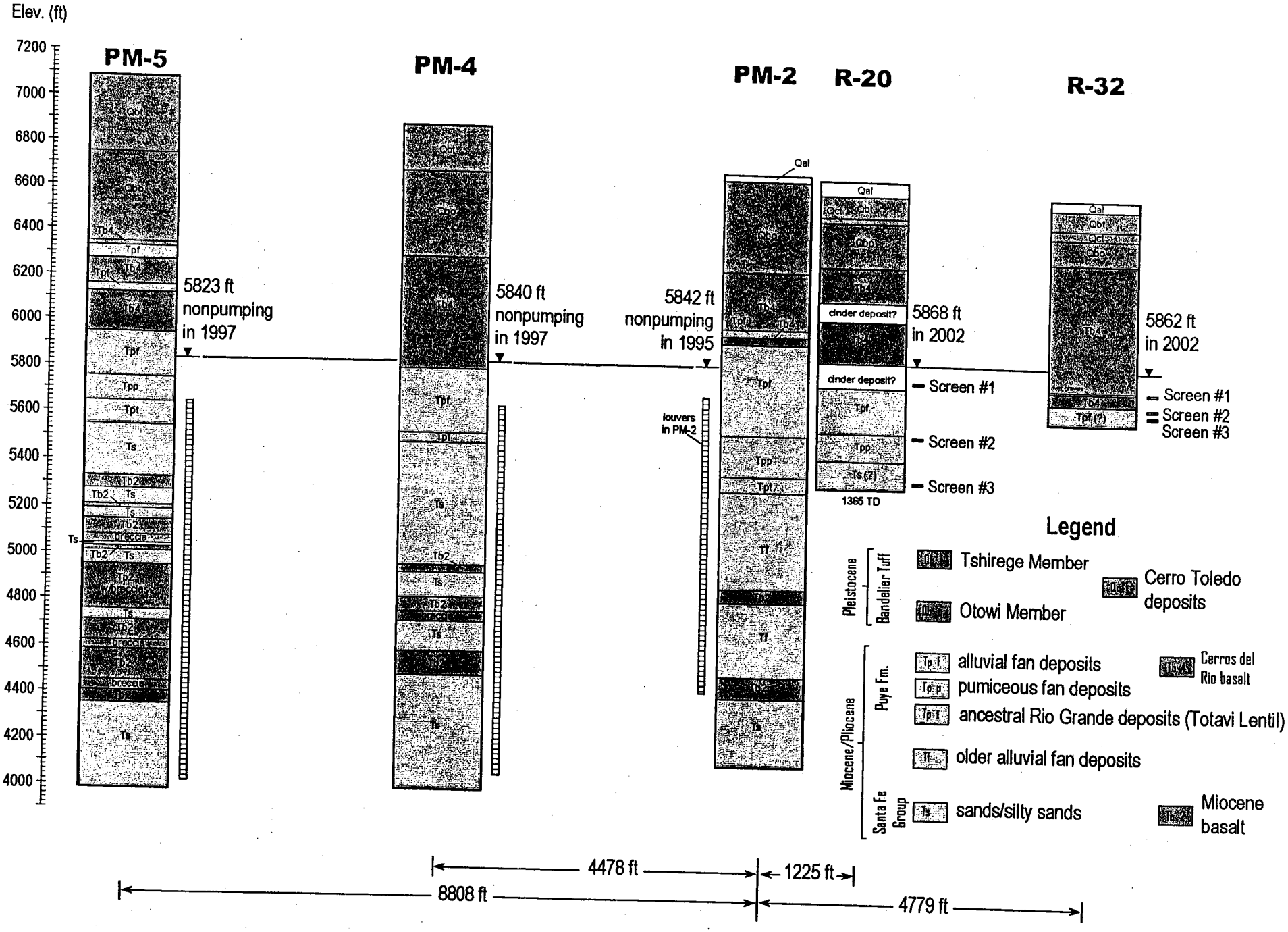
- **Multi-Well Pumping Tests**
  - pumping well = PM-2
  - observation wells = PM-5, PM-4, R-20, R-32
- **Single-Well Pumping Tests**
  - pumping well = R-15
- **Multi-Screened Well Injection Tests**
  - wells R-9i, R-13, R-19, R-22, R-31
  - wells R-14, R-16, R-20, R-32

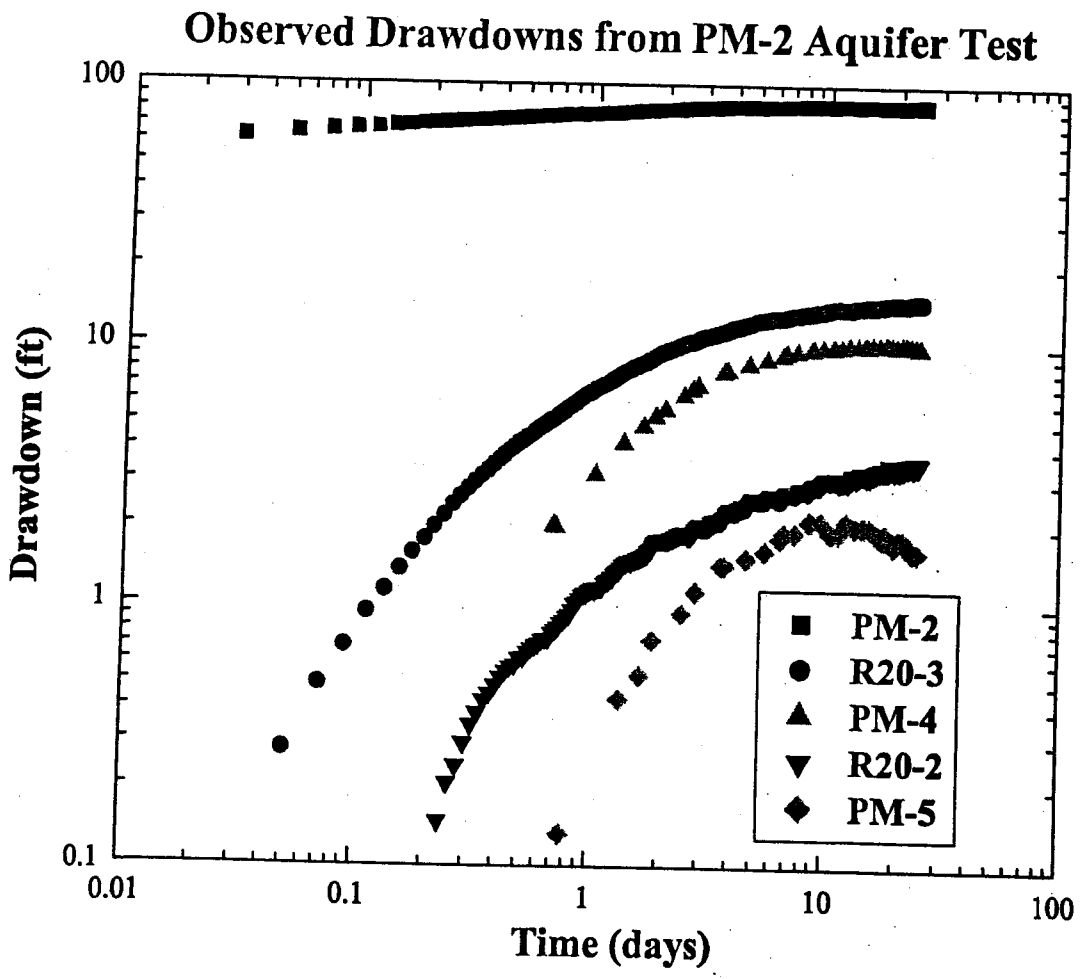
PM-2 Aquifer Pumping Test

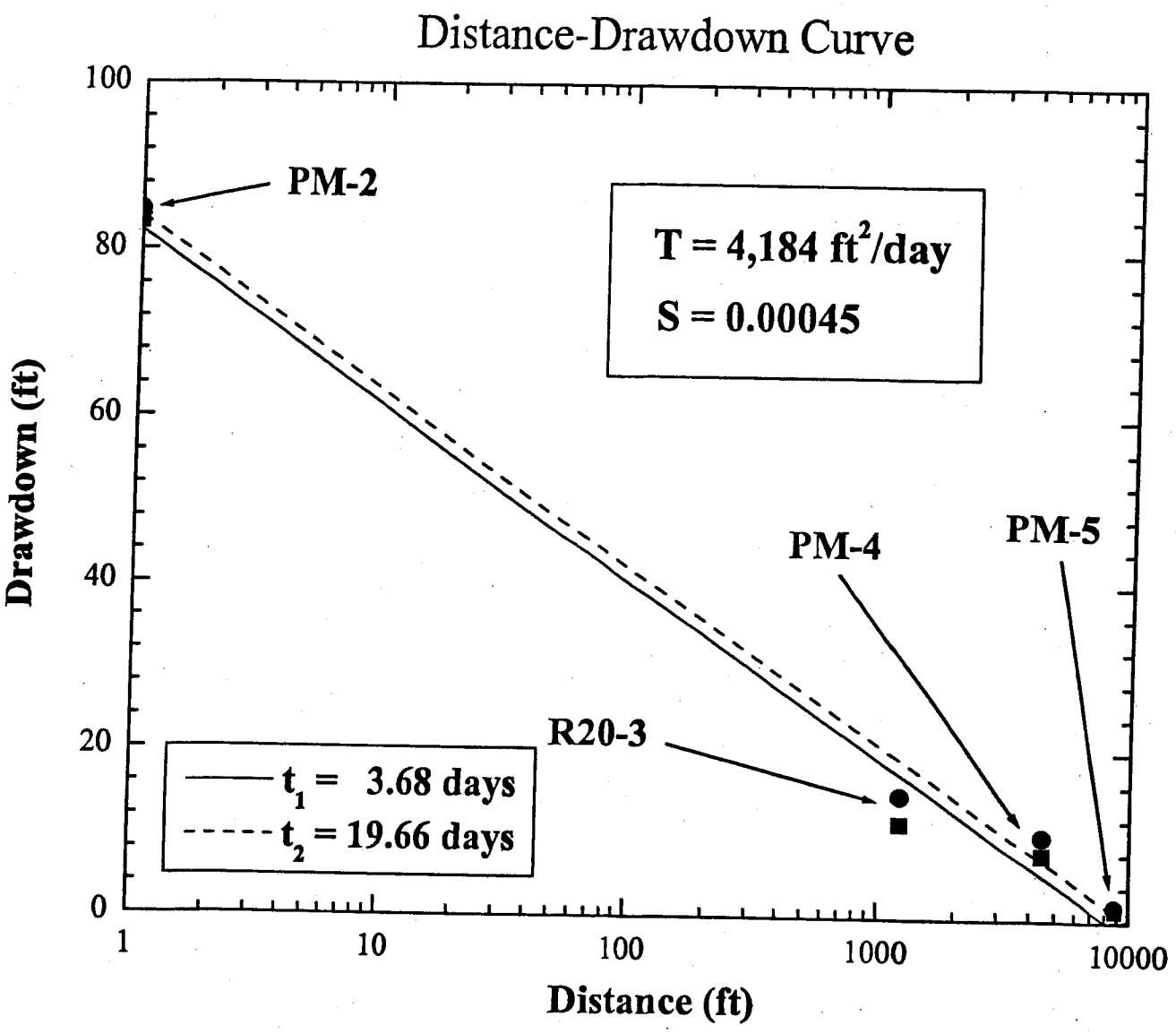


Data source: LANL GISLab #20061, 3/12/03; modified by cARTography by A. Kron 4/8/04

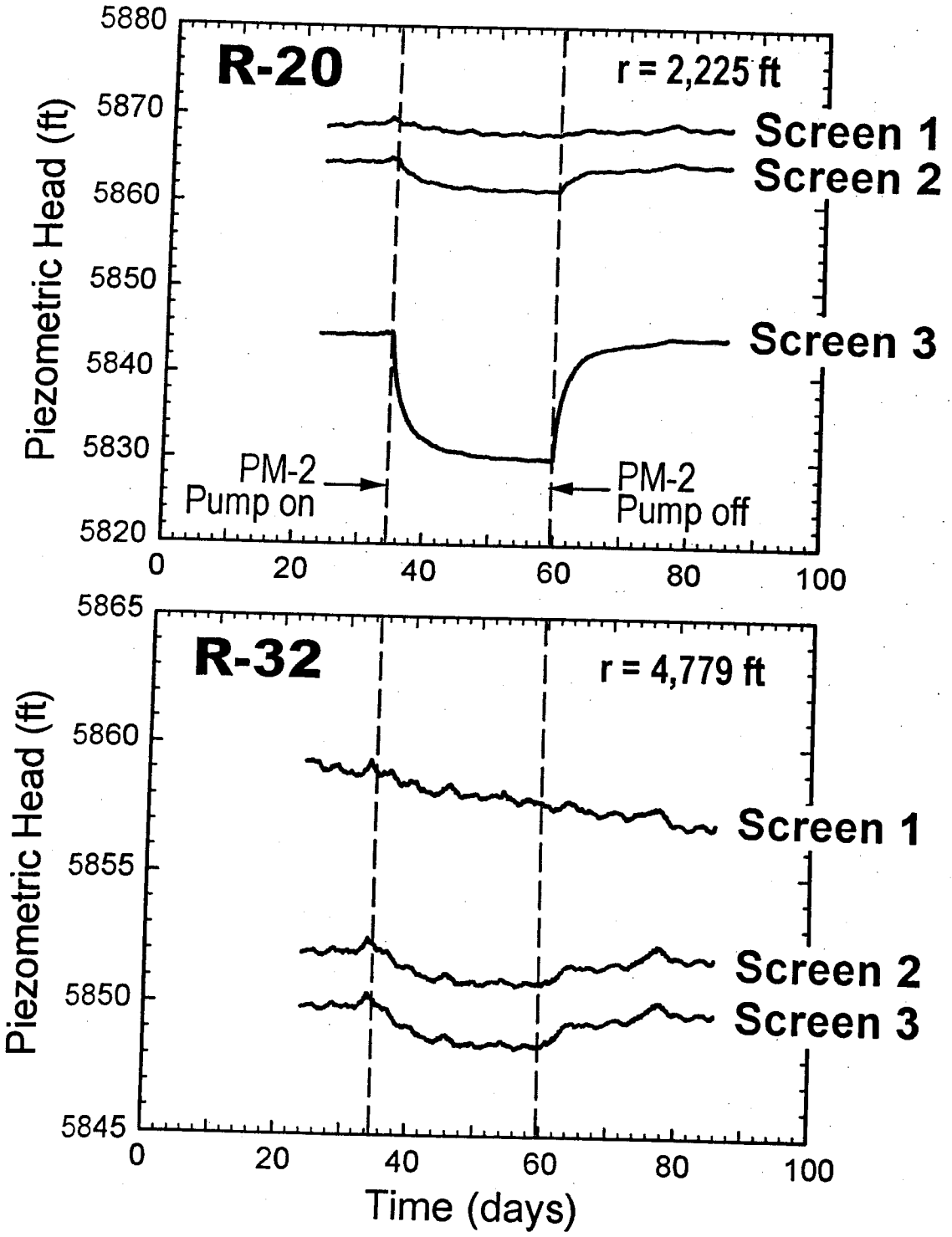
Geologic Section A-A'

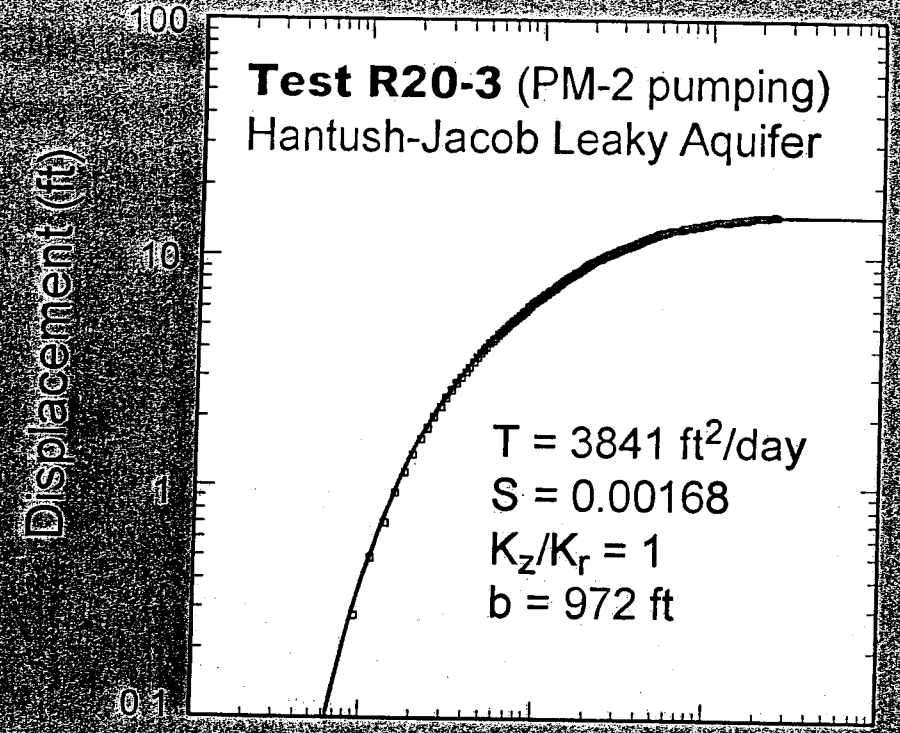


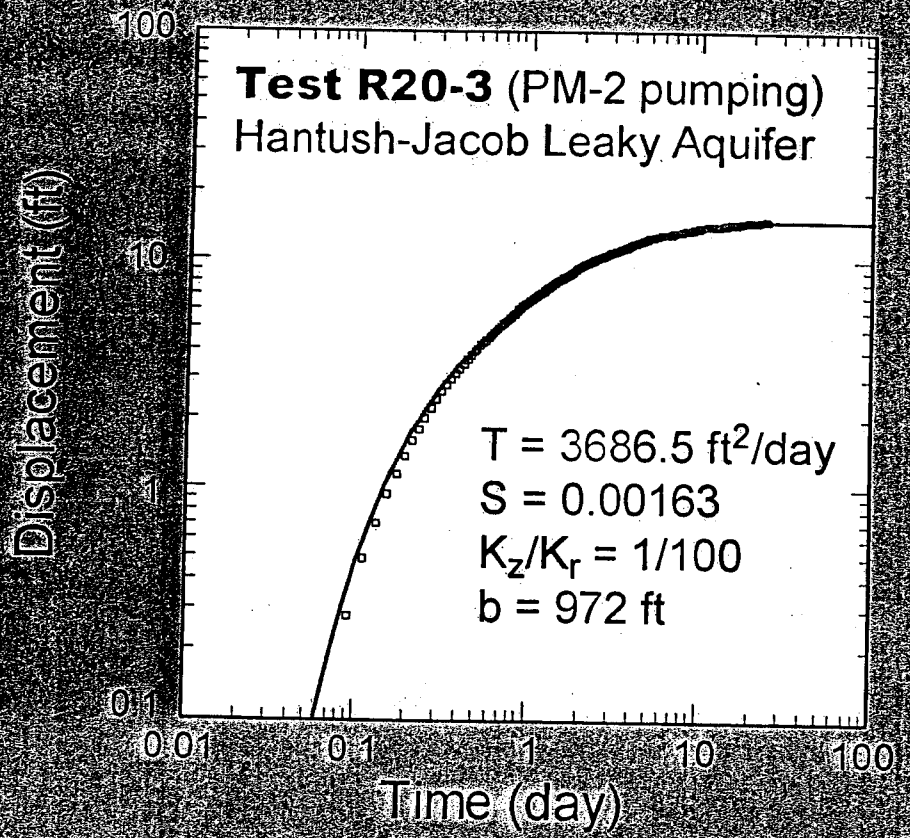

Observed Drawdowns from PM-2 Aquifer Test
Drawdown (ft)
100
10
1
0.1
0.01
0.1
1
10
100
Time (days)
PM-2
R20-3
PM-4
R20-2
PM-5


Distance-Drawdown Curve
PM-2
T = 4,184 ft²/day
S = 0.00045
PM-4
PM-5
R20-3
t1 = 3.68 days
t2 = 19.66 days
Drawdown (ft)
Distance (ft)
100
80
60
40
20
0
1
10
100
1000
10000

Water Levels in Observation Wells

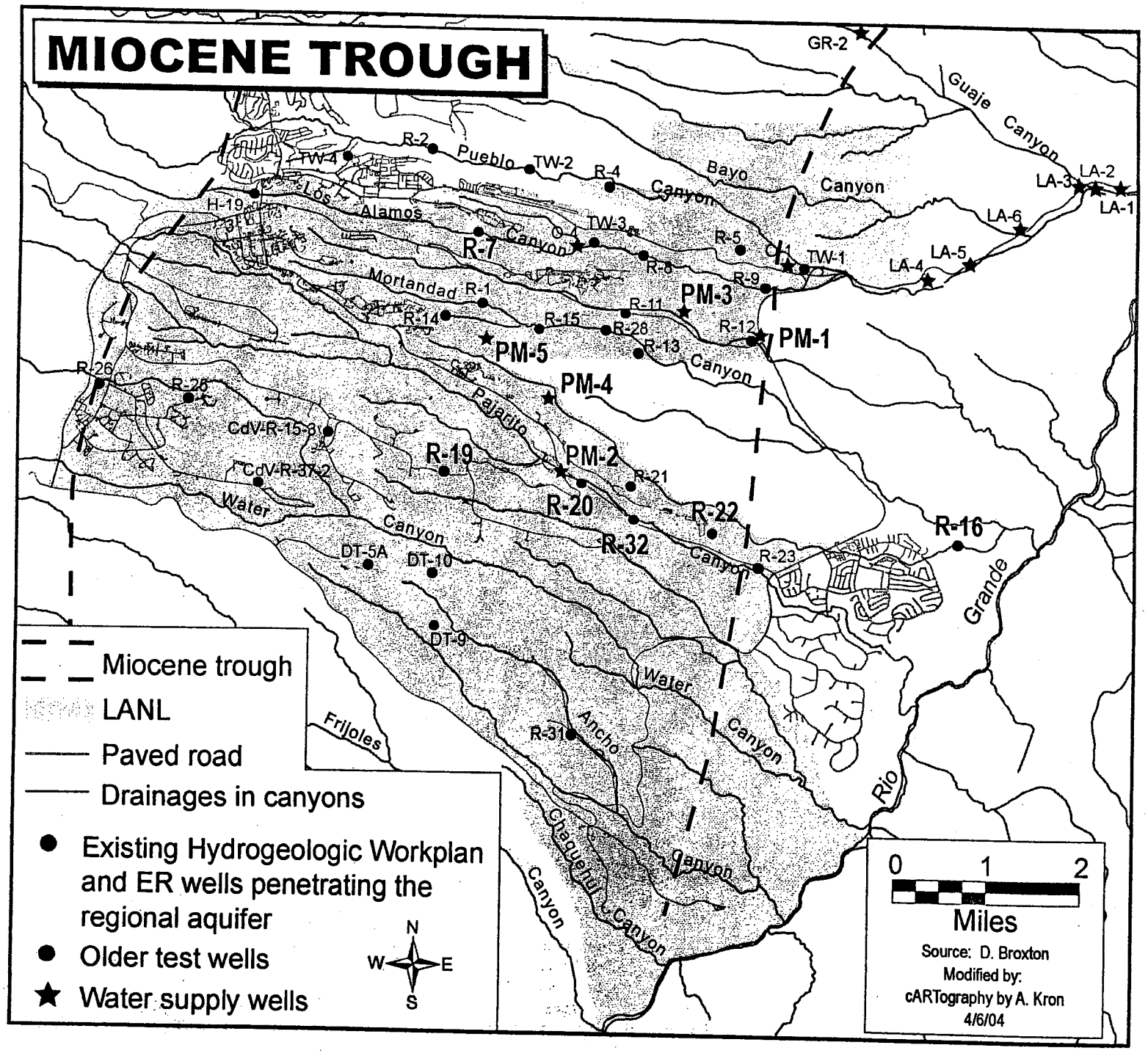



Test R20-3 (PM-2 pumping)
Hantush-Jacob Leaky Aquifer
T = 3841 ft²/day
S = 0.00168
Kz/Kr = 1
b = 972 ft
Displacement (ft)
100
10
1
0.1


Test R20-3 (PM-2 pumping)
Hantush-Jacob Leaky Aquifer
T = 3686.5 ft²/day
S = 0.00163
Kz/Kr = 1/100
b = 972 ft
Displacement (ft)
100
10
1
0.1
0.01
0.1
1
10
100
Time (day)

Observations from Hydrologic Testing Program

- Leaky aquifer behavior across plateau
- Extensive vertical & horizontal anisotropy
- Influence of complex hydrogeology (e.g., the Miocene trough)
- Pumping influences from municipal water supply wells


MIOCENE TROUGH
GR-2
Guaje Canyon
LA-1
LA-2
LA-3
LA-4
LA-5
LA-6
R-2
Pueblo
TW-2
R-4
Bayo
Canyon
TW-4
Los Alamos
H-19
TW-3
R-5
TW-1
R-7
Canyon
R-8
R-9
Mortandad
R-1
PM-3
R-11
R-14
R-15
R-28
R-12
PM-1
PM-5
R-13
Canyon
R-26
R-25
PM-4
Pajarito
CdV-R-15-3
R-19
PM-2
CdV-R-37-2
R-21
Water
R-20
R-22
Canyon
R-32
R-16
DT-5A
DT-10
R-23
Canyon
Grande
DT-9
Miocene trough
LANL
Paved road
Drainages in canyons
Existing Hydrogeologic Workplan and ER wells penetrating the regional aquifer
Older test wells
Water supply wells
Frijoles
R-31
Ancho
Water
Canyon
Rio
Chaquehui
Canyon
Canyon
Canyon
N
W
E
S
0
1
2
Miles
Source: D. Broxton
Modified by:
cARTography by A. Kron
4/6/04

Conclusions

- Multi-well pumping tests reveal complex hydrogeology under Pajarito Plateau
- Multi-well aquifer tests provide estimates for aquifer parameters, including T, S, and K_z/K_r
- Single-well pumping & injection tests reveal T and K values for individual geologic units

References

Broxton, D.E., and S.L. Reneau, 1996. Buried early Pleistocene landscapes beneath the Pajarito Plateau, northern New Mexico. New Mexico Geological Society, Guidebook to the Jemez Mountains, 47th Annual Field Conference, New Mexico Bureau of Mines and Mineral Resources, Socorro, pp. 325-334.

Rogers, D.B., A.K. Stocker, S.G. McLin, and B.M. Gallaher, 1996. Recharge to the Pajarito Plateau regional aquifer system. New Mexico Geological Society, Guidebook to the Jemez Mountains, 47th Annual Field Conference, New Mexico Bureau of Mines and Mineral Resources, Socorro, pp. 407-412.

McLin, S.G., 1996. Analysis of water level fluctuations in Pajarito Plateau wells. New Mexico Geological Society, Guidebook to the Jemez Mountains, 47th Annual Field Conference, New Mexico Bureau of Mines and Mineral Resources, Socorro, pp. 421-426.

Reneau, S.L., and D.P. Dethier, 1996. Pliocene and Quaternary history of the Rio Grande, White Rock Canyon and vicinity. New Mexico Geological Society, Guidebook to the Jemez Mountains, 47th Annual Field Conference, New Mexico Bureau of Mines and Mineral Resources, Socorro, pp. 317-324.

McAda, D.P., 2001. Simulation of a long-term aquifer test conducted near the Rio Grande, Albuquerque, New Mexico. USGS, Water Resources Investigation Report 00-4260.

McLin, S.G. and W.J. Stone, 2004. Hydrologic Tests at Characterization wells R-9i, R-13, R-19, R-22, and R-31. Los Alamos National Laboratory, report in review.

McLin, S.G., 2004. Aquifer test analysis for well R-15. Los Alamos National Laboratory, report in press.

McLin, S.G., and W.J. Stone, 2004. Hydrologic testing at characterization well R-14. Los Alamos National Laboratory, report in review.

McLin, S.G., and W.J. Stone, 2004. Hydrologic testing at characterization well R-32. Los Alamos National Laboratory, report in review.

McLin, S.G., 2004. Hydrologic testing at characterization well R-20. Los Alamos National Laboratory, report in review.

McLin, S.G., 2004. Hydrologic testing at characterization well R-16. Los Alamos National Laboratory, report in review.

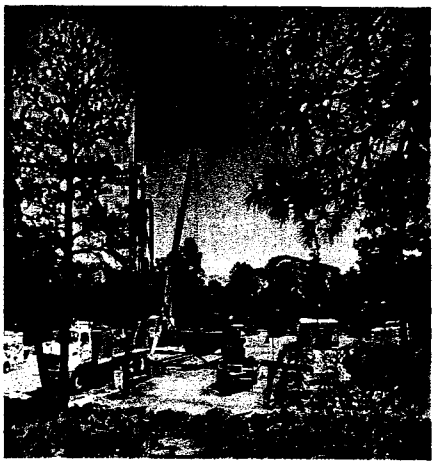
McLin, S.G., 2004. Hydrologic testing at municipal water supply well PM-2. Los Alamos National Laboratory, report in progress.

Thorn, C.R., 2001. Analytical results of a long-term aquifer test conducted near the Rio Grande, Albuquerque, New Mexico. USGS, Water Resources Investigation Report 00-4291.

Groundwater Protection Program FY04 Planned Work

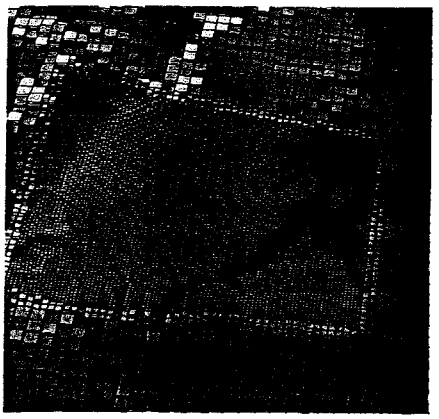
Charlie Nylander
Program Manager
nylander@lanl.gov

Planned FY04 Field Activities



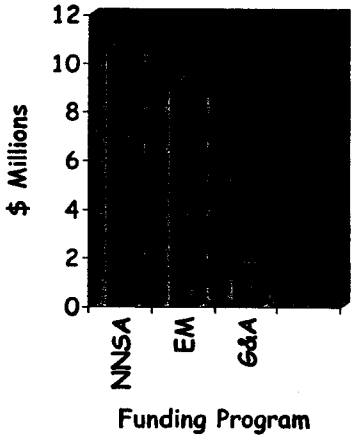
- Install wells in Mortandad Canyon Groundwater Investigation Plan:
  - 7 intermediate wells
  - 2 regional aquifer wells R-33 & R-34 (on San Ildefonso)
- Characterization sampling and analysis of CY 02 and 03 wells
- Hydrologic testing

FY04 Non-Field Activities



- Groundwater investigation work plans for Mortandad Canyon and Los Alamos and Pueblo Canyons
- Information Management
- Hydrogeologic Synthesis Report
- Sitewide monitoring plan
- Regional aquifer modeling
- Geologic Model
- Quarterly and Annual Meetings
- Groundwater Integration Team meetings and activities

FY04 Budget (estimated)



- NNSA funding is $10 million + $0.5 million in carry-over = $10.5 million
- EM funding is not finalized, but is expected to be on the order of $9 million
- G&A funding of $1.5 million is primarily for monitoring
- Total (estimated) = $21 million

STATUS REPORT FOR THE MULTIPLE PERMEABLE REACTIVE BARRIER, MORTANDAD CANYON

PATRICK LONGMIRE[1], ROBERT GRAY[2] AND JOHN KASZUBA[1]

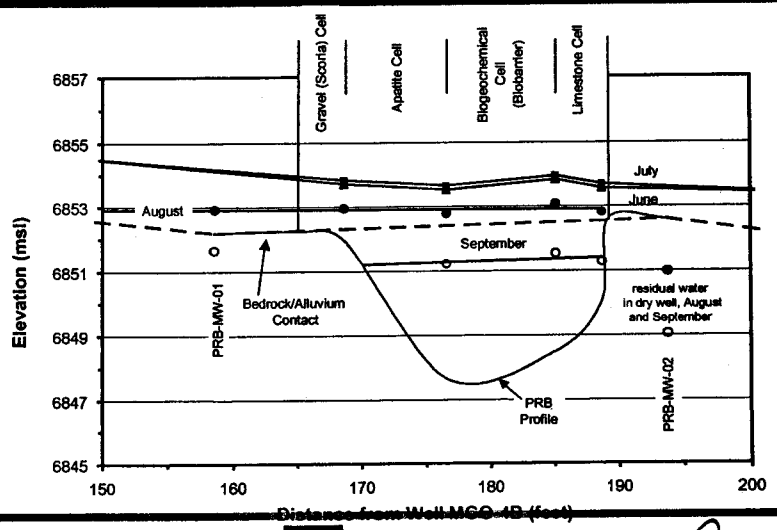
1. EARTH AND ENVIRONMENTAL SCIENCES DIVISION CHEMISTRY DIVISION, LOS ALAMOS NATIONAL LABORATORY
2. DANIEL B STEPHENS AND ASSOCIATES

APRIL 12, 2004

OBJECTIVES OF PRESENTATION

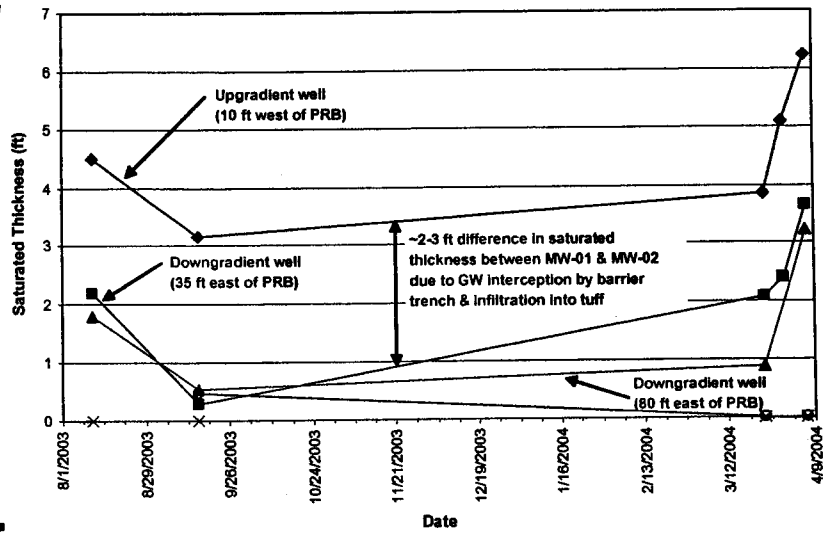
- Evaluate hydrologic conditions upgradient, within, and downgradient of the multiple permeable reactive barrier.
- Present a summary of water chemistry data collected at the multiple permeable reactive barrier.

Cross Section of Permeable Reactive Barrier & Water Levels June-Sept. 2003



NNSA LA-UR-04-2386 RRES Groundwater Protection Program Slide 3 Modified from John Kazubski Los Alamos NATIONAL LABORATORY

PRB Water Levels



NNSA RRES Slide 4 Analysis by R. Gilley Los Alamos NATIONAL LABORATORY

Permeable Reactive Barrier Hydrogeology

Saturation in the "alluvial" groundwater upgradient and in vicinity of the PRB occurs primarily in the underlying Bandelier Tuff

- MCO-4B: screened 9-29 ft; alluvium 5-19 ft; weathered tuff 19-29 ft; water level: August 1990 = 21.7 ft; April 2004 = 25.8 ft
- MW-01: screened 14-30 ft; alluvium 0-24 ft; weathered tuff 24-30 ft; water level: July 2003 = 25.0 ft; April 2004 = 24.0 ft
- MW-02: screened 14-29 ft; alluvium 0-27 ft; weathered tuff 27-29 ft; water level: July 2003 = 26.8 ft; April 2004 = 26.2 ft

Permeable Reactive Barrier Hydrogeology

- Comparison of water levels in MW-01 (upgradient) with MW-02 and MW-03 (downgradient) show a significant head decrease (~2-3 ft) downgradient of PRB likely caused by interception and infiltration of groundwater in PRB trench
- Added infiltration into the Bandelier Tuff may have increased the depth of saturation in the vicinity of the PRB.
- Ksat of Tuff is ~10^{-4} cm/sec versus Ksat of alluvium is ~10^{-3} cm/sec; when saturation levels rise into alluvium, a preferential flow regime through the alluvium occurs.

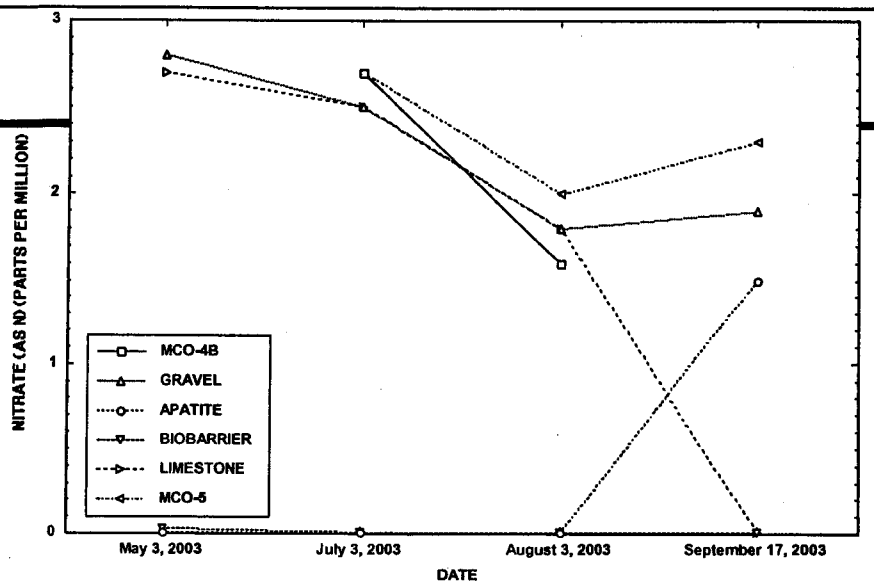


Figure 3. Time versus nitrate (as N) concentrations upgradient, within, and downgradient of the permeable reactive barrier in Mortandad Canyon

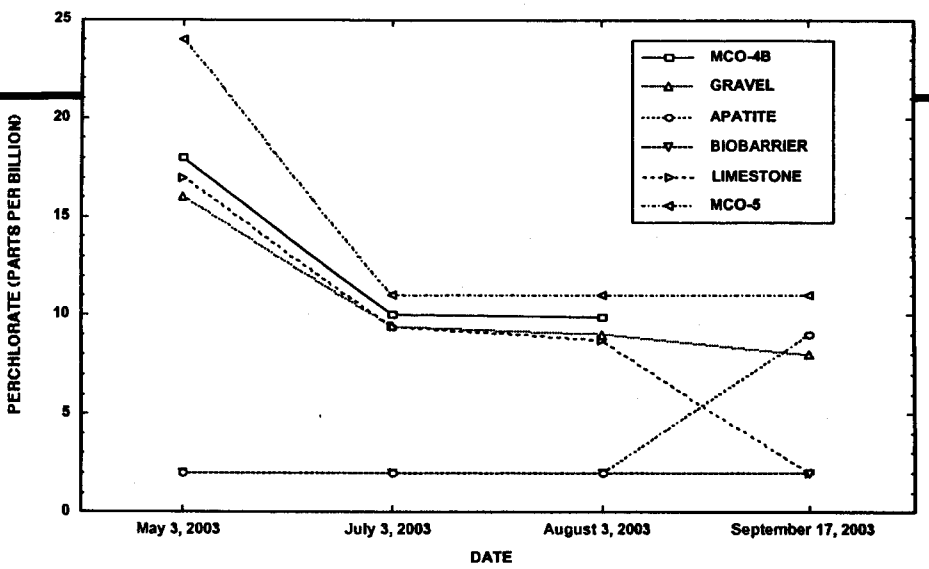


Figure 4. Time versus perchlorate concentration upgradient, within, and downgradient of the permeable reactive barrier (PRB) in Mortandad Canyon.

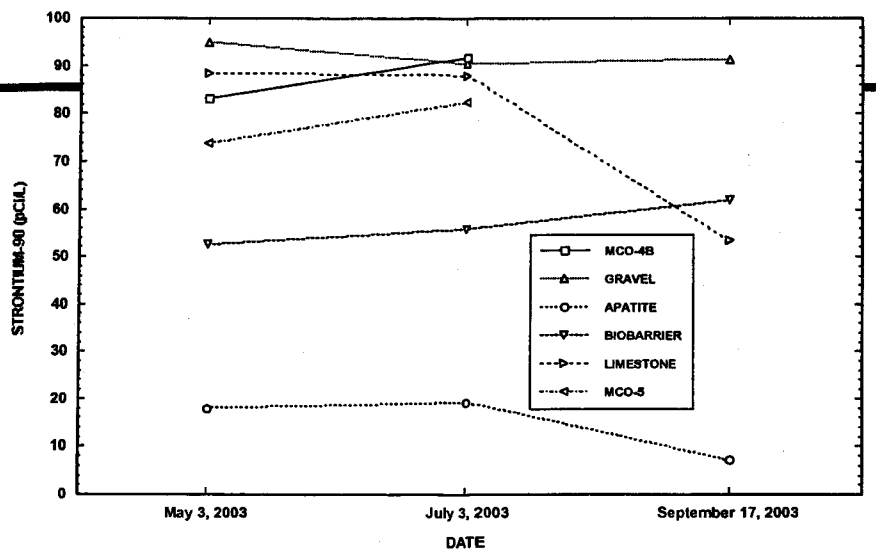


Figure 5. Time versus strontium-90 concentrations upgradient, within, and downgradient of the permeable reactive barrier in Mortandad Canyon.

SUMMARY

- The alluvium and weathered Bandelier Tuff are saturated near the permeable reactive barrier.
- Groundwater flow through the permeable reactive barrier is occurring at variable rates.
- Perchlorate and nitrate are being transformed within the apatite and biobarrier cells within the permeable reactive barrier.
- Strontium-90 is adsorbing onto apatite surfaces within the permeable reactive barrier.

Low-Level Perchlorate Analyses by LC/MS/MS

William R. Turney

LA-UR-03-7865

EPA Method 314 Determination of Perchlorate in Drinking Water Using Ion Chromatography

- Method 314 employs conductivity detection.
- Conductivity is not specific to perchlorate.
- IC can yield false positive results at concentrations in the low-ppb range.

2

EPA 314
Performance Evaluation Study
October 2001

- Method 314 does not produce reliable results in environmental groundwaters at low-ppb levels.
- High bias and high false positive rates occurred with real groundwater samples at low-ppb levels.
- Consensus reached amoung LANL, GEL, DOE, and NMED-OB
  - MDL = 4 ppb
  - PQL = 12 ppb

3

Liquid Chromatography / Mass Spectrometry / Mass Spectrometry (LC/MS/MS)

- Available in November 2001
- More perchlorate-specific than IC.
- Lower detection limits than IC.
- MDL = 0.25
- PQL = 0.5

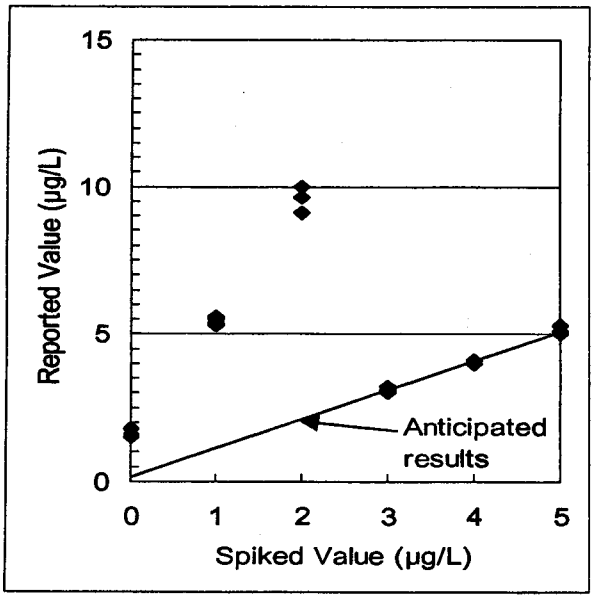
4

LC/MS/MS
Performance Evaluation Study
November 2001

- Conducted at Acculabs, Inc. – Golden, CO.
- Environmental groundwaters from 3 sites submitted (Locations A, B, and C).
- Spike concentrations = 1, 2, 3, 4, and 5 ppb

5

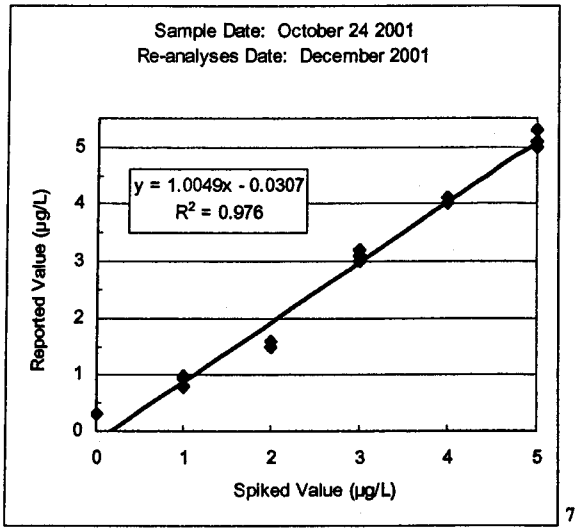
Groundwater A



6

Groundwater A
Re-analyses – December 2001

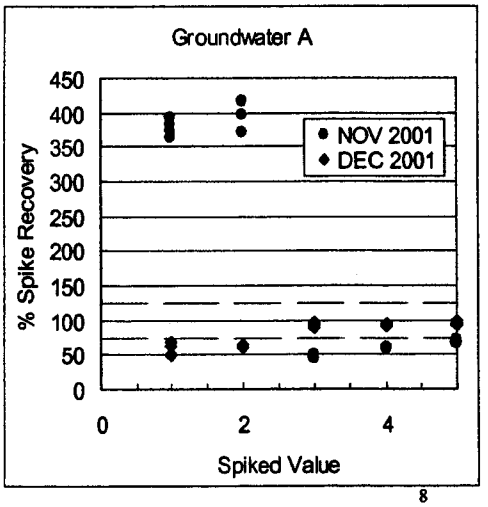
A calibration standards discrepancy and an electronics problem and led to re-analyses.



7

Spike recovery was used to gauge accuracy in the PE study.

- Recovery control limits, = 75% to 125%.
- Orig. analyses recoveries = 45 % to 563 %.
- No recoveries within control limits.
- Re-analyses recoveries = 45% to 159 %
- 80% of the re-analyses within control limits.



8

LC/MS/MS
Performance Evaluation Study
May/June 2003

- Conducted at General Engineering Laboratories, Inc. (GEL) – Charleston, SC.
- MDL = 0.05 ppb
- PQL = 0.20 ppb
- Environmental groundwaters from 8 sites
- De-ionized water

9

Objectives

- Determine if the method works in environmental groundwater samples.
- Verify the method detection limit of 0.05 ppb
- Verify the method practical quantitation limit of 0.2 ppb
- Determine whether perchlorate is present in LANL area and regional groundwater samples.

10

Spike perchlorate concentrations for 2003 PE study

Objective	Spike concentration
Unspiked	0 ppb
~ MDL	0.05 ppb
> MDL and <PQL	0.10 ppb
~PQL	0.20 ppb
> PQL	0.50 ppb

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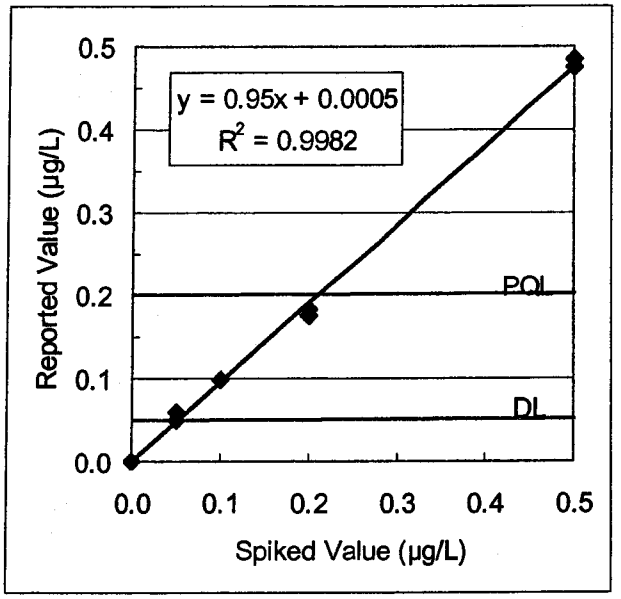
Environmental groundwater samples submitted for PE Study

Source	Spiked perchlorate concentration (ppb)					Trip Blank collected	Field Blank collected	Equipment Blank collected
	0	0.05	0.1	0.2	0.5			
A	✔	✔	✔	✔	✔	✔	✔	✔
B	✔	✔	✔	✔	✔		✔	
D	✔	✔	✔	✔	✔	✔	✔	✔
E	✔	✔	✔	✔	✔	✔	✔	
F	✔	✔	✔	✔	✔	✔	✔	
G	✔	✔	✔	✔	✔		✔	
H	✔	✔	✔	✔	✔		✔	
I	✔	✔	✔	✔	✔	✔	✔	
DI water	✔	✔	✔	✔	✔			

12

Results of DI Water Samples



13

Results of 2003 PE Study

Source	Result (µg/L)	MDL	PQL	R^2	slope
DI water	0	0.05	0.2	0.998	0.95
A	0.32	0.05	0.2	0.97	0.99
B	0.28	0.05	0.2	0.98	0.98
D	0.66	0.05	0.2	0.98	0.94
E	0.21	0.05	0.2	0.96	0.86
F	0.12	0.05	0.2	0.99	0.75
G	0.17	0.1*	0.4*	0.89	0.76
H	0.23	0.1*	0.4*	0.93	0.94
I	0.17	0.05	0.2	0.95	0.86

*Samples were diluted, resulting in higher MDL and PQL

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Results of QC Samples

Source	Trip Blank (ppb)	Field Blank (ppb)	Equipment Blank (ppb)
A	<0.05	<0.05	<0.05
B		<0.05	
D	<0.05	<0.05	<0.05
E	<0.05	<0.05	
F	<0.05	<0.05	
G		<0.05	
H		<0.05	
I	<0.05	<0.05	

15

Spike recoveries of environmental groundwaters (no DI water samples)

Spike Value	Within Control Limits	Outside Control Limits
<PQL	44%	56%
>PQL	87%	13%

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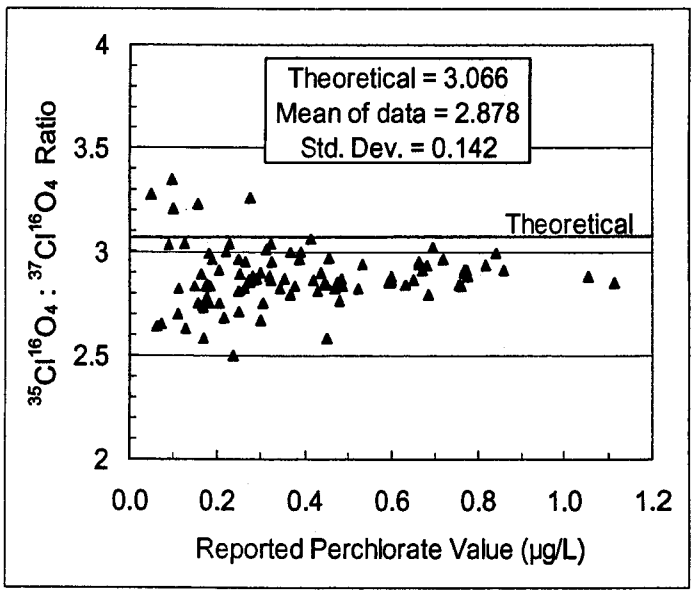
Isotopic Ratios

- Chlorine exists in nature as ^{35}Cl and ^{37}Cl.
- Theoretical ^{35}Cl:^{37}Cl ratio = 3.066
- Perchlorate result based upon the sum of $^{35}ClO_4$ and $^{37}ClO_4$ measurements.

$^{37}ClO_4$ (ppb)	$^{35}ClO_4$ (ppb)	Reported ClO_4 (ppb)
ND	<0.15	
0.05 = MDL	0.15	0.20
0.20 = PQL	0.61	0.81
0.24	0.75 = upper range	0.99

17

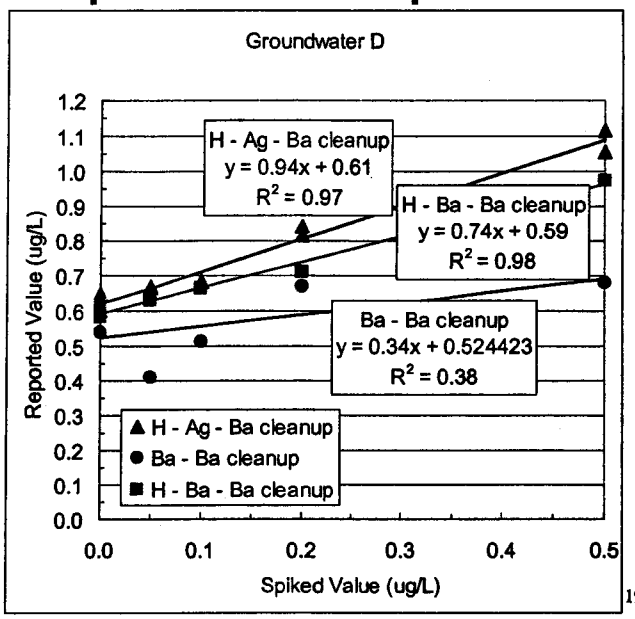
Isotopic Ratio Results



18

Sample Preparation Cleanup Columns

- Hydrogen – Barium – Silver
- Barium – Barium
- Hydrogen – Barium – Barium



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Historical LC/MS/MS data

Groundwater	Analytical Laboratory	Analysis Date	Reported Value (µg/L)
A	Acculabs	Dec-01	0.3
	Acculabs	Jan-02	<0.25
	Acculabs	Jan-02	<0.25
	Acculabs	Jan-02	0.3
	Acculabs	Jan-02	0.3
	GEL	Jun-03	0.3
	GEL	Jun-03	0.33
B	Acculabs	Dec-01	0.5
	Acculabs	Jan-02	<0.25
	GEL	Jun-03	0.49
	GEL	Jun-03	0.29
D	Acculabs	Dec-01	0.67
	GEL	Jun-03	0.60
	GEL	Jun-03	0.65
E	Acculabs	Dec-01	<0.25
	GEL	Jun-03	0.19
	GEL	Jun-03	0.12
DI Water	Acculabs	Dec-01	<0.25
	GEL	Jun-03	<0.05
	GEL	Jun-03	<0.05

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Conclusions

- QC blanks results were all non-detect – indicates the method is generally free from contamination.
- Sample analytical preparation addresses some analytical interferences, but low bias persists.
- Chlorine isotopic data demonstrate that such data may provide a useful and accurate means to discriminate false positive signals from perchlorate signals. PE Study isotopic results have a low bias.
- Perchlorate appears to be ubiquitous.

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Implementation of LC/MS/MS

Effective January 2004, all groundwater samples are analyzed for perchlorate by both EPA approved Method 314 and LC/MS/MS

22

Results of QC Samples

Source	Trip Blank (ppb)	Field Blank (ppb)	Equipment Blank (ppb)
A	<0.05	<0.05	<0.05
B		<0.05	
D	<0.05	<0.05	<0.05
E	<0.05	<0.05	
F	<0.05	<0.05	
G		<0.05	
H		<0.05	
I	<0.05	<0.05	

15

Spike recoveries of environmental groundwaters (no DI water samples)

Spike Value	Within Control Limits	Outside Control Limits
<PQL	44%	56%
>PQL	87%	13%

16

2004 Analyses of Pajarito Mesa (PM) wells by LC/MS/MS

Location	Date Sampled	Perchlorate Concentration (ppb)
PM-1	02/09/04	0.42
PM-2	02/09/04	0.29
PM-3	01/28/04	0.41
PM-3	02/09/04	0.38
PM-5	01/28/04	0.35
PM-5	02/09/04	0.30

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Future Directions

(Spring 2004 – PES with synthetic groundwaters)

- Evaluate the potential for the LC-MS-MS to generate false positives (*this may happen by the formation of perchlorate from chloride ion or by other unidentified means*).
- Interferences still exist that result in low bias at increasing concentrations. Evaluate matrix suppression effects.

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RRES Meteorology and Air Quality Group

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NNSA UNCLASSIFIED Los Alamos

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Public Involvement – MAQ

- MAQ: Gain public input to improve our programs
  - By review of recent data
  - By review of recent program changes
- Public: Gain knowledge of LANL impacts
  - Assure for yourself, that LANL is in compliance and reducing risk

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Meteorology and Air Quality at LANL

The Air Quality Group (MAQ) provides regulatory and environmental surveillance leadership and services to meet Los Alamos National Laboratory (LANL) air quality obligations and public assurance needs.

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Meteorology and Air Quality Goals

- Develop and implement programs to ensure:
  - institutional compliance with State and Federal Laws
  - institutional compliance with DOE Orders for air quality surveillance and dose assessment activities.
- Provide regulatory compliance assistance to LANL operating Groups
- Develop and implement programs to address community concerns related to air quality issues.

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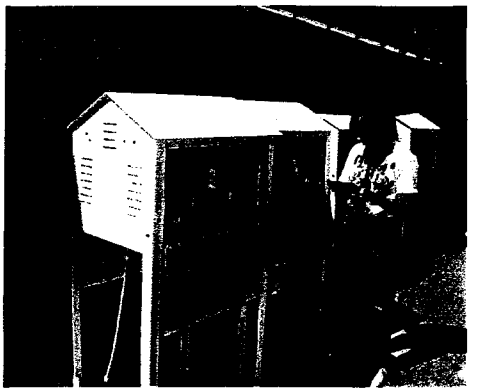
Meteorology and Air Quality Specific Programs

Environmental Surveillance

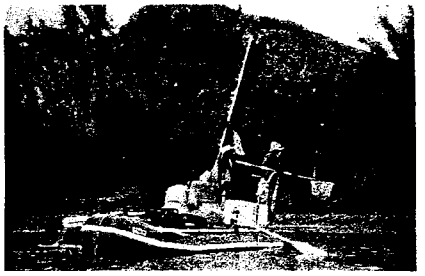
- Monitor ambient air for:
  - rad and non-rad air pollutants
  - direct penetrating radiation (gamma & neutrons)
- Calculate doses to members of the public



Meteorology and Air Quality Specific Programs

Environmental Surveillance

- Monitor Soils, Foodstuffs and Biota for rad/non-rad pollutants:
  - foodstuffs include produce, fish, game animals, dairy products, etc.
  - biota include native plants and animals.



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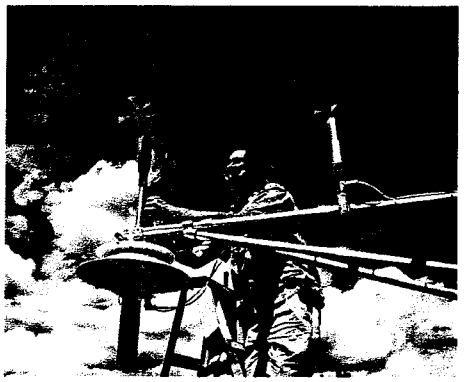
Meteorology and Air Quality Specific Programs

Meteorological Services

Provide meteorological services for routine & emergency operations



- monitor meteorological parameters to support dispersion, hydrology, and design studies
- atmospheric dispersion calculations for unplanned releases
- weather forecasts for severe weather (snow, forest fires, etc.)

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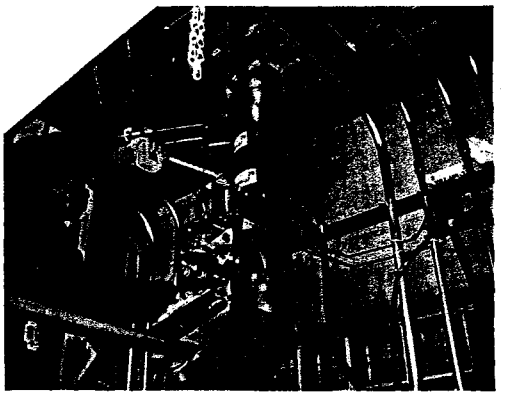
Meteorology and Air Quality Specific Programs

Regulatory Compliance

- Rad Stack Emissions Monitoring
  - monitor rad stack emissions
  - prepare permits
  - evaluate dose to the public



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Meteorology and Air Quality Specific Programs

Regulatory Compliance

- Air Quality Permits for Industrial Sources
  - Permit new/modified air emission sources (.e.g Asphalt Plant)

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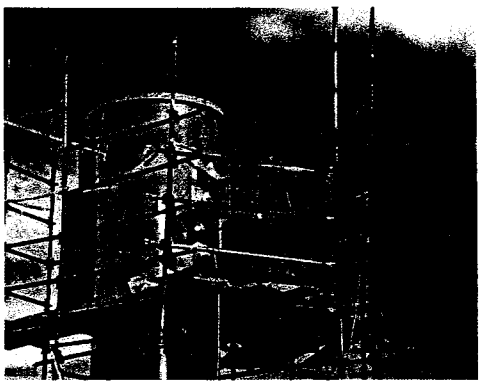
Meteorology and Air Quality Specific Programs

Regulatory Compliance

- Develop emissions inventories for non-rad emissions sources



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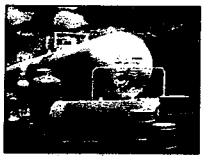
Meteorology and Air Quality Specific Programs

Regulatory Compliance



- Develop/oversee LANL asbestos & refrigerant disposal and maintenance programs required by the Clean Air Act

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Meteorology and Air Quality Specific Programs

Air Quality Assistance to Communities

- Provide support to the surrounding communities, including the Pueblos, concerning their questions on radiation in the environment
- Pueblo environmental technician certification

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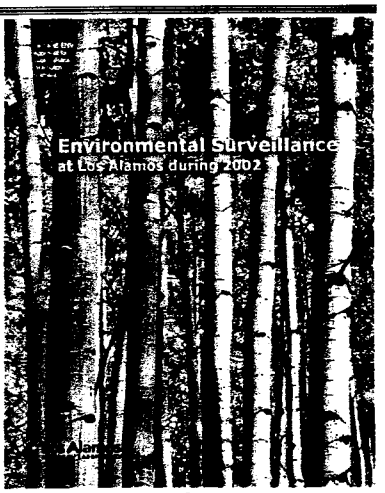
Meteorology and Air Quality Specific Programs

Environmental Surveillance

- Publish the annual environmental surveillance report:
  - compliance summary
  - public dose assessment/biota dose assessment
  - air surveillance
  - surface and groundwater monitoring
  - foodstuffs, soils, and biota monitoring



Los Alamos National Laboratory
Hydrogeologic Characterization Program
Master Publication List

Revised 5/13/04

Primary Author	Co-Authors	Date	Title	Report Number	Publishing Information
Ball, T.	M. Everett, P. Longmire, D. Vaniman, W. Stone, D. Larssen, K. Greene, N. Clayton, S. McLin	2002	Characterization Well R-22 Completion Report	LA-13893-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Ball, T.T.		2001	Use of Modern Project Management Techniques for the Hydrological Characterization Project at Los Alamos National Laboratory	ER2001-0930 and LA-UR-01-6171	Department of Energy Technical Information Exchange Workshop, November 13, 2001 Albuquerque, New Mexico
Birdsell, K.H,	Robinson, B.A., Stauffer, P.H. and Broxton, D.E.	2002	Validation of the Conceptual Model for Vadose-Zone Flow and Transport Beneath the Pajarito Plateau, Los Alamos, New Mexico		Geological Society of America Abstracts with Programs Vol. 34, No. 6, Denver, CO.
Broxton, D. E.		2004	Geologic setting of deep perched groundwater beneath the Pajarito Plateau	LA-UR-04-0291	Proceedings of the 3rd Annual Española Basin Workshop, Santa Fe, New Mexico, March 2-3, 2004 , U.S. Geological Survey Open-File Report 2004-1093
Broxton, D. E.	D. T. Vaniman		Geologic framework of a groundwater system on the margin of a rift basin, Pajarito Plateau, North-Central New Mexico		Vadose Zone Journal, submitted 2004
Broxton, D.E	Longmire, P.	2003	Groundwater Contamination in Mortandad Canyon, Los Alamos National Laboratory: a Summary of Ongoing Hydrogeologic Investigations	LAUR-02-5648.	National Groundwater Association, Phoenix,
Broxton, D.E.	R. Gilkeson, P. Longmire, D. Vaniman, J. Marin, R. Warren, A. Crowder, B. Newman, B. Lowry, D. Rogers, W. Stone, S. McLin, G. WoldeGabriel, D. Daymon, D. Wycoff	20001	Characterization Well R-9 Completion Report	LA-13742-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	P. Longmire	2003	Groundwater Contamination in Mortandad Canyon, Los Alamos National Laboratory: a Summary of Ongoing Hydrogeologic Investigations	LAUR-02-5648	National Groundwater Association, Tucson, AZ, 2003
Broxton, D.E.	D. Vaniman, P. Longmire, B. Newman, W. Stone, A. Crowder, P. Schuh, R. Lawrence, M. Everett, R. Warren, N. Clayton, D. Counce, E. Kluk, D. Bergfeld	2002	Characterization Well MCOBT-4.4 and Borehole MCOBT-8.5 Completion Report	ER2002-0715 and LA-13993-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	R. Warren , P. Longmire, R. Gilkeson, S. Johnson, D. Rogers, W. Stone, B. Newman, M. Everett, D. Vaniman, S. McLin, J. Skalski, D. Larssen	2002	Characterization Well R-25 Completion Report	ER 2001-0697 and LA-13909-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	C. Nylander	2001	Groundwater Investigations to Support Environmental Decisions at Los Alamos National Laboratory		US DOE 13th Technical Information Conference Abstracts, Albuquerque, New Mexico
Broxton, D.E.	D. Vaniman, W. Stone, S. McLin, J. Marin, R. Koch, R. Warren, P. Longmire, D. Rogers, N. Tapia	2001	Characterization Well R-19 Completion Report	ER2000-0398 and LA-UR-00-4085	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	D. Vaniman, W. Stone, S. McLin, M. Everett, A. Crowder	2001	Characterization Well R-9i Completion Report	ER2000-0446 and LA-UR-00-4255	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	P. Longmire, D. Counce, B. Newman	2001	Hydrochemical Characterization at R-15, Mortandad Canyon, Los Alamos National Laboratory		US DOE 13th Technical Information Conference Abstracts, Albuquerque, New Mexico
Broxton, D.E.	R. E. Lewis	2001	Use of Borehole Geophysics for Hydrogeological Characterization at Los Alamos National Laboratory		US DOE 13th Technical Information Conference Abstracts, Albuquerque, New Mexico
Broxton, D.E.	R. Gilkeson, P. Longmire, D. Vaniman, J. Marin, R. Warren, A. Crowder, B. Newman, B. Lowry, D. Daymon, D. Wycoff	2001	Completion Report for Characterization Well R-9	ER2000-0218 and LA-UR-00-4120	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	R. Warren, D. Vaniman, B. Newman, A. Crowder, M. Everett, R. Gilkeson, P. Longmire, J. Marin, W.J. Stone, S. McLin, D. B. Rogers	2001	Characterization Well R-12 Completion Report	ER2000-0290 and LA-UR-00-3785	Los Alamos National Laboratory, Los Alamos, New Mexico

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Primary Author	Co-Authors	Date	Title	Report Number	Publishing Information
Broxton, D.E.		2001	Geology of the Pajarito Plateau and Vicinity, North-Central New Mexico		P. Johnson, ed., Water, Watersheds, and Land Use in New Mexico, New Mexico Decision-Makers Field Guide No. 1, New Mexico Bureau Mines and Min Res.
Broxton, D.E.	C. Nylander, R. Gilkeson, P. Longmire, W. Stone, D. Rogers	1999	Groundwater Issues on the Pajarito Plateau		EOS, American Geophysical Union Transactions, 79
Broxton, D.E.	S. L. Reneau	1996	Buried early Pleistocene landscapes beneath the Pajarito Plateau, northern New Mexico		Goff, F., Kues, B. S., Rogers, M. A., McFadden, L. D., and Gardner, J. N., eds,The Jemez Mountains Region: New Mexico Geological Society 47th Field Conference Guidebook
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External Advisory Group		2000	Semi-Annual Report to the Groundwater Integration Team of the Los Alamos National Laboratory		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, June 26, 2000
External Advisory Group		2000	Semi-Annual Report to the Groundwater Integration Team of the Los Alamos National Laboratory		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, December 5, 2000
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Gallaher, B.M.	D.W. Efurd, and R.E. Steiner	2004	Uranium in Waters near Los Alamos National Laboratory: Concentrations, Trends, and Isotopic Composition through 1999	LA-14046	Los Alamos National Laboratory report, Los Alamos New Mexico
Hickmott, D.		2000	Progress Report for Plume-Chasing and Characterization Well Canon de Valle R-15-3	LA-UR-00-4527	Los Alamos National Laboratory, Los Alamos, New Mexico
Keating, E.H.	V.V. Vesselinov, E. Kwicklis, Z. Lu	2003	Coupling Basin- and Local-Scale Inverse Models of the Espanola Basin		Groundwater 41(2) pp 200-211
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Keating, E.H.	E. Kwicklis, V. Vesselinov, A. Idar, Z. Lu, G. Zyvoloski, M. Witkowski	2000	A Regional Flow Model and Transport Model for Groundwater at Los Alamos National Laboratory. Progress Report		Progress Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, October 31, 2000
Keating, E.H.	E. Kwicklis, M. Witkowski, T. Ballantine	1999	A Regional Flow Model for the Regional Aquifer beneath the Pajarito Plateau. Progress Report	LA-UR-00-1029	Los Alamos National Laboratory, Los Alamos, New Mexico
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Kleinfelder		2004	Final Well Completion Report Characterization Well R-28, Los Alamos National Laboratory, April 28, 2004		
Koch, R. J	D. B. Rogers, N. J. Tapia, and S. G. McLin	2004	Manual and transducer groundwater levels from test wells at Los Alamos National Laboratory, 1992-2003	LA-14132	Los Alamos National Laboratory report,Los Alamos New Mexico
Koch, R. J	D. B. Rogers	2003	Water Supply at Los Alamos, 1998-2001	LA-13985-SR	Los Alamos National Laboratory report,Los Alamos New Mexico
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LANL		2003	Characterization Well R-13 Completion Report	LA-UR-03-1373; GPP-03-023	Los Alamos National Laboratory Report, Los Alamos, NM.
LANL		2003	Characterization Well R-14 Completion Report	LA-UR-03-1644; GPP-03-030	Los Alamos National Laboratory Report, Los Alamos, NM.
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LANL		2003	Characterization Well R-20 Completion Report	LA-UR-03-1839; GPP-03-032	Los Alamos National Laboratory Report, Los Alamos, NM.
LANL		2003	Characterization Well R-23 Completion Report	LA-UR-03-2059; GPP-03-042	Los Alamos National Laboratory Report, Los Alamos, NM.
LANL		2003	Characterization Well R-32 Completion Report	LA-UR-03-3984; GPP-03-071	Los Alamos National Laboratory Report, Los Alamos, NM.
LANL		2003	Mortandad Canyon Groundwater Work Plan	LA-UR-03-6221	Los Alamos National Laboratory, Los Alamos, New Mexico.
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LANL		1997	Conceptual Design Report Monitoring Well Installation Project, 100% Conceptual Design Report		Los Alamos National Laboratory, Los Alamos, New Mexico
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Longmire, P.		2002	Characterization Well R-15 Geochemistry Report	LA-13896-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Longmire, P.		2002	Characterization Wells R-9 and R9i Geochemistry Report	LA-13927-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Longmire, P.		2002	Characterization Well R-22 Geochemistry Report	LA-13986-MS	Los Alamos National Laboratory, Los Alamos, New Mexico.
Longmire, P.		2002	Characterization Well R-12 Geochemistry Report	LA-13952-MS	Los Alamos National Laboratory, Los Alamos, New Mexico.
Longmire, P.		2002	Characterization Well R-19 Geochemistry Report	LA-13964-MS	Los Alamos National Laboratory, Los Alamos, New Mexico.