FACT SHEET
MEASUREMENTS OF TRITIUM IN GROUNDWATER AT LOS ALAMOS
June 10, 1994
(Updated for Test Well 8 Result))

NEW RESULT

Results recently received from the University of Miami low-level tritium laboratory indicate the presence of some recent recharge to the Los Alamos main aquifer beneath Mortandad Canyon. The levels of tritium measured in a sample collected in December 1993 show about 90 pCi/l. This level is high enough to indicate the source is likely to be the tritium-contaminated water released into mortandad Canyon from the Laboratory's Radioactive Liquid Waste Treatment Plant at TA-50 that started operating in 1963. The well is not used as a source of drinking water; however, as a basis for comparison, the present EPA and New Mexico State drinking water standard is 20,000 pCi/L. It is not possible to tell whether the tritium in the main aquifer is from downward migration through the rock or possibly leakage down the wellbore.

GENERAL SUMMARY

Measurements of tritium by extremely low detection limit analytical methods appear to show the presence of some recent recharge (meaning within the last 4 decades) in water samples from a few wells into the main aquifer at Los Alamos. Another 45 samples of well water show no apparent influence of recent recharge to the main aquifer. The levels measured range from less than a percent to less than a hundredth of a percent of current drinking water standards, and are all less than levels that could be detected by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations.

In some of the locations the results are understandable. The first is in Test Well 1, located in Pueblo Canyon near the confluence with Los Alamos Canyon, suspected for several years of having a well-bore leakage or other communication from the surface as inferred from other types of data. (See attached Map for generalized locations.) The second is in old water supply and observation wells, located in Los Alamos Canyon near its confluence with the Rio Grande, which have screened intervals starting at depths not far below the canyon alluvium. The tritium observed at these locations could be attributed to infiltration of water containing both past Laboratory releases (from Acid-Pueblo Canyon and from DP-Site and other Los Alamos Canyon sources) and precipitation containing post-atmospheric test fallout. The third location is a Test Well 8, in Mortandad Canyon, located about a mile downstream from the outfall of TA-50, the radioactive liquid waste treatment plant for the Laboratory. The shallow alluvial perched water in Mortandad CAnyon has contained high levels of tritium for about 30 years.

In two other locations, the results are questionable and require further investigation, starting with resampling incorporating meticulous quality assurance, to determine whether the results are real or might be an artifact of sampling or analysis error.

These first of these locations is Test Well 4, on the mesa east of Acid Canyon. That canyon received both untreated and treated effluents between 1944 and 1965. Test Well 4 was refurbished and equipped with a new pump in the last year; those operations introduced some water from the surface. This well is scheduled to be resampled in June or July 1994.

The second of these locations is Supply Well PM-3, located in Sandia Canyon, which showed no detectable tritium in a sample from August 1992, and then unexpectedly showed detectable tritium (about 6.7 TU or about 20 pCi/L) in a sample taken in May 1993. In November, the University of Miami reported reanalysis of previously unused portions of the May 1993 samples from Test Well 4 and supply well PM-3. The result for Test Well 4 was unchanged, at about 3 tritium units. The new result for the PM-3 sample was no detectable tritium, as compared to the earlier reported value of about 6.7 tritium units. The University of Miami noted that their quality control records enabled them to establish that the initial result for the PM-3 sample was attributable to contamination from the Test Well 2A sample, which had a level of about 700 tritium units. The reanalysis of the PM-3 sample is consistent with the August 1992 sample that was reported with no measurable tritium. Resampling of PM-3 at four specific depths was completed in April 1994, and analyses are in process.

BACKGROUND

In 1991 the Hydrology Team of the Environmental Protection Group initiated a study to help define the sources and times of recharge to the main aquifer at Los Alamos. The cooperative study involves participation by researchers in other divisions at Los Alamos (Earth and Environmental Sciences and Isotope and Nuclear Chemistry Divisions) and another DOE contractor (ChemNuclear at Grand Junction, CO.).

The study is attempting to apply a range of geochemical and geochronological techniques to help identify potential sources and ages of water in the main aquifer. Samples have been collected from the test wells and the water supply production wells that penetrate the main aquifer. A variety of radioactive and stable isotope measurements are being utilized. At present a number of measurements of carbon-14 and low-level tritium measurements are available that permit some preliminary estimates of the age of the water in the main aquifer at various locations.

"Age of water" means the time elapsed since the water, as precipitation, entered the ground to form recharge and became isolated from the atmosphere. The precipitation at the time of entry into the ground is assumed to have contained atmospheric equilibrium amounts of both tritium and carbon. Radioactive carbon-14 is mainly from natural sources. Tritium is from both natural and fallout from atmospheric nuclear weapons testing.

Before any atmospheric nuclear testing, the tritium levels in atmospheric water were about 6 Tritium Units (TU), or about 20 picocuries per liter of water (pCi/L). By the mid-1960s, tritium in atmospheric water in northern New Mexico reached a peak level of about 2000 TU or 6400 pCi/L (annual average for 1963-1964). Since then, both radioactive decay and dilution by mixing through the global hydrologic cycle have reduced the concentrations of tritium in atmospheric water. At present, general atmospheric levels in northern New Mexico are about 10 TU or about 30 pCi/L. As a basis for comparison, the present EPA and New Mexico State drinking water standard is 20,000 pCi/L (about 6200 TU). Routine compliance with the dringing water regulations is done by liquid scintillation counting with a detection limit of about 300 to 700 pCi/l (about 100 to 200 TU). The low-level tritium measurements employed by this study were performed at the University of Miami and have a detection limit of about 1 pCi/L (about 0.3 TU).

Once precipitated water enters the ground, radioactive decay and/or mixing with other older water would result in a reduction of the concentration of either isotope in the groundwater observable in present day samples. Carbon-14, with a half-life of about 5000 years, is useful for estimating ages ranging from a few thousand to several tens of thousands of years. Tritium, with a half-life of about 12 years is useful for estimating ages in the range of decades.

Preliminary interpretation of the results of carbon-14 analyses indicate that the minimum age of water in the main aquifer ranges from about a thousand years under the western portion of the Pajarito Plateau, increasing with eastward position, to about 30,000 years near the Rio Grande. These values are consistent with the general understanding of the Los Alamos main aquifer, based on physical and geologic conditions.

Of the more than 50 low-level tritium measurements, about 45 have been generally consistent with the carbon-14 results; however, a few samples show measurable tritium. Preliminary interpretation of about 45 low-detection-limit tritium analyses show no measurable tritium indicating the water in the main aquifer contains no significant component of "recent" recharge (that is precipitation from the last several decades and almost certainly not "post-bomb"). These results are consistent with the carbon-14 measurements and general understanding of the hydrogeologic setting of Los Alamos that indicates little if any expectable recharge through the hundreds of feet of nearly-dry rock separating the land surface and the main aquifer.

RECENT LOW-DETECTION LIMIT MEASUREMENTS AND INTERPRETATION

Six samples from wells into the main aquifer showed measurable tritium levels that indicate the presence of "recent" (that is less than 4 decades old) water. This "recent water" contains tritium that could be either from worldwide fallout or from Laboratory effluents. Results for two of the samples were not expected, results for two of the samples were expected, and results for threeof the samples were not surprising.

The two unexpected results include:

Water supply well PM-3 was sampled in August of 1992; with the analysis showing 0.37 +/- 0.09 TU, or about 1 pCi/L. This is considered to represent an essentially unmeasurable amount of tritium. A second sample was taken in May 1993; the analytical result was 6.67 +/- 0.22 TU, or about 20 pCi/L. The well, located in Sandia Canyon (see Map), had been in service without interruption since its completion in 1966. No known source of surface contamination occurs in its immediate vicinity. The well was completed with several grouted, telescoping casings. The casings reach a depth of 2552 feet below the surface and incorporate 1591 feet of inlet screens extending from 956 to 2547 feet. The nonpumping water level in recent years has been at about 770 feet below the surface. The pump operates at 1300 to 1400 gallons a minute and has produced about 15 per cent of the total Los Alamos water supply in recent years. Because of the considerable thickness of the aquifer tapped by the well, it would require a major influx of contaminated water to result in the apparent tritium level. Three other water supply wells within 1 to 2 miles (PM-1, PM-5, and O-4) have shown no measurable tritium including samples from O-4 and PM-2 in May 1993. Thus, the May 1993 sample result was unexpected, with no obvious explanation. In November, the University of Miami reported reanalysis of previously unused portions of the May 1993 samples from Test Well 4 and supply well PM-3. The result for Test Well 4 was unchanged, at about 3 tritium units. The new result for the PM-3 sample was no detectable tritium, as compared to the earlier reported value of about 6.7 tritium units. The University of Miami noted that their quality control records enabled them to establish that the initial result for the PM-3 sample was attributable to contamination from the Test Well 2A sample, which had a level of about 700 tritium units. The reanalysis of the PM-3 sample is consistent with the August 1992 sample that was reported with no measurable tritium. Resampling of PM-3 at four specific depths was completed in April 1994, and analyses are in process.

The zonal sampling was completed in supply well PM-3 in April, 1994 to increase confidence in results. The well service contractor completed removing the main pump from Supply Well PM-3 in January 1994. A downhole video camera inspection determined that the production casing was in good condition. Welded joints appeared sound, no broken louvers were seen, and no corrosion problems appeared. Some expectable scale deposits were observed at various depths. The bottom of the well was filled with sediments to a depth of about 2240 feet. A temporary submersible pump was installed in well PM-3 to conduct the zonal sampling. The well was left undisturbed until the sampling was conducted April 25 through 28, 1994. The low-level tritium analyses of those samples are expected by the end on June 1994. The analyses are being conducted by two independent laboratories (university of Miami and Teledyne) and the sample sets include several special Quality Assurance samples, both blanks and known spikes.

Test Well 4 is located on a mesa east of the former discharge points into Acid Canyon (untreated discharge from original Technical Area-1 between 1944 and 1951, and treated effluents from the former liquid waste treatment plant at Technical Area-45 1951 to 1964). It had been capped and out of service for about 20 years until the fall of 1992 when it was refurbished and equipped with a new pump. This operation included the introduction of some water for cleaning and priming the pump. The well is about 1200 feet deep and only penetrates into the main aquifer a short distance. Water fills less than the bottom ten feet of the well. It can only be pumped at a very slow rate. The sample taken in May 1993 showed a concentration of 3.34 +/- 0.11 TU, or about 11 pCi/L. Other data (for example temperature) suggests there is some doubt that the well was pumped long enough to completely purge any introduced water, which constitutes a possible source of tritium.

The two expected results include the analyses of two samples from Test Well 1. Test Well 1 is located in Pueblo Canyon near its confluence with Los Alamos Canyon. One sample was taken in August of 1992, with a result of 109 +/- 4 TU, or about 350 pCi/L; the second sample was taken in May 1993, with a result of 113 +/- 3.7 TU, also about 350 pCi/L. Other information and observations since 1991 had indicated a suspect communication with an adjacent shallower test well, Test Well 1A. Both wells were drilled in 1949 by cable tool, Test Well 1A to a depth of 225 feet penetrating the intermediate depth perched groundwater body in the basalts lying between the tuff and the main aquifer, and Test Well 1 to a depth of 642 feet, penetrating the top of the main aquifer in the Puye conglomerate. The intermediate perched groundwater has long been known to be affected by effluents discharged into Pueblo Canyon, starting with measurements made by the USGS in the 1950s and 1960s. Starting in 1991 indications of unexpectedly high water levels in Test Well 1 and some chemical quality data suggested a downward communication of water from the intermediate perched groundwater sampled by Test Well 1A to the main aquifer penetrated by Test Well 1. Results of those initial investigations were reported in the 1991 Environmental Surveillance Report for Los Alamos National Laboratory. The low level tritium samples were collected to help understand the potential problem. The two consistent results indicate the suspected problem does exist. One possible route of communication is along the ungrouted, cable-tool installed casings. The other possibility is a downward movement through the rock beneath the canyon.

A similar paired-well situation occurs upstream (further west) in Pueblo Canyon. These are Test Wells 2A and 2, reaching to the intermediate perched groundwater and the main aquifer respectively. Samples from those wells in October 1992 and May 1992 showed the presence of tritium in Test Well 2A, as expected from previous routine environmental monitoring. (The levels in Test Well 2A were about 700 TU, or about 2200 pCi/L, which is consistent with previously reported levels and measurements made in 1992 and 1993.) Test Well 2 showed no measurable tritium in either sample. This is taken as an indication that the seal around Test Well 2 is adequate to prevent downward movement in the well bore (even though it was installed by cable tool) and that there is no measurable migration through the rock formations in the immediate vicinity.

The results that are new but not considered surprising are from Test Well 8 in Mortandad Canyon and supply and observation wells in Lower Los Alamos Canyon, near the confluence with the Rio Grande.

Test Well 8 is located in Mortandad Canyon, about a mile downstream of the outfall of the Laboratory's radioactive liquid waste treatment plant at TA-50. The well was sampled in early December 1993 as part of the routine environmental monitoring program. The well had been out of service since 1992 because of pump failure. The last previous sample was collected as part of the routine program in 1991, and did not show any tritium. However, the 1991 and other previous tritium measurements on samples from this well (1991 and earlier) were completed with a less sensitive technique that cannot detect tritium at levels less that about 700 pCi/l. Thus, the new result is not inconsistent with those previous results, and it is impossible to tell how long low-level amounts of tritium have been present in the well. Low level tritium analysis of the December 1993 sample showed 89.4 +/- 2.9 pCi/l (27.6 +/- 0.9 TU). This result clearly shows the presence of recent recharge, and is high enough to indicate the source must be effluent.

The well was completed in December, 1960 as part of the U. S. G. S. hydrogeologic study of Mortandad Canyon prior to construction of the TA-50 treatment plant. The well was drilled by cable tool, and completed with 8-inch steel casing to a depth of 1065 feet in the Puye Conglomerate, with the bottom 112 feet torch slotted. Water level at that time was 968 feet. Water level in 1993 was about 994 feet. The well penetrates the shallow alluvial perched groundwater in Mortandad Canyon which contains the residual contaminants discharged by the TA-50 treatment plant. Tritium levels in the alluvial groundwater in the vicinity of Test Well 8 have been about 100,000 pCi/l in the last few years, ranging to as much as 1,000,000 pCi/l in the mid 1970s.

There are at least three possible pathways for the known source of tritium to be moving toward the main aquifer. There could be migration down the wellbore outside the steel casing as cable tool drilling does not include an annular seal. There could be saturated movement through fractures or faults. there could be movement in unsaturated flow through the vadose zone. Tritium is known to be migrating downward in the unsaturated zone beneath the alluvial perched groundwater in Mortandad Canyon based on measurement of cores collected to a depth of 100-200 feet at locations further west.

The Los Alamos Canyon data include the result of a sample from Observation Well LA-1A, constructed in 1946 as part of the USGS water supply investigations. This well is about 400 feet deep, penetrating about 78 feet of channel alluvium and then into the main aquifer formations; and flowed under artesian pressure. However, neither the completion method nor the depth of any perforations are documented. It is not believed to be grouted. The tritium content of the May 1993 sample was 19.7 +/- 0.7 TU, or about 63 pCi/L. The second result is from former supply well LA-2, completed to a depth of 882 feet in 1946; penetrating about 60 feet of alluvium and then into the Santa Fe group. Screens or slotted casing start at 105 feet depth. Because of the construction of these wells and their shallow depth of first screen it is not surprising to expect at least some downward movement of surface water. Another nearby Supply Well, LA-1B completed in 1960, is cased to 1750 feet with screens starting at 326 feet. Its construction included 64 feet of surface casing set through the alluvium and cemented. This well showed no measurable tritium in samples collected in October of 1991 and May of 1993. This is consistent with the construction method that would be expected to seal out infiltration along the wellbore and the greater depth of first screen further into the Santa Fe Group formations of the main aquifer.

Also at the mouth of Los Alamos Canyon are two private residences with shallow wells of undocumented construction. The Otowi House, north of Los Alamos Canyon, has a shallow well, probably drawing water from the alluvium and gravels of the Rio Grande and possibly some from the alluvium of Los Alamos Canyon (but not deep enough to reach the main aquifer). A sample taken in May 1993 from this well had a result of 44.9 +/- 1.5 TU, or about 145 pCi/L. This result is reasonable as the alluvial water would reflect recent water from both precipitation and flow from the portions of Los Alamos Canyon within the Laboratory with known tritium. The second well, at the Halladay House, located on the south side of Los Alamos Canyon, was sampled in February 1992 and May, 1993, with both results showing no measurable tritium. This is consistent with the chemical quality of the well, which is similar to other main aquifer waters, and its location far enough away from the stream channel as to be unlikely to penetrate any saturated alluvium.

PLANNED FUTURE WORK

Additional work is required to resolve the questions raised by the unexpected results. The most immediate need is to resample the wells in the main aquifer for low-level tritium analyses. This will have to be done with extensive Quality Assurance samples to verify that no possible cross-contamination of the samples occurs during the sampling, sample handling and transportation, and analytical steps. This is especially critical for these very low levels.

Immediate plans are to resample all the operable test wells and all the operable Water Supply Wells in the Pajarito and Otowi fields. This will include Test Wells 1, 2, 3, 4, 8, DT5A, DT9, and DT10, and Water Supply Wells PM-1, PM-2, PM-4, PM-5, and O-4.

Additional results of Carbon-14 analyses are presently underway, on samples collected at the same time as the May 1993 low-level tritium samples discussed already and samples collected from the PM-3 zonal sampling. The results should add insight about the hydrogeologic system. This effort and other sensitive geochemical or geochronometric studies will be considered to help improve understanding of the hydrogeologic conditions.

Other projects already underway include analysis of data on water level fluctuations in test wells in the main aquifer. The fluctuations result from the effects of changing barometric pressure at the surface and earth tides that compress the aquifer. Interpretation of that data should result in quantitative estimates of the degree of confinement of the main aquifer at various locations, which would help understand the likelihood downward moving materials entering the main aquifer.

Longer term actions being considered include the need to install new or replacement test wells to the main aquifer constructed to contemporary standards.

LOW-LEVEL TRITIUM ASUREMENTS IN GROUNDWAT

SAMPLE LOCATION	SAMPLE DATE	TRITIUM CONCENTRATION (Tritium Units, 1TU = 3.2 pCi/L)
Main Aquifer Production Wells		
LA-1B	10/22/91	0.02 +/- 0.09
	5/12/93	0.18 +/- 0.09
LA-1A	5/12/93	19.7 +/- 0.7
LA-2	5/12/93	4.04 +/- 0.13
LA-5	5/12/93	0.25 +/- 0.1
PM-1	10/23/91	0.51 +/- 0.1
	8/18/92	0.69 +/- 0.09
PM-2	2/14/92	0.04 +/- 0.09
	8/18/92	0.15 +/- 0.09
	5/19/93	0.49 +/- 0.09
PM-3	8/18/92	0.37 +/- 0.09
	5/19/93	6.67 +/- 0.22 Original Analysis
	5/19/93	0.12 +/- 0.09 Renalysis 1, Nov. 93
	5/19/93	- 0.06 +/- 0.09 Renalysis 2, Nov. 93
PM-5	10/23/91	0.09 +/- 0.09
	8/18/92	0.39 +/- 0.12
0-4	Feb-March 93	<0.96 +/- 0.11
		Avg. 0.32 +/- 0.19
G-1	8/18/92	0.34 +/- 0.09
G-1A	8/18/92	0.28 +/- 0.11
G-2	8/18/92	0.28 +/- 0.09
G-4	8/18/92	0.19 +/- 0.10
G-5	8/18/92	0.43 +/- 0.09
	10/22/91	0.08 +/- 0.09
G-6	8/18/92	0.56 +/- 0.10
Main Aquifer Test Wells		
TW-1	10/8/92	109 +/- 4
	5/19/93	113 +/- 3.7
TW-2	10/8/92	0.22 +/- 0.09
	5/19/93	0.85 +/- 0.1
TW-3	5/20/93	0.89 +/-0.09
TW-4	5/19/93	3.34 +/- 0.11
DT-5A	10/23/91	-0.07 +/- 0.09
	5/20/93	0.07 +/- 0.09
DT-8	12/6/93	89.4 +/- 2.9
DT-9	5/20/93	0.14 +/- 0.09
DT-10	5/20/93	0.41 +/- 0.09

LOW-LEVEL TRITIUM MEASUREMENTS IN GROUNDWATER

SAMPLE LOCATION	SAMPLE DATE	TRITIUM CONCENTRATION (Tritium Units, 1TU = 3.2 pCi/L)
Intermediate Perched Zone, Pueblo Canyon (150-250 ft depth)		
TW-1A	10/8/92	41.3 +/- 1.4
	5/19/93	45.8 +/- 1.5
TW-2A	10/8/92	698 +/- 23
	5/19/93	699 +/- 23
Intermediate Perched Zone, Los Alamos Canyon Basalt Spring		
Basalt Spring	6/11/91	37.9 +/- 1.3
	12/29/92	50.1 +/- 1.7
San Ildefonso Wells		
Eastside Artesian	2/5/92	-0.13 +/- 0.09
	5/12/93	0.31 +/- 0.10
Westside Artesian	2/5/92	0.13 +/- 0.09
	5/18/93	0.12 +/- 0.09
Halladay House	2/5/92	-0.21 +/- 0.15
	5/12/93	0.29 +/- 0.09
Otowi House	5/12/93	44.9 +/- 1.5
Pajarito Pump#1	2/5/92	-0.04 +/- 0.11
Pajarito Pump#2	5/18/93	0.94 +/- 0.09
Don Juan	2/5/92	-0.05 +/- 0.09
	5/12/93	0.16 +/- 0.09
New Comm.Well	5/12/93	8.00 +/- 0.26
Martinez House	5/18/93	1.81 +/- 0.10
Sanches House	5/18/93	6.90 +/- 0.23

Related information for Context

Pre-Bomb Atmospheric moisture	about 6 TU (20 pCi/L)
Peak Levels in atmospheric precipitation in Northern NM (mid-60's)	about 2000 TU (7000 pCi/L)
Those levels decayed to present	about 200 TU (700 pCi/L)
Typical level in contemporary precipitation	
North American Continent	10-15 TU (30-45 pCi/L)
Los Alamos Vicinity	20-100 TU (60-350 pCi/L
EPA Drinking Water Standard	6200 TU (20,000 pCi/L)
Proposed EPA MCL & DOE Guide for drinking water	18750 TU (60,000 pCi/L)
Low-Level Analys Detection Limit (U. of Miami thru EES-1 contract)	0.3 TU (1 pCi/L)
Standard liquid scintillation analysis detection limit (EM-9, NMED)	100-200 TU (300-600 pCi/L)