Department of Energy
Albuquerque Operations Office
Los Alamos Area Office
Los Alamos, New Mexico 87544

NOV 1 4 1997

Mr. Hank L. Daneman
1304 Calle Ramon
Santa Fe, NM 87501

Dear Mr. Daneman:

Subject: Detection of Strontium 90 in Main Aquifer Monitoring Wells at Los Alamos National Laboratory (LANL)

At the recent November 4 planning meeting of the Northern New Mexico Citizens' Advisory Board, you raised concerns about detection of Strontium 90 in the main aquifer below LANL. I have compiled and enclosed relevant sections from the 1994, 1995, and 1996 LANL Environmental Surveillance reports for your use on this subject.

The Department of Energy (DOE) was concerned with the apparent elevated levels of strontium detected during a 1994 sampling, particularly in Test Well 3 located in Los Alamos Canyon. The 1994 sampling results for strontium levels were 35.1, 6.2, and 2.1 pCi/l for Test Wells 3, 4, and 8 respectively. Independent sampling by the New Mexico Environment Department (NMED) DOE Oversight Bureau showed a strontium level of 6.6 pCi/l in Test Well 4 for the same year. These levels compare to an Environmental Protection Agency drinking water standard of 8 pCi/l. Our concerns led to more rigorous "time series sampling" performed in 1995 (see enclosure). The 1995 results and subsequent 1996 sampling by both LANL and the State of New Mexico, did not confirm the presence of strontium in elevated levels. Our concern was reduced by these two years of data showing no elevated strontium in the main aquifer. Other detections of strontium have occurred in only shallow groundwater at LANL, such as in Mortandad Canyon, and are being addressed through the Environmental Restoration Project at LANL.

We continue to monitor these wells and watch test results closely. Independent monitoring by the State also continues at these wells with results closely matching LANL data. In addition to the follow-up sampling already performed, DOE is initiating a Hydrogeologic Workplan designed to provide better contamination detection capabilities at LANL through installation of more monitoring wells. Protection of the quality of the main aquifer below LANL is important to DOE. I understand you have a copy of the draft Workplan and that you are aware that we are working with various NMED bureaus on this plan.

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I have asked Ann Dubois to make copies of this letter available at the next Board meeting. Please contact me at (505) 667-0575 with any further questions.

Sincerely,

Mat Johansen

Mat Johansen, P.E.
Office of Environment

LAAME:3MJ-011

Enclosure

cc w/o enclosure:
G. T. Todd, Area Manager, LAAO
J. Vozella, AAME, LAAO
T. Taylor, LAAME, LAAO
R. Armenta, LAAO
A. Dubois, Scientech, LAAO

saturated conditions. They were all completed as observation wells for future monitoring of potential saturation (Purtymun 1990b).

In 1987, nine observation wells were installed in Cañon del Valle adjacent to inactive Waste Disposal Area P in TA-16. These wells, drilled on the toe of the landfill above the channel alluvium, revealed no saturation and showed no evidence of leachate or seepage from the landfill.

In 1992, five new holes were drilled in Cañada del Buey to document the conditions in and beneath the alluvium. Two of them, completed as monitoring wells, were added to the routine monitoring locations in conformance with a Groundwater Discharge Plan submitted to the NMED for discharge from the new sanitary waste treatment plant at TA-46.

C. Analytical Results

1. Radiochemical Constituents.

The results of radiochemical analyses of groundwater samples for 1994 are listed in Table VII-1. Discussion of the results will address the main aquifer, the canyon alluvial groundwater, and finally the intermediate perched groundwater system.

a. Radiochemical Constituents in the Main Aquifer. For samples from wells or springs in the main aquifer, most of the results for tritium, ^{90}Sr, uranium, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and gross beta were below the DOE DCGs or the EPA or New Mexico standards applicable to a drinking water system. The exceptions are discussed below. In addition, most of the results were near or below the detection limits of the analytical methods used.

Some samples from wells and springs contained levels of plutonium or americium slightly (generally less than a factor of two) above analytical method detection limits. Because of inconsistencies between the types of analyses, (i.e., apparent ^{238}Pu without any corresponding $^{239,240}Pu$ or vice versa), the large counting uncertainties in the measurements at the low levels near average detection limits (often 50% or more of the value), and, in the case of springs, the fact that such samples often must be collected in contact with surface rocks or channel sediments, none of the findings are interpreted to represent contamination of the main aquifer by plutonium or americium.

All of the uranium values were determined using the kinetic phosphonimetric analysis (KPA) method. In the past, uranium was evaluated with the induction coupled plasma emission spectroscopy (ICPES) method, which ordinarily gives high values for prepared standards; the alternative KPA method gives low values. La Mesita Spring and Spring 3B have high uranium concentrations; springs in this area have always contained a relatively high concentration of natural uranium (Purtymun 1980b). The uranium concentrations for these springs are both below the EPA primary drinking water standard MCL of 20 µg/L, however. These two springs also have high gross alpha values. Spring 3AA had a gross alpha value of 17 pCi/L, above the EPA primary drinking water standard of 15 pCi/L.

Three wells and one spring showed noticeable values of ^{90}Sr. For Test Well 4 (6.2 ± 3.4 pCi/L) and Test Well 8 (2.1 ± 0.7 pCi/L), the values are less than 2 to 3 times the radioactivity counting uncertainty and are therefore not a definite detection. Analysis of a split sample from Test Well 4 by the NMED/Agreement in Principle (AIP) showed a ^{90}Sr level of 6.6 ± 1.0 pCi/L, supporting a possible detection in that well.

The values of ^{90}Sr found in Spring 8 (19.7 ± 3.8 pCi/L) and Test Well 3 (35.1 ± 2.2 pCi/L) are well above the limits of analytical uncertainty and also above the EPA primary drinking water standard MCL of 8 pCi/L. However, these ^{90}Sr values are questionable because of the very low gross beta measurements for the samples, of 7 ± 1 pCi/L for Spring 8 and 2.2 ± 0.4 pCi/L for Test Well 3. The apparent detection of ^{90}Sr in Test Well 3 is plausible, as high levels of ^{90}Sr are present in the overlying Los Alamos Canyon alluvial groundwater.

In order to address these detections of ^{90}Sr, resampling of Test Wells 3, 4, and 8 will be conducted. Preliminary results of tests conducted during 1995 indicate no trace of strontium in any of these test wells. The samples were collected periodically during continual pumping of the wells, in order to ascertain the extent of possible contamination within the aquifer. All of the ^{90}Sr values were close to zero, less than 1 or 2 times the radioactivity counting uncertainty. These values are therefore viewed as nondetections.

All ^{137}Cs measurements of samples from the main aquifer wells and springs for 1994 are less than 5% of the DCG applicable to DOE Drinking Water Systems. Cesium measurements in past years have raised some questions about the potential presence of ^{137}Cs contamination in some areas because the previously used analytical method had a detection limit that was relatively high in comparison with the relevant guidelines or standards, and also

Table VII-1. Radiochemical Analysis of Groundwater for 1994

	Tritium (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (µg/L)	^{238}Pu (pCi/L)	^{239,240}Pu (pCi/L)	^{241}Am (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
MAIN AQUIFER ON SITE										
Test Wells										
Test Well 1	0.4 (0.3)[a]	N/A[b]	-2.7 (4.0)	2.5 (0.3)	-0.001 (0.030)	0.008 (0.020)	N/A	2 (1)	4 (1)	20 (60)
Test Well 3	0.1 (0.3)	35.1 (2.2)	<2.0[c]	0.6 (0.1)	-0.009 (0.030)	-0.001 (0.020)	0.043 (0.030)	-1 (1)	2 (0)	20 (50)
Test Well 8	-0.1 (0.3)	2.1 (0.7)	<0.6	0.3 (0.1)	-0.003 (0.005)	0.188 (0.032)	0.034 (0.017)	1 (0)	3 (0)	10 (50)
Test Well DT-5A	-0.1 (0.3)	0.1 (0.8)	<1.0	0.3 (0.1)	0.001 (0.005)	0.018 (0.09)	0.054 (0.017)	1 (1)	2 (1)	110 (50)
Test Well DT-9	0.1 (0.3)	0.7 (0.7)	<1.2	0.2 (0.0)	-0.004 (0.030)	0.026 (0.020)	0.062 (0.030)	1 (1)	4 (1)	90 (50)
Test Well DT-10	-0.1 (0.3)	0.0 (0.7)	<1.1	0.2 (0.1)	0.001 (0.030)	0.010 (0.020)	0.031 (0.030)	0 (0)	3 (0)	30 (50)
Water Supply Wells										
O-4	-0.03 (0.1)	N/A	<2.3	<1.0	0.019 (0.017)	0.003 (0.007)	N/A	0 (2)	4 (2)	N/A
PM-1	-0.3 (0.3)	0.3 (0.8)	<1.0	1.0 (0.0)	-0.007 (0.005)	0.055 (0.017)	0.020 (0.020)	1 (1)	3 (1)	110 (50)
PM-2	-0.2 (0.1)	N/A	<1.7	<1.0	0.005 (0.009)	-0.003 (0.010)	N/A	0 (2)	3 (2)	N/A
PM-4	-0.1 (0.1)	N/A	<2.2	<1.0	0.002 (0.011)	-0.006 (0.012)	N/A	2 (3)	2 (3)	N/A
PM-5	0.04 (0.1)	N/A	<1.4	<1.0	-0.003 (0.016)	0.006 (0.011)	N/A	1 (2)	1 (2)	N/A
MAIN AQUIFER OFF SITE										
Test Wells										
Test Well 2	0.2 (0.3)	N/A	0.9 (11.0)	0.1 (0.0)	-0.011 (0.030)	-0.012 (0.020)	N/A	1 (0)	1 (0)	20 (60)
Test Well 4	0.4 (0.3)	6.2 (3.4)	<1.1	0.8 (0.1)	0.030 (0.030)	-0.010 (0.020)	0.021 (0.013)	3 (1)	8 (1)	10 (50)
Water Supply Wells										
G-1A	-0.02 (0.1)	N/A	<1.1	<1.0	0.021 (0.016)	-0.002 (0.006)	N/A	1 (2)	2 (2)	N/A
G-2	-0.1 (0.1)	N/A	<0.8	<1.0	0.015 (0.021)	0.014 (0.016)	N/A	1 (2)	4 (2)	N/A
G-4	-0.1 (0.1)	N/A	<0.8	N/A	0.012 (0.010)	-0.001 (0.006)	N/A	1 (2)	1 (2)	N/A
MAIN AQUIFER SPRINGS										
White Rock Canyon Springs Group I										
Sandia Spring	0.1 (0.3)	0.0 (0.7)	<0.5	1.1 (0.1)	0.011 (0.030)	0.037 (0.020)	0.025 (0.030)	1 (1)	8 (1)	120 (50)
Spring 3	0.2 (0.3)	0.1 (0.7)	<0.9	1.4 (0.2)	-0.003 (0.030)	0.021 (0.020)	-0.006 (0.030)	0 (1)	9 (1)	90 (50)
Spring 3A	0.4 (0.3)	-0.1 (0.7)	<0.5	1.1 (0.3)	-0.001 (0.030)	0.021 (0.020)	0.016 (0.030)	1 (1)	8 (1)	50 (50)
Spring 3AA	0.1 (0.3)	0.1 (0.8)	<1.2	5.8 (1.0)	-0.003 (0.030)	0.010 (0.020)	0.068 (0.030)	17 (5)	15 (2)	40 (50)
Spring 4	0.3 (0.3)	-0.5 (9.1)	<0.9	1.3 (0.3)	0.013 (0.030)	0.003 (0.020)	0.057 (0.030)	-1 (1)	3 (0)	50 (50)
Spring 4A	0.0 (0.3)	-0.2 (0.7)	1.4 (0.7)	0.9 (0.2)	0.004 (0.030)	0.018 (0.020)	0.079 (0.030)	-1 (1)	2 (0)	60 (50)
Spring 5	0.2 (0.3)	0.5 (0.7)	1.1 (0.5)	0.8 (0.1)	-0.001 (0.030)	0.001 (0.020)	0.035 (0.030)	1 (1)	2 (0)	150 (50)
Ancho Spring	0.5 (0.3)	0.0 (0.8)	<1.2	0.5 (0.1)	-0.007 (0.030)	0.032 (0.020)	0.008 (0.030)	1 (1)	3 (0)	-10 (50)
White Rock Canyon Springs Group II										
Spring 5A	0.4 (0.3)	0.2 (0.7)	1.6 (0.7)	6.6 (1.3)	0.006 (0.030)	0.022 (0.020)	0.070 (0.030)	11 (3)	14 (1)	-20 (50)
Spring 5B	0.5 (0.3)	-0.3 (0.7)	<1.3	3.6 (0.5)	-0.004 (0.030)	0.008 (0.020)	0.047 (0.030)	4 (1)	6 (1)	60 (50)
Spring 6	0.3 (0.3)	0.9 (0.9)	<1.1	0.4 (0.0)	0.025 (0.030)	0.052 (0.020)	0.071 (0.030)	-0 (1)	4 (1)	220 (50)
Spring 6A	0.3 (0.3)	0.9 (0.7)	<1.8	0.9 (0.1)	-0.002 (0.030)	0.010 (0.020)	0.033 (0.030)	1 (1)	4 (1)	10 (50)
Spring 7	0.5 (0.3)	0.2 (0.7)	<1.1	1.4 (0.1)	0.005 (0.030)	0.022 (0.020)	0.040 (0.030)	0 (0)	2 (0)	10 (50)
Spring 8	0.2 (0.3)	19.7 (3.8)	<1.2	2.0 (0.2)	0.001 (0.030)	0.013 (0.020)	0.046 (0.030)	6 (2)	7 (1)	80 (50)
Spring 8A	0.3 (0.3)	-0.3 (0.8)	1.2	0.4 (0.1)	-0.008 (0.030)	0.039 (0.020)	0.044 (0.030)	0 (1)	4 (1)	20 (50)
Spring 8B	0.5 (0.3)	0.0 (0.8)	<1.0	0.2 (0.0)	0.021 (0.030)	0.047 (0.020)	0.056 (0.030)	-1 (1)	3 (0)	50 (50)

that concentrations of some constituents were higher in the new HSWA wells than the older wells in Los Alamos Canyon.

In response to this request, the Laboratory sampled these wells on a quarterly basis during 1995. Only the first two quarters (sampling done on March 29 and June 23, 1995) of data are available at the time of this report preparation. A complete presentation of the 1995 and 1990 data will be presented in a forthcoming report.

Results for three canyons (Acid/Pueblo, Los Alamos, and Mortandad) are represented in the 1995 sampling series. The wells drilled in other canyons as a result of the HSWA permit Module VIII special conditions have remained dry. The sampling results are presented in Tables 5-36 through 5-38. Groundwater samples drawn from the canyon bottom alluvium can be quite turbid, containing a significant quantity of suspended sediment which has entered the well casings. Both filtered and unfiltered samples were collected at each of the stations, in order to evaluate the quantity of metals and radionuclides associated with the suspended sediment portion of the water samples. Due to a miscommunication, however, all samples for radiochemical analysis were filtered in the laboratory.

Several preliminary observations can be made regarding the radiochemical results (Table 5-36). Strontium-90 is clearly detected in all three of the canyons. In Los Alamos and Mortandad Canyons strontium-90 concentrations are largest at the upstream stations and decrease downstream. Americium-241 and plutonium-239,240 were detected in Acid/Pueblo Canyon. Americium-241, plutonium-238, and possibly cesium-137 were found in Los Alamos Canyon. Tritium; strontium-90; plutonium-238; plutonium-239,240; and americium-241 are present in Mortandad Canyon. The levels of uranium in Mortandad Canyon are generally about 2 µg/L, compared to about 0.5 µg/L in Acid/Pueblo Canyon and 0.1 to 0.4 µg/L in Los Alamos Canyon.

An important observation that comes from these data is that there is significant variability in radionuclide concentrations at the same station at different times. Strontium-90 concentrations at LAO-3 and nearby LAO-3A decreased by a factor of two between March 29 and June 23, 1995. A similar conclusion applies to APCO-1.

There also appears to be variability in concentrations between some adjacent wells. The strontium-90 concentrations at LAO-3A are consistently higher than at nearby LAO-3. Americium-241 was apparently detected in LAO-3A but not in LAO-3. Tritium concentrations are higher at MCO-6 than at MCO-6B, while strontium-90 concentrations are lower. Comparisons at other paired wells show that concentrations of particular radionuclides at the two wells are similar. The differences in concentrations between adjacent wells may indicate that concentrations vary as much in space as in time in a given part of the canyon alluvium.

The general chemistry (Table 5-37) results from the sampling show trends similar to those discussed for radionuclides. Concentrations of several constituents show significant variability between sampling periods. One observation needs to be qualified: the high chromium values discovered in the results for wells APCO-1 and LAO-3 in the March 29 sampling appear to be due to a sample bottle switch (see Section 5.B.1).

Organic results from the special alluvial sampling (Tables 5-39 and 5-40) show four possible detections. Two of these are discounted as the compounds were also detected in the laboratory method blanks and are probably the result of contamination during analysis. Acetone (a common laboratory chemical and probably the result of contamination during analysis) and chloromethane were detected in samples from wells MCO-7A and MT-4.

2. Special Sampling of Test Wells 3, 4, and 8.

The 1994 surveillance sampling of three test wells, TW-3, TW-4 and TW-8, showed unexpected levels of strontium-90 (EG 1996). For TW-4 (6.2 ± 3.4 pCi/L) and TW-8 (2.1 ± 0.7 pCi/L), the values were near 0, within 2 to 3 times the analytical uncertainty and are regarded as nondetections. (See Section 5.B.1 for a discussion of evaluation of radiochemical results near the detection limit). However, an analysis of a split sample from TW-4 by the NMED/DOE Oversight Bureau staff showed a strontium-90 level of 6.6 ± 2.0 pCi/L, supporting a detection in that well.

The value of strontium-90 found in TW-3 (35.1 ± 2.2 pCi/L) was well above the limits of analytical uncertainty and also above the EPA proposed primary drinking water standard MCL of 8 pCi/L. However, this strontium-90 value was questionable because of the very low gross beta measurements for the sample, of 2.2 ± 0.4 pCi/L. Strontium-90 is a beta emitter, and the values for strontium-90 and gross beta should be about the same. Chloride and tritium were not found in the TW-3 sample. These substances should also be present, as they are also found in the alluvial groundwater (the likely source of the strontium-90) and are transported more readily than strontium-90.

Nonetheless, the apparent detection of strontium-90 in TW-3 is plausible, as high levels of strontium-90 are present in the overlying Los Alamos Canyon alluvial groundwater.

In most uncontaminated regional aquifer waters in the Los Alamos area, chloride and nitrate occur at levels of about 1 to 3 mg/L for chloride and less than 1 mg/L NO_3-N (nitrate as nitrogen). These ions are useful indicators of contamination because their transport is generally conservative (concentrations are unaffected by adsorption or other chemical reactions and reflect the general movement of water) and because their presence at levels above background is usually from man-made sources.

In 1994 TW-8 in Mortandad Canyon also showed a large increase in nitrate, from values of about 0.2 mg/L in prior years, to 5.1 mg/L. Nitrate is a common contaminant found in Mortandad Canyon alluvial groundwater, as a result of effluent disposal from the TA-50 Radioactive Liquid Waste Treatment Plant. Trace levels of tritium found earlier in TW-8 in Mortandad Canyon indicate the presence of recent recharge at that location. Therefore, the presence of elevated nitrate levels is not surprising, but tends to confirm the initial interpretation of the trace level tritium discoveries in this well.

In response to these 1994 findings, ESH-18 conducted a time series sampling study on test wells TW-3, TW-4, and TW-8 in July 1995. The normal sampling procedure for wells is to collect a water sample after pumping at least three well bore volumes, in order to ensure that stagnant water in the well casing and the surrounding aquifer formation has been removed and that the sample represents water from the formation surrounding the well screen. The July 1995 water samples were collected at nearly every well bore volume for 10 to 15 bore volumes and analyzed for strontium-90, tritium (using low-detection limit techniques at the University of Miami), chloride, and nitrate. The results of this study are given in Table 5-41, and shown in Figures 5-10 through 5-12.

The volumes for each well were determined from the depth of water in the bottom of the casing and the casing diameter. These volumes are, in gal. per well bore: 206.5 gal. for TW-3, 78 gal. for TW-4, and 220 gal. for TW-8.

In addition to the July 1995 time series tests, quarterly sampling of TW-TW-3, TW-4, and TW-8 is being carried out in 1996. These samples are being analyzed for trace-level amounts of tritium, general inorganic chemistry, and radionuclides.

The intent of the July 1995 tests was to see whether there were changes in the concentration of any of the constituents with volume pumped. Unfortunately, such results are not definitive regarding the source of any contamination found. In the case of a steady concentration over the series, aquifer contamination is indicated or ruled out depending on the concentration. A declining concentration with time might suggest limited aquifer contamination due to either flow of some contaminants down the well bore or limited contamination present in only the upper portion of the aquifer.

Results of the 1995 sampling indicate no trace of strontium in any of these test wells (Figure 5-10). The detection limit for strontium-90 is about 3 pCi/L. All of the strontium-90 values were near 0, within 2 to 3 times the analytical uncertainty and are regarded as nondetections. (See Section 5.B.1 for a discussion of evaluation of radiochemical results near the detection limit).

The results for tritium (Figure 5-11) suggest that it is present in the aquifer at TW-3 and 8, but not at TW-4. Tritium has previously been observed in TW-8 in a 1993 sample at 89 pCi/L. The presence of tritium and gradual drop off in concentration after prolonged pumping of this well suggests that recharge to the main aquifer of some water from the overlying alluvium has occurred. An alternative hypothesis of leakage of water down the well bore cannot be ruled out but seems unlikely because of the high volume of contaminated water which would be required to produce the tritium concentrations observed while sampling TW-8.

The presence of tritium in TW-3 is a new discovery, as tritium was not noted in this well during sampling in 1993. Possible sources of the tritium are infiltration or vapor movement from the overlying alluvium or leakage along the well casing. The sharp drop off in concentration after a few well bores could indicate that tritium contamination in the aquifer is not pervasive here. Results of the 1996 quarterly sampling may clarify this matter.

The time-series tritium results for TW-4 show that tritium is not present in the aquifer at this location. TW-4 was not sampled from 1962 to 1992, as it had no pump. A sample collected from this well in 1993 showed 11 pCi/L of tritium, but contaminated water introduced during pump priming was suspected as the source of tritium. Other chemical irregularities noted in samples from TW-4 including the 1994 detection of strontium-90 may also be related to the contaminated water. The fact that the depth of water in the well was only 10 ft prevented adequate purging of the well during collection of the 1993 and 1994 samples.

Time-series plots for chloride and nitrate (Figure 5-12) show that for all three test wells, chloride is fairly constant during the sampling. If water were leaking down the borehole from above and carrying higher amounts of

chloride, the chloride concentration would be expected to drop off during pumping, as water with less chloride was drawn into the well from the surrounding aquifer. For all three of the test wells, the nitrate concentrations increase at about well bore 5, at which point it stabilizes. This effect may be due to differences in the oxidation state of nitrogen, to biological depletion of nitrate, or to volatilization of nitrogen in water near the well bore compared to farther back in the formation.

Several other test well samples were analyzed for tritium by low-detection limit methods. Table 5-41 shows these results. Prior analytical results for tritium were published in EARE (1995). The 1995 results for TW-1, 1A, and 2A are in the ranges previously observed, although these values are all lower than earlier results. TW-2 had a 1995 value of about 16.8 pCi/L compared to values of 0.71 and 2.8 pCi/L in 1992 and 1993.

Before atmospheric testing of nuclear weapons began, tritium levels in precipitation were about 20 pCi/L (Adams 1995). This is 5 to 10 times the tritium levels detected in the Los Alamos public water supply wells. By the mid-1960s, tritium in atmospheric water in northern New Mexico reached a peak level of about 6,500 pCi/L. At present, general atmospheric levels in northern New Mexico are about 30 pCi/L, and those in the Los Alamos vicinity range from 20 to 450 pCi/L (Adams 1995). Groundwaters that contain between 16 and 65 pCi/L of tritium are most likely the result of recent recharge, that is within the last four decades (Blake 1995). Waters with tritium concentrations below about 1.6 pCi/L are likely to be old: the ages of these waters are more than 3,000 years, but there may be large errors associated with small tritium concentrations. With a tritium concentration below 0.5 pCi/L, modeled ages are more than 10,000 years, but this is at the limit of tritium age determinations. Waters with tritium concentrations more than 1,000 pCi/L and collected after 1990 cannot have their ages modeled, and can only be the result of contamination (Blake 1995).

Thus, the tritium levels in TW-1, 1A, and 2A are the result of infiltration of recent precipitation, with a possible contribution of a component of radioactive industrial effluent. This latter conclusion is supported by high levels of chloride and nitrate, supporting an anthropogenic source for part of this water (Blake 1995). For TW-2, the tritium levels are also the result of infiltration, perhaps of recent precipitation.

Test wells DT-9 and DT-10 also both showed higher tritium values in 1995 than in prior years. The 1993 values for Test wells DT-9 and DT-10 were 0.45 and 1.3 pCi/L, compared to 1995 values of 1.5 and 3.2 pCi/L. These tritium values fall into a possible age range between 40 and 3,000 years.

3. Environmental Surveillance at Accord Pueblos

During 1995, cooperative efforts between the Laboratory and the Pueblos of San Ildefonso, Santa Clara, Cochiti, and Jemez and the Pueblo Office of Environmental Protection resulted in sampling of water for tritium in the four Indian Pueblo communities. The locations of the four Accord Pueblos are shown in Figure 5-13. A Laboratory/Tribal-developed sampling plan was the basis for testing of community and private wells, streams, and springs on pueblo lands. General chemical and organic analysis results for pueblo waters are discussed for each pueblo below, as well as results for sediments collected at the Pueblo of San Ildefonso. These results are presented in Tables 5-42 through 5-48. Following these discussions, the results of low-detection limit tritium analyses for the pueblos are discussed as a group.

a. Pueblo of San Ildefonso. To document the potential impact of Laboratory operations on lands belonging to Pueblo of San Ildefonso, DOE entered into a memorandum of understanding (MOU) with the Pueblo and the BIA to conduct environmental sampling on pueblo land. The agreement, entitled "Memorandum of Understanding Among the Bureau of Indian Affairs, the Department of Energy, and the Pueblo of San Ildefonso Regarding Testing for Radioactive and Chemical Contamination of Lands and Natural Resources Belonging to the Pueblo of San Ildefonso," No. DE-GM32-87AL37160, was concluded in June 1987. The MOU calls for hydrologic pathway sampling (including water and sediments), and air, soils, and foodstuff sampling. This section deals with the hydrologic pathway. From 1987 to 1994, water, soil, and sediment samples were collected in accord with the MOU, and the results were reported in Purtymun (1988) and the annual environmental surveillance reports, the latest of which is EG (1996).

The groundwater, surface water, and sediment stations sampled on the Pueblo of San Ildefonso are shown in Figures 5-14 and 5-15. Aside from stations listed in the accompanying tables, the MOU also specifies collection and analysis of additional water and sediment samples from sites that have long been included in the routine environmental sampling program, as well as special sampling of storm runoff in Los Alamos Canyon. These

Table 5-16. Radiochemical Analyses of Groundwater for 1995 (pCi/L[a])

Station Name	Date	Codes[b]	^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Main Aquifer												
Test Wells:												
Test Well 1	06/19	1	−100 ± 300[c]	−.5 ± 1	<.97[d]	2.1 ± .5	.041 ± .014	.026 ± .012	.034 ± .021	−.3 ± 1.1	4.7 ± .7	110 ± 50
Test Well 1	06/19	R1	0 ± 400									
Test Well 2	08/01	1	100 ± 300	−.2 ± 1.9	.45 ± .25	.19 ± .03	.043 ± .023	−.007 ± .018	.032 ± .015	−.1 ± .7	4 ± .6	−20 ± 50
Test Well 3	07/18	1	0 ± 300	.4 ± .8	.31 ± .47	.41 ± .04	.003 ± .019	.002 ± .013	.009 ± .017	−.1 ± .4	2 ± .5	−40 ± 40
Test Well 4	07/19	1	400 ± 300	.7 ± .7	1.1 ± .59	.8 ± .08	.001 ± .009	.01 ± .013	.007 ± .014	.5 ± .7	2 ± .4	30 ± 40
Test Well 8	07/17	1	−100 ± 300	.3 ± .8	.63 ± .96	.04 ± .01	−.001 ± .014	−.007 ± .016	.033 ± .019	.2 ± .5	1.3 ± .3	30 ± 40
Test Well DT-5A	11/13	uf 1	100 ± 300	1.7 ± 1.1	.24 ± .37	.45 ± .05	−.007 ± .004	.025 ± .012	.05 ± .05	.4 ± .4	2 ± .3	80 ± 50
Test Well DT-5A	11/13	f 1	−200 ± 300	.5 ± 1.3	.48 ± .71	.4 ± .07	−.002 ± .006	.016 ± .013	.028 ± .016	.5 ± .4	2 ± .3	70 ± 50
Test Well DT-9	05/31	1	500 ± 300	.4 ± .8	<1.22	.41 ± .04	0 ± .005	.01 ± .012	.017 ± .013	−.6 ± .5	1.3 ± .3	100 ± 50
Test Well DT-10	05/30	1	2,100 ± 400	.1 ± 1.1	1.69 ± .64	.58 ± .06	.003 ± .031	.061 ± .037	.032 ± .015	0 ± .4	1.11 ± .3	130 ± 50
Test Well DT-10	05/30	R1					.0053 ± .0143	.0266 ± .0166				
Test Well DT-10	12/21	1	400 ± 300	−.5 ± 6.1	−.01 ± .8	.43 ± .04	.001 ± .004	.056 ± .015	.047 ± .013	2 ± .6	9 ± 1	30 ± 40
Water Supply Wells:												
PM-1	06/12	1	0 ± 500	4.6 ± 10.8	−.14 ± .8	2.09 ± .21	.009 ± .015	−.017 ± .009	.052 ± .03	.5 ± .9	4.3 ± .5	100 ± 40
PM-2	06/12	1	0 ± 500	0 ± .9	.08 ± .12	.15 ± .04	−.009 ± .01	.013 ± .011	.028 ± .017	−.6 ± .6	2.4 ± .4	40 ± 40
PM-2	06/12	D1		−.1 ± .8		.14 ± .03						
PM-2	06/12	d 1	−200 ± 500	6.6 ± 18.2	.04 ± .08	.16 ± .04	−.013 ± .005	.024 ± .013	.029 ± .018	−1.4 ± .5	1.7 ± .3	70 ± 40
PM-3	06/12	1	−100 ± 500	−.1 ± .8	.67 ± 1	1 ± .12	−.005 ± .009	.023 ± .02	.064 ± .019	−.5 ± .9	3.9 ± .5	110 ± 40
PM-4	06/12	1	−100 ± 500	.5 ± 1.1	.31 ± .47	.4 ± .06	.013 ± .022	.052 ± .025	.109 ± .028	−.6 ± .6	3 ± .4	80 ± 40
PM-4	06/12	R1					.017 ± .006	.025 ± .006	.023 ± .009			
PM-5	06/12	1	0 ± 500	−.1 ± .8	.2 ± .3	.59 ± .1	−.02 ± .013	.012 ± .017	.067 ± .021	−1.3 ± .6	2.7 ± .4	120 ± 50
PM-5	06/12	R1								−.5 ± .6	2.7 ± .4	
G-1	06/12	1	−300 ± 500	.2 ± .8	.08 ± .12	.97 ± .1	.007 ± .009	.011 ± .011	.099 ± .031	−.6 ± .8	4.3 ± .5	80 ± 40
G-1A	06/12	1	100 ± 500	3.9 ± .7	−.01 ± .8	.49 ± .06	.008 ± .017	−.005 ± .011	.076 ± .027	−1.4 ± .7	2.9 ± .4	50 ± 40
G-1A	06/12	R1										50 ± 40
G-1A	06/12	d 1	0 ± 500	7.4 ± 3.5	.03 ± .04	.47 ± .05	−.005 ± .007	.028 ± .016	.096 ± .023	−.4 ± .6	2.8 ± .4	60 ± 40
G-2	06/12	1	300 ± 500	−.2 ± .8	−.04 ± .8	.86 ± .09	.009 ± .008	.025 ± .013	.077 ± .022	−.4 ± .8	2.7 ± .4	80 ± 40
G-6	06/12	1	−100 ± 500	1.1 ± 3.7	.2 ± .3	.54 ± .08	−.005 ± .002	.008 ± .009	.049 ± .017	−.4 ± .6	2 ± .4	30 ± 40

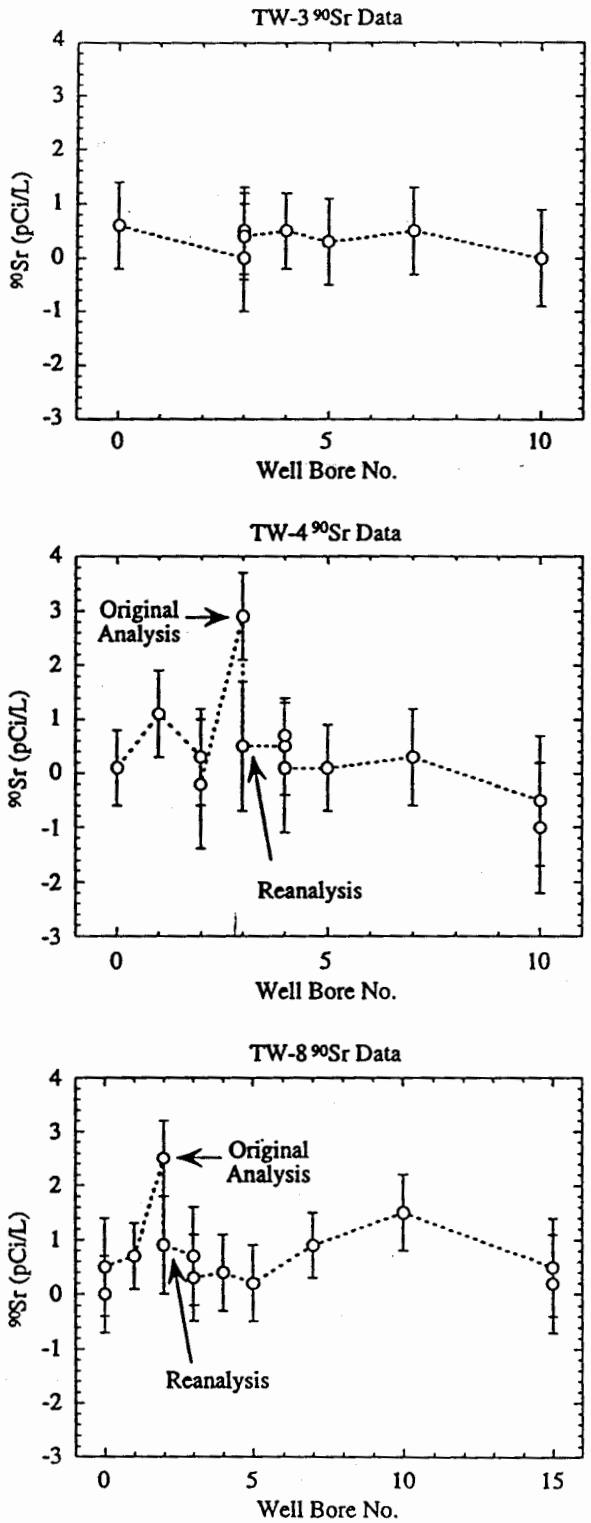

Figure 5-10. Results for strontium-90 in test wells from July 1995 time series sampling.

3. Radiochemical Analytical Results for Groundwater

The results of radiochemical analyses of groundwater samples for 1996 are listed in Table 5-22. Tables 5-23 and 5-24 contain lists of radionuclides detected in water samples and of possible detections, according to criteria discussed in Section 5.F. Because uranium, gross alpha, and gross beta are ubiquitous at detectable levels, occurrences of these measurements above significant levels (chosen to be below the EPA MCLs or screening levels) are reported. The specific values are 5 µg/L for uranium, 10 pCi/L for gross alpha, and 40 pCi/L for gross beta. Discussion of the results will address the main aquifer, the canyon alluvial groundwater, and finally the intermediate perched groundwater system.

a. Radiochemical Constituents in the Main Aquifer. For samples from wells or springs in the main aquifer, most of the results for tritium; strontium-90; uranium; plutonium-238; plutonium-239, -240; americium-241; and gross beta were below the DOE DCGs or the EPA or New Mexico standards applicable to a drinking water system. The exceptions are discussed below. In addition, most of the results were near or below the detection limits of the analytical methods used. Dissolved uranium is a common constituent of groundwater (Hem 1989), so only occurrences close to the proposed EPA MCL of 20 µg/L are discussed here.

The 1994 surveillance sampling of three test wells, TW-3, TW-4, and TW-8, showed unexpected levels of strontium-90 (ESP 1996a). Several of the sampling results were suspect because there were no corroborating measurements such as correspondingly elevated gross beta measurements in some of the samples. Special time-series sampling was carried out in 1995 to evaluate possible aquifer contamination near these wells, during which no strontium-90 was detected (ESP 1996b). These wells were sampled four times during 1996, with no radionuclides detected, except naturally occurring uranium and trace levels of tritium. The tritium results are discussed in Section 5.D.3.c.

Test Well 1 had a tritium detection of 749 pCi/L. Tritium values in this range cannot be accurately quantified by the analytical method, but the result does indicate a detection of tritium. The results of previous low-detection-limit tritium measurements done by the University of Miami on samples from this well have ranged from 277 to 366 pCi/L (ESP 1995; ESP 1996b). Water supply well G-2 showed a possible americium-241 detection; however, the americium-241 values found at small levels this year are suspect because of similar levels found in field blank samples (see Section 5.F).

Strontium-90 was detected in Sandia Spring. Spring 5A showed evidence of plutonium-238. La Mesita Spring has a significant uranium concentration of 10 µg/L. Samples from springs in this area have always contained a relatively high concentration of natural uranium (Purtymun et al., 1980). However, the uranium concentration for La Mesita Spring is below the proposed EPA primary drinking water MCL of 20 µg/L. The spring also has a high gross alpha value of about 14 pCi/L, near the EPA primary drinking water standard of 15 pCi/L.

In 1995, water supply well G-1A had an apparent strontium-90 detection of 3.9 ± 0.7 pCi/L. This value is just above the strontium-90 detection limit of 3 pCi/L. Another 1995 analysis gave a result of 7.4 ± 3.5 pCi/L, which has a very high uncertainty, making interpretation of this result difficult. No previous strontium-90 data are available for this well for comparison. The results of 1996 samples indicate no trace of strontium-90 in samples from this well.

All cesium-137 measurements of samples from the main aquifer wells and springs for 1994 are less than 5% of the DCG applicable to DOE Drinking Water Systems and less than the detection limit of 4 pCi/L.

b. Total Committed Effective Dose Equivalent from the Ingestion of Drinking Water from Los Alamos and White Rock. Table 5-25 presents the summary of the CEDE from the ingestion of drinking water collected in 1996. The CEDE for 1995 is presented for comparison. Because drinking water aquifers are regional, there is no "background" drinking water source available to determine the total net positive CEDE between the monitored source and a "background" source. The total annual CEDEs (i.e., the annual CEDE, without any error term, summed over all radionuclides) for all drinking water samples collected from Los Alamos water distribution wells are below 4 mrem. No samples collected exceeded the radioactive MCLs for drinking water systems (EPA 1989). The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) using the two liters per day drinking water consumption rate for samples collected in 1996 is 0.12 mrem as modified by the percent contribution to the distribution system for each monitored well. The radionuclides that contributed to more than 5% of the total CEDE in 1996 are strontium-90, cesium-137, total uranium, plutonium-238, plutonium-239, and americium-241.

Table 5-22. Radiochemical Analyses of Groundwater for 1996 (pCi/L[a])

Station Name	Date	Codes[b]		^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Main Aquifer													
Test Wells:													
Test Well 1	08/01	u	1	749 (147[c])	-0.3 (.6)	.65 (.44)	2.04 (.21)	-.016 (.005)	.009 (.010)	-.038 (.010)	2.23 (.8)	4.75 (.6)	-37 (50)
Test Well 2	08/21	u	1	161 (136)	-0.1 (.5)	-.98 (.32)	-.01 (.01)	-.003 (.003)	.019 (.011)	-.022 (.009)	-.49 (.12)	1.35 (.18)	-57 (50)
		u	R1			—	-.01 (.01)						
Test Well 3	01/29	u	1	52 (330)	0.5 (.8)	-.23 (.34)	.05 (.06)	.039 (.013)	.008 (.009)	-.014 (.030)	.44 (.26)	3.55 (.5)	243 (60)
		u	2					.039 (.013)	.008 (.009)				
		u	R1					.013 (.010)	.005 (.010)	-.004 (.030)			
		u	R2					.013 (.010)	.005 (.010)				
	07/03	u	1	544 (74)	0.1 (.3)	-.32 (1.31)	.11 (.01)	.004 (.007)	-.010 (.007)	-.013 (.012)	-.23 (.05)	2.15 (.3)	-87 (50)
		u	D1			-2.01 (.80)							
		u	R1							-.003 (.016)	-.51 (.12)	1.05 (.2)	-87 (50)
	09/30	u	1	-52 (136)	-0.2 (.4)	.29 (.33)	.33 (.03)	.017 (.012)	.004 (.010)	.011 (.016)	-.43 (.12)	2.25 (.3)	-27 (50)
		u	R1	11 (137)									
	11/15	u	1	-336 (139)	-0.7 (.8)	.59 (2.67)	.62 (.06)	.010 (.007)	-.007 (.006)	.045 (.024)	1.13 (.4)	4.05 (.6)	-17 (50)
Test Well 4	01/23	u	1	-253 (178)	0.7 (1.0)	.03 (.41)	.12 (.12)	.004 (.007)	.006 (.009)	.036 (.040)	-.071 (.002)	2.65 (.4)	323 (70)
		u	2					.004 (.007)	.006 (.009)				
		u	D1			-.16 (1.56)							
		u	D2			-.16 (1.56)							
		u	R1								-.057 (.004)	-.6 (.04)	
	07/03	u	1	530 (73)	-1.0 (.2)	-.43 (1.14)	.04 (.01)	.010 (.009)	.004 (.012)	.010 (.018)	-.37 (.07)	3.45 (.4)	-107 (50)
		u	2					-.007 (.001)	-.014 (.005)	-.004 (.014)			
		u	D1		-0.5 (.2)		.04 (.01)						
		u	R1	-298 (62)				.007 (.009)	-.011 (.001)				
	09/27	u	1	-179 (135)	1.3 (.4)	-.44 (1.12)	.15 (.02)	-.006 (.002)	-.017 (.002)	-.036 (.008)	-.28 (.07)	2.95 (.4)	43 (50)
	11/15	u	1	-278 (139)	-0.1 (.8)	.14 (2.00)	.66 (.07)	-.003 (.005)	.005 (.009)	.050 (.026)	.55 (.2)	4.15 (.6)	-37 (50)
		u	R1				.67 (.07)						
Test Well 8	01/29	u	1	-241 (322)	1.2 (.8)	.48 (2.50)	.48 (.05)	-.003 (.006)	-.003 (.009)	.006 (.040)	8.93 (3.2)	12.45 (1.5)	-97 (50)
		u	2					-.003 (.006)	-.003 (.009)				
		u	D1				.55 (.06)						
		u	R1										-107 (50)
	07/23	u	1	-289 (144)	-0.6 (.2)	-1.87 (.80)	.48 (.05)	-.003 (.008)	.003 (.009)	-.017 (.016)	.11 (.05)	1.15 (.2)	3 (50)
		ud	1	-41 (140)	0.4 (.3)	-1.70 (.80)	.47 (.05)	.017 (.009)	.003 (.009)	.017 (.025)	1.23 (.3)	1.55 (.2)	-27 (50)
		ud	2					.020 (.013)	.033 (.015)	.009 (.016)			
		ud	R1										-37 (50)

Table 5-22. Radiochemical Analyses of Groundwater for 1996 (pCi/L[a]) (Cont.)

Station Name	Date	Codes[b]		^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Test Wells (Cont.):													
Test Well 8 (Cont.)	09/30	u	1	–99 (136)	–0.1 (.4)	.21 (.35)	.58 (.06)	.003 (.009)	.019 (.014)	–.020 (.010)	–1.47 (.5)	1.65 (.2)	–47 (50)
		u	R1				.58 (.06)	–.004 (.006)	.020 (.012)	–.019 (.011)			
	11/15	u	1	20 (141)	–0.5 (.8)	.89 (.70)	.68 (.07)	.008 (.013)	.000 (.017)	–.008 (.015)	1.33 (.4)	2.05 (.3)	–47 (50)
		u	R1					–.003 (.006)	–.007 (.007)	.049 (.024)			
Test Well DT-5A	11/27	u	1	–56 (141)	–0.1 (.3)	–1.87 (.80)	.33 (.03)	–.006 (.006)	.029 (.015)	–.015 (.016)	.71 (.19)	2.37 (.3)	–57 (50)
		u	R1				.32 (.03)	.000 (.007)	.003 (.009)	–.041 (.013)			–57 (50)
		u	1										–97 (50)
		u	R1										43 (50)
Test Well DT-9	09/18	u	1	–9 (133)	0.0 (.3)	–.40 (.26)	.41 (.04)	.016 (.010)	.016 (.011)	–.025 (.010)	.47 (.14)	.95 (.1)	–7 (50)
		u	D1			–.61 (.23)							
		u	R1	–267 (131)									
	12/05	u	1	–129 (139)	0.3 (.3)	–1.43 (.80)	.39 (.04)	.003 (.008)	–.001 (.008)	–.011 (.018)	.46 (.1)	1.85 (.3)	–197 (50)
		u	2	–129 (139)									
		u	R1		–0.1 (.3)								
Test Well DT-10	09/19		1	170 (135)	1.4 (.5)	.17 (.32)	.57 (.06)	.014 (.012)	.025 (.014)	–.020 (.020)	–1.97 (.5)	7.45 (.9)	–67 (50)
			R1								.81 (.25)	7.95 (.9)	
	12/06	u	1	211 (143)	–0.8 (.6)	–1.27 (.80)	.59 (.06)	–.003 (.004)	.014 (.011)	–.018 (.015)	1.33 (.3)	3.15 (.4)	–157 (50)
		u	R1					–.001 (.006)	.022 (.012)	.032 (.026)			–137 (50)
Water Supply Wells:													
O-1	12/17	u	1	–236 (140)	0.3 (.4)	–.79 (.60)	3.16 (.32)	.005 (.009)	–.002 (.009)	.018 (.019)	5.83 (3.2)	2.75 (.5)	–47 (50)
	12/18	u	1	–397 (139)	0.3 (.4)	.03 (1.83)	3.10 (.31)	–.008 (.002)	–.002 (.007)	–.022 (.012)	3.83 (2.2)	2.35 (.5)	–77 (50)
		u	R1	–652 (137)									
	12/19	u	1	–347 (140)	0.5 (1.0)	–.51 (1.01)	3.05 (.31)	–.012 (.003)	.006 (.010)	–.008 (.017)	3.83 (2.2)	2.75 (.5)	–97 (50)
		u	R1							.002 (.016)			
			1	–724 (137)	–0.1 (.4)	–.45 (1.12)	2.81 (.28)	.001 (.008)	.007 (.010)	–.007 (.015)	7.63 (4.1)	2.85 (.5)	–77 (50)
			1	–66 (136)	0.0 (.4)		1.71 (.17)	.020 (.018)	–.004 (.011)	–.026 (.014)			–7 (50)
			R1	–379 (133)		—		–.003 (.010)	–.007 (.009)	.032 (.027)			
O-4	12/16	u	1	–506 (138)	0.2 (.4)	–.04 (1.72)	.88 (.09)	.004 (.007)	–.005 (.009)	–.003 (.014)	2.13 (1)	5.45 (.9)	–77 (50)
PM-1	04/25	u	1	–105 (322)	0.2 (.9)	–1.29 (.80)	1.49 (.15)	.006 (.008)	.024 (.013)	–.006 (.016)	.33 (.2)	3.25 (.4)	–47 (50)
PM-2	04/25	u	1	3 (325)	–0.1 (.9)	–1.20 (.80)	.25 (.03)	–.003 (.005)	–.006 (.007)	–.026 (.009)	–.37 (.1)	7.95 (1)	–77 (50)
		u	2					–.005 (.001)	–.012 (.001)	.017 (.019)			
		u	R1										–67 (50)
PM-3	04/25	u	1	–270 (317)	–0.1 (.8)	1.84 (.73)	.81 (.08)	–.007 (.003)	.022 (.011)	–.021 (.014)	.13 (.1)	3.15 (.4)	–87 (50)
		u	D1	2.6	(.8)								
		u	D2	2.6	(.8)								