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FACT SHEET
MEASUREMENTS OF TRITIUM IN GROUNDWATER AT LOS ALAMOS
September 29, 1993

SUMMARY

Several recently-completed 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 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 two 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 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.

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.

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. (Well PM-3 pumps water from the main aquifer at a depth interval from about 950 to 2550 feet below the surface.) There is no known surface contamination source for PM-3. One plausible source could be from the known tritium contamination in the shallow alluvial water (that is less than 100 foot depth) in Mortandad Canyon. That contamination is from effluent from the currently-operating radioactive liquid waste treatment plant at Technical Area-50. The contaminated groundwater in Mortandad Canyon is at least a mile to the west of well PM-3. Other knowledge of the hydrogeologic conditions below Mortandad and Sandia Canyons makes it unlikely that the contaminated water could move fast enough or in sufficient quantity to result in the apparent appearance of tritium in Supply Well PM-3.

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

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(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 seven 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, indicating flow from west to east with major recharge occurring from the west.

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

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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 two of 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.

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

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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 Test Well 1A to 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 likely 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 2, as expected from previous routine environmental monitoring. (The levels in Test Well 2 were about 700 TU, or about 2200 pCi/L, which is consistent with previously reported levels.) 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 two results that are new but not considered surprising are from wells in Lower Los Alamos Canyon, near the confluence with the Rio Grande. These 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.

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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, DT5A, DT9, and DT10, and Water Supply Wells PM-1, PM-2, PM-4, PM-5, and O-4. These samples could be collected in October; expected time for completion of the low-level analyses by an off-site analytical laboratory is about one month

The next steps will include resampling presently inoperable wells. Test Well 8 in Mortandad Canyon is presently inoperable, it is expected to be pulled and repaired during October 1993. It will be sampled as soon as feasible. The pump in Supply Well PM-3 failed in August 1993. It is expected to be pulled by the end of October 1993. During the time the production pump is out of PM-3 an effort will be made to obtain samples at several discrete depths. probably by using straddle packer testing. This type of sampling would result in much more specific information and confidence regarding the analyses that will either support or disprove the presence of actual contamination. This phase of sampling could occur as early as November 1993. The time required for analyses by an off-site analytical laboratory is estimated at about one month.

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. 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.

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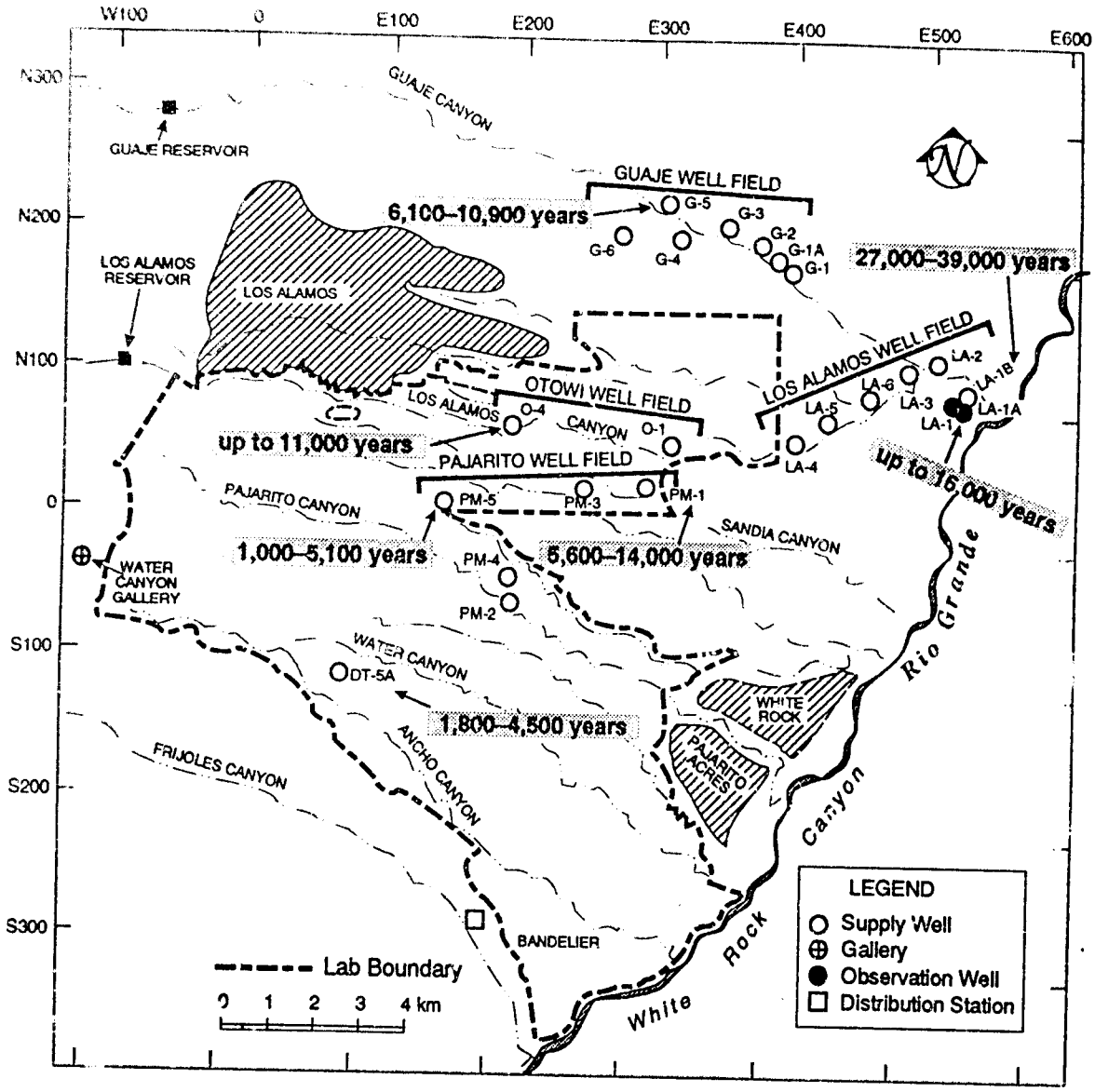
Carbon Dating and Water Supply at Los Alamos



Preliminary measurements of age of water in main aquifer based on Carbon-14 dating process. Range results from uncertainty about how much carbonate in rocks dissolves as water moves.

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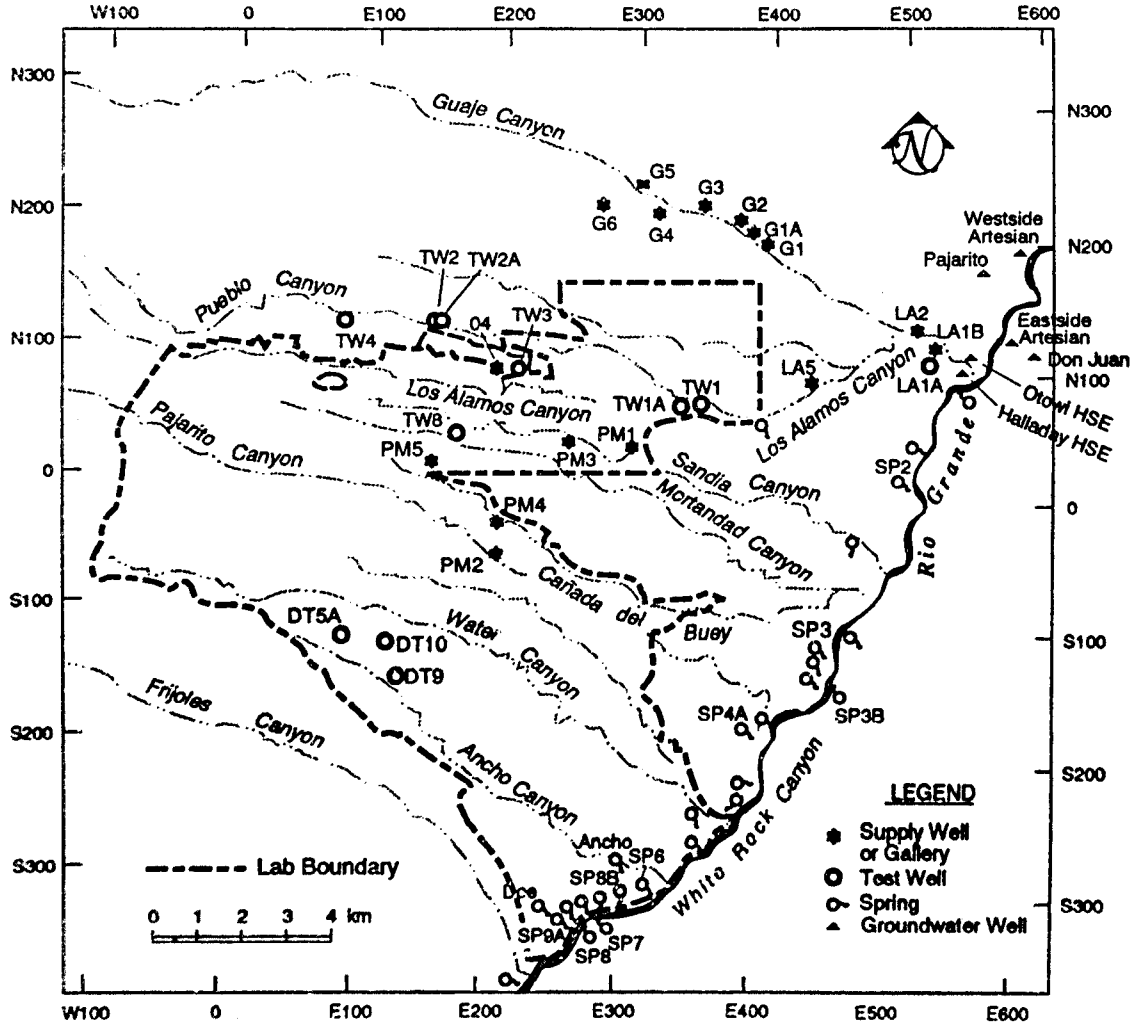

Groundwater sampling locations on and near the Laboratory site.

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LOW-LEVEL TRITIUM MEASUREMENTS IN GROUNDWATER

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
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-9	5/20/93	0.14 +/- 0.09
DT-10	5/20/93	1 +/- 0.09
Intermediate Perched Zone, Pueblo Canyon (150-250 ft depth)		
TW-1A	10/8/92	41.3 +/- 1.4 fast turn over
	5/19/93	45.8 +/- 1.5
TW-2A	10/8/92	698 +/- 23
	5/19/93	699 +/- 23

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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
Sanchez 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	10-15 TU (30-45 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)

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