

# **Health Consultation**

Plutonium Contamination in Big Trees Park

LAWRENCE LIVERMORE NATIONAL LABORATORY

LIVERMORE, ALAMEDA COUNTY, CALIFORNIA

CERCLIS NO. CA2890012584

MAY 17, 1999

**U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES**

**Public Health Service**

Agency for Toxic Substances and Disease Registry

Division of Health Assessment and Consultation

Atlanta, Georgia 30333

## **Health Consultation: A Note of Explanation**

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR TOLL FREE at  
1-888-42ATSDR

or

Visit our Home Page at: <http://atsdr1.atsdr.cdc.gov:8080/>

# HEALTH CONSULTATION

Plutonium Contamination in Big Trees Park

LAWRENCE LIVERMORE NATIONAL LABORATORY

LIVERMORE, ALAMEDA COUNTY, CALIFORNIA

CERCLIS NO. CA2890012584

Prepared by:

California Department of Health Services  
Under a Cooperative Agreement with the  
Agency for Toxic Substances and Disease Registry

**EXECUTIVE SUMMARY  
HEALTH CONSULTATION**

**LAWRENCE LIVERMORE NATIONAL LABORATORY  
PLUTONIUM CONTAMINATION IN BIG TREES PARK  
LIVERMORE, ALAMEDA COUNTY, CALIFORNIA  
CERCLIS NO. CA2890012584  
March 31, 1999**

The California Department of Health Services (CDHS), Environmental Health Investigations Branch, is conducting health assessment activities at the Lawrence Livermore National Laboratory (LLNL) site in a co-lead capacity with the Agency for Toxic Substances and Disease Registry (ATSDR) Federal Facilities Assessment Branch under cooperative agreement between the two agencies. LLNL is a multi-program research facility about 50 miles southeast of San Francisco and operated by the University of California for the Department of Energy; it was placed on the National Priorities ("Superfund") list in 1987.

The purpose of this health consultation is to evaluate the health impact to residents because of plutonium in Big Trees Park in Livermore, California. Furthermore, this document explores the possible pathways that resulted in plutonium contamination, and evaluates the vertical and horizontal extent of contamination documented in the park. Under current conditions present in the park, the concentrations of plutonium fall below recommended dose limits, and therefore are not considered to be a health concern.

Members of the public expressed concerns about why plutonium was found in a public park and to what extent this contamination exists. Furthermore, ATSDR and CDHS believe that understanding how plutonium came to be in the park is an important step in determining whether or not plutonium contamination may exist at other, now unrecognized locations. Investigating the extent of contamination as well as potential human exposure pathways that may impact public health is the essence of the ATSDR Public Health Assessment process and mandate.

This health consultation reviews two plutonium survey documents: a 1994 report by the United States Environmental Protection Agency (USEPA) which included plutonium data from three public parks, and a 1995 report by LLNL on Big Trees Park. USEPA found plutonium in Big Trees Park at concentrations above what would be attributable to background in 1 and 5 centimeter (cm) deep soil samples. At Big Trees Park, the plutonium 239 (Pu 239) concentration at 5 cm appears to be higher than the concentration at 1 cm. This is in contrast with the other two parks where the concentrations were either comparable, or appeared to decrease at deeper sample depths.

In a follow-up study by LLNL, the elevated concentration of plutonium was confirmed in Big Trees Park at the same location. Additional locations were also above background, but not as high as the original location.

Three potential pathways were evaluated for how the plutonium could have reached the park:

A) Plutonium-contaminated processed sewage sludge (due to plutonium releases from LLNL to the Livermore Water Reclamation Plant), which could have been brought into the park;

B) Aerial dispersion, as plutonium could have been dispersed through air releases and that the park is downwind less than 10% of the year and;

C) Distribution of sediments from Arroyo Seco Creek, as plutonium-contaminated soil has been verified in the southeastern portion of LLNL and surface drainage from this area enters the Arroyo Seco.

Since Big Trees Park and the Arroyo Seco Elementary School are areas where children play and other community members frequent, there is a concern that soils deeper than 5 cm could be brought to the surface, where the public could then be exposed if deep soils are indeed contaminated.

**Recommendations for Further Action:**

1) We recommend further sampling of Big Trees Park and the Arroyo Seco Creek sediments to determine the vertical extent of the plutonium contamination.

2) We recommend further evaluation of the distribution of contaminated sludge throughout the Livermore Valley, and other areas. This would include assessing the different avenues for gathering information on where sludge may have been distributed, and if locations are identified that may have received contaminated sludge, assessing the feasibility of various approaches to characterize the potential plutonium in those areas.

## BACKGROUND AND STATEMENT OF ISSUE

In 1989, the Agency for Toxic Substance and Disease Registry (ATSDR) completed a Preliminary Public Health Assessment that recommended that environmental data be reviewed to assess the potential that human health could have been affected by activities at the Lawrence Livermore National Laboratory (LLNL) Superfund site (1). The California Department of Health Services (CDHS), Environmental Health Investigations Branch (EHIB), is conducting health assessment activities for the LLNL site in a co-lead capacity with ATSDR's Federal Facilities Assessment Branch (FFAB), Division of Health Assessment and Consultation under cooperative agreement between the two agencies.

The purposes of this health consultation are 1) to explore and define the possible pathways (routes) which resulted in plutonium-239 (Pu 239) contamination in Big Trees Park, a public park in Livermore approximately one half mile west of LLNL, and, 2) to evaluate the consequences of plutonium in the park. This contamination was discovered when samples were taken from three city parks in an attempt to obtain information on plutonium concentrations in areas presumed to be unaffected by LLNL operations (2).

The USEPA and CDHS-Radiologic Health Branch (RHB) concluded that the health risk from the maximum concentration of Pu 239 found in the surface samples in the park posed no significant lifetime cancer risk, and that there was no unacceptable risk to human health or the environment (3). This health consultation additionally describes a toxicological review of the data done by ATSDR, which similarly concluded that the concentrations found fall below recommended dose limits for members of the public.

### *The Lawrence Livermore National Laboratory Site*

The Livermore site is approximately 50 miles east of San Francisco. The Livermore site occupies 826 acres and is in the southeast section of the Livermore Valley in Alameda County. Since 1951, LLNL has been an active multi-program research facility, which is operated by the University of California for the Department of Energy (DOE). Many operations at LLNL handle or generate hazardous materials, mixed wastes and radioactive wastes. Some activities at LLNL have resulted in off-site contamination and the potential for exposure to the community of Livermore. In 1987, the United States Environmental Protection Agency (USEPA) placed the Livermore site on the National Priorities List (NPL) of hazardous waste sites, due to volatile organic chemical (VOCs) contamination in the groundwater.

### *Big Trees Park*

Big Trees Park is a community park in a residential tract between Charlotte Way, Kathy Way, and Irene Way, in the city of Livermore (Figure 1). The Arroyo Seco creek (channel) borders the northern boundary of the park. The Arroyo Seco Elementary School is between Irene and Charlotte Way, near the western boundary of the park. Residential homes border the south and west sides of the park. The park consists of a baseball field, a grass playing field, picnic areas,

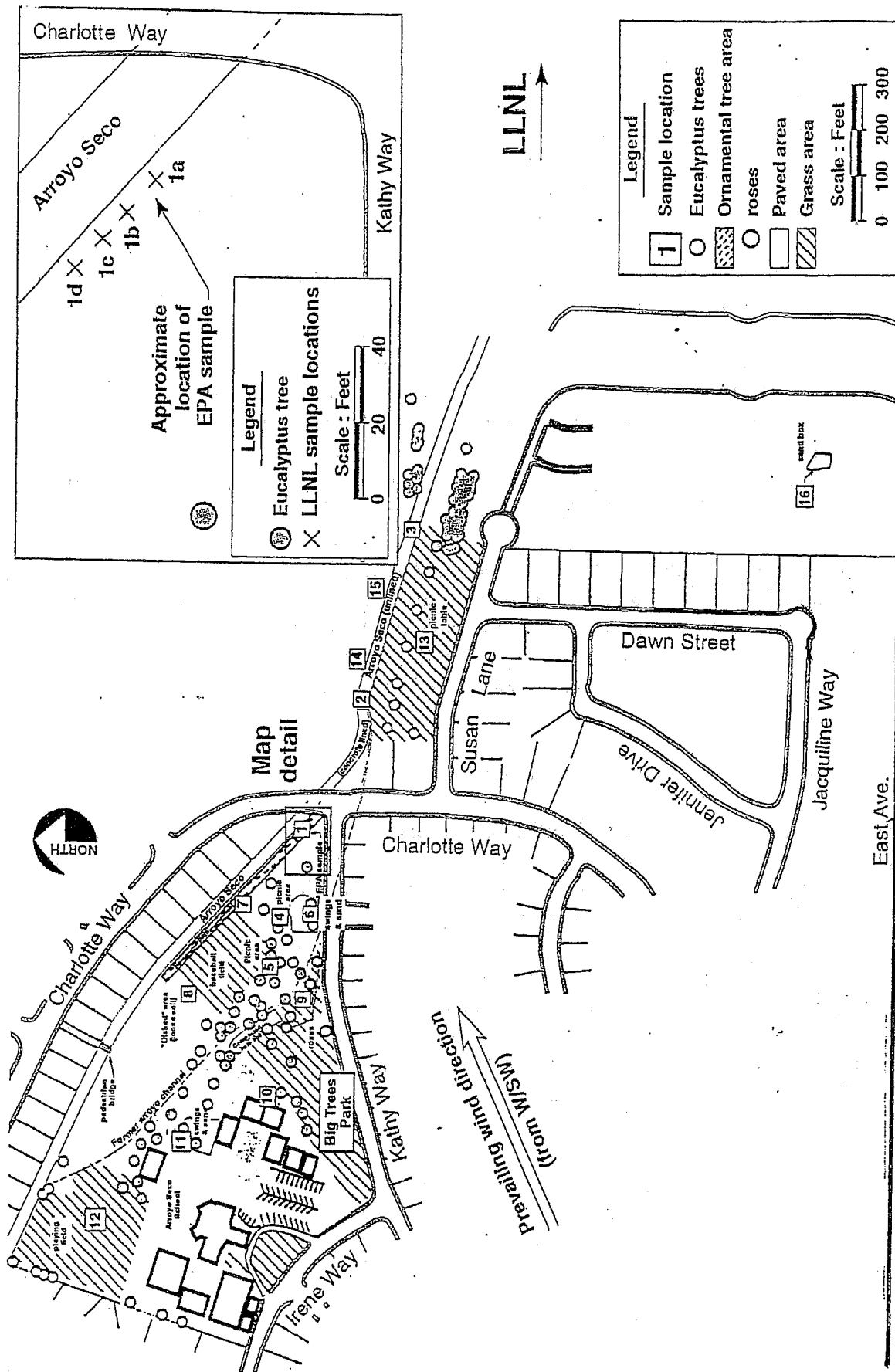


Figure 1. Big Trees Park and vicinity, soil survey sample locations.  
 (Taken from: MacQueen D. Livermore Big Trees January 1995 Soil Survey Results. LLNL; 1995 July UCRL-ID-121045.)

swings and other playground equipment, with many eucalyptus trees throughout. The school population consists of 643 students and 55 staff. Several times between January and June 1997, CDHS-EHIB staff visited Big Trees Park. During those visits, we observed several community members and children using the park and off-road type bicycling in the creek.

### **Rationale and Objectives**

Plutonium is a long-lived, radioactive and hazardous substance. Plutonium-239 contamination at concentrations above what would normally be considered "background" from global fallout has been found at Big Trees Park, in Livermore, California. In a previous study by the USEPA (1994), concentrations of plutonium were measured in three city parks, including Big Trees Park. Based on this limited information, at two of the parks plutonium concentrations appeared to be stratified in the top 5 centimeters of soils decreasing with depth. In the Big Trees Park samples however, plutonium concentrations appear to increase with depth. Although the concentrations in the top 5 centimeters of soil in this park have been determined by ATSDR not to pose a health problem, there is a natural concern about why plutonium was found in a public park and to what extent this contamination exists vertically. Furthermore, ATSDR and CDHS-EHIB believe that understanding how plutonium came to be in Big Trees Park is an important step in determining whether or not plutonium contamination may exist at other, now unrecognized locations. Investigating the extent of contamination as well as potential pathways that may impact the public is the essence of the ATSDR public health assessment process and mandate.

This evaluation at Big Trees Park is especially important because of the park's proximity to an elementary school and its frequent use by community members. Exposure to children is of particular concern. ATSDR and CDHS-EHIB recognize that children are not just "small adults" in terms of assessing how environmental exposures may affect them, and that special consideration must be given to ensure their protection.

Thus, the specific objectives of this consultation are as follows:

- 1) Provide an overview of existing information on plutonium in Big Trees Park;
- 2) Review the potential impact on human health of Pu 239 at the concentrations found in Big Trees Park;
- 3) Describe and evaluate 3 possible pathways by which plutonium could have entered Big Trees Park: a) distribution of processed sewage sludge; b) aerial dispersion, and c) distribution of sediments from Arroyo Seco Creek;
- 4) Evaluate whether or not the sampling performed to date has been adequate to characterize fully the extent of contamination and;
- 5) Make recommendations, if needed, for further investigation based on the information reviewed.



## Methods

### *USEPA 1995 NAREL Study*

In 1994, the USEPA's National Air and Radiation Environmental Laboratory (NAREL) reported on their study to verify the magnitude and extent of plutonium (Pu) contamination in the southeast corner of the LLNL site, which had been confirmed during a survey performed by LLNL in 1991. Plutonium contamination in this area has been documented by LLNL as early as 1971 (2). As part of the USEPA study, soil samples at depths of 1 centimeter (cm) and 5 cm were collected on-site and from three locations believed to be background: Big Trees Park; Sycamore Grove Park; and Sunflower Street Park. These areas were presumed to be unaffected by the operations at LLNL (Figure 2).

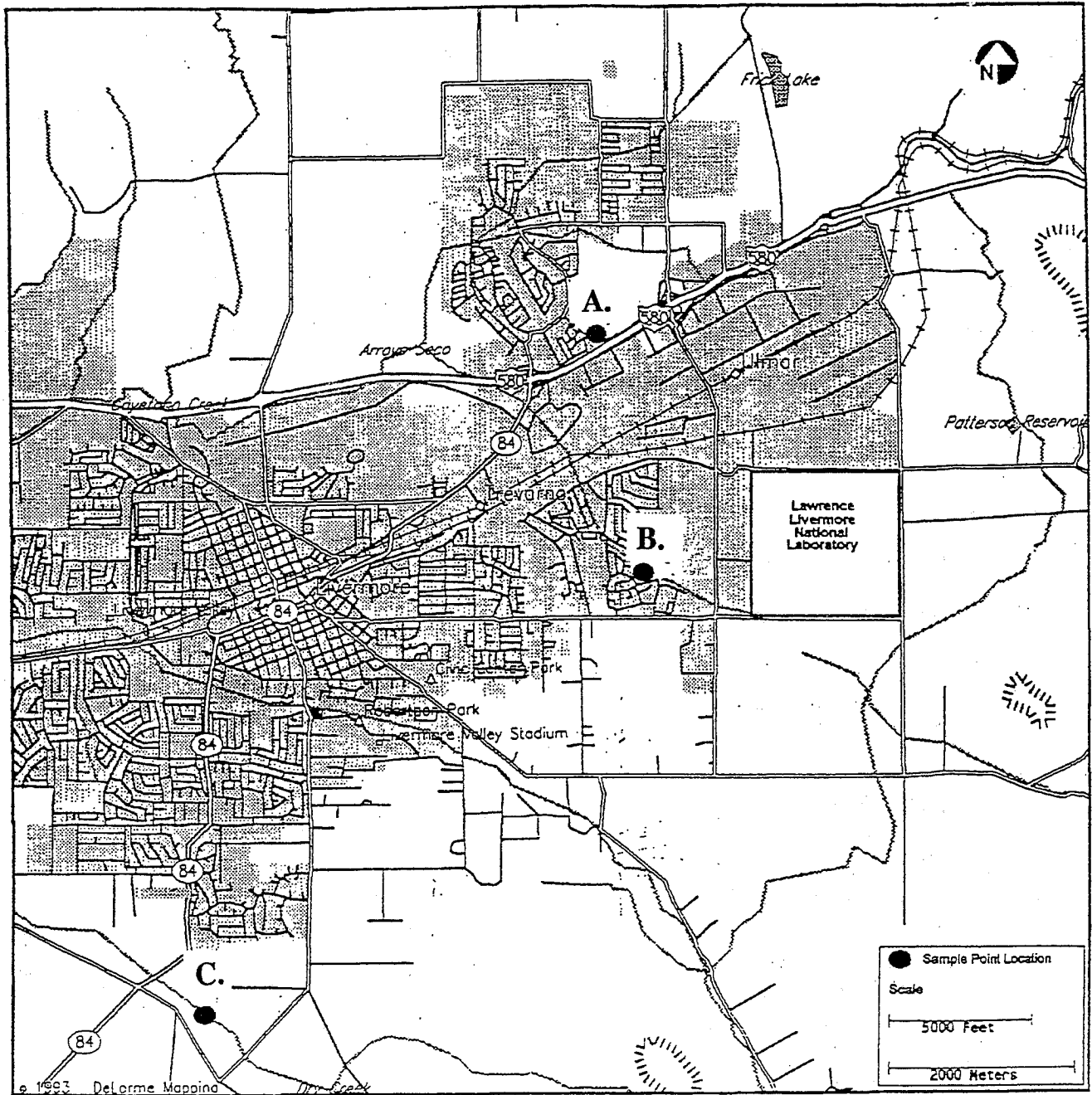
NAREL analyzed the soil samples for cesium 137 (Cs 137), Pu 238, and Pu 239, the results of which are shown in Table 1. Cs 137 concentrations ranged from 0.02 to 0.11 picocuries per gram (pCi/g), 0.0007 to 0.0041 becquerels per gram (Bq/g)<sup>1</sup>, at the three background locations and are present at levels associated with global fallout (0.1 to 3.5 pCi/g [0.0037 to 0.1296 Bq/g]) (4). Pu-238 concentrations in the 1 cm samples from the three locations ranged from 0.012 to 0.014 pCi/g (0.0004 to 0.0005 Bq/g) and are above global fallout (background) levels (0.0005 to 0.002 pCi/g [0.00002 to 0.00007 Bq/g]) (4). Pu-238 concentrations were lower in the 5 cm samples compared with the 1 cm samples collected from Sycamore Grove Park and Sunflower Street Park and were within normal background levels. However, the Pu-238 concentration in the 5 cm sample (0.011 pCi/g [0.0004 Bq/g]) collected at Big Trees Park was about 5 times higher than background level (Table 1).

Table 1 also shows concentrations of Pu 239 at these locations. In the 1 cm and 5 cm samples collected at the Sunflower Park location, the Pu 239 concentrations were 0.007 pCi/g (0.0003 Bq/g) and 0.006 pCi/g (0.0002 Bq/g), respectively, which are attributed to global fallout (0.001 to 0.01 pCi/g [0.00004 to 0.00037 Bq/g]) (2). The Pu 239 concentration in the 1 cm sample (0.046 pCi/g [0.0017 Bq/g]) collected at the Sycamore Park location was above background; however, the 5 cm sample result (0.009 pCi/g [0.0003 Bq/g]) was in the range attributed to global fallout (2). At the Big Trees Park location, Pu 239 concentrations in the soil ranged from 0.075 pCi/g (0.0028 Bq/g) at 1 cm to 0.164 pCi/g (0.0061 Bq/g) at 5 cm (2). Thus, in contrast with Sunflower and Sycamore Park, the Pu 239 concentrations at Big Trees Park appear to increase with depth; however, due to the limited sampling making definitive conclusions regarding stratification of Pu 239 is not possible. Since these values were above the concentrations that could be attributed to global fallout, the USEPA recommended additional sampling in Big Trees Park, which LLNL performed the following year (2).

---

<sup>1</sup> A picocurie (pCi) is equal to 2.2 disintegrations per minute. One becquerel (Bq) is equal to 1 disintegration per second, or 27 pCi. Both are units to describe radioactivity. A pCi of a radioactive contaminant per gram of soil is expressed as pCi/g. A Bq of a radioactive contaminant per gram of soil is expressed as Bq/g.

**Figure 2: Background Locations Sampled for the 1994 NAREL Study.**



- A. Sunflower Street Park**
- B. Big Trees Park**
- C. Sycamore Grove Park**

Table 1. 1994 USEPA/NAREL Study Results at Background Locations <sup>1</sup>

Sample Location	Pu 239/240		Pu 238		Cs 137	
	1cm depth pCi/g (Bq/g)	5cm depth pCi/g (Bq/g)	1cm depth pCi/g (Bq/g)	5cm depth pCi/g (Bq/g)	1cm depth pCi/g (Bq/g)	5cm depth pCi/g (Bq/g)
Sycamore Grove Park	0.046 (0.0017)	0.009 (0.0003)	0.012 (0.0004)	-0.004 (-0.0001)	0.07 (0.0026)	0.07 (0.0026)
Sunflower Street Park	0.007 (0.0003)	0.006 (0.0002)	0.013 (0.0005)	-0.003 (-0.0001)	0.07 (0.0026)	0.02 (0.0007)
Big Trees Park	0.075 (0.0028)	0.164 (0.0061)	0.014 (0.0005)	0.011 (0.0004)	0.11 (0.0041)	0.09 (0.0033)

1. Negative values are assigned by the analyzing systems and computers. A negative value indicates that no material was detected; however, the computers attempt to assign a value.

Typical Backgrounds:

Pu 239/240	0.001 to 0.01 pCi/g [0.00004 to 0.00037 Bq/g]
Pu 238	0.0005 to 0.002 pCi/g [0.00002 to 0.00007 Bq/g]
Cs 137	0.1 to 3.5 pCi/g [0.0037 to 0.13 Bq/g]

*LLNL 1995 Big Trees Survey*

In January 1995, LLNL, with the USEPA and the CDHS-RHB, conducted another soil survey of Big Trees Park to determine if the Pu 239 concentrations reported in the earlier USEPA study represented the soil throughout the park (3). This study consisted of 19 soil samples, collected from 16 locations. One location ("location #1") included 4 samples that were collected in a row, about 10 feet apart, and about 30 feet in length close to where the previous samples were collected for the 1994 USEPA/NAREL study as shown in Figure 1 (3). A coring device was used to collect core samplers to a depth of 5 cm, and the soil from each coring was mixed. Samples were not taken at 1 cm depth nor were any samples deeper than 5 cm taken. The mixture was divided among USEPA, CDHS-RHB, and LLNL staff, who submitted the material for laboratory analysis at the EPA's NAREL, CDHS's Radiological Laboratory, and Lockheed Analytical Laboratories, respectively (3). CDHS tested only 7 samples, so each sample site has either 2 or 3 associated measurements.

Pu 239 concentrations, as reported in Table 2, ranged from -0.00045 to 1.02 pCi/g (-0.00002 to 0.038 Bq/g), a negative value indicating no detection, with the highest concentrations detected in

the four samples collected along the fence next to the Arroyo Seco channel (location #1). This sample was in the general proximity of the samples collected during the 1994 EPA study (Figure 3). The highest concentration of 1.02 pCi/g (0.038 Bq/g) is above the upper range normally attributed to background and about half the USEPA's proposed Preliminary Remediation Goal of 2.5 pCi/g (0.0926 Bq/g), for residential areas (5). Based on this evaluation, the USEPA concluded that "The important thing is that the levels of plutonium detected offsite do not pose an unacceptable risk to the local residents" (5).

## **DISCUSSION**

The following discussion will address several topics including an evaluation of the radiation dose and its impact on public health because of the Pu 239 contaminated soil in Big Trees Park, a general discussion of uncertainty associated with environmental radiation measurements, the route for the Pu 239 found in Big Trees Park, the adequacy of sampling to date in addressing the potential for elevated concentrations of plutonium in Big Trees Park, and additional concerns related to plutonium contamination.

### **1. Evaluation of Radiation Dose**

In April 1995 at USEPA's request, ATSDR reviewed these data from the Big Trees Park sampling events and concluded that the maximum concentration of Pu 239 found in the soil is not at a concentration of health concern (6). The following is an explanation of ATSDR's review.

The calculation as performed by ATSDR used a pica child exposed to the highest measured value of Pu in the park; that is, this is a worst case evaluation representing the maximally exposed individual at the single point of the highest Pu value found only in one location of the park. Anyone digging or playing in this area could be exposed by ingestion of the contaminated soil or by inhalation of resuspended soil particles. Since the origin of the Pu 239 is not known, the particle size was assumed to be very small (0.1  $\mu$ m Activity Median Aerodynamic Diameter [AMAD]) and easily inhaled. The maximum annual airborne particulate count for the Livermore area (7) was assumed to be solely soil particulates. ATSDR also assumed that the Pu 239 in the samples was uniformly mixed and not in a single "hot" particle, especially since split samples and other samples in the vicinity showed similar results (4, 8). Plutonium from fallout is present in soil as an oxide that is not readily soluble nor easily absorbed into the bloodstream (9). Because the chemical form of the Pu 239 in the park is unknown, ATSDR assumed the worse case when determining exposure by ingestion and by inhalation. The estimated committed

effective dose<sup>2</sup> for a two- to three-year old pica child<sup>3</sup> playing in the highest contaminated soil at the park for five

days per week, 50 weeks per year was less than 1 millirem per year (0.01 millisievert per year)<sup>4</sup> above natural background. This estimate of committed effective dose included both exposure from ingestion of soil and inhalation of suspended soil particles (10, 11, 12, 13).

The International Commission on Radiological Protection (ICRP) has evaluated accumulated world-wide data describing radiation damage at low doses, in part to recommend dose limits for occupational and public exposures to radiation. Because there may be no dose of radiation below which no cell damage occurs, the potential for adverse health effects from very low radiation doses are estimated by extrapolating the data from high radiation doses that cause known effects to doses at which adverse health effects are less likely to occur. The ICRP considered, among other types of data, known concentrations of naturally occurring radiation, risks associated with lethal and curable cancers, and hereditary harm.

During the 1970's, the ICRP originally established dose limits at 500 mrem (5 mSv) per year. In 1990, the ICRP recommended a new dose limit for members of the public of 100 mrem (1 mSv) per year from radiation sources other than medical and those occurring naturally in the environment (14). However, no adverse health effects had been observed at 500 mrem (5 mSv) per year. One reasoning for the new dose limit recommendation was to keep exposures "as low as reasonably achievable" (the ALARA principle).

Based on the methodology of ICRP Reports 60 and 61, the cancer risk associated with the ingestion of Pu 239 containing soil for the scenario described above is estimated to be  $5.6 \times 10^{-8}$  for one year and  $1.4 \times 10^{-6}$  for 70 years of exposure. The cancer risk associated with the inhalation of soil particulates is estimated to be  $6.5 \times 10^{-9}$  for one year and  $9.7 \times 10^{-7}$  for 70 years of exposure (14, 15). ATSDR also compared these results with the USEPA's cancer slope factors from their Health Effects Assessment Summary Tables (16). The lifetime excess total cancer risk from the exposure scenario described is similar to the estimate reported by USEPA.

In response to public comments concerning organ doses and the adverse effects on individual organs, ATSDR also estimated committed equivalent doses<sup>5</sup> for the organs of most concern. The maximum committed equivalent doses are given in Table 3 and are:

---

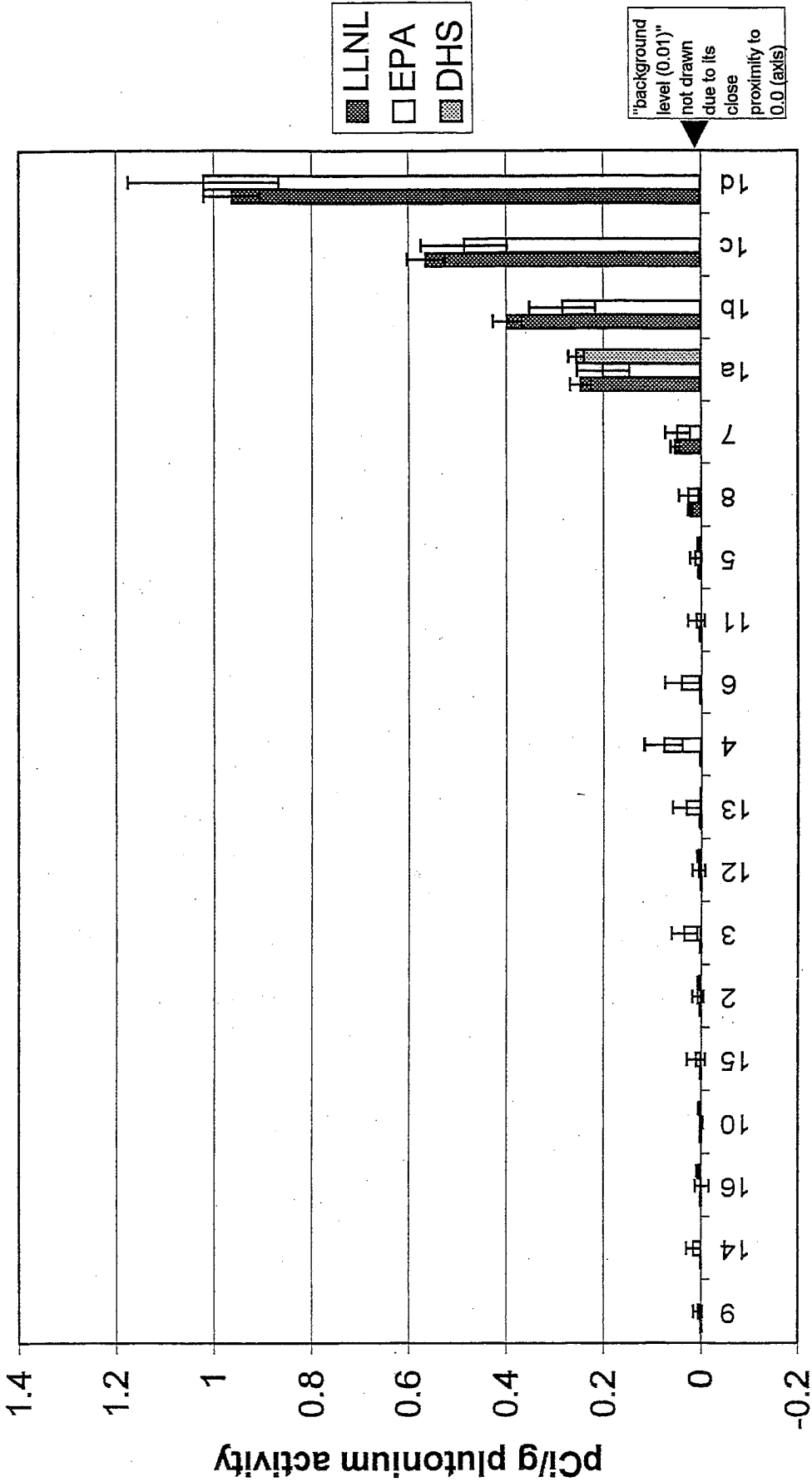
<sup>2</sup> Effective dose is the sum of the weighted equivalent doses in all tissues and organs of the body.

<sup>3</sup> A pica child is a child with a craving for unnatural food, e.g. soils or ashes.

<sup>4</sup> A millirem (mrem) and a millisievert (mSv) are units of dose equivalent or effective dose. One millirem is equal to 0.01 millisievert (1 mrem = 0.01 mSv).

<sup>5</sup> Committed equivalent dose is the absorbed dose average over a tissue organ (rather than at a point) and weighted for the radiation quality (type of radiation).

Figure 3: Plutonium-239 levels<sup>1</sup> in soil samples taken at Big Trees Park, Livermore, California, 1995; analyzed by USEPA, LLNL, and CDHS.



Lab used and sample location number

Background plutonium levels:  
 1) 0.001-0.01 (DOE 1991)  
 2) 0.011-0.013 (LLNL 1995)  
 3) 0.005 (LLNL, Gales, 1990)  
<sup>1</sup>error bars represent measurement uncertainty

Table 2. Pu 239 in Surface Soil Samples from Big Trees Park, Livermore CA, 1995

Laboratory	LLNL/LAL	EPA/NAREL	CDHS/RHB
Location Number (see Figure 1)	Measured Activity in pCi/g (Bq/g)	Measured Activity in pCi/g (Bq/g)	Measured Activity in pCi/g (Bq/g)
9	-0.00045 (-0.00002)	0.00645 (0.00024)	NA
14	0.00035 (0.00001)	0.0153 (0.00057)	NA
16	0.0004 (0.00001)	-0.0021 (-0.00008)	0.006 (0.00022)
10	0.00043 (0.00002)	-0.0013 (-0.00005)	0.004 (0.00015)
15	0.0007 (0.00003)	0.0105 (0.00039)	NA
2	0.0009 (0.00003)	0.0066 (0.00024)	0.004 (0.00015)
3	0.0009 (0.00003)	0.034*(0.00126)	NA
12	0.0009 (0.00003)	0.00483 (0.00018)	0.005 (0.00019)
13	0.0012 (0.00004)	0.0301 (0.00111)	0.001 (0.00004)
4	0.0014 (0.00005)	0.0772 (0.00286)	NA
6	0.0017 (0.00006)	0.0393 (0.00146)	NA
11	0.0017 (0.00006)	0.00953 (0.00035)	NA
5	0.0036 (0.00013)	0.0111 (0.00041)	0.004 (0.00015)
8	0.0215 (0.00080)	0.0251 (0.00093)	NA
7	0.0533 (0.00197)	0.0481 (0.00178)	NA
1a	0.247 (0.00915)	0.2 (0.00741)	0.256 (0.00948)
1b	0.397 (0.01470)	0.284 (0.01052)	NA
1c	0.564 (0.02089)	0.486 (0.01800)	NA
1d	0.962 (0.03563)	1.02 (0.03778)	NA

NA: Not analyzed

(\*): EPA/NAREL 0.034 pCi/g value has a large measurement of uncertainty 0.026. Negative values are a result of background subtraction by the laboratory (data source: LLNL Big Trees Survey. UCRL-ID-1210451. 1995).

Table 3. Radiological doses to the organs

Organ	Maximum Committed Equivalent Dose	Individual Type
Bone surface	9.1 mrem/yr ( $9.1 \times 10^{-5}$ Sv/yr) 6.5 mrem/yr ( $6.5 \times 10^{-5}$ Sv/yr)	Pica Child Adult
Red Marrow	0.95 mrem/yr ( $9.5 \times 10^{-6}$ Sv/yr) 0.31 mrem/yr ( $3.1 \times 10^{-6}$ Sv/yr)	Pica Child Adult
Liver	3.2 mrem/yr ( $3.2 \times 10^{-5}$ Sv/yr) 1.4 mrem/yr ( $1.4 \times 10^{-5}$ Sv/yr)	Pica Child Adult
Lung	0.05 mrem/yr ( $4.9 \times 10^{-7}$ Sv/yr) 0.01 mrem/yr ( $1.2 \times 10^{-7}$ Sv/yr)	Pica Child Adult

No detrimental effects on the functions of these organs are expected from these estimated doses for the maximally exposed individual. Additional information regarding weighting factors is found in appendix A.

## **2. Uncertainty issues associated with the evaluation of environmental radiation levels**

Many considerations must be taken into account during the evaluation of environmental radiation samples, especially those samples at or near values considered background values. For example, each measurement has an associated level of uncertainty, called the error of the measurement and is usually expressed as a 95% confidence interval (C.I.). The C.I. represents an error of 2 standard deviations. This means that the reported value is thought to be correct 95% of the time with only a 5% chance that the “true” number is outside the range in the given interval. Because of this, the true measurements may be greater or less, within a given range, than the specific value reported. When radiological samples with concentrations that approach either the lowest level that can be detected by the instrumentation or approach the levels associated with background are analyzed, the C.I. increases dramatically because of the counting procedures and instrumentation parameters. Therefore, it is common to find C.I. values approaching 50% or more of the measured value.

As an example and using the previous sampling events in Big Trees Park, the C.I. associated with each value is shown by the bars in Figure 4 that shows Pu 239 concentrations along with a line representing nominal background concentrations at 0.01 pCi/g ( $3.7 \times 10^{-4}$  Bq/g). For example, location #5 the measured activity was  $3.6 \times 10^{-3}$  pCi/g [ $1.3 \times 10^{-4}$  Bq/g] by Lockheed Analytical Laboratories, has a C.I. of  $2.3 \times 10^{-3}$  pCi/g, and thus the “true” value could be as low as  $1.3 \times 10^{-3}$  pCi/g [ $5 \times 10^{-5}$  Bq/g] or as high as  $5.9 \times 10^{-3}$  pCi/g [ $2.2 \times 10^{-4}$  Bq/g]. As an initial observation of any of these types of data, one can argue that if the C.I. overlaps among the data points, then there is no significant difference among those data.



Figure 4 excludes the four “hot spot” values to magnify the scale to show the variation in measurements present at these low concentrations. The reference ranges of background concentrations of Pu 239 values attributable to atmospheric testing and fallout are as follows:

0.001 pCi/g to 0.01 pCi/g	[0.00004 Bq/g to 0.00037 Bq/g]	(2);
0.005 pCi/g	[0.00019 Bq/g]	(17);
0.011 pCi/g to 0.013 pCi/g	[0.00041 Bq/g to 0.00048 Bq/g]	(4);

therefore, the data suggest that Pu 239 may be present in surface soil of big Trees Park greater than accepted background levels and this excess is not confined to a single area or “hot spot.”

### **3. Pathway (Route) Investigation**

#### **A) Processed Sewage Sludge**

##### *1967 Accidental Pu 239 Release*

Between May 25 and June 15 of 1967, an accidental release of Pu 239/Americium 241 (Am 241) from LLNL (known as Livermore Radiation Laboratory in 1967) to the city’s sanitary sewer, resulted in contaminating the sewage sludge at the Livermore Water Reclamation Plant (LWRP) (18). Characterization of the sludge by LLNL was based on estimations from measurements of gross alpha activity in the liquid effluent and suspended sediment. However, there was no sampling of the waste solids from in any part of the LWRP process (18). Since Pu 239 associates with solids, the amount of Pu 239 may have been underestimated because the activity in solids was never measured. Thus, it appears that Pu 239 concentrations in the sludge at LWRP may not have been adequately characterized. It is important to note, however, that besides possible contaminants such as Pu 239, gross alpha measurements also contain activities of naturally occurring radionuclides such as uranium 238 and thorium 232 with their associated decay products, many of which are alpha emitters. Thus, there was no direct measurement of Pu 239 at that time.

Since the release of the Public Comment Draft of this health consultation, CDHS has obtained historic effluent and sewage sludge radiologic data from the Radiologic Health Branch (RHB) of the CDHS (19). These data were part of the State of California’s radiologic monitoring of public sewage treatment facilities. LWRP collected monthly effluent and digester sludge samples, which were sent to RHB (formerly known as the State of California, Department of Public Health, Bureau of Radiologic Health) for analysis. Historic concentrations of alpha activity as high as 297 pCi/g [11.0 Bq/g] were measured in dried digester sludge from LWRP in 1964. Alpha activity was measured in digester sludge at LWRP during May and June of 1967 (general time frame of the accidental release. The alpha activity was reported at a concentration of 258 pCi/g (9.6 Bq/g) and 229 pCi/g (8.5 Bq/g), respectively (19). While these data indicate high levels of alpha activity, they may not be representative of alpha activity that could be found in processed sewage sludge, the form of sludge that was available to the public. Processed sewage

sludge is the end result of the waste treatment processes after the sludge has left the digesters and is transferred to sludge lagoons or drying beds, where some mixing with fresh sludge and uncontaminated soils would occur (17). Correspondence from LLNL to LWRP indicates LLNL first began monitoring for Pu 239 in processed sewage sludge at the LWRP in 1973 with the highest concentration of Pu 239 (4.4 pCi/g; 0.16 Bq/g) reported in the drying beds in 1975 (20).

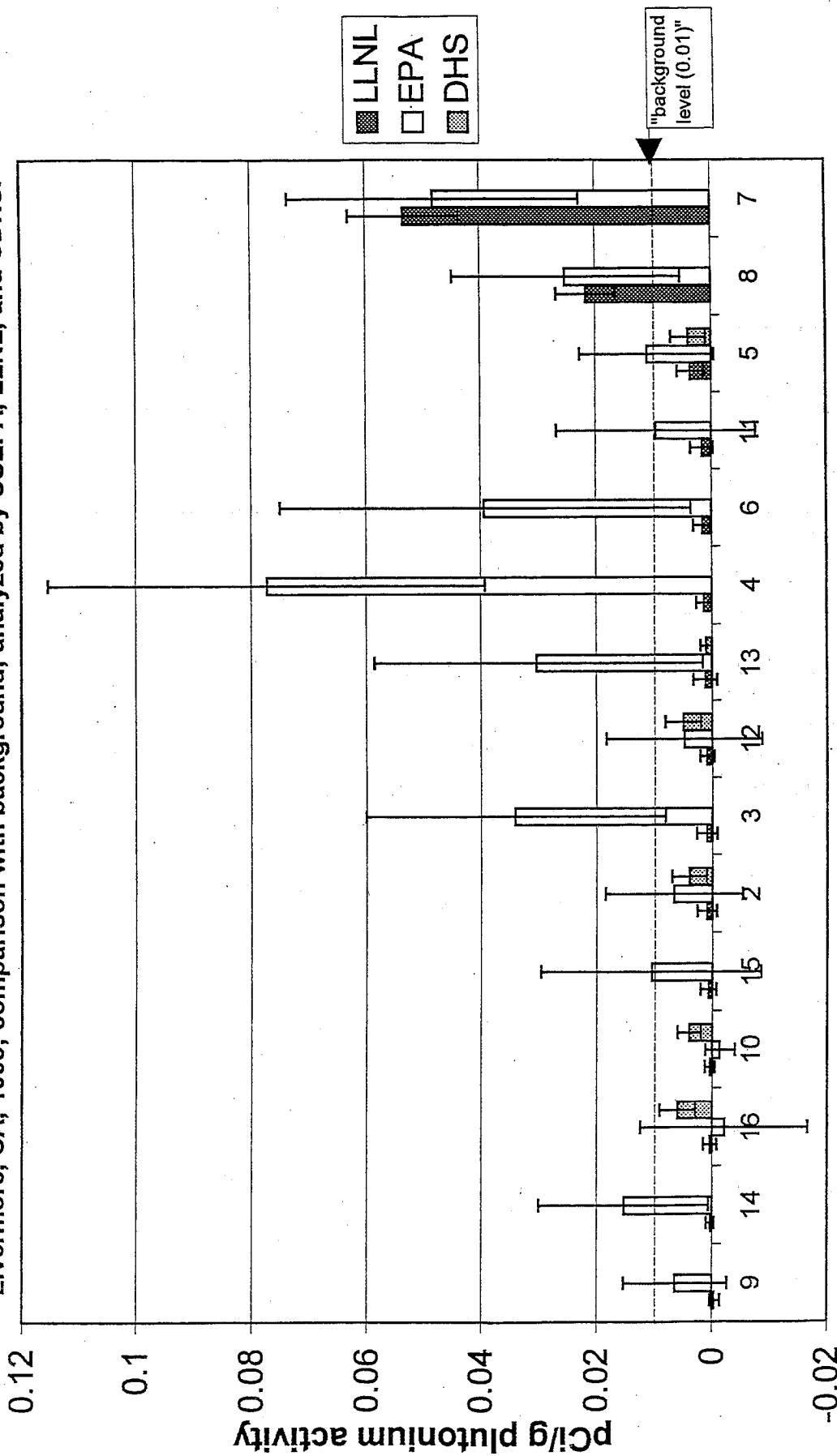
#### *Use of sludge as a soil amendment*

An LLNL report from 1975 states that processed sludge from the LWRP was available to the public and commonly was used as a soil amendment for gardens and lawns (21). To verify this, CDHS-EHIB interviewed a former employee of the LWRP, who worked there during the late 1960's and 1970's. The former LWRP employee confirmed that sewage sludge was available and widely distributed to the public (22). During this interview, CDHS-EHIB also learned that LWRP maintained a visitor's log book containing the names and addresses of citizens who obtained the sludge during that time (22). LLNL also confirmed the existence of such a log book, based on their (appended) comment to this document that states, "Lab employees visiting the LWRP in 1974 met with sewer plant employees and saw the log book" (Appendix B). CDHS-EHIB has attempted to obtain a copy of the visitor's log book to gain an understanding of the quantity and potential locations of the contaminated sludge distributed to the public. CDHS-EHIB staff requested this information from LWRP, receiving response that no such log book exists.

In a fact sheet distributed by the USEPA, the placement of soil containing Pu 239 contaminated sewage sludge was suggested as the most logical hypothesis for the route by which the Pu 239 contaminated Big Trees Park (5). No records exist that show how or when the "placement" of the contaminated soil occurred. One possible scenario is that Pu 239 contaminated sewage sludge was used as a soil amendment during the development of Big Trees Park during or after the early 1970's. To investigate this, CDHS-EHIB staff in April 1997 interviewed the Superintendent of Parks and Planning for the Livermore Area Recreation and Parks District (LARPD) who was involved with the development of Big Trees Park. He informed us that soil amendments are only used when specified in the construction plans, and no such specification was found in the construction plans for Big Trees Park (23). He also stated that LARPD never used sewage sludge as a soil amendment in any public park (23).

LLNL staff also suggested that residents obtained sewage sludge from the LWRP for use in their yards, and also distributed the sludge in Big Trees Park (24). Without the LWRP's visitor's log book, this theory can neither be discounted nor verified.

Figure 4: Plutonium-239 levels<sup>1</sup> (excluding 4 high values) in soil samples from Big Trees Park, Livermore, CA, 1995; comparison with background; analyzed by USEPA, LLNL, and CDHS.



Lab used and sample location number

Background Pu-239 levels:

- 1) 0.001-0.01 (DOE 1991)
- 2) 0.011-0.013 (LLNL 1995)
- 3) 0.005 (LLNL, Galles, 1990)

<sup>1</sup>Error bars represent measurement uncertainty

## B) Aerial Dispersion

### *Wind factors relating to aerial dispersion*

The airborne release and transport of contaminants from emission sources can occur in many ways. Aerial dispersion is a complex process governed by many factors such as wind direction, wind speed, turbulence, mixing height, diffusion, terrain, biota presence, particle size, and chemistry. The transport of air pollutants from point sources, such as stack emissions, is more sensitive to wind direction than any other factor (25). The predominant wind direction in the Livermore Valley is from a west/southwest direction, during which times Big Trees Park is upwind from LLNL. The annual wind rose for the Livermore Valley (26) suggests that Big Trees Park is downwind from LLNL less than 10% of the year. This is based on the percentage of time that winds originate from directions between east to northeast, the wind directions that would cross LLNL property traveling toward the park. Since aerial dispersion in the downwind direction has been verified in studies by LLNL staff (26) as based on annual environmental monitoring reports, this suggests the plausibility of aerial deposition at Big Trees Park as a pathway for a one time “puff” release or minute releases over time from LLNL. However, aerial deposition does not explain the higher concentrations or “hot spot” seen in the four samples collected from location #1 in Big Trees Park.

### *Eucalyptus trees as pathway*

As a possible pathway of the Pu 239 found in the park, a community member has suggested that aerial deposition of Pu 239 onto the leaves of eucalyptus trees, followed by the leaves and branches naturally falling to the ground, deposited plutonium to the soil. Location #1 is an area near a eucalyptus tree and thus this may seem like a plausible explanation for the higher concentration of Pu 239 measured in this sample. However, we would expect to see similar elevated Pu 239 concentrations near other eucalyptus trees, and this was not seen. For instance, samples collected from location #5 were taken near eucalyptus trees, and were elevated compared to background, but much lower than samples collected from location #1 (Figure 1 and Table 2). Since it is unlikely that this phenomenon occurred only to the trees near sample #1, the plutonium-laden leaf theory may not be the most likely explanation.

## C) Sediments from Arroyo Seco Creek

### *Drainage from LLNL to the Arroyo Seco*

The distribution of contaminated sediments originating from the Arroyo Seco channel to Big Trees Park is another potential source that CDHS-EHIB staff has explored. While we cannot state with certainty that the Arroyo Seco is the source, the following is known: 1) plutonium-contaminated soil has been verified in the southeastern portion of LLNL and; 2) historically surface drainage from this area may have entered the Arroyo Seco although LLNL made engineering changes to on-site drainage directions in the 1960s (Figure 5) (27).

### *Radiation laboratory sewer line break under the Arroyo Seco*

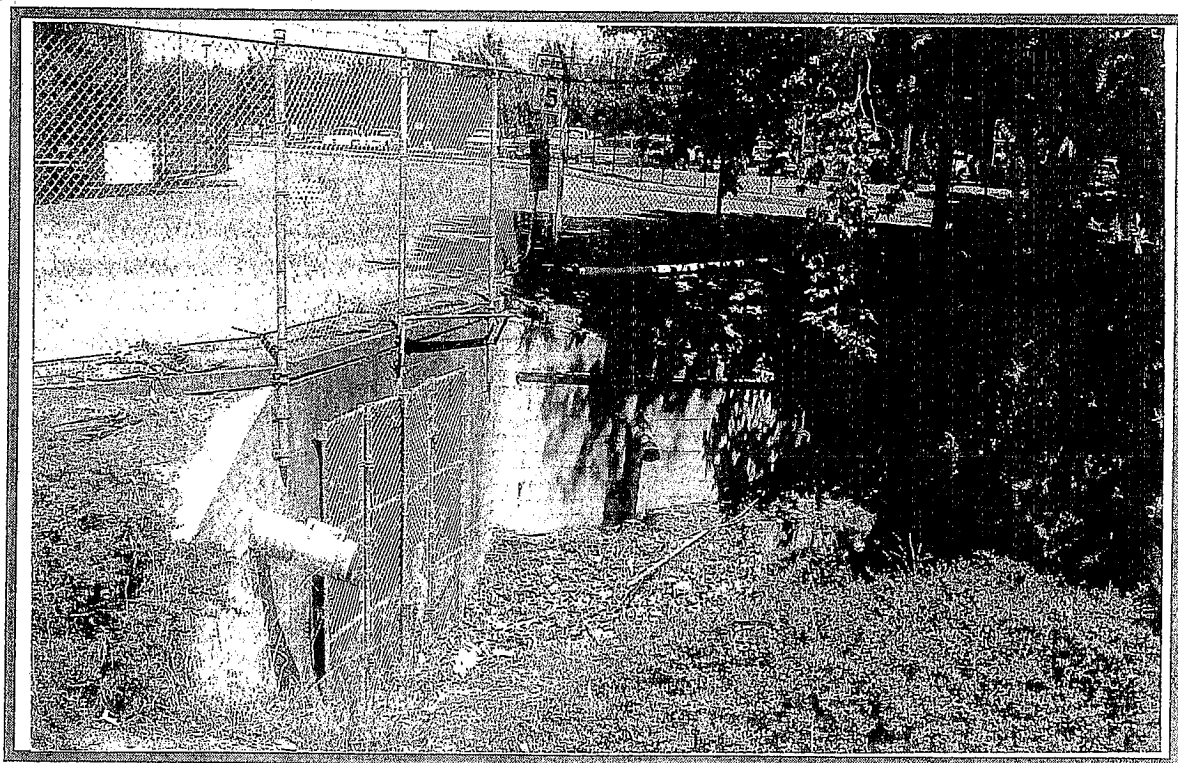
Since the release of the Public Comment Draft of this health consultation, CDHS-EHIB staff has learned of another potential pathway that may have contaminated the sediments in the Arroyo Seco. CDHS-EHIB staff interviewed the former Superintendent of LWRP, who informed us that the radiation laboratory sewer line from the LLNL and Sandia National Laboratory (SNL) crosses under the Arroyo Seco, upstream of Big Trees Park (28). We were also told that this sewer line had been broken for an indeterminate amount of time during the early 1970's (28). CDHS-EHIB has formally requested information from LWRP relating to the location and history of breaks and repairs of the sewer line. The City of Livermore has responded with a letter stating that they are not able to fulfill our request (29). CDHS-EHIB, therefore, raised this issue in our comments to the LLNL Draft 1998 Sampling Plan for Big Trees Park.

### *Development of Big Trees Park and the Arroyo Seco realignment*

CDHS-EHIB postulates that plutonium-contaminated sediments from the Arroyo Seco were redeposited during the development of the park. During its development, the Arroyo Seco was realigned and structural improvements made (31) (Figure 1). In an effort to reconstruct how the Arroyo Seco was realigned, CDHS-EHIB staff reviewed the "Soil Investigation Report / Grading Plans" and the "Progress Report of Inspection and Testing of Lot Grading and Backfilling of Portions of Old Drainage Channel" (31, 32). Before the realignment of the Arroyo Seco in the early 1970's, the creek was approximately 135-200 feet south of its current location, and flowed through what is now Big Trees Park and the Arroyo Seco Elementary School (31). Prior to the development of Big Trees Park and construction of the Arroyo Seco Elementary School, the depth of the original Arroyo Seco ranged from approximately 3 feet to 9 feet below natural grade. Compaction test results taken in the former Arroyo Seco and in the lots suggest that only soils generated on-site (cut areas) were used as fill material (32).

As part of the channel improvements, the realigned portion of the channel bed and walls were lined with a 5" thick section of concrete. In the areas where the channel was not concreted (locations #2, 14, 15), improvements were made to the slopes, as explained in the Soils Report "where the existing gully bank has a slope ratio steeper than 5 horizontal feet to 1 vertical feet, horizontal benches at least four feet wide shall be cut into the natural slope" (Figure 1) (31). Cutting into the existing slope would generate excess soil from the banks and the channel bottom that may have been used as fill material for the former Arroyo Seco, Big Trees Park, or the development tract. When CDHS-EHIB staff visited Big Trees Park, they observed that improvements to the slopes obviously had been made in the areas where the two creek bottom samples were collected during the 1995 Soil Survey (Figure 6a.). After observing the cut along the bottom of the slope, CDHS-EHIB believes that part of the channel bottom may have been cut, generating fill material (Figure 6b.)

Figure 5. Arroyo Seco Discharge Points at LLNL.  
(Photograph taken June, 1997 during dry season)



CDHS-EHIB and ATSDR staff believe that based on currently available information and observations, the sediments in the Arroyo Seco channel may have been the major contributing source of the Pu 239 discovered in Big Trees Park. The sediments could have been distributed in the park during grading operations, possibly by heavy equipment tracking channel sediments through the park.

#### **4. Adequacy of the sampling conducted to date**

##### *Lack of vertical sampling*

In the 1995 Soil Survey Report, LLNL concluded that the source of Pu 239 could not have come from the sediments out of the Arroyo Seco channel because the two samples collected from the channel bottom at 5 cm depth did not reveal plutonium concentrations above background (3). According to several LLNL documents, the methodology that should be used to characterize radionuclides in sediments involves collecting samples at depths of 11.7 inches to 17.6 inches (30 to 45 cm) (27, 33). The shallower sampling methodology (1 cm and 5 cm) used in both the 1994 NAREL study and the LLNL 1995 Soil Survey of Big Trees Park was not, according to LLNL's own documents, the correct method to characterize sediments. Sampling should have been done at greater depths, if the sampling were to investigate sediment (27, 33). Even if the contamination is due to distribution of sludge, defining the vertical extent of contamination is still important, especially since higher concentrations were noted at 5 rather than 1 cm depths, as discussed earlier.

##### *Potential for soil-disturbing activities*

Since Big Trees Park and the Arroyo Seco Elementary School are areas where children play and other community members frequent, CDHS-EHIB and ATSDR feel that there is a possibility for potentially contaminated soils deeper than 5 cm (about 2 inches) to be brought to the surface, whereby the public could then be exposed. This could easily happen several ways, such as children digging in the park, future landscaping changes or park improvements, or excavation for irrigation lines or other utilities throughout the park and the school.

#### **5. Additional concerns related to plutonium contamination**

Although the issue of Big Trees Park receiving sludge remains unresolved, the practice of sewer sludge distribution raises the question about other destinations for this material. If this distribution occurred to municipal agencies and the public for many years prior to 1973 when processed sludge monitoring at LWRP began, then there is a substantial period for which the levels of Pu 239 in sludge distributed to the public are not known.

Figure 6a. Arroyo Seco Channel Slope Walls.

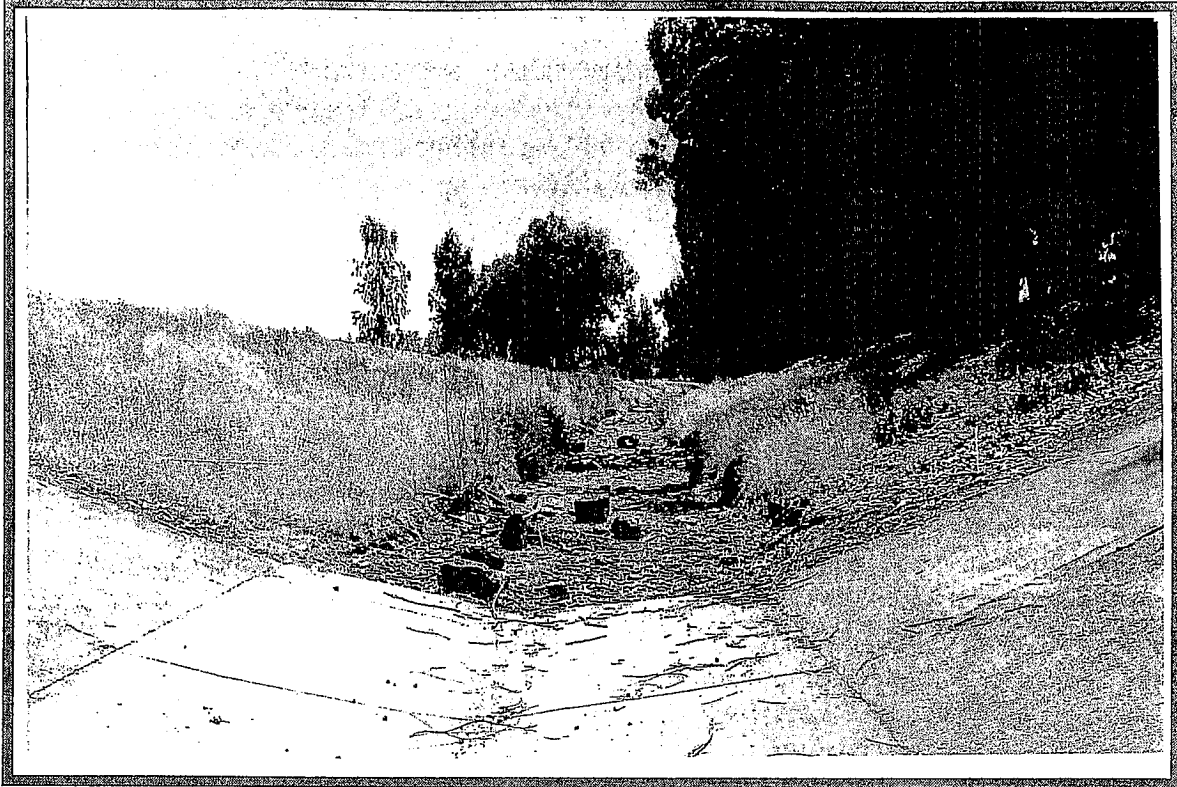


Figure 6b. Cut Along Toe (Bottom) of Slope





## CONCLUSIONS

CDHS-EHIB and ATSDR have evaluated the health impact to residents because of plutonium in Big Trees Park and offer the following conclusions.

### *1. Radiation contamination analysis*

The radiological analysis included the reevaluation of two exposure routes: 1) ingestion of contaminated soil and; 2) inhalation of resuspended soil particles. The routes considered a young child playing in the park where the maximum Pu 239 concentration (1.02 pCi/g [0.03778 Bq/g]) was found. ATSDR has confirmed that Pu 239 found in surface soil at Big Trees Park is below a concentration of health concern.

### *2. Pathway analysis*

CDHS-EHIB staff has investigated three potential pathways for the Pu 239 to reach Big Trees Park: sewage sludge; aerial deposition; and sediment distributions from the Arroyo Seco. Although CDHS-EHIB cannot draw conclusions without additional investigations, we have shown the plausibility that the Pu 239 discovered in Big Trees Park may be the result of sediment distribution from the Arroyo Seco channel.

It is also plausible that limited aerial deposition may have occurred. Although sludge distribution from LWRP probably occurred, it is not known whether Big Trees Park was a recipient, and a reliable source disputes this theory.

### *3. Adequacy of sampling*

Because the previous investigations only sampled surface soil to a depth of 5 cm, additional soil sampling is needed to define the vertical and horizontal extent of Pu 239 contamination in the Arroyo Seco channel and in Big Trees Park. This is necessary to: 1) determine if the previous sampling efforts truly represent the extent of plutonium contamination in Big Trees Park and; 2) determine if additional hazards to human health exist from potential exposure to Pu 239 that may exist at greater depths.

### *4. Additional areas warranting investigation*

The possible past distribution of contaminated sewage sludge throughout the Livermore area is a potential health concern that warrants further investigation, especially since alpha activity as high as 297pCi/g (11.0 /g) was documented in digester sludge from the LWRP in 1964.

## **PUBLIC HEALTH ACTION**

The Public Health Action Plan for the Big Trees Park site contains a description of actions that have been taken or will be taken by ATSDR and CDHS-EHIB. These recommendations are based on the findings presented in this health consultation.

### **A. Recommendation for Further Action:**

- 1) We recommend further sampling of Big Trees Park and the Arroyo Seco Creek sediments to determine the vertical and horizontal extent of the Pu 239 contamination.

*Status: This recommendation has been addressed by the 1998 Big Trees Sampling event and the results will be the subject of an ATSDR-prepared public health consultation.*

- 2) We recommend further evaluation of the distribution of contaminated sludge throughout the Livermore Valley, and other areas. This would include assessing the different avenues for gathering information on where sludge may have been distributed, and if locations are identified that may have received contaminated sludge, assessing the feasibility of various approaches to characterize the potential plutonium in those areas.

*Status: ATSDR, the state, and regulatory agencies will be discussing this issue at later meetings.*

- 3) We recommend that potential contaminant releases from sewer line ruptures be investigated in future health consultations focusing on sediments in the Livermore Valley or LLNL discharges to the sanitary sewer system.

## PREPARERS OF REPORT

### Environmental and Health Effects Assessors:

Tracy Barreau Research Specialist Impact Assessment, Inc., Contractor to Environmental Health Investigations Branch California Department of Health Services	Marilyn C. Underwood, Ph.D. Staff Toxicologist Environmental Health Investigations Branch California Department of Health Services
--	---

Sumi Hoshiko, M.P.H. Epidemiologist Impact Assessment, Inc., Contractor to Environmental Health Investigations Branch California Department of Health Services	Carol Connell Health Physicist Federal Facilities Assessment Branch Agency for Toxic Substance and Disease Registry
--	--

### Community Relations Coordinator:

Gina Margillo, M.A.  
Community Relations Coordinator  
Impact Assessment, Inc., Contractor to  
Environmental Health Investigations Branch  
California Department of Health Services

## ATSDR REGIONAL REPRESENTATIVES

William Nelson  
William Deviny  
Gwendolyn Eng  
Dan Strausbaugh  
Regional Services, Region IX  
Office of Regional Operations

## REFERENCES

1. Agency for Toxic Substance and Disease Registry. Preliminary Public Health Assessment. U.S. Department of Health and Human Services; 1989 April.
2. National Air and Radiation Environmental Laboratory. Confirmatory Sampling of Plutonium in Soil from the Southeast Quadrant of the Lawrence Livermore National Laboratory. United States Environmental Protection Agency; August 15, 1994.
3. MacQueen, Don. Livermore Big Trees Park January 1995 Soil Survey Results. Lawrence Livermore National Laboratory; 1995 July. UCRL-ID-121045.
4. United States Environmental Protection Agency. Radiation Site Cleanup Regulations: Technical Support Document of Radionuclide Cleanup Levels for Soil. Office of Air and Radiation; Draft September 1994.
5. United States Environmental Protection Agency. Lawrence Livermore National Laboratory Plutonium Fact Sheet; 1995 September.
6. Agency for Toxic Substance and Disease Registry. ATSDR record of activity for telephone communication with EPA/Region IX representative. 1995 April 12.
7. United States Environmental Protection Agency. Aerometric Information Retrieval System, Office of Air Quality Planning and Standards, Research Triangle Park, NC; July 1997.
8. McConachie, W. Livermore Big Trees Park Soil Survey. Lawrence Livermore National Laboratory; January 1995.
9. Kathren, RL (1984). Radioactivity in the Environment-Sources, Distribution, and Surveillance. New York: Harwood Academic Publishers. 397 pp.
10. International Commission on Radiological Protection. ICRP Publication 56, Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 1. Pergamon Press, New York; 1989 April.
11. International Commission on Radiological Protection. ICRP Publication 67, Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 2. Pergamon Press, New York; 1993 April.
12. International Commission on Radiological Protection. ICRP Publication 66, Human Respiratory Tract Model for Radiological Protection. Pergamon Press, New York; 1993 September.

13. International Commission on Radiological Protection. ICRP Publication 71, Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 4 Inhalation Dose Coefficients. Pergamon Press, New York; 1995 September.
14. International Commission on Radiological Protection. ICRP Publication 60, 1990 Recommendations of the International Commission on Radiologic Protection. Pergamon Press, New York; 1990 November.
15. International Commission on Radiological Protection. ICRP Publication 61, Annual Limits on Intake of Radionuclides by Workers Based on the 1990 Recommendations. Pergamon Press, New York; 1990 November.
16. United States Environmental Protection Agency. Health Affects Summary Tables, FY-1995 Annual. USEPA; 1995 May. 9200.6-303 (95-1), EPA/540/R-95/036, PB95-921199.
17. Lawrence Livermore National Laboratory. Letter to Dan Cloak (LWRP) from Harry Galles (LLNL) re: Plutonium at the Water Reclamation Plant. 1990 December 4.
18. Lawrence Radiation Laboratory (LRL). Letter to E.C. Shute, U.S. Atomic Energy Commission from D.C. Sewell, Associate Director, LRL re: Summary Hazards Analysis - Pu Am Release to Sanitary Sewer. 1967 August 22.
19. California Department of Health Services, Radiologic Health Branch. Data sheets entitled Gross Radioactivity in Sewage Samples: 1960-1969.
20. Lawrence Livermore National Laboratory. Letter to Dan Cloak (LWRP) from Harry Galles (LLNL) re: Historical Measurements of Plutonium at the Water Reclamation Plant. 1990 December 10.
21. Lawrence Livermore National Laboratory. Evaluation of the Use of Sludge Containing Plutonium as a Soil Conditioner for Food Crops; 1975 September. UCRL-77318.
22. Personal Communications with a former representative of the Livermore Water Reclamation Plant, August 1997.
23. Personal Communication with the Superintendent of Parks and Planning, Livermore Area Recreation and Parks Department. 1997 April 21, and 1997 June.
24. Personal Communications with a representative of the Environmental Protection Department, Lawrence Livermore National Laboratory. 1997 July 1.
25. Stern, A., Babble, R., Turner, B., and Fox, D. Fundamentals of Air Pollution, Florida: Academic Press, Inc., 1984.

26. Gallegos, Gretchen. Surveillance Monitoring of Soils for Radioactivity: Lawrence Livermore National Laboratory 1976 to 1992. Health Physics 1995 Oct.; 69(4): 487-493.
27. Lawrence Livermore National Laboratory. Environmental Monitoring at the Lawrence Livermore National Laboratory Annual Report 1987; 1988. UCRL-50027-87.
28. Personal Communications with the former Superintendent of the Livermore Water Reclamation Plant. 1998, February.
29. The City of Livermore. Letter to the California Department of Health Services/Environmental Health Investigations Branch. 1998, April.
30. Cooper Clark and Associates. Report Soil Investigation Tract 3064, Livermore California for Kaufman and Broad; 1969 December 11.
31. Cooper Clark and Associates. Progress Report Inspection and Testing of Lot Grading and Backfilling of Portions of Old Drainage Channel Proposed Residential Subdivision Lots 9 through 12, Tract 3064, Unit 1 for Kaufman and Broad; 1970 September 24.
32. Lawrence Livermore National Laboratory. Final Environmental Impact Statement and Environmental Impact Report for the Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratory; 1992 August. SCH90030847.

## Appendix A

### Weighting Factors

When estimating radiation doses from the ingestion or inhalation of radioactive materials, weighting factors are used to convert from units of radiation dose, the rad to units of equivalent dose ( $H_T$ ) and effective dose (E), the rem or sievert. These weighting factors modify the response by taking into account a number of variables such as the type and energy of the particle or photon (radiation weighting factor) and the risk of cancer induction of a particular organ (tissue weighting factor) as a function of the absorbed dose. These factors are developed and described by the International Commission on Radiological Protection (ICRP) in ICRP Report 60, (ICRP, 1990).

The radiation weighting factors, signified as  $W_r$ , are defined as discrete values although there is some uncertainty associated with experimental results. The values, listed by the ICRP (1990) are given in the following table.

Type of Radiation	Radiation Weighting Factor	Example Radionuclide
Beta particles	1	tritium
Gamma radiation	1	cesium-137 (also has beta particle)
Alpha particles	20	plutonium-239

To apply  $W_r$  to determine the effective dose, all associated radiation emissions from a radioactive substance or substances are evaluated and the absorbed dose calculated. The absorbed dose depends on the amount of energy deposited within the mass of the tissue or organ. The organ masses do vary among individuals but if the specific values are not known, the ICRP developed a standard, reference man, woman, and child. These values are discussed and listed in ICRP Report 23 (ICRP, 1975). The absorbed dose from each type of emission is then multiplied by  $W_r$  and summed to give the total equivalent dose. The equation for this is:

$$H_T = \sum(W_r \times D_{T,R})$$

where  $D_{T,R}$  is the absorbed dose in a particular tissue (T) from radiation (R) (ICRP 1990).

Once the equivalent dose is calculated, the effective dose is then estimated. The effective dose is the sum of the effective doses multiplied by the tissue weighting factors,  $W_T$ . The  $W_T$  values range from 0.2 for the gonads, 0.12 for bone marrow, colon, lung, and stomach, 0.01 for bone surfaces and the skin, and 0.05 for all other organs such as the liver, thyroid, and breast. The equation for the effective dose is:

$$E = \sum(W_T \times H_T)$$

This is the methodology that ATSDR used to develop our estimates of radiation doses to both the entire body and specific organs. This method does not take into account the radiation dose delivered to a single cell.

#### References

ICRP (1975). International Commission on Radiological Protection. ICRP Publication 23, 1975. Report of task group on Reference Man. New York, Pergamon Press.

ICRP (1990). International Commission on Radiological Protection. ICRP Publication 60, 1990. Recommendations of the International Commission on Radiologic Protection. New York: Pergamon Press.



## APPENDIX B: RESPONSE TO PUBLIC COMMENTS

On February 9, 1998, copies of this document, "Health Consultation, Lawrence Livermore National Laboratory, Plutonium Contamination in Big Trees Park, Livermore, Alameda County, California," were distributed to the Lawrence Livermore Public Health Assessment (PHA) Site Team for review. Copies of this document were placed in the Livermore Public Library for all interested parties to review. Also, additional copies were sent to individuals who requested this document. Furthermore, the major points of the consultation were presented by staff from the Environmental Health Investigations Branch (EHIB) of the California Department of Health Services (CDHS-EHIB) at the PHA Site Team/public meeting held on February 25, 1998.

There was approximately eight weeks (February 9, 1998 to April 15, 1998) allotted for the public to comment on this document. During this period, CDHS-EHIB held a Site Team/public meeting (February 25, 1998) where the public expressed their comments and concerns.

This appendix contains the comments received from community members, governmental regulators, community based organizations, and Lawrence Livermore National Laboratory (LLNL), and responses to the comments were prepared by CDHS-EHIB, and the Agency for Toxic Substance and Disease Registry (ATSDR). Occasionally there were questions/comments that were unanswerable in the context of this health consultation. Several sections of the health consultation have been updated to include information provided to us during the public comment period. Enclosures supplied by the commenting groups are not included in this document but are available through the ATSDR Administrative Record.

The first 20 comments were received at the Site Team/public meeting held on February 25, 1998. The remainder of the comments were received during the public comment period and will be presented under descriptive subheadings. CDHS-EHIB's and ATSDR's responses are presented in italics as *Agencies Response*.

1. Comment (from general community members): a. "When will the whole problem be cleaned up? b. When the lab dumped plutonium into the sewer system did the Health Department know this? c. Why did they distribute the sludge? d. I think the whole area should be checked and cleaned up now by the Department of Energy."

*Agencies Response: a. The sampling that has been conducted to date has not shown plutonium contamination at levels which would require cleanup under current Federal Regulations. CDHS-EHIB and ATSDR have recommended additional sampling to determine if there are higher levels in Big Trees Park or in the Arroyo Seco channel which may be at a level of health concern or require cleanup. b. According to LLNL staff, the State Health Department was notified of the 1967 accidental release of plutonium to the sanitary sewer. c. According to LLNL staff, the 1967 accidental release of plutonium was within acceptable discharge limits for that time period. Until the early 1970's LWRP routinely distributed sludge as a soil amendment. As the 1967 accidental release of plutonium was within acceptable discharge limits for that time period, LLNL staff did not notify LWRP of the release. Consequently, LWRP personnel continued normal sludge*

*distribution. Although sludge distribution was halted by 1973, this consultation recommends further evaluation of the potential contaminant exposures from the sludge. d. Comment noted.*

2. Comment (from several community members): “Want to urge that adequate funding for CDHS/ATSDR to continue to define source of contamination including; a. Further testing of vertical deposition of plutonium, particularly at Big Trees Park where gradient appears to increase with depth. b. Further investigation of disposal of sludge in community.”

*Agencies Response: Additional characterization has been completed in the park. Further investigation of disposal of sludge is being considered.*

3. Comment (community member): “Was or could samples be taken at Spruell park on Jessica & Felicia Ave. to determine if any contamination exists at this site, which is not far from Big Trees Park, and is also in the vicinity of the lab.”

*Agencies Response: Further investigation at Big Trees Park may help us understand the mechanism of the plutonium in Big Trees Park. Depending upon the mechanism, it may be appropriate to sample in other locations in the Livermore area.*

4. Comment (community member): “Further investigation: Determine how plutonium got to Big Trees Park. The extent of contamination through further testing. Also, proper funding for the above. The lab historically has been sloppy with its handling of plutonium and should be brought to the highest level of safety so the community isn’t threatened”.

*Agencies Response: Additional characterization has been completed in the park. The remainder of the comment stands alone and does not require a response.*

5. Comment (community member): “Is there any reason the continued production, manufacture and proliferation of nuclear weapons needs to continue? The termination of such activities would eliminate the source of radioactive materials and thereby preventing the further contamination of the environment. Stop nuclear weapons manufacture now.”

*Agencies Response: This comment stands alone and does not require a response.*

6. Comment (community member): “a. Why are you so anxious to get into such micro questions? b. Your executive summary says you are conducting health assessment activities. That sounds promising, especially given that cancer rates in this country are way out of line with natural averages. However, you immediately get down to one incident which you insist has not resulted in any danger. As a citizen I don’t want you telling me what isn’t a problem but finding out what is. c. Why is the cancer rate so high in this country? Answer that question and we can find out whether Livermore Lab is culpable or not. Otherwise you are just blowing smoke.”

*Agencies Response: a. We appreciate your comment; however, we feel that the route by which plutonium reached a public park is much more than a “micro-question” needing to be answered.*

*Investigating the route for the plutonium found in Big Trees Park was an important step in determining whether there are other areas in the community which may have been affected.*  
*b. There are many factors, known and unknown, which contribute to the cancer rates in this country. A lengthy discussion about all of these factors is beyond the scope of this health consultation.*

7. Comment (community member): "A pack of cigarettes will put more alpha-activity than a teaspoon of soil inhaled."

Agencies Response: *This comment stands alone and does not require a response.*

8. Comment (community member): " 1. Why if the "release" was known about at least 2 weeks after the event, was the sewer sludge allowed to be sold or distributed to the City of Livermore for parks, or for resident's home use? Why did this distribution continue? 2.) Did any sewer sludge with plutonium taken to any landfill? If so, which ones? Where are the records? 3.) Comment: There is no such thing as "natural" background caused by plutonium fallout - plutonium fallout is unnatural nuclear bomb testing. 4.) Andre Sakharov before he died had made significant studies on effects of low doses of radiation over time. These studies can be applied to survivors of Chernobyl. Please comment. 5.) In analysis of health risk to the community of Livermore, you must consider cumulative doses from all sources - point source from park is only one source."

Agencies Response 1.) Refer to the response given for comment #1-C. 2.) CDHS-EHIB and ATSDR will be addressing issues relating to sewer discharges and treatment plant practices in future public health evaluation. 3.) This comment stands alone and does not require a response. 4.) We appreciate the aforementioned reference and recognize the validity of studies on the effects of low dose exposure to radiation; however, this is beyond the scope of this document. 5.) We appreciate the comment. As we evaluate the environmental data associated with LLNL, all sources and contaminants present at levels of health concern will be included in our assessment.

9. Comment (community member): "The DOE's own study of health effects of plutonium on beagle dogs (at UC Davis) found that NO particle of plutonium placed in the lung was so small it did not cause a cancer. Every one of the dogs died. Moreover, the BEIR committee of the National Academy of Science found that any level of exposure to ionizing radiation - no matter how small - carries adverse health risks. I could go on, but my point is that it is not sufficient for the Lab to rely solely on current regulatory standards to support its mantra: "There is no danger to public health". The public knows better. The lab has to do much better.

Agencies response: *This is not a completely valid comment; yes all dogs died but not all died as a result of plutonium inhalation. The studies to which you refer were carried out in the laboratory of Dr. Otto Raabe. Dr. Raabe developed 3-dimensional plots over the course of his research showing that in the case of low level plutonium exposures, the dogs died of natural causes; that is, before lethal cancers developed in the animals. As he increased the amount of plutonium inhaled, then death occurred at earlier times. The BEIR committee reports,*

*specifically BEIR IV and BEIR V, did state that they believed a risk exist at all levels; that is, a linear non-threshold effect (LNT) as a function of radiation dose. This theory is used in the field of risk assessment and risk management as an upper bound to the effects thought to occur. To date, there is no conclusive proof for or against an increased LNT risk at environmental levels of radiation exposure. ATSDR has supplied additional discussion on this topic later in this appendix.*

10. Comment (community member): “The amount of tritium (H3) and associated radiological impact on east county and east Livermore has not been made available to the public. Of special interest would be a determination of how much tritium has become bound into the biosphere, and what is the radiological impact on the biosphere. This entire issue needs to be addressed in future CDHS studies”.

Agencies Response: *We plan to address the topic of tritium in a separate document.*

11. Comment (community member): “Are you going to test at more sites and schools in Livermore”.

Agencies Response: *See our response to comment #3.*

12. Comment (community member): “1.) When did Livermore Water Reclamation Plant stop distributing sludge to homeowners and others for use as soil amendment”? 2.) A suggestion: CDHS/ATSDR should issue a public call for Livermore area community members who received sludge from LWRP between 1967 and ending year (to be determined) to come forward so that their yards can be sampled for plutonium contamination. A notice could be published in local newspapers”.

Agencies Response: *1.) The exact date when the distribution of sludge ceased is unclear; the early 1970's is a rough estimate . 2.) We will pass this suggestion on to the USEPA as they have jurisdiction over sampling issues.*

13. Comment (community member): “Have all of the residents of the surrounding community past and present been interviewed to determine whether or not an unusually high rate of cancer or other diseases prevails around the Laboratory? 2. Have any soil samples been taken in the neighborhood around the Lab?”

Agencies Response: *1.) Cancer rates in the city of Livermore have been evaluated by the Cancer Surveillance Section of the California Department of Health Services, in collaboration with the Northern California Cancer Center. This analysis was conducted using routinely collected data that must be reported for any cancers occurring in California residents. It was not necessary to interview residents personally to conduct this study. The analysis examined invasive cancer in Livermore from 1988-1993, the years for which data was available at the time of the request. The number of cancers of all anatomical cancer sites combined was examined, as well as for some of the most common cancers and cancers that have been associated with exposure to radiation.*

*These numbers of observed cancers were compared with what would be expected for the city of Livermore. Some were below what was expected, and some were above what would be expected, but as a whole, no substantial elevation was found. Earlier studies of LLNL workers identified an elevated level of melanoma, a type of skin cancer. An additional study of children and young adult residents in Livermore found an elevated rate of melanoma in this group, also. More detail on health studies and health statistics reviews, such as the one just cited, will be included in an upcoming document which will include a discussion of health studies of in the Livermore area and employees.*

*Regarding other diseases, the only other issue that has been evaluated is the incidence of birth defects in the area. This was examined by the California Birth Defects Monitoring Program, for the years 1983-89, the only years for which this information was available. There was a rate of 2.5 birth defects per 100 live births, which is very similar to the overall rate of 2.9 per 100 live births found across the state. Also, the number of specific birth defects that have been associated with ionizing radiation in the literature were either similar or lower than what would be expected, based on statewide rates. Thus, there is no evidence of an increased rate of birth defects among people living around Livermore. Again, this will be reported in more detail in a subsequent document.*

*As part of the health assessment process, when reviewing a site we decide if an epidemiological health study is warranted. Generally, conducting such a study requires that an exposure to a specific population be identifiable as well as the health outcome(s) of interest. However, at all sites, we are interested in hearing from community members about site-related specific illnesses they may have experienced or be concerned about, and staff are available to meet with any community member who wishes to discuss these issues. 2.) It is unclear to which "neighborhood around the Lab" the comment is referring to. LLNL does conduct environmental monitoring. CDHS-EHIB is unaware of any additional sampling that has been conducted as a special study at specific locations in the neighborhood.*

14. Comment (community member): "Has any consideration been made to plant or sod the undeveloped areas NE of Arroyo Seco Elementary, NW of Big Trees Park. This undeveloped area is plowed and mowed during the spring, summer, fall to clear weeds and generates dust that blows over the homes in the immediate area. Children and pets cross, play, and dig in this area."

Agencies Response: CDHS will refer this suggestion to the City of Livermore, who maintains that area.

15. Comment (community member): " 1.) Has Spring Valley / Springtown area been tested for this and has any link to thyroid conditions been investigated? If not, what do you think in your best opinion? 2.) Has any comparative study have been done on the areas upwind from LLNL? 3.) Why is the depth of sample only to 5cm and not lower?"

Agencies Response: 1.) CDHS does not have any knowledge of testing in the Spring Valley or Springtown area. Investigations regarding a link to thyroid conditions is out of the scope of this

health consultation. Therefore, CDHS is not able to state an opinion at this time. 2.) The only comparative study CDHS is aware of is a journal article written by LLNL staff, entitled, *Surveillance Monitoring of Soils for Radioactivity: Lawrence Livermore National Laboratory 1976 to 1992. Health Physics 1995 Oct; 69(4): 487-493. The article compares upwind and downwind concentrations of radionuclides at the Livermore site and Site 300. The article shows that downwind levels are statistically significantly higher than upwind. 3.) It is CDHS's understanding that surface soil sampling is conducted for preliminary investigations because inhalation of resuspended particles is the primary route of exposure. CDHS agrees that deeper sampling, in addition to surface soil sampling, should have been done during the 1995 sampling in Big Trees Park and the Arroyo Seco. The text and recommendations of this health consultation reflect our concerns regarding this matter.*

16. Comment (community member): "Do LLNL safety systems monitor all release levels or only those deemed clinically significant by LLNL, EPA or etc..?"

Agencies Response: *This question is out of the scope of this health consultation.*

17. Comment (community member): "1.) What sampling has taken place recently? 2.) What sampling was done during the Arroyo Seco grading? 3.) What is the National Ignition Facility (NIF) excavation plan, sampling plan? 4.) Does isotopic/chemical composition reveal sources? 5.) Has the possibility of sabotage been considered? 6.) Is anything being done to gather health statistics on Lab employees, offspring?"

Agencies Response: *1.) CDHS is not aware of any recent sampling. 2.) CDHS is not aware of any sampling conducted during the recent regrading of the Arroyo Seco. 3.) This comment is out of the scope of this health consultation. 4) Isotopic analyses has various uses including identification of source and relevance to backgrounds. In many cases, however, any type of agricultural or soil disturbing activities can significantly affect this isotopic ratio. In the case of Big Trees Park, the park has been heavily cultivated and isotopic ratios will not assist in our evaluations. In addition, the only sources of plutonium in Livermore Valley are LLNL and fallout. 5.) CDHS must evaluate all potential pathways 6.) ATSDR's mandate is to evaluate health effects among residents of the community who may be affected by a site; as such it does not directly cover employees of a site. Another federal agency, the National Institute for Occupational Safety and Health (NIOSH), is responsible for worker studies. NIOSH has a group which can be reached at (513) 841-4400, that works specifically with Department of Energy sites, and a group that conducts industry-wide studies on various topics (513) 841-4476. NIOSH also conducts a Health Hazard Evaluation Program, which is a request-driven program under which NIOSH will come and conduct an assessment of any health hazards in a workplace (513) 841-4409. Their address is: NIOSH, 4676 Columbia Parkway, Cincinnati, OH 45226*

18. Comment (community member): "1.) What are the cancer levels in the area? 2.) Did any of the developers in the area such as Kaufman and Broad use sewage sludge in the top soil for their housing developments?"

Agencies Response: 1.) See response to comment 13. 2.) CDHS's research did not include a determination and interview of Livermore area developers, predating and including the early 1970's (time frame of sludge distribution 1960 to the mid 1970's).

19. Comment (community member): "What about the possibility of a microscopic particle of plutonium being kicked up out of the dirt and inhaled by a child. That seems to be the people's biggest fear. How much higher is the chance, in that case, of that child getting lung cancer later in life?"

Agencies Response: Our evaluation of radiation doses included this scenario. The radiation doses were also estimated for long term health effects.

20. Comment (community member): " 1.) Did the Public Health Assessment consider the pica child - one that eats large amounts of soil? 2.) Did the Public Health Assessment consider the possible impacts to human health related to something other than cancer? Could plutonium have a greater impact on an individual that has a compromised immune system? pregnant women? fetuses? 3.) Please identify the short comings of a Public Health Assessment? What does a Public Health Assessment not consider in its evaluation (cumulative, synergistic, tetragenicity and so forth)?"

Agencies Response: 1.) This document discusses these issues. See our response to the previous comment. 2.) As for other health effects of exposure other than cancer, there is no scientific, peer-reviewed information that correlates low level environmental exposures to either cancer or other non-cancer health effects. Because plutonium is not easily transported from either the maternal respiratory system or the gastrointestinal system to the blood, the transport to the embryo is substantially reduced as well as the associated dose. Animal studies have shown that plutonium transfer to the fetus is greatest following injection; however, in a radiation worker who inhaled plutonium and several years later became pregnant, plutonium was found in the umbilical cord at a concentration of less than  $2 \mu\text{Bq}$  ( $5 \times 10^{-5} \text{ pCi}$ ) (NCRP Report 128 issued in 1998). 3.) Under ideal situations and with all available data reviewed, pathway analyses complete, and contaminants present at levels of health concern, these topics are considered.

Community Form Letter: CDHS received 140 copies of the following form letter (77 Livermore residents and 63 non-Livermore residents).

"I am extremely concerned about the risks to public health and safety and to the environment caused by the plutonium-laden sludge and other, airborne and waterborne, plutonium contamination referred to in the above-named report. Plutonium, a man-made, radioactive substance, is often called the "most toxic substance on Earth" and, if inhaled or ingested, can cause death by cancer as well as other negative health effects. This risk of cancer is especially high for children.

The report states that both Lawrence Livermore National Laboratory (LLNL) and the City of Livermore knew the sludge was contaminated by LLNL with plutonium, but still allowed it to be made available for public use in gardens, as topsoil, groundfill, etc.

I wholeheartedly agree with the report's following recommendations:

Follow-up on distribution of the sludge must be done to locate where the plutonium went within the community.

The report suggests airborne and waterborne (via the arroyo) contamination as the probable sources of the plutonium found in Big Trees Park in Livermore, and I agree that follow-up soil samples, including to deeper levels than were done previously, should be taken and analyzed from Big Trees Park. Moreover, other neighborhoods and areas including those east of Livermore Lab that are likely "hot spots" should be analyzed too.

I strongly urge these measures be taken, as they will help to assess the plutonium risk to the community, which, in turn, is a first step in taking whatever measures we can to protect the public, especially the children, from contact with this radioactive hazard."

*Agencies Response: Comments noted.*

**Public Comments: (received during the public comment period)**

21. Comment (community member): "I have survived two cancer surgeries and I have a great deal of concern regarding environmental toxic substances as they may impact the health of myself, my husband, children, and grandchildren - all of whom live in Livermore. Kindly follow up on the reports, sample soil (and air) for any toxins relating to our health and well being. I thank you for your concern."

*Agencies Response: This comment stands alone and does not require a response.*

22. Comment (community member): "I am stunned to think any decent person might stand in the way of testing and public education about plutonium contamination in Big Trees Park, Livermore and anywhere plutonium was spread. (see DHS report entitled, Lawrence Livermore National Lab Plutonium Contamination in Big Trees Park, Livermore, Alameda County., CA, CERCLIS No. CA 2890012584). As a mom of 2 toddlers I am dumbfounded to know parents still take their kids to this park; clearly they trust their government and it would be appropriate to be able to do so; however it appears information has been held away from the majority of the people rather than widely distributed for the sake of public health. As a result, all these innocent kids in the dawns of their lives, may see greatly shortened or cancerous and sickly lives. It is as though whole communities are being held guinea pigs in a wide-ranging experiment. For shame. Please respond. Please aggressively analyze plutonium hot spots, discover them all and educate the residents of these areas and all of us.



*Agencies Response: ATSDR staff performed a radiation dose evaluation based on the worst case scenario for a three year old child exposed to the highest level of plutonium found in the soil at Big Trees Park. ATSDR determined that the plutonium soil concentrations are not at a level of health concern. An extensive investigation to define the extent and pathway of plutonium in Big Trees Park was scheduled to begin in August, 1998. That sampling has been completed. The findings and results of the study will be shared with the community when the analyses are complete.*

23. Comment (community member) I am concerned about the discussion that took place at the meeting with the panel and the LLNL. I would like to see action taken now re: plutonium in Livermore. I feel that the lab is dragging their heels on several issues.

First issue, I feel they are not digging deep enough at the three parks they took soil samples from. Five centimeters is not deep enough, I would like further testing done at those parks, but deeper soil samples taken. I am not comfortable with them just walking away from these parks because they feel that they meet the guidelines of acceptable levels of plutonium for humans. I do not feel that there is an acceptable level, especially for the children of Livermore. They are not lab rats but our children. Secondly, I would like more testing done in other parks (Springtown) for example and the schools as well. Thirdly and equally as important I would like the lab to find the missing book which contained names of who bought that contaminated sludge from the lab. Apparently the lab allowed it to be made available for public use in gardens as topsoil, groundfill etc. If they cannot find that information then take the appropriate steps necessary to find out who bought the sludge. Whatever it costs whatever they have to do. Or take samples all over Livermore on request, free of course. My other concern on this issue is the builders buying it for landfill when building homes. I need to know if I am sitting on the sludge. I want an immediate action taken on this request.

I love Livermore my family is very happy here. We wanted to raise our family here, but I am not trusting our giant neighbor at this point. So unless these items are taken seriously and done, a move might be eminent. This is a last resort of course, I hope our voices of Livermore are being heard because the citizens of Livermore deserve to live, work and play here safely.

*Agencies Response: Comment noted. See response to previous comment regarding additional sampling in Big Trees Park. Currently, there are no plans to sample additional areas within the Livermore valley. However, ATSDR and CDHS have discussed this issue with EPA and the laboratory.*

*The following section contains the comments submitted by national, regional, and community based organizations, regulatory agencies, and Lawrence Livermore National Laboratory. CDHS-EHIB has tried to replicate the comments to the greatest extent possible, (text only), as they were received. Agency responses are presented in italics. ATSDR requires that all identification of non-governmental groups, organizations, and personal identifiers be removed. Descriptions of organizational functions are removed as well. In those instances where information was either enclosed with the comments or attached, that information has been removed but is available in the ATSDR Administrative Record.*

### Comments from Regional and National Organizations

*Identical comments were submitted by two organizations. For the sake of brevity, only one set is included and responded to in this section.*

#### Regional and National Organization Comment:

##### **Plutonium in Big Trees Park**

The Organization strongly supports the CDHS/ATSDR recommendations for additional environmental sampling and a thorough investigation of the plutonium-laced sludge issue. The Organization recommends that follow-up activities meet the following criteria:

Criteria 1. The goal of future environmental sampling and other follow-up activities must be to demonstrate with reasonable certainty whether or not the community health has been harmed by activities at LLNL over the past half century.

Criteria 2. The process by which the health consultation is conducted should be transparent, independent, and timely, and should demonstrate the inclusion of an informed public in all follow-up decisions.

*Agencies Response: We are committed to making the public health assessment process transparent and independent. Timeliness is probably most related to available resources. We will try to include and inform the public of the follow-up decisions we make.*

Regional and National Organization Comment: The Organization recommendations for meeting each of these criteria are specified below.

Criteria 1. The goal of future environmental sampling and other follow-up activities must be to demonstrate with reasonable certainty whether or not the community health has been harmed by activities at LLNL over the past half century. Clearly, meeting this goal requires a much higher burden of proof than simply quantifying additional plutonium levels in Big Trees Park. However, this organization believes this is a justifiable goal because: there is compelling evidence that plutonium traveled from the Lab into the community through multiple pathways; the historical

record demonstrates insufficient environmental stewardship on the part of the Lab; and up until the present time members of the community have not been fully informed about their potential exposures.

The CDHS/ATSDR report indicates three potential pathways for the plutonium to have traveled from the Lab into the community: air emissions, through the dissemination of plutonium-laced sludge, and water runoff. However, existing data gaps preclude a clear understanding of these pathways.

The Organization recommends an environmental sampling program that can validate assumptions about the pathways of exposure, and adequately characterize the extent of plutonium contamination in the community. These data are needed to judge the potential health impacts of exposure, and to ensure that these exposures are not continuing.

*Agencies Response: We agree this is necessary, to the extent possible, for all potential contaminants and pathways of exposure.*

### **Air Pathway**

**Regional and National Organization Comment:** The CDHS/ATSDR report indicates the potential for widespread contamination of the Livermore community with plutonium that may extend beyond Big Trees Park. The report shows that soil at all three parks tested is contaminated with plutonium at concentrations in excess of global fallout levels. This is an unexpected and disturbing signal that requires further investigation. It is highly improbable that all three random soil samples would demonstrate plutonium at concentrations above background levels if assumptions about the underlying distribution of environmental plutonium levels are correct, (i.e., plutonium from global fallout is log-normally distributed and plutonium levels in Livermore fall at or below the upper bound of global fallout levels). Therefore, the elevated levels of plutonium in all three parks may reflect widespread contamination of the community from an air pathway. Based on the discussion of this issue at a meeting with the Lab at CDHS on March 26, 1998, it is The Organization's understanding that the Lab attributes the elevated levels of plutonium in Sycamore Grove and Sunflower Street Parks to the limitations of the analytical methods used to measure environmental plutonium. This explanation may be true, but it may also be true that the plutonium levels measured are accurate, or are underestimates of the true value.

The Organization recommends that additional sampling be conducted in Sunflower Street and Sycamore Grove Parks to demonstrate to the community with reasonable certainty what the true levels of plutonium in these locations. An accurate understanding of plutonium levels in these parks is also needed to interpret the significance of earlier findings.

*Agencies Response: CDHS also recommended this as part of our comments to the 1998 Big Trees Park Sampling Plan. As you pointed out in your comment, a major discussion point between the regulatory agencies, CDHS, and ATSDR has been the evaluation of the environmental data collected within the city parks in question. To this point, there is no agreement if the levels of*

*plutonium found in the parks are significantly elevated above background because of the uncertainties in the error of measurements. Nonetheless, atmospheric dispersion from a sole source usually exhibits a specific pattern of deposition which is more pronounced as one approaches the source. Based on the distribution of the "hot spots" within Big Trees Park, it is unlikely that the air pathway is responsible for plutonium in the parks. The current sampling event completed in September 1998 is expected to further delineate the source of the contamination.*

Regional and National Organization Comment: The Organization recommends soil sampling in areas more frequently downwind of the Lab than Big Trees Park, i.e., east of the Lab. Although sampling in public areas with a high density of a vulnerable population, such as schools, parks and residential areas is a priority, future use of currently undeveloped areas cannot be ruled out. Locations frequently downwind but not currently populated should not be excluded a priori from sampling, as these data may help to characterize the air pathway.

Agencies Response: *As part of the health assessment process, ATSDR staff will be investigating air emissions from the LLNL main site and evaluating soil data for the Livermore area. The results of these investigations will help determine the necessity of recommendations for additional soil sampling.*

Regional and National Organization Comment: The Organization recommends that CDHS/ATSDR follow-up on suggestions made at a meeting with the Lab and other Site Team members at CDHS on April 2, 1998 by Dr. Owen Hoffman, President of SENES and a member of the federal Advisory Committee for Energy-Related Epidemiological Research. Among his suggestions, Dr. Hoffman noted that there may be alternative methods for measuring environmental levels of plutonium that may be useful to CDHS/ATSDR follow-up efforts. At this same meeting, the possibility was raised that plutonium contamination due to fallout might be distinguished from airborne plutonium resulting from activities at LLNL by looking at the ratio of cesium 137 levels to plutonium 239 levels in the environment. The Organization urges CDHS/ATSDR to evaluate the applicability of these and other potential approaches to environmental sampling for plutonium.

Agencies Response: *CDHS has recommended analysis of other radioactive materials and isotope ratio determination be part of the 1998 sampling of Big Trees Park and the Arroyo Seco. However, ATSDR believes, and literature supports the fact that the cesium to plutonium ratios are not a valid test as the behavior of cesium salts and plutonium salts differ in the environment. Some of these differences include differential solubilities and different binding affinities to soil types. Furthermore, ATSDR discussed this issue with other environmental radiation specialists and their opinions have been that if soils have been disturbed by cultivation, agriculture, soil amendments, or any other soil disturbing activities, the ratios you mention are meaningless; that is, no information can be drawn from the results.*

Regional and National Organization Comment: The Organization recommends that ATSDR engage the limited services of an independent expert such as Dr. Hoffman as a consultant to the

LLNL PHA process. The information that Dr. Hoffman could impart based on his experience at other DOE nuclear weapons sites would allow specific technical knowledge as well as other "lessons learned" to be incorporated into the LLNL work quickly, and could therefore enhance the quality of, and shorten the time needed to complete the PHA at LLNL.

*Agencies Response: Comment noted. "We recognize Dr. Hoffman's contributions to the science of uncertainty analysis and have discussed these issues with him. We will continue to interact with him."*

Regional and National Organization Comment: The Organization recommends that CDHS/ATSDR request the release of all LLNL data related to the Lab's ongoing identification of gamma emitters by routine air flights over the Livermore Valley. Based on the discussion of this activity with the Lab at the April 2, 1998 meeting at CDHS, it is our understanding that these flights result in "anomaly maps" that indicate any deviations from "what is to be expected".

*Agencies Response: We believe this information may be useful and will try to obtain these data for review.*

Regional and National Organization Comment: The Organization recommends that the possibility of air emissions from open air detonations at Site 300 and unreported open air detonations at the LLNL main site be investigated. These concerns have been expressed to The Organization by community residents.

*Agencies Response: As part of the health assessment process, ATSDR staff will be investigating air emissions from LLNL Main site and Site 300, a separate NPL site.*

Regional and National Organization Comment: The Organization recommends that the CDHS/ATSDR health consultation acknowledge that plutonium may not be the only contaminant of concern from the air pathway. In fact, plutonium may only be a tracer or indicator of other air emissions of public health concern. This possibility must also be taken into consideration when planning future environmental sampling strategies.

*Agencies Response: Future public health evaluations focusing on air emissions will look at all potential contaminants.*

### **Plutonium-laced sludge pathway**

Regional and National Organization Comment: Existing data indicate that problems associated with the release of plutonium by LLNL into the sanitary sewer system extend well beyond the 1967 release and subsequent distribution of plutonium-laced sludge addressed in the CDHS/ATSDR report. LLNL releases to the Livermore Water Reclamation Plant (LWRP) have been documented as recently as 1987, and are not limited to plutonium.

A September 1986 LLNL release was the subject of an October 1986 DOE Incident Analysis Report.<sup>1</sup> That report strongly criticized LLNL's hazardous waste handling practices, particularly LLNL's "controls" to prevent excessive releases to the sewer system. The report also noted that the release resulted in "minor damage" to the LWRP treatment process and cost over \$150,000 to clean up. (p 14-15) The September 1986 incident also shows that the Lab's reliance on the sounding of an alarm when "pollutant limits are exceeded" as a mitigation measure is significantly exaggerated. In a June 22, 1987 letter to LWRP Superintendent William Adams, the Associate Director of LLNL Plant and Technical Services wrote:

[T]he function and intent of [the alarm] system has been erroneously perceived as a compliance detection tool. The alarm system was developed primarily as a means of detecting any unusually large release of radioisotopes and secondarily as an early warning system for very high concentrations of key metals ... [T]he available technology does not permit the accurate detection of low metal concentrations necessary to ensure continuous compliance with the City of Livermore's sewer discharge limits."<sup>2</sup>

Elevated concentrations of plutonium were also released by LLNL into Livermore's sanitary sewer system in May 1987. A letter dated May 17, 1988 to Robert O. Godwin, Associate Director, Plant and Technical Services, LLNL from John C. Hines, Assistant Director of Public Works indicates that these releases were apparently not disclosed to Livermore Water Reclamation Plant personnel until a year later.<sup>3</sup> Mr. Hines wrote:

During the meeting [of May 12, 1988] it was disclosed that elevated concentrations of plutonium were released to the City's sanitary system beginning in May 1987 by LLNL ... The method and timing of the disclosure of elevated plutonium level releases to the sanitary sewer system by LLNL, were at best, poorly handled from our perspective. LLNL may well have treated this release as a non-incident when considering level limits, but this approach does not give consideration to the public's health concerns. LWRP personnel share the public's concern regarding the danger to human health posed by this or any other radionuclide releases to the environment. LWRP personnel are particularly concerned that they are unprotected, while facing possible radiation exposure, and are totally dependent on LLNL to advise them of potential health risks in a timely manner. ... (Attached letter in the ATSDR Administrative Records)

Moreover, the distribution of plutonium-laced sludge may not be the only pathway of community exposure from discharges by LLNL into the sanitary sewer system. Leakage from the sanitary sewer lines on-site and off-site, and air-borne plutonium from sludge piles at the LWRP may also be sources of community (and worker) exposure. A 1987 DOE study<sup>4</sup>, noted that:

Untreated sewage and potentially hazardous or radioactive constituents may escape the sanitary sewer system through cracks in the sewer lines resulting from seismic activity or other damaging events such as acid releases or negligent construction activities. In the event that there is an accidental release of hazardous wastes (e.g. the chromium/nickel discharge of September 18, 1986), thousands of gallons could percolate into the ground

even though the main flow is carefully impounded prior to entering the LWRP. This potential problem applies to the LLNL on-site sanitary sewer system, the SNLL [Sandia] system, and the trunk line carrying the combined waste waters to the LWRP (emphasis added)."

The 1987 report states that ... "contamination of aquifers and soils underlying the LLNL/SNL sites with heavy metals, radionuclides, toxic organics, and fecal coliform may be occurring as a result of exfiltration from breaks in the sanitary sewer because the integrity of the sanitary sewer is open to question."

The 1992 Draft Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore (DEIS/DEIR) states that, "The infiltration study and video investigation has shown that exfiltration (leakage) of waste water is possible from the LLNL sewer lines." (A-95) The DEIS/DEIR also indicates that this problem may not be solved completely for some time: "[t]here are numerous physical and operational constraints associated with the design of this project." (A-96)

An undated summary report of a May 1987 plutonium release (see ATSDR Administrative Record) estimates that approximately 110 tons of plutonium-contaminated sludge had been deposited in the open air at the LWRP. The report also states that "Historical plutonium levels (above natural background) adjacent to LWRP may make it difficult to measure the impact of the recent sludge on the soil environment".

The Organization strongly supports the CDHS/ATSDR recommendation to thoroughly investigate the distribution of sewer sludge throughout the Livermore Valley, and other areas, in order to identify other locations that may have received plutonium contaminated soil.

The Organization recommends that in the absence of a log-book or other credible evidence of where the plutonium-laced sludge went, community members should be offered the option of testing their household soil free of charge. This testing should not be limited to plutonium, but should also include lead, and other heavy metals which are significant concern to the public health and may also be found in sludge.

The Organization recommends that an air pathway from sludge piles at LWRP be investigated.

*Agencies Response: Comments noted.*

Regional and National Organization Comment: The Organization recommends that a soil and/or water pathway from exfiltration of hazardous materials from the LLNL sanitary sewer lines both on-site and off-site be investigated. Given the unusual finding at Big Trees Park of higher levels of plutonium in deeper soil samples, a first question to address would be, do or have sanitary sewer lines ever run beneath Big Trees Park ?

*Agencies Response: We plan to further investigate contaminant releases from LLNL to the sanitary sewer in a future document..*

### **Water runoff into the Arroyo Seco pathway**

**Regional and National Organization Comment:** The Organization strongly supports further sampling in the Arroyo Seco sediments as recommended by CDHS/ATSDR.

The Organization recommends that the potential exposure pathway of water run-off from LLNL to the community be investigated independent of the question of Big Trees Park contamination. There may be other areas of on-site contamination and/or other locations that are more greatly impacted by water drainage from the Lab that require assessment.

*Agencies Response: Comment noted. We had planned to address these issues in a subsequent document.*

### **Reliability of LLNL environmental stewardship**

**Regional and National Organization Comment:** From February 26 to April 5, 1990 the U.S. Department of Energy (DOE) conducted an independent, comprehensive assessment of the Environmental Health and Safety program at LLNL. The findings of this "Tiger Team" investigation were reported by DOE in April 1990. Among its key findings the Tiger Team reported that:

Environmental findings, associated root causes, and observations of LLNL operations reveal an environmental protection program that is informal, fragmented, inconsistently implemented, uncoordinated, and hindered by poor communications. ... The key areas of concern are: environmental programs lack key elements needed for effective implementation, air monitoring programs do not have some necessary elements for accurate characterization and monitoring, systems are not in place to properly characterize and manage wastes, and quality assurance programs for environmental activities have not been developed or implemented. ... There is one underlying root cause for all the findings:

Management at all levels has failed to acknowledge that environmental objectives are more important than programmatic goals and that environmental concerns must become an integral part of LLNL operations. (emphasis added) (ES-2)

The Tiger Team report also states:

LLNL management systems lack the control, discipline, and formality necessary to consistently accomplish ES&H [environment, safety, and health] objectives. The consistent accomplishment of ES&H objectives, including strict compliance with regulatory requirements and DOE orders, demands a rigorous, disciplined management



approach. LLNL's management systems do not embody such rigor and discipline. Nor do they have the necessary controls in place to assure safe, reliable and environmentally sound operations. (emphasis added) These inadequacies in essential management systems, such as quality assurance, operating policies and procedures, and operational document control, substantially impair the effectiveness of the EH&S implementation program. ( 2-9)

In addition, findings of the Tiger Team report specifically cast doubt on the reliability of LLNL historical air monitoring data:

Overall, the deficiencies of the Air Monitoring Program have the potential to adversely affect the accuracy and defensibility of the data. For example, no calibration has been performed on much of the equipment used in the monitoring program for ambient air particulate radionuclides such as flow-rate recorders, hi-vol. samplers, and orifice calibration units ... In addition, LLNL has neglected to investigate the causes of measurable offsite plutonium contamination. LLNL has not developed uniform or formal standards for maintenance of stack monitoring equipment, and for ventilation system design. ( 3-5) "LLNL effluent monitoring/sampling activities are inadequate to identify and quantify releases of radionuclides to the atmosphere to accomplish a thorough assessment of the effective dose equivalent to the public." (3-13)

Quality assurance, quality control, and instrument control practices at the Environmental Analytical Sciences Laboratory (EASL) are not sufficient to demonstrate the validity of the data generated by the laboratory and do not satisfy the requirements of DOE orders 5400.1 and 5700.6B. The EASL is used by the Environmental Protection Department to perform the radiological analysis of environmental, effluent, and waste samples. (3-127)

Another example of the unreliability of the Lab's environmental monitoring data is provided in the CDHS/ATSDR report which indicates that sampling of sludge for plutonium did not begin until six years after the Lab's release of plutonium into the sanitary sewer system in 1967. Moreover, since plutonium associates with the solids in sludge, and because the Lab did not test the solids for plutonium, CDHS/ATSDR state that the levels of plutonium in the sludge reported by the Lab are likely to have been substantially underestimated by the Lab.

If data on releases is not reliable, then CDHS/ATSDR risk assessments and other impact analyses based on that data cannot be considered reliable. Therefore, public health impact and risk analyses based solely on Lab data prior to 1990 will not provide the public with adequate information on which to understand the public health consequences of LLNL activities up to that time. If CDHS/ATSDR public health assessments are to be based on data collected after the problems identified in 1990 by the Tiger Team Assessment had been remedied, CDHS/ATSDR should clearly identify the measures taken to remedy those deficiencies.

Due to the historical inadequacies of the environmental record compiled by LLNL, it is not possible to understand the community's cumulative exposure over the past half century of

operations at the Lab using only Lab data. Many community residents have expressed health concerns, including but not limited to cancer, potentially related to LLNL activities. A thorough and unbiased account of the Lab's past environmental record is needed to respond successfully to these concerns, and to meaningfully carry out ATSDR's mandate to conduct an assessment of the Lab's potential human health impacts. Therefore, The Organization recommends that environmental sampling and other follow-up activities recommended above must be augmented by other sources of data. Local knowledge about the distribution of the sludge, and other observations related to potential exposures or health issues are primary sources of data that must be actively pursued. The Organization recommends that CDHS establish an 800 number and an e-mail list server to encourage dialogue on the issue. This could also serve as a key way to provide the community with educational information in a timely and widespread manner. A review of historic controversies between the Lab and state and federal regulatory authorities may also assist in the interpretation of the historical record. At other DOE sites, identifying the "reading lists" [document tracking systems] of managers has helped to expedite the identification of relevant documents that could be otherwise overlooked. The Lab's "institutional memory" should be tapped as a key source of data. The chain of command throughout the history of the Lab should be reviewed, and when possible, interviews with former employees and supervisory personnel should be conducted to gather pertinent data.

*Agencies Response: Thank you for the comment, we will consider this recommendation.*

#### **Additional recommendations related to exposure assessment:**

Regional and National Organization Comment: The Organization recommends that the report fully describe CDHS/ATSDR assumptions about global fallout levels in Livermore. Please discuss what is known, and what is not known, about the distribution of fallout levels of plutonium, cesium and other relevant radionuclides in this area. This information is critical to interpreting the results of future environmental sampling. In addition to the figures and tables already in the health consultation, it would be helpful to present the data on environmental levels in a table showing how they compare with the range of fallout levels. (i.e., 10 times greater, 100 times, etc.)

*Agencies Response: The global fallout levels in the Livermore area are an issue, and we recommended that part of the proposed sampling effort be directed to address this question. As a complete answer to this question is beyond the scope of this document, we plan to consider this topic fully in a future document on soils, including review of data on soil levels that are contained in LLNL site annual environmental reports.*

*The background reference values we have cited in this health consultation come from several sources. We have repeated these values in the following table. Depending on which set of data is used, a value may or may not exceed a certain standard. Also, because there are several proposed values that could represent the upper end of background, whether or not something is above background or not depends on the choice of the value.*

Table: Different estimations of the upper level of background (pCi/g) of Pu 239

background estimate (pCi/g)	description of scope	Source of data / reference	Citation
0.001-0.01	"worldwide fallout"	US DOE, "Environmental Report for 1991 Lawrence Livermore National Laboratory," UCRL, 50027-91, UC-702, 1991.	National Air and Radiation Environmental Laboratory. Confirmatory sampling of plutonium in soil from the southeast quadrant of the Lawrence Livermore National Laboratory. USEPA, 1994 August 15.
0.005	"regional background due to worldwide fallout"	none given.	Lawrence Livermore National Laboratory. Letter to Dan Cloak (LWRP) from Harry Galles (LLNL) re: Plutonium at the Water Reclamation Plant. 1990 December 4.
0.011-0.013 and 0.0077-0.0091 (70% of 0.011 and 0.013)	a range among 4 San Francisco and Oakland measured values. Oakland and San Francisco will have higher values than Livermore because of greater precipitation; "it would be expected that the fallout measured in Livermore would be $\approx$ 70% of the fallout measured in San Francisco and Oakland." (Gallegos)	Hardy, EP. Regional uniformity of cumulative radionuclide fallout. In: Fallout Program Quarterly Summary Report. New York: Health and Safety Laboratory; HASL-288, I2 to I10; 1975.	MacQueen, Don. Livermore Big Trees Park January 1995 Soil Survey Results. Lawrence Livermore National Laboratory; 1995 July. UCRL-ID-121045.
0.00316 $\times/\div$ 2.57	Upwind soil concentrations of Pu-239-240	Gallegos (1995) HP 69:487-493.	

We hope the above information gives you at least a general sense of the ranges that may be expected, and we hope that additional data and analysis will address this question more adequately.

**Regional and National Organization Comment:** The Organization recommends that CDHS/ATSDR anticipate questions about assessing community exposure through the use of biological monitoring. It would be helpful to provide current information as to the interpretability of biological monitoring data on a community and individual level.

*Agencies Response: If measurements are taken for chemicals or radionuclides which pass through the body very quickly, they must be taken within a small window of time following exposure. However, if chemicals last a long time in the body, measuring them would be more reflective of historic exposure. Plutonium was one contaminant that would have been a potential candidate for biomonitoring, because it has a long half-life and may be stored in the body. However, the information we have learned from LLNL's monitoring experience to date do not suggest that attempting to measure plutonium in biological material (e.g. taking measurements in blood samples) would show detectable levels, other than if someone had received a large dose. At a previous site team meeting, Dave Myers, of LLNL, reported that although workers are monitored for plutonium, only rarely has any detectable level been noted, and this has been associated with an accidental exposure. We do not believe that if biological specimens (e.g. blood samples) from non-employees in the community would show detectable levels of plutonium. Such analyses would not be useful in this situation in which we are attempting to understand historic or current exposures. As the health assessment process proceeds, we may be directed to other chemicals or contaminants which would be appropriate for biomonitoring, and their potential utility would be considered at that time.*

**Regional and National Organization Comment:** Criteria 2. The process by which the health consultation is conducted should be transparent, independent, and timely, and should demonstrate the inclusion of an informed public in all follow-up decisions. Because CDHS/ATSDR activities will have a profound affect on the health and welfare of the Livermore community, the foremost criteria by which to judge the credibility of CDHS/ATSDR future efforts is the demonstrated inclusion of an informed public in a meaningful way in decision making related to the PHA and follow-up.

*Agencies Response: ATSDR is committed to making the health assessment process transparent and independent. Timeliness is probably most related to available resources. We will try to include an informed public in the follow-up decisions that we make.*

### **Community decision making about risk**

**Regional and National Organization Comment:** The Organization recognizes that it is appropriate for ATSDR to do a risk assessment on the "hot spot" of plutonium in Big Trees Park. The Organization agrees that a risk assessment based on the hot spot is needed as a quick estimate of risk to inform the public health response in the short-term. However, The Organization believes that the CDHS/ATSDR report indicates that the full health impact of the Lab's release of plutonium into the community environment is not yet known. The Organization cautions that the maximum concentration of the community soil samples taken to date should not be confused with the highest level of plutonium that a child may be exposed to at Big Trees Park or other locations

throughout Livermore. In the absence of clear evidence as to how the plutonium got into the soil at Big Trees, Sycamore Grove and Sunflower Street Parks, and convincing data as to the environmental burden of plutonium from air, surface drainage, sludge and other potential sources of excess plutonium in the Livermore community, there is no basis for the assumption that the "hot spot" in Big Trees Park is the "hottest spot" in town, nor a unique event.

*Agencies Response: Comment noted. Please note that ATSDR does not perform risk assessments but public health assessments. Furthermore any type of assessment on a "hot spot" is not a valid assessment but should only used as a screening tool.*

Regional and National Organization Comment: In addition, the health risks of exposure to radiation at low levels may be greater than recognized by current regulatory standards that ATSDR used to assess risk. A 1997 UCLA study of cancer mortality among workers exposed to radiation on the job found that the excess relative risk of "low dose" radiation was at least 6 to 8 times greater than the risks previously assumed by current regulations. Other research of more subtle measures of the effects on cells exposed to radiation suggest the possibility of intergenerational effects from low-level exposures.

*Agencies Response: We recognize that there is much discussion in the scientific community over the issue of "low dose" radiation, and we encourage research to define this issue. In fact, the National Academy of Sciences has proposed to re-evaluate the "low dose" controversy. At present, unfortunately, much of this research is preliminary. ATSDR policy recognizes that the interpretation and recommendations provided are based on the information available at the time of writing, and additional data could alter interpretation and advice presented.*

Regional and National Organization Comment: Moreover, there is general agreement among scientists that there is no threshold dose of radiation below which cancers or genetic damage do not occur. ATSDR should clearly state an estimate of the number of people who will die from cancer over time from ingestion and inhalation of plutonium in soil. Moreover, radiation protection recommendations are based in part on a principle of "justification" that states that, "No practice involving exposures to radiation should be adopted unless it produces enough benefit to offset the radiation detriment it causes." ATSDR scientists should acknowledge that embedded in their finding that "the highest level of plutonium measured in the soil at Big Trees Park does not pose an unacceptable risk to human health" is the assumption that the development of nuclear weapons produces enough benefit to offset the consequent numbers of deaths from plutonium contamination in the Livermore community.

*Agencies Response: The Linear-No Threshold Theory (LNT) is based on the theory that there is no threshold radiation dose below which there is a zero risk; however, the theory will probably never be proven or disproven because of factors such as length of time to develop adverse health effects, confounders that interfere, and larger numbers of natural occurrences in our population. The current scientific belief is that the LNT is conservative, and without evidence to the contrary, it is generally applied as a regulatory guideline, not fact. For the Big Trees Park health consultation, we estimated the risk of developing cancer from ingestion and inhalation for the*

most sensitive population (a pica child) for one year of exposure (5.6 cases in 100 million equivalent exposures) and for 70 years of exposure (9.7 cases in 10 million equivalent exposures). These numbers were based on international recommendations and are similar to EPA cancer slope factors. The number of deaths in these periods of time would be less. The risk numbers estimated here have nothing to do with a risk/benefit analysis. They are based on scientific research. ALARA (as low as reasonably achievable) and risk/benefit practices are used when determining if an application using radioactive material should be allowed and are not appropriate for this application.

Regional and National Organization Comment: The Organization recommends that the health assessment be reformulated to clearly acknowledge current uncertainties about plutonium exposures in the community. The report should note that the ATSDR risk assessment to date is related only to one spot in Big Trees Park. The report should state that the ATSDR risk assessment does not describe the risk for exposure to plutonium in the Livermore community overall, because this risk is not currently known.

Agencies Response: *The ATSDR public health assessment when it is prepared will include discussions on uncertainty for both environmental sampling and estimation of health effects.*

Regional and National Organization Comment: The Organization recommends that all uncertainties in risk assessment methodology, especially surrounding the current scientific debate about exposure to low-level radiation, be presented in the final health consultation. An appendix should clearly present all the assumptions on which the risk assessment is based. The assumptions that dominate the uncertainty in the risk assessment should be clearly identified. ATSDR should acknowledge the principle of justification in the report.

Agencies Response: *ATSDR staff believe the current document discusses the assumptions and general methodology used in the radiation dose evaluation sufficiently. We will address the uncertainty in future documents.*

Regional and National Organization Comment: The Organization recommends that CDHS/ATSDR include a summary of findings from community and worker health studies conducted by the CDHS Environmental Health Investigations Branch, the CDHS Cancer Registry, and any others that are related to Livermore. This should also be a topic for a future public meeting. It would also be helpful to articulate at future public meetings and in the final health consultations how CDHS/ATSDR exposure assessment activities can ultimately contribute to the community's understanding of health effects.

Agencies Response: *These issues will be addressed in a future document.*

## **Public participation and notification**

**Regional and National Organization Comment:** The Organization recommends that how decisions are being made regarding follow-up activities be clearly stated before follow-up activities proceed. If nobody is in charge, nobody is accountable to the public. This is clearly unacceptable.

**Agencies Response:** *Comment noted.*

**Regional and National Organization Comment:** The Organization recommends that all follow-up activities be conducted under the auspices of the public health agencies responsible for the PHA, namely ATSDR and CDHS, in conjunction with the Site Team, which includes LLNL, regulatory agencies and community members, and with the full participation of the community, through public meetings, and other outreach and education efforts. For follow-up activities to be credible they cannot be directed by LLNL as the Lab is the self-acknowledged responsible party for the presence of plutonium in excess of global fallout levels in the community. There is an inherent conflict of interest if the "fox" is put in charge of investigating the "chicken coop."

**Agencies Response:** *Comment noted.*

**Regional and National Organization Comment:** The Organization recommends that community members who want to speak at public meetings not be asked to fill out a form as they were asked to by CDHS at the last Site Team meeting. This process created a great deal of confusion and was intimidating to some people, who understood it to mean that they had to write out their comments. This practice is clearly a barrier to full community participation.

**Agencies Response:** *The comment form process is meant to provide some organization to the public comment period and to provide a written record of citizen's concerns at each meeting. The site team meetings are not recorded. Thus, the blue forms provide documentation of the citizen's concern; and it also makes it easier for the meeting note taker to recall what comments were made.*

**Regional and National Organization Comment:** The Organization recommends that a sign be posted in Big Trees, Sunflower Street and Sycamore Grove Parks alerting the public to the plutonium contamination. Community residents have the right to know what is known to LLNL, CDHS and ATSDR, so they can determine for themselves what action, if any, they care to take. We stress that posting a sign should be considered a temporary measure only, because ultimately it may be more appropriate to remove the plutonium-contaminated soil from the community.

**Agencies Response:** *The posting of signs is ultimately the decision of the City of Livermore.*

**Regional and National Organization Comment:** The Organization recommends that notices about the presence of plutonium-laced sludge should be placed in supermarkets, other public locations,

and in newspapers. These notices should direct residents to the 800 number, e-mail or other avenue to CDHS for more information.

*Agencies Response: CDHS has recommended that the distribution of sludge throughout Livermore be thoroughly investigated. The suggestions made in the comment have been discussed with the USEPA.*

Regional and National Organization Comment: The Organization recommends that CDHS/ATSDR investigate community concerns about exposure to plutonium in the area around Big Trees Park and make recommendations for preventing avoidable exposures. For example, at the February 25, 1998 Site Team meeting, a resident on Charlotte Way suggested that exposures to plutonium in dust potentially generated each year as a result of rototilling nearby soil (presumably as a fire control measure) could be reduced by planting grass or other groundcover as an alternative method of weed control.

*Agencies Response: The recent sampling event completed in September 1998 collected soil samples from the rototilled area. Those results will be made public following evaluation.*

Regional and National Organization Comment: The Organization recommends that all comments received at the public meetings and in writing be incorporated into the health consultation as an appendix.

*Agencies Response: CDHS does not record the meetings. However, we did collect all the comments that people wrote on the blue forms. Those comments have been included in this document. Such comments not directly related to an ATSDR document are not incorporated into the document but do become part of the public record and are included in the ATSDR administrative record for the site.*

## **Conclusions**

Regional and National Organization Comment: The Organization recognizes that our recommendations on these health consultations are extensive and will be costly to implement. Although these follow-up activities fall within the mandate and scientific expertise of the public health agencies involved, e.g., the CDHS Environmental Health Investigations Branch and ATSDR, they will require additional funding. DOE is responsible for funding the PHA being conducted by CDHS/ATSDR as well as clean-up activities at LLNL. Funding for clean-up must be maintained or increase as new DOE funds are targeted to the PHA follow-up activities. It would be a perversion of these public health efforts if the community were to be told that they must choose between PHA activities and clean-up efforts, because DOE will not fund both at adequate levels.

The Organization notes that DOE is currently funding LLNL to build the most expensive element of the DOE "Stockpile Stewardship and Management" Program, a mega-laser that will produce miniature thermonuclear explosions, providing data for the "advance" of nuclear weapons science.



Known as the National Ignition Facility, the installation will cost more than \$1 billion to build, and billions more to operate. The Organization anticipates that funding for all of the public health activities we have recommended constitute far less than the "rounding error" associated with the cost of the National Ignition Facility.

The Organization believes the burden of proof as to the potential public health impacts of LLNL activities on the community should rest with LLNL which is the self acknowledged source of the plutonium contamination. In the absence of adequate follow-up that addresses all of the community concerns, residents are in effect being told to shoulder potential risk from exposures, that if identified, could be prevented in the future.

It is a sad fact that although the full risk to the public health is not known at this time, and could prove in the long run to be small, assurances by LLNL that there is no public health concern from their activities cannot be relied on. As evidenced by the Tiger Team report, these assurances have historically been based on inadequate environmental data. In addition, the fact that LLNL's main site and Site 300 have been placed on the National Priorities List (i.e., are Superfund Clean-up Sites) demonstrates that LLNL's historical environmental stewardship practices have resulted in the Lab being one of the most highly contaminated sites in the U.S.

Moreover, The Organization recommends CDHS/ATSDR follow-up activities demonstrate that there has been no harm to the public health because historically, assurances by the DOE have often been found to have nothing in common with the facts that emerge over time. Recent disclosures at the Hanford Nuclear Reservation reported in the New York Times on March 23, 1998 provide just one illustration of this problem. In "Admitting Error at Nuclear-Weapons Plant", Matthew Wald reports:

For almost 50 years, managers at the nuclear-weapons plant with the United States' largest concentration of radioactive waste, in Hanford, Wash., steadfastly maintained that leaks from underground tanks were insignificant because the radioactive material would be trapped by the surrounding soil. But they now admit that they were wrong. ... A General Accounting Office report scheduled for release on Monday cites warnings to the Energy Department going back to 1989 that it needed to pay closer attention to the issue. As late as last July, an employee at the plant for 20 years was dismissed by a contractor for raising the issue too vigorously, according to a Labor Department ruling. ... The reason the department never studied the problem adequately, it now appears, is that it did not want to know. ... The department had said for decades that no waste from the tanks would reach the ground water in the next 10,000 years at least, but it is already there. ... At the Washington State Department of Ecology, Suzanne Dahl, a hydrogeologist who is the tank waste project manager, said the Energy Department's position was in part simply wishful thinking. ... " It was a little bit of burying their heads in the sand and hoping it wouldn't get there, hoping they wouldn't have to deal with it yet," she said. ... The department's failure to study the issue properly is shaking outsiders' faith in the department, which has been trying to portray itself as a competent environmental steward. (full text of article attached)

Thank you again for your efforts to date on behalf of public health of the community around LLNL.

Enclosures are available in the ATSDR Administrative Record.

#### References cited by The Organization

<sup>1</sup>DOE Incident Analysis Report SAN-86-05, Report of Incident Analysis Committee on Nickel Chromium Release to the Sanitary Sewer on September 18, 1986. October 1986.

<sup>2</sup>Godwin (LLNL) to Adams (Livermore Water Reclamation Plant), Response to May 11, 1987 Letter Concerning the 1986 Nickel & Chromium Spill. June 22, 1987.

<sup>3</sup> Letter dated 5/17/88 to Robert O. Godwin, Associate Director, Plant and Technical Services, LLNL from John C. Hines, Assistant Director of Public Works; Brekke (LLNL) to DeGrange (LLNL), Investigation Report of the August 4, 1987 Radiation Release to the Sanitary Sewer System 9/2/87.

<sup>4</sup>U.S. DOE, Environment, Safety and Health, Office of Environmental Audit, Environmental Survey, Preliminary Report, LLNL, DOE/EH/OER-09-P. December 1987  
p 3-74.

<sup>5</sup>Elevated Plutonium Levels in LLNL Sewer Effluent, May 1987. Dated 9/3/87 and 9/30/87; also see Brekke (LLNL), regulatory Analysis: May Plutonium Release 9/10/87.

## Regional Organization

### **I. General Comments:**

1. **Regional Organization Comment:** We believe investigation of air pathway plutonium deposition to be a top priority. As noted in the CDHS/ATSDR Report, samples of Pu 238 and/or Pu 239 at the three Livermore parks (Big Trees, Sycamore Grove, and Sunflower) show evidence of aerial deposition above global fallout background levels. Moreover, even if the greatest contamination found so far at Big Trees is- in whole or in part- the result of sediment distribution from the Arroyo Seco channel, as seems likely, contamination of the Arroyo Seco may have originally occurred from aerial contamination (either instead of or in addition to contaminated storm run-off).

*Agencies Response:* Currently there is insufficient information to ascertain any pathway that led to deposition of plutonium in any park in the Livermore area. As part of the health assessment process, ATSDR staff will be evaluating air quality around the LLNL main site and Site 300.

2. **Regional Organization Comment:** The title and production of the Report should better reflect the two major, but distinct, concerns of the Report -- a) park contamination, and b) distribution of contaminated sludge into the community. While both issues relate to plutonium contamination, the latter is clearly distinct from contamination at Big Trees Park. Subsuming this area of investigation under an overall rubric that only focuses on one park could hinder public clarity and understanding by confusing the sludge pathway hypothesis for contamination at Big Trees, which we agree appears unlikely, with the distribution of contaminated sludge to residents and municipal agencies, which unquestionably occurred.

*Agencies Response:* Contamination in Big Trees Park and the distribution of sewage sludge are issues needing to be separately addressed. The main focus of this health consult, however, was an investigation into the possible routes for the plutonium contamination in Big Trees Park, not an investigation of the distribution of contaminated sewage sludge. Contaminant releases from LLNL to the City of Livermore's sanitary sewer system will be the focus of a future document.

3. **Regional Organization Comment:** Design, planning, implementation and reporting for additional soil sampling should be conducted under the auspices of CDHS/ATSDR and the Site Team, since this public review process is now well-established and ensures the greatest chance of broad discussion and transparency.

*Agencies Response:* We support and will be a proponent for public transparency in additional soil investigations. As a result of this consultation, the ATSDR, DOE, EPA, and the state, developed, drafted, and released for public comment a new sampling plan for Big Trees Park. The new sampling has been completed and ATSDR will discuss the process of data validation and the results of the sampling at future site team meetings.

4. Regional Organization Comment: The funding for the activities outlined in Regional Organization's (and others') comments should be provided by LLNL, the "responsible party" under the Superfund law. Further, it is essential that such funding be in addition to funding for other cleanup activities undertaken at the LLNL main site and site 300, e.g. activities pursuant to CERCLA codified in the FFA, main site ROD and other documents. In short, funding activities related to the above-listed CDHS/ATSDR report should not become an LLNL excuse for slowing other cleanup schedules or milestones, nor should the funding needed for those activities become an LLNL excuse not to carry out needed follow-up to this CDHS/ATSDR public health assessment process.

*Agencies Response: Comment noted.*

## **II. Specific Comments:**

### **A. Radiological Issues**

1a. Regional Organization Comment: Plutonium is a serious risk to public health and safety. A man-made, radioactive substance, plutonium is often called the "most toxic substance" on Earth and, if inhaled or ingested, can cause death by cancer as well as other negative health effects, including genetic damage. This risk of negative health outcomes is especially high for children. Please see the attached copy of "No Dose Too Low," an article from the December, 1997, issue of The Bulletin of the Atomic Scientists which demonstrates that the prevalent opinion today among radiation scientists is that even very small doses of radiation - i.e., below background levels and whose effects are hard to detect- do increase the risk of cancer. Also attached is a citation from the Fernald, Ohio case in which DOE admits there is no safe level of radiation exposure. Regional Organization is extremely concerned about the risks to public health and safety and to the environment caused by the plutonium-laden sludge and other, airborne and waterborne, plutonium contamination referred to in the report. The report states that both LLNL and the City of Livermore knew the sludge was contaminated by LLNL with plutonium, but still allowed it to be made available for public use in gardens, as topsoil, groundfill, etc. An additional, special concern is the fact that the plutonium "hot spots" discovered in the soil at Big Trees Park are in an area frequented by children as they go to and from an adjacent school, and as they play in the park daily.

*Agencies Response: According to LLNL staff, the 1967 accidental release of plutonium to LWRP was within discharge limits; and thus, required no further action. We share your concern regarding exposure of children to soils in the park, which the plutonium levels are unknown. This is one of the reasons we recommended additional sampling.*

2a. Regional Organization Comment: The Radiological Evaluation part of the Report (pp. 6-8) needs expansion to provide enough information to make the formulation of conclusions totally transparent. All assumptions in the analysis should be clearly defined and explained. For

example, how the equivalent doses (for various organs) were weighted to arrive at the effective dose should be clearly laid out, along with the underlying assumptions.

It would also be useful to include a discussion on the calculation of the equivalent dose, defined in the Report as "the absorbed dose average over a tissue organ (rather than at a point) and weighted for the radiation quality (type of radiation)." Moreover, how does the assumption of averaging a dose over the whole organ, instead of the more likely real scenario of a plutonium particle lodging in one spot in the lung, for example, possibly alter dose estimations?

*Agencies Response: We added additional information to answer the question regarding weighting factors. The assumptions ATSDR used are also included in the document – we used the most conservative values of dust loading, particle size, and ingestion rates for the radiation dose determinations. With regard to organ doses versus particles deposited into a single spot, the recommended methodologies do not consider this "hot spot" to be an appropriate method for determination of radiation dose to an individual. "Hot spots" usually apply to localized areas, not entire organs and do not necessarily affect organ function. There is no detriment to the organism as a result of a "hot spot".*

3a. Regional Organization Comment: Linear extrapolation from high radiation doses to very low doses may be appropriate, and is common practice given the current state of knowledge. However, the section on Radiological Evaluation should somewhere acknowledge there is controversy on this point, with a number of scientists postulating that proportionately greater harm may result from low-level exposures (see Specific Comment #1 above).

*Agencies Response: In discussing low dose effects, the major factor is defining the qualitative term low dose. Low dose, from the lowest to the highest, can indicate low environmental dose, low occupational dose, or low medical treatment dose. Each of these "low" doses can cover separate, but important, numerical ranges. Environmental doses can cover from a background of approximately 2 millisieverts (mSv) [0.2 rem; 200 millirem], not including radon, to perhaps as much as 5 mSv (0.5 rem) depending on geographical location. Low occupational doses can range from 5 mSv to perhaps as much as 10 to 40 mSv (1 to 4 rem). Low medical diagnostic doses can range from skin entrance doses of 0.15 mSv to 1 Sv (15 millirem to 100 rem). The following is a brief discussion of low dose and linear-no threshold issues.*

#### ***Alice Stewart***

*Alice Stewart and her coworkers, most notably Kneale have evaluated both atomic bomb survivor data as well as data from DOE's Hanford facility in Washington. With respect to the atomic bomb survivor data, they presented evidence of biological competition between early death or other radiation effects. They also discuss the evidence that late effects of radiation include marrow damage as well as cancer (ref - Stewart AM and Kneale GW (1990). A-bomb radiation and evidence of late effects other than cancer. Health Phys 58:729-735.) In an earlier analysis of these data, they reported differences between cardiovascular and other non-malignant diseases. Both effects were believed to be related to the dose received during the bombings. (Ref - Stewart*

AM and Kneale GW (1984). *Non-cancer effects of exposure to A-bomb radiation. J Epidemiol Community Health 38:108-112.*) These studies all relate to doses much higher, by orders of magnitude, than those received from exposure to plutonium in Big Trees Park.

In Stewart and Kneale's studies regarding the Hanford facility, they reanalyzed cancer deaths covering the years 1944 through 1986. They estimated that less than 5 percent of the cancer deaths prior to 1987 had occupational exposures to external radiation that induced cancer and these appeared to be age-related. Their analysis also provided no support for radiation causing leukemia more than solid tumors. Stewart and Kneale also state that "for all recorded exposures of Hanford workers, the estimated doubling dose was close to 26 rem; for exposures after 58 years, it was close to 5 rem, and for exposures after 62 years, it was less than 1 rem. Again, these doses are much higher than those calculated for Big Trees Park. (Ref - Kneale GW and Stewart AM (1993). *Reanalysis of Hanford data: 1944-1986 deaths. Am J Ind Med 23:371-389.*)

### **Linear-No Threshold Controversy<sup>6</sup>**

The radiation protection and scientific communities currently are discussing the significance and relevance of the linear-no threshold hypothesis (LNTH); an hypothesis is an unproven theory or model. The LNTH was developed to establish practical scientifically based radiation protection standards to minimize detriment but also to enhance benefits of radiation exposure. The LNTH states that any exposure no matter how small carries a risk of detriment or harm to the exposed system. Current scientific methods have not been developed to either prove or disprove this theory of low level radiation effects.

More recently, an international group of radiation experts met to discuss what could be considered a safe radiation exposure. One outcome of this meeting was that the experts agreed that a radiation dose below 10 rem can be considered safe for an adult; however, they also agreed that the LNTH should not be abandoned because of the lack of scientific evidence<sup>7</sup>.

From an historical perspective, the LNTH, although only a model, was developed to explain a particular set of radiation experiments on fruit flies. After the second world war, interest in the LNTH model expanded because of its simplicity and its representation of the upper risk level. Over time the LNTH has become a "fact" in spite of the apparent lack of strong scientific proof, especially at doses near the levels associated with the environmental radiation dose range.

As with any scientific thought, there are many scientific publications in the literature that support a LNTH concept for radiation effects as well as those publications that do not support such

---

<sup>6</sup>Kathren, R.L. (1996). *Pathway to a paradigm: The linear non-threshold dose-response model in historical context: The American Academy of Health Physics 1995 Radiology Centennial Hartman Oration. Health Physics 70: 621-635).*

<sup>7</sup>Risk Policy Report, September 19, 1997. Page 15

*claims. Furthermore, there is much literature on hormesis with purports that low doses of radiation (approximately related to environmental dose ranges) are beneficial.*

*As currently represented, radiation protection standards using the LNTH believe that any exposure above naturally occurring background levels results in some detriment to health, especially an increase in the risk of cancer. Furthermore, this risk is directly proportional, or linear, to the dose above background. This belief is based on studies at the cellular and organism level, survivors of the atomic bombings, radium dial painters, and those receiving medical radiotherapy. Problems exist, however, with these studies is that they focus on exposures and doses nominally in the 100s of millisieverts (mSv), equivalent to 10s of rems which is still much higher than environmental exposure levels which are in the single digit millisievert ranges (average of about 3 mSv). Furthermore, there is much difficulty in comparing animal studies to human studies. In essence, the scientific community still does not know what the cellular or organism response to radiation at levels approaching background radiation levels.*

*Individuals who disagree with the LNTH model point to methods of data analysis purported to support the LNTH model. For example, even though it is impossible to have zero radiation exposure and thus a hypothetical no exposure, researchers fit their data to a zero point in their experiments. This effectively rules out hormesis (protection at low levels) as well as increased sensitivity as supported by the work of Alice Stewart and others. Additional problems are in the arena of terminology. What is meant by "low level exposures?" Is this low level occupational or low level environmental? Generally occupational exposures are in the range of 10 mSv or higher; whereas, environmental exposures are on the order of 3 mSv. A large, unknown gap exists in the dose response curves between 1 and 10 mSv; that is, the shape of the curve is unknown – hence use of the linear no threshold model as an upper boundary to protect human health.*

*Summary: As related to exposure one receives from background radiation and because of the unknowns associated with the LNTH, the significance of doses slightly greater (2 to 5 times higher) than the doses associated with background radiation is unclear at the present time. All data at these levels are open to interpretation - there is no clear right or wrong answer.*

4a. Regional Organization Comment: This section should also clearly emphasize that the risk calculated considers ONLY cancer. As plutonium can cause other health problems, such as genetic damage, immune system dysfunction, and other adverse effects, it is important that the public know these are NOT considered in this analysis. This means that the risk estimator is necessarily an underestimate of the total negative health effects on the community.

Agencies Response: *Current peer reviewed science recognizes radiation as a carcinogen, other illnesses have not be conclusively shown to be related to radiation exposures. As more studies are identified that associates plutonium or radiation and non cancer illnesses, then ATSDR will be able to evaluate additional health concerns.*

5a. Regional Organization Comment: Plutonium is an extremely long-lived source of alpha radiation with a half-life of just over 24,000 years. Actual public health risks considered should

therefore include impacts on the many future generations likely to be exposed. There should be some discussion about whether a resulting cumulative health risk assessment might be included as well, and might better represent some of the actual danger posed by the plutonium contamination so far discovered, qualitatively if not quantitatively.

*Agencies Response: Our dose assessment assumes a 70 year life span following exposure resulting from pica behavior which normally lasts one to two years. Other individuals would receive much less dose because ingestion rates are approximately 2 orders of magnitude lower.*

6a. Regional Organization Comment: On page 8, you state that USEPA's "proposed cleanup regulation limits the projected exposure of any reasonably maximally exposed (RME) member of the public to 15 mrem... per year above background..." As we understand it, present EPA Region IX guidelines establish a "screening level," also called the Preliminary Remediation Goal, of 2.4 picocuries per gram. The "hottest" spot thus far discovered at Big Trees Park is a little less than half this figure -- 1.02 picocuries per gram. But on page 6, you estimate an effective dose of less than 1 mrem for the RME individual (a pica child), which is less than 1/15th of EPA's proposed cleanup limits. How do these two EPA measurement guidelines - proposed and current - compare? Do the proposed EPA regulations represent a relaxation of health or cleanup standards? What is the estimated risk of cancer that the ATSDR and EPA calculated for the RME individual for this investigation?

*Agencies Response: Currently there is no enforceable national standard for radiologically contaminated sites. The EPA has a proposed rule for an effective dose limit of 15 mrem. This limit was mentioned in the public comment release of the health consultation. However, ATSDR removed this section from the final version of the health consultation. Until a comprehensive, protective set of cleanup regulation for sites contaminated with radioactive materials is available, ATSDR will continue to use the EPA Region IX-specific Preliminary Remediation Goal (PRG) as a screening tool.*

7a. Regional Organization Comment: On page 7, paragraph 3, please clarify how the 70-year risk of cancer from ingestion was calculated to be  $1.4 \times 10^{-6}$ . By multiplying the yearly estimated risk ( $5.6 \times 10^{-8}$ ) by 70, we get  $3.92 \times 10^{-6}$ . Similarly, multiplying the yearly estimated risk of cancer from inhalation,  $6.5 \times 10^{-9}$ , by 70, gives us  $4.55 \times 10^{-7}$ , not  $9.7 \times 10^{-7}$ . Assuming that the calculations in the draft report were done correctly, an explanation of how the calculations should be done should answer the question for us and for other readers of the report, and should be included so the reader is not confused.

*Agencies Response: The dose calculation is not a straight forward mathematical effort. Our calculations are based on age dependence and dose conversion factors that vary as an individual ages.*



## **B. Big Trees Park**

1b. Regional Organization Comment: The report suggests airborne and waterborne (via the nearby Arroyo Seco) contamination as probable causes of the plutonium found in Big Trees Park, and we agree with the report's recommendations that follow-up soil samples, including sampling to deeper levels than previously done, should be collected and analyzed from Big Trees Park. However, we suggest that soil samples from other neighborhoods and from areas east of LLNL also be collected and analyzed.

*Agencies Response: As part of the PHA process, ATSDR staff will be evaluating air and soil in the Livermore area. These evaluations will help determine the necessity for recommendations relating to additional soil sampling. The need for additional sampling in the Livermore valley has been discussed by the regulatory agencies and ATSDR.*

2b. Regional Organization Comment: We concur that contaminated sludge deposits are the least likely scenario to explain plutonium contamination in Big Trees Park (given especially the repeated testimony of the sewage treatment plant personnel and the parks department personnel). We also concur with your conclusion that since Big Trees Park is usually upwind of LLNL, "a small percentage of aerial deposition from releases at LLNL may have occurred at Big Trees Park." However, we note that if there were plutonium accidents that occurred in the past, and are potential contributors to contamination, then the wind direction and other relevant factors for the day or days of the accident(s) would need to be considered. (See also comment C 1 .)

*Agencies Response: ATSDR staff will be evaluating air quality around the LLNL main site and Site 300.*

3b. Regional Organization Comment: We agree that soil and sediment sampling at depths of 30 to 45 cm should have been conducted in the 1995 soil sampling at Big Trees Park. Given that LLNL's 1974 report on plutonium sampling in Livermore soils went to a depth of 25 cm, this range of 30 to 45 seems most appropriate. (This 1974 report was previously submitted by Regional Organization to CDHS and should be made part of the record along with our comments.) We further advocate that samples be adequately "stratified" to identify the amounts of plutonium found at different depths.

*Agencies Response: CDHS and ATSDR recommended that samples collected during the 1998 sampling of Big Trees Park be adequately stratified and at depths necessary to define the vertical extent of the contamination.*

4b. Regional Organization Comment: What municipal agencies received sewage sludge (p. 13)?

*Agencies Response: The statement referred to in the comment was obtained from a LLNL report. We have modified the health consultation to reflect the reference from which the information was obtained. CDHS does not know to which municipal agencies the LLNL report is referring.*

5b. Regional Organization Comment: We believe the scientific quibbling by LLNL in its "data verification" comments over the appropriate methods to analyze the 1995 split samples largely misses the point. Whether 3 or 13 of the 19 samples conclusively show higher than background levels of plutonium, they indicate that the park is contaminated with plutonium at more than one location, clearly suggesting the need for greater investigation.

Agencies Response: *This uncertainty is one of the reasons we recommended additional sampling in Big Trees Park and the Arroyo Seco.*

6b. Regional Organization Comment: Notices should be posted and maintained at Big Trees Park and at other parks and public places where plutonium is located so that the public be informed as to its presence. In the past, our members have posted such notices at Big Trees Park, only to have them removed (to the best of our knowledge and belief) by the City of Livermore.

Agencies Response: *The posting of signs is ultimately the decision of the City of Livermore.*

7b. Regional Organization Comment: The plutonium "hot spots" should be removed from Big Trees Park as well as from other public and private places where they are found, and the plutonium-contaminated soils should be stored at LLNL, isolated from workers and/or the public, until such technology has been developed to dispose of it safely.

Agencies Response: *Comment noted.*

8b. Regional Organization Comment: Regional Organization' members who live in the vicinity of Big Trees Park have noticed a series of substantial changes to the physical surfaces at the park and along Arroyo Seco between the park and LLNL. These alterations have occurred since the 1995 samples were taken and reported by LLNL. First, an unknown entity (though we made calls to try and track it) deposited a large volume of soil over the area at Big Trees Park containing the highest concentrations of plutonium. This soil formed a small hill, rising several feet. On top were originally planted some flowers, though they were promptly left to die. Then, one day, unannounced as far as we can tell, our members saw that earth moving equipment had been used to remove the "hill", scraping as well all the loose dirt, and additional dirt going down at least several inches, over that entire segment of the park. The scraping marks of the machinery used were evident for weeks. Additionally, there have been substantial changes made to the arroyo between LLNL and the park during the past year. Dirt has been moved, and piles of rocks lining the arroyo have been added. An investigation into the extent of these alterations, focusing on the implication these changes have for sampling plans and related activities should be undertaken. If these activities may confound future sampling results, that should be noted.

Agencies Response: *CDHS would recommend that any soil disturbing activities that have taken place in areas where future sampling is proposed be noted, and alternate locations in undisturbed areas be sought when possible.*

### **C. Recommendations re: Additional Sampling & Determine Likely Contaminant Pathways and Levels**

1c. **Regional Organization Comment:** CDHS/ATSDR, with the strong involvement of the public health assessment Site Team (which includes but is not limited to LLNL personnel), should jointly develop the appropriate sampling plan and any follow-up. As the party responsible for the contamination, LLNL should pay the costs of additional soil sampling, but it would be inappropriate for LLNL to take a sole leadership role in sampling design, implementation, reporting and/or follow-up.

*Agencies Response: The 1998 sampling activities planned for Big Trees Park fall under the USEPA's purview. However, we supports that this process should be conducted in a manner which is transparent and inclusive of the public.*

2c. **Regional Organization Comment:** CDHS/ATSDR should conduct a literature review of specific issues re: sampling for plutonium, including likely collection areas, further disintegration of plutonium deposits and subsequent possible dispersal, and rates of plutonium migration in soil.

*Agencies Response: CDHS and ATSDR have conducted an initial review on this subject and will continue to review literature pertinent to issues surrounding the Public Health Assessment.*

3c. **Regional Organization Comment:** CDHS/ATSDR should consult with individuals and groups experienced in sampling for plutonium, possibly including SENES of Oak Ridge, TN, Dr. Alan Benson (consultant for Hanford and other U.S. & international sites of radioactive contamination), and/or others.

*Agencies Response: Comment noted.*

4c. **Regional Organization Comment:** Sampling design should be appropriate to test air pathway contamination in the community. This is partly because plutonium levels higher than expected were found at the depth of 1 cm in Big Trees, Sunflower and Sycamore parks. It is also because even if Big Trees park contamination is found to be principally via the Arroyo Seco, the question remains of how the Arroyo Seco became contaminated at LLNL - a question which must be answered. As mentioned above, it is reasonable to postulate that the Arroyo Seco was contaminated at least in part by airborne plutonium deposits, especially since LLNL now claims its annual monitoring reports were in error and that therefore it is unlikely that contamination occurred as a result of run-off from plutonium contaminated soil on-site at LLNL. (More investigation of the storm run-off patterns seems warranted as well.)

*Agencies Response: The objectives of the 1998 sampling of Big Trees Park is to further investigate the potential pathway for the contamination found in Big Trees Park, including via of the air and via the Arroyo Seco. In addition CDHS or ATSDR will be evaluating air and sediment monitoring in future health evaluations.*

5c. Regional Organization Comment: Sampling for possible aerial pathway plutonium contamination should be designed to highlight areas most likely to experience contamination from the plutonium facility's (Building 332) smokestacks. Any model used should take into consideration the windrose, height of stack(s), range of speeds at which air is emitted from the stacks, range of temperatures of air emitted from the stack(s), and an average or typical range of wind speed. (This modeling effort should be further informed by a more thorough knowledge and review of plutonium accidents at LLNL, with specific data included for those events.)

Agencies Response: *ATSDR staff will be evaluating air emissions from the LLNL main site and Site 300.*

6c. Regional Organization Comment: Since the prevailing winds in Livermore travel east, additional sampling for air pathway deposition should be to the east of LLNL, chosen according to the results from a modeling effort as described in (5) above. In this regard we note as well that the DOE "Tiger Team" in 1990 found evidence that in 1988 elevated levels of plutonium were found in an off-site air monitor to the east of LLNL.

Agencies Response: *See above response to comment #5c.*

7c. Regional Organization Comment: Future sampling should include an analysis of plutonium particle size and distribution (e.g. percentage of particles that are .1 microns) as a method to assist in the determination of whether the plutonium deposition in Big Trees and elsewhere was airborne. Since HEPA filters have a transparency in the 0.1 micron range, an abundance of particles that size would indicate "routine" airborne emissions as the major pathway. In conjunction with other methods, looking at particle distribution could help answer questions about pathway.

Agencies Response: *Comment noted. Particle size determination is not a viable option once materials have been in the environment. Only during atmospheric releases is this type of determination important.*

8c. Regional Organization Comment: Additional sampling for water pathway deposits should be done in Arroyo Seco in areas farther away from the Big Trees sites. Sampling of sediments should include locations at Arroyo Seco's lowest points, where water is likely to "pond." These deposits are likely to be older, but, since deposits tend to build up over time, and, since rains wash away some surface sediments (especially in recent storms), it may be necessary to sample as deep as several feet deep. It is also advisable to sample along Arroyo Seco's original path, before it was diverted, taking samples from deeper than the fill depth (i.e., if it took five feet of soil to fill in the Arroyo, samples should be taken from a depth of at least six to eight feet).

Agencies Response: *Generally, the substance of these comments are part of the 1998 sampling of Big Trees Park and the Arroyo Seco.*

9c. Regional Organization Comment: Efforts should be made to obtain additional data from LLNL and to review the adequacy of the in-stack air monitors at the plutonium facility (Building 332) and elsewhere at LLNL. It should be noted that air monitors at the "fenceline" could easily miss aerial pollutants from the stacks because the lift (from heat and original emission speed) of aerial emissions can cause emissions to go over these monitors. In addition, a review of when these monitors might have been turned off or inoperable would be useful. We know of one off-site monitor that was inoperable for as long as nine months, but from which, nonetheless, data was reported during that time.

Agencies Response: See our response to comment #5c.

10c. Regional Organization Comment: Additional data collection and review should be done concerning the efficacy of the HEPA filters and any prefilters, including any adjustments for the likely contaminant load it might receive at peak times (e.g., uranium or plutonium "burns," potential accidents, etc.). The issue of transparencies, such as for particulates that are a tenth micron in size, should also be examined. In addition, maintenance/replacement records and procedures for the HEPA filters in the plutonium building and other relevant locations should be reviewed and evaluated by CDHS/ATSDR and reported out in the final document.

Agencies Response: See our response to comment #5c.

11c. Regional Organization Comment: Additional information should be obtained from LLNL regarding plutonium accidents and also other "high point-source emissions." For example, historically, plutonium chips, filings etc. were oxidized in plutonium burn pans. At other times, and perhaps into the present, this activity was conducted in glove boxes. The burn method(s) used, amounts of plutonium involved and emissions therefrom need to be known to CDHS/ATSDR and considered as a source of plutonium in Big Trees Park and perhaps elsewhere. Similarly, CDHS/ATSDR needs more data on accidents, leaks, spills and other releases of plutonium during operations and in wastes at LLNL.

Agencies Response: See response to comment #5c.

#### **D. Investigation of Lawrence Livermore National Laboratory.**

1d. Regional Organization Comment: Building 332 - LLNL's Plutonium Facility  
Regional Organization suggests that LLNL be thoroughly investigated to determine whether any subsequent and/or current problems with releases of plutonium exist. If any such problems exist, steps to eliminate them must be taken. (Please note that while most plutonium operations both historically and in the present are at the main site, court testimony in Tracy during the 1980s disclosed that LLNL had used small amounts of plutonium at site 300.)

As of this writing, approximately 25 violations of plutonium criticality safety regulations have occurred in LLNL's plutonium facility (Building 332) since May, 1997, resulting in its being

closed down for now. This indicates an extreme problem at LLNL regarding chronic noncompliance with safety regulations as to the handling of plutonium.

Further, it is our understanding that LLNL does not properly maintain and/or replace its HEPA filters in Building 332. Specifically, the filters (which are supposed to catch airborne plutonium particles, thus preventing them from escaping into the environment) have been left in place for decades. They have become, and remained over periods of time, encrusted with plutonium. Moreover, it is well-documented that aging of HEPA filters lowers their resiliency (e.g. resistance to "breakout") and increases the potential for leakage both along the filters' edges where they are glued to their frames and in the filter material itself where small rips and tears may occur. These conditions increase the amounts of plutonium that reach the outside environment.

Additionally, should a fire break out in the plutonium facility (plutonium has an inherent tendency to burst into flame in some configurations), causing the fire prevention sprinklers to turn on and moisten the filters, the wet filters could then very easily be blown out of the facility along with their large "payloads" of plutonium, posing a great risk to LLNL employees, the public, and the environment. Indeed, this scenario has already occurred in another DOE nuclear weapons facility, Rocky Flats (Colorado), so it is not just speculation to consider this a potential threat to public health and safety here.

Regional Organization has already suggested in its October, 1997, public comment to the State of California Department of Toxic Substances Control (DTSC) concerning LLNL's application for a permit to operate its own on-site hazardous waste facility- that an Environmental Impact Report (EIR) be done at both LLNL's main site and site 300. This EIR would likely include an investigation into LLNL's methods of handling, using, machining, treating and storing plutonium, in that the above mentioned criticality violations and other incidents at Building 332 and elsewhere raise questions as to how LLNL deals with hazardous materials. CDHS might coordinate with DTSC regarding this EIR so that, if it's completed, the EIR may be used by CDHS as one investigatory tool into LLNL's plutonium issues.

*Agencies Response: Comments noted.*

### **E. Follow-up Community Health Activities**

1e. Regional Organization Comment: Implement a search for the Livermore Water Reclamation Plant's (LWRP) "logbook" with a public record of who took the sludge. Even if found, however, it is likely to be a casual, incomplete record. Therefore, there is a need to identify and interview LLNL personnel, and LWRP and other City of Livermore personnel involved in sludge monitoring and distribution to gain information about where the sludge went, both in Livermore and outside Livermore.

Agencies Response: CDHS staff have spent considerable time and effort in conducting the activities the comment suggests. CDHS staff are concerned about the past distribution of sewage sludge, and will continue to be involved with this issue until it has been resolved.

2e. Regional Organization Comment: Publicize widely the potential problems with past use of sludge soil amendments, including notices in supermarkets and other public places as well as in newspapers and other media. Seek cooperation with the City of Livermore to put notices in any City-generated newsletters or other notices, as well as in the public library. Advertise an 800 number for people to call who are concerned about possible plutonium contamination of their soil. In this we concur with the EPA's recommendation, contained in the agency's March 1998 letter to LLNL.

Agencies Response: CDHS has had informal discussions with the USEPA about such activities. ATSDR also has discussed this issue with the regulatory agencies.

3e. Regional Organization Comment: Provide free testing of soil and soil replacements to Livermore residents, where plutonium contamination is discovered, costs to be absorbed by LLNL.

Agencies Response: Comment noted.

4e. Regional Organization Comment: If possible, develop and disseminate a fact sheet with information about competent, licensed soil testing laboratories for those residents who wish to pursue independent soil testing. The fact sheet should include information on appropriate testing/sampling procedures to ensure useful test results.

Agencies Response: We will consider this suggestion.

5e. Regional Organization Comment: Where plutonium-contaminated soil is discovered, it should be removed and stored at LLNL's site, isolated from workers and/or the public, until such technology has been developed to otherwise dispose of it safely.

Agencies Response: Comment noted.

6e. Regional Organization Comment: Investigate and evaluate the efficacy of monitoring and containing LLNL-source radioactive and hazardous contaminants which potentially could enter the sewage waste stream, or already have.

Agencies Response: These issues will be considered in the public health assessment addressing contaminant releases from LLNL to the sanitary sewer.

7e. Regional Organization Comment: Evaluate the possibility or likelihood of LLNL-source contaminants, especially plutonium, entering the sewage waste stream currently or in the future.

(In regard to this and #6 above, we note that plutonium and other radionuclide releases by LLNL to the sewage treatment plant have not been limited to the 1967 accident.)

*Agencies Response: These issues will be considered in a future health document addressing contaminant releases from LLNL to the sanitary sewer.*

8e. Regional Organization Comment: Regional Organization is very concerned about those in the community who have been exposed to plutonium (please see Section II-A. above). Therefore, we suggest that CDHS/ATSDR investigate the ways in which health testing could be made available to the public. We urge that these testing services be free to the public (i.e., LLNL as the "responsible party" as defined by the Superfund law and other appropriate bases should bear the cost). Further, anyone from the community (or his/her survivors) found to be adversely affected by plutonium should be compensated (e.g., for health care costs, loss of work, loss of education, burial costs, etc.) by LLNL.

*Agencies Response: ATSDR can work with the Association of Occupational and Environmental Clinics (AOEC) to have clinical health evaluations conducted if circumstances are appropriate. However, there does not yet seem to be a need for these health evaluations based on the plutonium levels evaluated in this health consultation or other exposures in other health consultations completed thus far.*

Encl: "No Dose Too Low," The Bulletin of Atomic Scientists, December, 1997. In Re: Fernald Litigation, Admission #89 on radiation protection is available through the ATSDR Administrative Record.



### Private Institute Comments

I was provided with a copy of the above-mentioned document at the request of (private individual). I also received the following documents from Lawrence Livermore National Laboratory:

Livermore Big Trees Park Soil Survey, January 1995

- Livermore Big Trees Park January 1995 Soil Survey Results, July 1995
- Lawrence Livermore National Laboratory Plutonium Fact Sheet

I have conducted a limited review of the materials. My comments are summarized below.

### **Dose estimate**

#### Private Institute Comment:

On page 6 of the Health Consultation, the dose to a two- to three-year old pica child playing 250 days per year in the highest contaminated soil (1.02 pCi Pu 239 per gram) was estimated to be less than 1 mrem EDE per year (effective dose equivalent, EDE). It appears that this dose as well as the doses estimates on page 7 are actually committed effective dose equivalent (CEDE) because they were compared with the ICRP dose limit to members of the public of 100 mrem/yr. The difference between the annual and committed doses from Pu 239 intake is more than an order of magnitude owing to its long physical and biological half-life. If the estimates are indeed CEDE, this should be stated accordingly.

The estimate is presented without adequately addressing the uncertainties of the input parameters. It indeed appears quite unlikely that a child spends that much time in just this one location and would eat this much soil at the same time. The impression in the calculation is given that the three factors (maximum soil concentration, pica child and 250 day access to the park) guarantee a conservative estimate.

While I agree that it is indeed conservative to base calculations on the maximum measured soil concentration and 250 day access to the Park, I do not believe that the actual dose calculated for this condition is a conservative estimate.

My survey of transuranics in bone of former residents of Rongelap Atoll in the Marshall Islands (article enclosed) allows to estimate the doses from a median transuranic soil concentration of 110 Bq/kg = 3 pCi/g (Pu 239/240 and Am 241 combined). The effective dose equivalent (EDE), assuming a single uptake in the first year of exposure, is calculated to be in the range of <0.2 to 0.6 mrem per year (ICRP 60 weighting factors applied).

If one were to calculate the 70-yr committed effective dose equivalent (CEDE), the results are expected to be in the range of 5-20 mrem. Scaling the numbers to the concentration of 1 pCi/g Pu 239 and an exposure period of 250 days per year, the dose range would be 1-5 mrem CEDE. In other words: the Rongelap data suggests that for the selected exposure scenario (Pu 239 in soil:

1 pCi/g, 250 day stay in the Park), the dose could actually exceed 1 mrem CEDE for an average child. Since the Rongelap survey did not focus on pica children, inclusion of pica behavior would increase the estimated dose.

*Agencies Response: The terminology used in the above comment was changed in ICRP 60. The ICRP replaced the term effective dose equivalent (EDE) with effective dose to simplify the terminology used in radiation protection. The committed effective dose is now the committed effective dose (CED). The CED dose received from a single intake integrated over 70 years (for members of the public). The ATSDR dose estimates are derived from this methodology and the terms have been corrected. The ICRP recommendation of 100 mrem per year is annual effective dose. The comparison was to put the CED into perspective with the ICRP recommendation.*

### **Further sampling**

*Private Institute Comment: The sampling program allows a good evaluation of the surface contamination. The reasoning appears convincing that the contamination is likely due to material that was excavated during the realignment of the Arroyo Seco. If this is the case, sampling deeper soil layers is highly recommended.*

Given the fact that the release mechanisms associated with the contamination remains unknown, there is no information on the particle size of the activity. While it is likely that the contamination consists of small particles, it would be prudent to perform alpha track survey to identify the density of plutonium contamination.

*Agencies Response: Defining the vertical extent of the plutonium contamination in Big Trees Park and the Arroyo Seco was one of CDHS's recommendations in this health consultation. For the estimated committed effective dose (CED) calculations, 0.1 micron was assumed since the largest percentage of particles get to the deep lung. The estimated CED does not present a health hazard; therefore, the actual particle size is not important. Also, for this scenario and the levels of contamination, an alpha track survey would not contribute any additional information for this consultation as it would detect radon, radium, uranium or any other alpha emitters.*

### *Private Institute Comment:*

The documents, which I have reviewed, did not indicate that analysis for other alpha emitters such as Pu 238 and Am-241 or for beta and gamma emitters was performed. If so, the results should be reported and interpreted. If not, such analysis would be useful not only to further characterize the source but also to calculate the total dose from all radionuclides.

*Agencies Response: Comment noted.*

### **Other potentially affected areas**

Since airborne and/or liquid releases from LLNL are the apparent cause of the contamination, a proper evaluation of historic releases including the associated uncertainties would be an important step in the evaluation of the potential for further hitherto unrecognized areas of contamination. I would see the review of historical data as a prerequisite of further environmental sampling.

*Agencies Response: As part of the public health assessment process, CDHS and ATSDR will be evaluating historical and current data for all media (water, soil, air), which may have been impacted by operations at LLNL.*

Encl. are available in the ATSDR Administrative Record

## United States Environmental Protection Agency Comments

The US Environmental Protection Agency (EPA) has received the subject document and provides the following comments. Although the 1995 sampling results from the park showed no unacceptable health hazards, we agree that the past efforts did leave some questions unanswered and that more should be done to address these unknowns. Present and future residents have also added their concerns whether enough is known about contamination in the park and the surrounding area. Therefore, we agree with the consultation's recommendations. As you know, because of recent events surrounding the health consult, DOE/LLNL has agreed to perform deeper soil sampling at Big Trees Park. A draft sampling plan is currently being developed and as we understand, should be available for Site Team review by early April. As a result, some of our previous comments on the health consult (EPA letter dated December 18, 1997) no longer stand. Other comments, however, are repeated below. Comments include those of Steve Dean of our Technical Support Section.

DOE/LLNL has stated that they will also be providing a comprehensive historical survey of sludge use with a goal of determining if sludge was the source of the low levels of plutonium detected in Big Trees Park in the 1995 sampling. If you have any questions, please call me at 415-744-2385.

EPA Comment: 1. Our previous comment #2 regarding radiation cleanup standards is repeated below. The response in your letter of February 10, 1998 discussing the cleanup levels of radiation contaminated media reflected an apparent misunderstanding of our comment. This comment, with new page number and paragraph references, stated:

Page 7 (last paragraph), Page 8 (first paragraph). The report's interpretation of EPA's proposed cleanup rule is incorrect. The latest OSWER directive regarding the CERCLA process for determining cleanup levels at Superfund sites states that the cancer risk range and Preliminary Remediation Goals (PRGs) based on plutonium soil concentrations (not 15 millirem per year dose) is the appropriate methodology to be applied here. The phrases "USEPA's proposed radionuclide cleanup regulation is not intended to decide if cleanup at a particular is warranted..." and "...proposed regulations are not intended to be equated with a level of health concern..." are incorrect statements and should be removed from the text.

Agencies Response: *The section has been deleted from the text.*

EPA Comment: 2. We hereby repeat previous comment # 4 (with new page and paragraph): Page 10, paragraph 1. To perform a complete investigation of finding a source of the plutonium in the park, the report should consider the possibility of a one time "puff" release of plutonium from the facility while the prevailing winds were blowing towards Big Trees Park.

Agencies Response: *The health consultation has been modified to reflect the comment. Refer to Aerial Dispersion section of the health consultation for discussion.*

## Department of Energy and LLNL Data Validation Comments

The Department of Energy and Lawrence Livermore National Laboratory (DOE/LLNL) wish to ensure that an accurate Agency for Toxic Substances and Disease Registry (ATSDR) Health Consultation is developed and given to the public. Therefore, we are providing the following general comments which are supported and explained in more detail in the enclosed "Specific DOE/LLNL Comments on the Factual Accuracy of the draft ATSDR/CDHS Health Consultation."

### **General Comments:**

(1) ATSDR and California Department of Health Services (CDHS) seem to agree with the assessment done in 1995 by the US Environmental Protection Agency and CDHS Radiological Health Branch (CDHS-RHB) that the highest level of Pu 239/240 found in the 1995 sampling of soil at Big Trees Park is not of a level for health concern. We believe this should be mentioned early on in the report to avoid unnecessary public concern.

(2) The Consultation only uses a subset of the pertinent available soils data (the Consultation restricts its analysis to some of the data from one laboratory). The Consultation fails to use or even discuss the counting error (counting uncertainty) for the results used. It overlooks the analyses of splits of the soil samples analyzed by two independent laboratories (the CDHS-RHB laboratory and that of a commercial lab). This is statistically and scientifically invalid, and leads to insupportable conclusions.

(3) There are differing opinions on the range of global fallout of Pu 239/240 to be expected in the Livermore Valley. Nonetheless, even assuming the value of global fallout used by the Consultation, the results of the analyses by the three independent laboratories, when evaluated logically and with accepted statistical methods, show Pu 239/240 above global fallout levels in only three of the sixteen locations which were sampled in and near the park. None of the three locations exhibiting Pu 239/240 concentrations above background levels is in Arroyo Seco.

(4) Logical evaluation of the existing data fails to support either the airborne or Arroyo Seco pathways to transport Pu from LLNL to the three locations at Big Trees Park where it is found above global fallout levels.

(5) The use of sewage sludge by the public has already been shown not to be a health problem by the work of Myers, et al., 1975.

In summary, we find that the Consultation is factually inaccurate on several critical elements, and that has led to unsupported and incorrect assumptions, inferences, and conclusions in the Consultation.

We would like to meet with the ATSDR at their earliest convenience to help clarify our factual accuracy comments. Because DOE/LLNL wishes to ensure that an accurate ATSDR Health Consultation is developed and given to the public, we are providing the following comments on the factual accuracy of the draft Health Consultation.

1. Health Consultation, p. 2, paragraph 2:

"The purpose of this health consultation is to explore and define the possible source for the plutonium 239 (Pu 239) contamination found in Big Trees Park..."

DOE/LLNL Comment: Note that the source of the plutonium in Big Trees Park has already been defined; it is clearly LLNL, as there are no other users of plutonium in the Livermore Valley. LLNL has stated this publicly and in reports on the park; only documentation is missing to conclude it came from the 1967 sewage release to the Livermore Water Reclamation Plant (LWRP): the values found in the Big Trees Park samples are within the framework of those expected in the sludge after use as a soil amendment. Note that paragraph 1 on p. 2 indicates that the ATSDR recommended "that environmental data be reviewed to assess the potential that human health could have been affected by activities at [LLNL]." This very assessment has already been done for Big Trees Park in 1995 by the ATSDR at the request of the USEPA (see paragraph 2 of p. 4 of the Consultation).

We also note that other health consequences evaluations which have been performed are not mentioned until page 4. At that point the reader learns that the ATSDR evaluation (1995) agrees with the USEPA. Unstated in this draft Health Consultation is that the California Department of Health Services Radiological Health Branch (CDHS-RHB) agrees with the USEPA (Health Consultation Reference number 5). Their joint conclusion is that the plutonium (Pu) found in the park is not at a level of health concern even using worst-case assumptions about hypothetical maximally exposed individuals (presumed to be children eating and breathing dirt from the area with the most Pu).

Therefore, it is clear that both of the stated purposes of this Consultation were completed two years ago.

Considering that the answers to both questions are already known, it would be reasonable to state them unequivocally in the "Background and Statement of Issue" section; otherwise this Health Consultation may mislead the reader by suggesting ATSDR did not do what it has documented.

We suggest that the Health Consultation be re-titled to more accurately state its purposes. These appear to be (1) reiterate the results of the 1995 ATSDR review and that of the USEPA and CDHS-RHB, and (2) investigate how the plutonium got from LLNL to Big Trees Park. The Consultation should also state why is believed to be necessary by CDHS, given that ATSDR has determined even the highest levels of Pu in the park are not of health concern for the hypothetical maximally exposed child.

*Agencies Response:* Though the original source may be LLNL, "source" is used in this context as the place or route from which the plutonium came from directly before it ended up in Big Trees Park. We have revised the text by adding the word "route" in places where "source" is used. Though the levels of Pu 239 are not at levels of health concern, the investigation into the potential source(s) (route) for the plutonium found in Big Trees Park is necessary in order to evaluate whether or not other areas in the community could have been impacted. As stated by the DOE/LLNL Comment, "only documentation is missing to conclude it came from the 1967 sewage release to the Livermore Water Reclamation Plant".

2. Health Consultation, p. 2, 3rd paragraph:

"A number of activities at LLNL handle or generate hazardous materials, mixed wastes and radioactive wastes. Some of the activities at LLNL have resulted in off-site contamination and the potential for exposure to the community of Livermore. Due to these activities, the United States Environmental Protection Agency (USEPA) placed the Livermore site on the National Priorities List (NPL) in 1987."

DOE/LLNL Comment: LLNL was placed on the NPL due to ground water contamination by halocarbon solvents that LLNL discovered in 1983. This ground water contamination resulted from past spills and disposal of solvents. LLNL was not placed on the NPL due to activities involving mixed or radioactive materials or waste.

*Agencies Response:* The text in document has been modified to reflect comment. The text now reads, "In 1987, the United States Environmental Protection Agency (USEPA) placed the Livermore site on the National Priorities List (NPL) of hazardous waste sites, due to volatile organic chemical (VOCs) contamination in the groundwater".

3. Health Consultation, p.2, last paragraph:

"...contamination ... which had been first identified during a survey performed by LLNL in 1991..."

DOE/LLNL Comment: Numerous site annual environmental reports comment on the Pu in the SE quadrant of LLNL. LLNL clearly identified Pu in the SE quadrant of LLNL in the 1971 site annual environmental report (UCRL-51242), 20 years before the 1991 date proposed in the Health Consultation. The SE quadrant was also sampled in 1974 and later years (see annual reports) and studied extensively in 1982-1983 (Buerer, "Taxi Strip cleanup", UCID20869, wherein the assessment and cleanup activities which were performed are discussed).

*Agencies Response:* The text in document has been modified to reflect comment.

4. Health Consultation, p.3, 2nd full paragraph:

"...global fallout (0.001 to 0.01 pCi/g [0.00004 to 0.00037Bq/g])"...

DOE/LLNL Comment: While various values for fallout background ranges have been presented by different authors and organizations, we believe that the fallout background range in the

Livermore area independent of LLNL is as high as 0.0155 pCi/g based on sampling locations that are generally upwind and distant from LLNL (MacQueen, 1995), and possibly as high as 0.02 pCi/g based on surveillance monitoring results from Site 300, and statistical considerations.

*Agencies Response:* We believe the comment refers to the background levels referenced in the MacQueen 1995 Survey Results, specifically a 1976 background level. This is in contrast to background levels for the Livermore area cited in 1990, as 0.005 pCi/g (1).

5. Health Consultation, p.4, 1st full paragraph:

"The elevated value of 1.02 pCi/g (0.03778 Bq/g) is several orders of magnitude above the range normally attributed to background..."

DOE/LLNL Comment: Please note that the highest value reported is 2 orders of magnitude and not several orders of magnitude greater than the Consultation's fallout background value of 0.01 pCi/g.

*Agencies Response:* The text has been modified to reflect the comment and now reads, "The elevated value of 1.02 pCi/g (0.03778 Bq/g) is above the range normally attributed to background..."

6. Health Consultation, p. 4, 2nd full paragraph through p. 5: "Radiological Evaluation":

"In April, 1995 at USEPA's request, ATSDR reviewed these data from the Big Trees Park sampling events and concluded that the maximum concentration of Pu 239 found in the soil is not at a level of health concern." "The estimated effective dose for a two- to three-year old pica child playing in the highest contaminated soil at the park for five days per week, 50 weeks per year was less than 1 millirem per year... A pica child is a child with a craving for unnatural food, e.g., soils or ashes."

DOE/LLNL Comment: It is important to note that the ATSDR agrees with the USEPA and CDHS Radiologic Health Branch determinations that "the maximum concentration of Pu 239 found in the soil is not at a level of health concern." The EPA/CDHS-RHB/LLNL sampling results and the EPA/CDHS-RHB conclusions and health evaluation were widely and publicly shared.

We suggest that for accuracy you clarify for the readers the fact that the health risk calculation you performed using a pica child exposed to the highest measured value of Pu in the park is a worst case evaluation representing the maximally exposed individual at the single point of highest Pu value found only in one location. The result of this worst-case evaluation is a dose of less than 1 mrem/year, which is very small relative to the average natural background radiation in the United States of roughly 300 mrem/y, which should also be stated for reference, as should the number of pica children in the population. It is also well below the USEPA's proposed maximum allowable level for exposure to any maximally exposed member of the public of 15 mrem and the ICRP's recommended dose limit of 100 mrem/y (see Consultation Reference #3). Based on all of the available data (see comment #11 below), the level of Pu is even lower elsewhere in the park;



doses calculated based on those Pu levels would be proportionally lower than the less than 1-mrem worst-case analysis. Therefore, the Consultation's health evaluation is even more extremely conservative for other locations in the park.

*Agencies Response: Comment noted. We have added additional information in the body of the consultation.*

7. Health Consultation, p. 6, data table

DOE/LLNL Comment: It is not clear what is being explained or demonstrated by the data table. The purpose, whether to give examples of how the dosimetry modeling health-protectively calculates a higher dose for children than adults or to demonstrate that the results of the calculations are not of a level of health concern, should be clearly stated. It may even be best to eliminate this table so as to avoid confusion for the public reader. The Consultation states that the ATSDR agrees with the USEPA and CDHS Radiologic Health Branch determinations that "the maximum concentration of Pu 239 found in the soil is not at a level of health concern."

*Agencies Response: This information is placed in the document in response to comments received from the public at a site team meeting in 1997.*

8. Health Consultation, p. 6, first full paragraph:

"...the USEPA's proposed radionuclide cleanup regulation... is not intended to decide if clean up at a particular site is warranted..."

DOE/LLNL Comment: The USEPA's Preliminary Remediation Goal (PRG) "is a health protective screening level that was developed using health conservative exposure and risk assumptions" (US EPA Plutonium Fact Sheet, 1995, Consultation Reference 5). We agree that the PRG is not a proposed clean up level; it is in fact a screening value and can be a point of departure for negotiating clean up levels to a higher value if adequately health protective. Furthermore, values below the PRG are often cause for no further action at sites being investigated for contamination.

*Agencies Response: We have deleted this section.*

9. Health Consultation, p. 6, first full paragraph:

"These proposed regulations are not intended to be equated with a level of health concern."

DOE/LLNL Comment: See comment 8 above.

*Agencies Response: We have deleted this section.*

10. Health Consultation, p. 6, 2nd paragraph, 1st sentence: "...there has been a great deal of community concern as to the source of the Pu 239."

DOE/LLNL Comment: The concern has been expressed and promoted by a small but highly vocal minority. The residents around Big Trees Park (as represented by the Rhonewood Homeowners Association and members of the public attending LARPD and City of Livermore meetings where the results of sampling for Pu in the park were discussed), the City of Livermore, LARPD, and School District have not expressed concern about the source. Quite the contrary was determined by a Livermore City council committee and the LARPD. This is probably because LLNL has publicly stated that LLNL is the source and because the levels are, as the Health Consultation points out, not at a level of health concern using worst-case conservative assumptions.

Agencies Response: *Comment noted and appropriate changes have been made in the text.*

11. Health Consultation, p.6, 2nd paragraph, 2nd and 3rd sentences:

"Sixty eight percent of the split samples analyzed by NAREL in the 1995 survey contained Pu 239 concentrations above the upper end of the range ... considered to be attributed by global fallout. This indicates that there is an additional burden of Pu239 throughout Big Trees Park which cannot be attributed to global fallout (2)."

DOE/LLNL Comment: Reference 2 does not support the 3rd sentence.

What follows is our major point in disagreement over the data as used and presented in the Health Consultation.

It is not considered scientifically valid to evaluate the radiological results without considering the counting error (also referred to as counting uncertainty). Consideration of error or uncertainty is fundamental in measurement processes-especially in measurement or analysis of radioactivity. For discussions of statistics in radiochemical measurements see:

Friedlander et al., 1981 (Nuclear and Radiochemistry, Wiley, New York, 1981, Chap. 9 "Statistical Considerations in Radioactivity Measurements").

ANSI N42.23,1995 (Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories, 1995, Section A.7.3, Interpretation of Individual Measurement Results);

Wang, et al, 1975 (Radiotracer Methodology in the Biological, Environmental, and Physical Sciences, Prentice-Hall, New Jersey, 1975, Chap. 12 "Nuclear Statistics").

Altshuler and Paste Mack, 1963 ("Statistical Measures of the lower limit of detection of a radioactivity counter, "Health Physics,9:293,1963).

Currie,1968 ("Limits for qualitative detection and quantitative determination-application to radiochemistry," Analytical Chemistry, 40:586,1968).

For general statistical discussions on measurements and errors see:

Wheeler and Lyday, 1989 (Evaluating the Measurement Process, SPC Press, Knoxville, 1989, p. 22 "The Classification of Measured Items Relative to Specifications").

Miller and Freund, 1977 (Probability and Statistics for Engineers, Prentice-Hall, New Jersey, 1977, Chap. 6 "Sampling Distributions").

It is also invalid, as we show in the text below, to consider only one source of data when three sources of data are available (see the references just noted). These data can be found in documents cited in the Consultation. As a result of this scientifically invalid use in the Consultation of a partial data set, the assumptions, hypotheses, inferences, and conclusions throughout the Consultation should be reevaluated.

The Consultation states several times that surface soil throughout the park contains levels of Pu 239 greater than can be attributed to global fallout (i.e. at levels above background concentrations).

In order for this assertion to be correct, it is necessary that there be samples collected throughout the park with Pu 239 concentrations definitely greater than background levels. Such data do not exist. The basis for the assertion that Pu 239 is above background levels throughout the park appears to be the Consultation's "observation" that 68% (13 out of 19) of the split samples analyzed by NAREL were reported to contain Pu 239 above the 0.01 pCi/g value which the Consultation uses as the upper limit of the range for global fallout background concentrations. The following discussion examines the question of how many locations are above fallout background.

There are three samples with concentrations definitely above background concentrations. There are not samples above background throughout the park.

We illustrate this first with examples from two specific sample locations (5 and 13), followed by a general discussion of all the available data.

#### Example 1 - Location 5:

At Location 5 (see Appendix A, Figure A-1), the USEPA National Air and Radiation Environmental Laboratory (NAREL) estimated concentration is 0.0111 pCi/g. This is above the 0.01 pCi/g "background concentration range" and is therefore one of the 13 samples considered by the draft Consultation to be "above background levels." However, the NAREL uncertainty estimate for this sample is 0.0115 pCi/g. This means that if NAREL were to reanalyze the sample, there would be a significant chance (probability) the reanalysis result would be below 0.01 pCi/g. Therefore, it is impossible to conclude that this sample is definitely above background concentration.

It would be possible to suggest from the NAREL data alone that Pu data from Location 5 might be above background levels. However, there are additional data for Location 5. Location 5 is one of the locations where the CDHS-RHB took a split sample and had it analyzed by the CDHS-RHB

laboratory. The CDHS RHB result for this sample is  $0.004 \pm 0.003$  pCi/g. This is within the range of possible values indicated by NAREL ( $0.0111 \pm 0.0115$ , or- 0.0004 to 0.0226). Therefore, the NAREL and CDHS-RHB results are consistent with each other. The CDHS-RHB result shows that within the range of possible values given by the NAREL result, the most likely sub-range is 0.001 to 0.007 pCi/g, which is within the range of expected background concentrations. Not only is it impossible to conclude that Pu data from Location 5 are definitely above background levels, the data strongly indicate that the soil Pu concentrations from this location are within the range expected for background concentrations.

Finally, the split from the Location 5 sample that was sent to the Lockheed Analytical Laboratory (LAL), a commercial analytical laboratory, by LLNL has a result of  $0.0036 \pm 0.0023$  pCi/g. Out of three splits of a single well-mixed sample from a single location, two agree very closely, and are within the range expected for background concentrations, and one has a large uncertainty estimate whose range includes that of the other two. The conclusion is clear and inescapable: this location does not exhibit soil Pu concentrations above those expected from global fallout.

#### Example 2 - Location 13:

At Location 13 (see Appendix A, Figure A-2), the NAREL estimate is  $0.0301 \pm 0.0284$  pCi/g. This result was also counted as one of the 68% above background levels. In this case, the uncertainty range indicates only a small chance of the result being representative of background concentrations. By itself, this indicates probable, though not definite, evidence of the result being above expected background levels. However, the CDHS-RHB and LAL results for this location are  $0.001 \pm 0.001$  and  $0.0012 \pm 0.0021$  pCi/g respectively. In this case, the overlap between the NAREL range and the other ranges is small. Perhaps the splits really were different, despite the mixing that took place before the sample was split. Or perhaps the NAREL result is in error due to cross contamination within that lab or for some other unknown reason. Whatever the reason, results from the other two labs agree with each other, have greater analytical precision, and do not agree with the results from NAREL.

All nineteen samples were collected for the purpose of being representative of a portion of the park in the vicinity of the sample location. Having been collected in an identical manner, each of the splits is equally representative. Therefore, in order to come to a conclusion about the area of the park the collective split samples represent, it is necessary to average them. This best represents the concentration to which an individual in that area might be exposed. The mathematically correct way to average measurements with varying degrees of uncertainty is to weight them by their uncertainty. When this is done, the estimated concentration at Location 13 is well below 0.01 pCi/g. The evidence that soil Pu levels at this location are above background is weak, at best, and far from definitive.

#### General discussion of all Big Trees Park data sets:

Appendix A, Figures A-1 and A-2 show estimated concentrations and uncertainty ranges from all three laboratories for all samples except those from Location 1. There is one horizontal line on each plot at 0.01 pCi/g and another at 0 (zero). It is clear from these figures that NAREL consistently has a very large analytical uncertainty compared to the other two laboratories

(Location 10 is the only exception). In all cases but two, the NAREL uncertainty extends below 0.01 pCi/g. In nine of the fifteen cases, the NAREL uncertainty extends well below 0.01 pCi/g. The analytical results generally fall into one of two cases:

- (1) A large NAREL uncertainty range that includes the LAL and CDHS-RHB results (Group A on Figure A-1).
- (2) A large NAREL uncertainty that does not include the LAL and CDHS-RHB results (Group B on Figure A-2).

In the first case, there is no contradiction between results from the different laboratories; the sensible thing to do is to use the more precise measurements. Nine out of fifteen samples (i.e., excluding the four Location 1 samples) fall into this case.

In the second case, it is possible that the splits really are different. The sensible thing to do is to average them; this best represents the concentration to which people in that area might be exposed. The mathematically correct way to average measurements that have uncertainty is to use the uncertainty in the calculation of the average. The other six samples fall into this case. Although one of the splits from a given sample may have exhibited concentrations above background levels, it does not follow that soils from that area of the park definitely have concentrations above background concentrations.

#### Summary of all Big Trees Park data sets

When all 19 samples are examined, taking into account their uncertainties, and combining results from splits, only three locations are found to exhibit soil Pu concentrations definitely above 0.01 pCi/g. These are Location 1 (4 samples, the smallest of which shows  $0.240 \pm 0.0204$  pCi/g), Location 7 ( $0.0526 \pm 0.0091$  pCi/g), and Location 8 ( $0.0217 \pm 0.0049$  pCi/g; see MacQueen, 1995, which is Reference 4 in the Consultation, for a complete discussion of all the sampling data, evaluated in a statistically valid and scientifically defensible manner).

Thus, the draft Health Consultation statements that soil throughout Big Trees Park contains Pu above 0.01 pCi/g, and therefore above expected fallout background concentrations, are incorrect and contradicted by the data.

These Consultation statements should be corrected wherever they occur (for instance, see the next to the last paragraph on p. 7 and also the 2nd paragraph on p. 8).

*Agencies Response: 1) Whether Pu 239 is above background throughout the park and whether Pu 239 distribution is consistent with aerial deposition of global fallout:*

*The term "throughout" has been dropped. As discussed elsewhere, while not every sample had a clearly elevated level of plutonium-239, several other locations were clearly elevated. Again, different labs measured different results, and those of EPA tended to be higher and had greater uncertainty bands associated with them. Nevertheless, each of the 3 data sets are in agreement that several locations are elevated. These include the 4 points of Location 1, which were spaced*

along a length of about 30 feet; location 7, and location 8. These differences are great enough from background to suggest another source other than aerial deposition of global fallout. While it is plausible that aerial deposition from LLNL-originating sources contributed to these elevated levels, we recommend that more data be collected to assess this hypothetical route.

12. Health Consultation, p. 7, 1st paragraph:

"Thus, it appears that Pu 239 levels in the sludge at the LWRP which was contaminated as a result of the 1967 release were never quantified."

DOE/LLNL Comment: The Pu 239 in the sludge was quantified in 1967 (see D.C. Sewell, Lawrence Radiation Laboratory, letter to E. C. Shute, San Francisco Operations Office, U.S. Atomic Energy Commission, August 22, 1967), 1974 (see Myers, et al., 1975, Health Consultation Reference 22) and 1990 (see the letters to Cloak, 1990, Health Consultation References 20 and 21).

Agencies Response: The letter (D.C. Sewell, LRL, letter to E.C. Shute San Francisco Operations Office, U.S. Atomic Energy Commission, August 22, 1967) referenced by the comment provides estimations of Pu 239 levels in the sludge ( Table 1 of letter)(1). The estimations are based on liquid effluent releases and measurements of gross alpha radiation. Because gross alpha radiation could also include naturally occurring radioactive materials as well as plutonium, we feel that the characterization was not adequately performed. We also realize that the method employed at that time was the method normally used in these situations. Although a large quantity of Pu 239 reported as gross alpha radiation was found in both the aeration tank and the digester suspended sediments, there was no sampling of the solids in any part of the process where the solids would not be in suspension. LLNL (formerly Livermore Radiation Laboratory (LRL)) "assumed" 1% solids in the digesters, when as much as 2% solids were measured. This suggests that the measured concentrations could be lower than actually present in the solids. Also, the report states the difficulty in obtaining a representative sample from the sludge lagoons. Thus, it is not clear whether LLNL actually sampled/analyzed the sludge in the lagoons , and did not use the results, or did not sample the material. Instead of actual sampling data, it seems that "background" sludge concentrations were used as a measure of the concentration of Pu in the sludge lagoons. Thus, it does not seem reasonable that adequate characterization of the concentrations in the sludge could have been determined from the limited LWRP process sampling. CDHS has learned through interviews that: 1) The Livermore Sewage Treatment Plant staff were not notified by LLNL (formerly LRL) of the 1967 plutonium release until the early 1970's, when the first sampling of the sludge (1973) at the sewage treatment plant occurred by LLNL; 2) LRL did not collect or regularly analyze digester samples or the sludge at the Livermore Sewage Treatment Plant for radionuclides during the 1960's (as stated above, LLNL has not provided any data that disputes this statement).

13. Health Consultation, p. 7, 3rd paragraph, 3rd sentence:

"One possible scenario is that Pu 239 contaminated sewage sludge was used as a soil amendment during the development of Big Trees Park during the early 1970's."

DOE/LLNL Comment: Placement of Pu contaminated sludge in the park did not have to occur at the initial development of the park. It could have been brought in later and used as a soil amendment when planting trees in the park. We would argue that this is the most probable scenario based on sample values representative of the sludge.

Agencies Response: *The health consultation already addresses this issue.*

14. Health Consultation, p. 7, 4th paragraph, 2nd sentence:

"Given the fact that the surface soil throughout the park contains elevated Pu 239 levels and in order for this scenario to have occurred, one must assume that residents deposited sewage sludge in a manner consistent with a random distribution throughout the park."

DOE/LLNL Comment: As discussed and shown above, the Pu distribution in the park is not random and not throughout the park. Therefore the statement is not factual and should not say it is a fact. Nor can anyone assume sewage sludge would be distributed randomly. The distribution found in the USEPA/CDHS-RHB/LLNL sampling is consistent with the use of sludge as a soil amendment in planting trees along the lined, artificial drainage channel.

Agencies Response: *We have edited the document to clarify our point.*

15. Health Consultation, p. 7, 4th paragraph, last sentence:

"In the absence of LWRP's sewage sludge distribution log book, this theory can be neither discounted nor verified."

DOE/LLNL Comment: The values found during sampling strongly argue for this theory.

Agencies Response: *Comment noted.*

16. Health Consultation, p. 8, 1st paragraph, last 2 sentences:

"The annual wind rose ... indicates Big Trees Park is located downwind from LLNL approximately 15% of the year. This suggests that a small percentage of aerial deposition from releases at LLNL may have occurred at Big Trees Park (27)."

DOE/LLNL Comment: A windrose shows the direction from which the wind is blowing. The windrose in Reference 27 indicates wind blowing westerly from LLNL towards Big Trees Park less than 10% of the time. The authors of the Health Consultation may have read the windrose backwards. Moreover, the winds coming from the east (i.e., blowing to the west) tend to occur during the winter months concurrent with maximum rainfall when resuspension is low, further reducing the possibility of redistribution of resuspended material to the west of LLNL and casting additional doubt on the airborne distribution of Pu "theory."

Gallegos, 1995 (Consultation Reference 27) does not support the last sentence in the referenced paragraph.

*Agencies Response: The text has been modified to reflect comment. Based on the windrose cited, Big Trees Park is downwind of the laboratory less than 10% of the time. Therefore, the possibility exists that plutonium in the park could be the result of aerial deposition. Please be advised that the authors read the windrose correctly. We also verified our interpretation with an air modeler.*

17. Health Consultation, p. 8, 2nd paragraph:

"Most of the samples collected from Big Trees Park have similar Pu 239 levels and the distribution is consistent with that of aerial distribution (Figure 3) .... aerial dispersion is a plausible explanation for the above 'background' levels of the Pu 239 found throughout Big Trees Park with the exception of location #1."

DOE/LLNL Comment: The NAREL results, if considered by themselves without the counting uncertainties as was done by CDHS for the draft Consultation, are not similar to each other. Even excluding Location 1, they have a fairly wide distribution, varying from less than zero to 0.0481 pCi/g.

Most of the locations in Big Trees Park have similar Pu values (as pointed out in comment 11 and by MacQueen, 1995, Consultation Reference 4), and the distribution is consistent with aerial deposition of global fallout (again, see MacQueen, 1995, Consultation Reference 4).

As indicated in the Health Consultation (p.8 paragraph 2), aerial deposition resulting in 1.02 pCi/g of Pu in soil at Location 1 is clearly not likely. A release of Pu sufficient to result in aerial deposition at those levels would have been seen in other offsite soil samples and on continuously operating LLNL perimeter air monitors.

As shown in Factual Accuracy Comment #11 above, the last sentence in the referenced paragraph is not factually accurate as Pu is not widely distributed above global fallout background concentrations.

*Agencies Response: Comment noted.*

18. Health Consultation, p. 8, last paragraph and the 1st through 3rd paragraphs on p. 9:

"...plutonium-contaminated soil has been verified in the southeastern portion of LLNL and surface drainage from this area enters the Arroyo Seco (Figure 5)(28)" and regarding further text asserting that arroyo sediments were a contributing source or the source of Pu at Location 41.

DOE/LLNL Comment: Arroyo Seco has not received surface runoff water from the southern portion of the SE quadrant of LLNL since prior to 1965 (see Figure 3.1-7 in the CERCLA Remedial Investigations Report for the LLNL Livermore Site, UCAR-10299). The site annual environmental reports for the calendar years 1986-89 (the Consultation Reference number 28 is



the 1987 annual) were in error in stating that SE quadrant drainage flowed to Arroyo Seco. Most of the SE quadrant has consistently drained to the north even prior to 1965 because of the surface topography - the site elevation drops off over 80 feet from the southeast corner of the site to the northwest (see Figure 3.112 of the CERCLA RI Report).

It's also worth noting that Buerer, 1983, indicates that the lined evaporation trays and ponds whose use resulted in soil contamination in the eastern quadrant of LLNL were used from about 1962 until 1976. For Pu to have gotten into runoff going to Arroyo Seco, it would have to have had occurred between 1962 and 1965. The Pu would then have to have settled out somewhere nearby or upstream of Big Trees Park until being moved from the arroyo bottom into the park. For this to have occurred with the 1970 construction of the new lined channel and realignment of the old arroyo channel into the newly lined portion, the hypothetical Pu in the sediments would have had to survive 5 to 8 winters of storm events with associated scouring, moving, and redepositing of sediments. Then, presumably in 1970 in connecting the old unlined arroyo with the newly excavated, concrete lined channel, some sediments from the natural channel may have been excavated and placed in the park.

It is very unlikely that such a string of events could occur with the result of as much as 1.02 pCi/g of Pu being placed in the park.

The two references (29 and 30) in these three paragraphs of the Consultation do not support the arroyo source assertion. The new channel for the concrete-lined portion of the arroyo was dug and lined prior to the filling of the old drainage channel through the park and the school (30). This generated excess dirt to be used as fill in the park and in the old drainage channel. Except for a very short portion of the arroyo east of the bridge over the arroyo, no excavation from the old arroyo channel needed to take place.

*Agencies Response: The DOE/LLNL Comment suggests the 1986-1989 LLNL site annual reports for were "in error in stating that the SE quadrant flowed to Arroyo Seco." The comment references the CERCLA Remedial Investigations Report for the LLNL Livermore Site, 1990, UCAR-10299, Figures 3.1-7 and 3.1-12 for clarification. CDHS staff looked at these figures and this information does not seem to answer the alleged "errors" in the 4 years of Annual Reports published by LLNL. Figure 3.1-11 is the only diagram which shows surface drainage routes, and it does not show the entire site. Figure 3.1-11 does not show the surface drainage for areas south or west of building 4230 (viz. the radioactive waste operation facility, solar evaporation pit, B-332). According to the RI, the ground surface slopes gently to the northwest changing in elevation from 675 ft above mean sea level (MSL) at the southeast corner to 575 ft above MSL at the northwest corner of the lab perimeter. Furthermore, the slope from the southeast to the southwest declines from 675 ft to 600 ft above MSL. The Arroyo Seco is at the southwest boundary, and given this change in elevation from east to west, it seems reasonable that some surface water from the southeast quadrant could drain into the Arroyo Seco.*

*CDHS staff have reviewed the 1990 Annual Groundwater Report and found no reference to the "errors" of the previous reports.*

*The Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore, US Department of Energy, August 1992, states, "...only surface water along the southern boundary and some storm drains in the southwest corner of the LLNL Livermore site drain into the Arroyo Seco. This supports the statements made by CDHS in the health consultation, regarding the Arroyo Seco as a potential pathway.*

*The USEPA/NAREL report, Confirmatory Sampling of Plutonium in Soil from the Southeast Quadrant of the Lawrence Livermore National Laboratory, 15 August 1994, states, "the western extent of the soil containing plutonium in the southeastern quadrant remains unidentified by either the 1991 DOE Study or this study." The Arroyo Seco is west of the southeastern quadrant. This further supports the statements made in health consultation.*

*Discussions with LLNL staff on March 26, 1998 offered some clarification on this issue, which the documents referenced by the DOE/LLNL Comment do not address. However, it is clear that historically the Arroyo Seco did receive some surface water drainage from the southeast quadrant of the site.*

19. Health Consultation, p. 9, last paragraph:

"In the 1995 Soil Survey Report LLNL concluded that the source of the Pu 239 could not have come from the sediments out of the Arroyo Seco channel because the two samples collected from the channel bottom did not reveal plutonium concentrations above background (4)."

DOE/LLNL Comment: As pointed out above, the conclusion that the arroyo did not contribute Pu to that found in the 3 locations exhibiting Pu concentrations above expected fallout levels is supported by several lines of evidence. Historic surveillance sampling shows Pu in the Arroyo Seco sediments at levels expected from global fallout. This, combined with the sampling done in 1995, plus the logic that digging and lining a new channel generates clean, uncontaminated fill further supports the conclusion that arroyo sediment was not the source of Pu.

Agencies Response: *We disagree that there are only 3 locations exhibiting Pu above global fallout. The DOE/LLNL Comment does not reference a time period or specific locations for the "historic surveillance sampling;" therefore, we cannot give validity to the comment at this time. We will be reviewing sediment data for future public health evaluations. We agree that the digging of a new channel would generate clean fill. This health consultation discusses the potential distribution of contaminated sediments from work which was done in the original channel, not the new channel.*

20. Health Consultation, p. 9, last paragraph, last 2 sentences and top of P. 10:

"The shallower sampling methodology (1 cm and 5 cm) used in both the 1994 NAREL study and the LLNL 1995 Soil Survey of Big Trees Park was not, according to LLNL's own documents, the correct method to characterize sediments. Sampling should have been done at greater depths, if the sampling was to characterize sediments (28, 31)."

DOE/LLNL Comment: The Big Trees Park sampling in 1995 was performed with a methodology agreed to, and in some sense, specified, by USEPA NAREL and the CDHS Radiological Health Branch (McConachie and Failor, 1995, Consultation Reference 8). Note also that the sampling was performed to gather information on Pu, if any, that was shallow to ascertain its potential availability for exposing people to harm. LLNL's own documents indicate that deeper sampling is appropriate for volatile organic compounds (halocarbon solvents) and volatiles such as tritiated water. Our standard protocol for soil sampling for radionuclide analyses (other than tritium) is to collect samples from the surface to 5 cm since ingestion or inhalation from resuspension is the potential pathway to public health problems.

Agencies Response: *The sampling methodology to analyze sediments is quoted by LLNL staff to be conducted in this fashion: samples are taken with a split-spoon sampler driven into the ground to a depth of 2 feet to allow for better characterization of volatile organic compounds. The bottom 6 inches of the core are analyzed for metals and organics. The next 6 inches are analyzed for tritium, gamma emitters, and plutonium. However, the sampling conducted in Big Trees Park and in the Arroyo Seco was consistent of surface soil sampling. CDHS has merely pointed out that the sampling methodology used in the 1995 Big Trees Park Survey, was not the methodology LLNL typically uses when characterizing "sediments".*

21. Health Consultation, p. 10, paragraph 2 full paragraph:

"...CDHS ... have shown the plausibility that the source of the Pu 239 discovered in Big Trees Park may have been the result of both aerial deposition and sediment distribution from the Arroyo Seco channel."

DOE/LLNL Comment: CDHS has made serious scientific errors in trying to use the USEPA/NAREL data without considering the analytical uncertainties of the USEPA/NAREL data the independent analyses performed by CDHS Radiological Health Branch and by a commercial contract laboratory (see Factual Accuracy Comment 11 above). When the set of available data is used with accepted scientific methodology, it is clear that all of the Pu concentrations found in the 1995 soil sampling are consistent with global fallout background levels except for those from 3 locations (Locations 1, 7, and 8). It is not plausible that air dispersion would deposit Pu in the those 3 locations and miss the other 13 locations. Likewise, the history of the park and the physical realities discussed above do not support the arroyo sediments as a pathway or transport mechanism.

Agencies Response: *1) We disagree with LLNL's criticism of CDHS's analysis. In our opinion, no scientific methodology mandates that sample measurements must be averaged together. Naturally, various techniques are available for summarizing and manipulating the data in various ways, and we support use of methods which will gain greater understanding of trends or patterns in the data. LLNL's suggested method for using an uncertainty-weighted average is an acceptable technique to summarize data. However, we believe that our evaluation of the data is more health-conservative in that it does not dismiss higher values as simply due to uncertainty in the laboratory process, or obscure them in the averaging process, but recognizes them as possibly legitimate. Therefore, using it as a standard for additional verification in opposition to the*

*NAREL measurements may prove inappropriate. In any case, the current situation of varying results further underscores the rationale for additional sampling.*

*2) Although aerial dispersion would probably not be the primary cause of the high levels seen, a pathway may exist and a site-related contribution of Pu 239 cannot be ruled out. While it is unlikely that dispersion from worldwide nuclear tests and accidents would have resulted in such wide variation, we do not know that emissions from LLNL could not have varied depending on the particle deposition in a particular sample. The distribution of plutonium and other contaminants in soils -- not solely in Big Trees Park -- will be the topic of a future public health evaluation, and further research may shed light on this question.*

*3) LLNL states that, "Likewise, the history of the park and the physical realities discussed above do not support the arroyo sediments as a pathway or transport mechanism." The information we have obtained regarding runoff and, more recently, regarding sewer line breaks that may have affected the Arroyo, certainly point to this as a plausible pathway. The topic of sediments (both Arroyo Seco and Arroyo Las Positas) will be explored with more depth as the focus in the public health assessment.*

22. Health Consultation, p. 10, paragraph 4:

"Because the previous investigations only sampled surface soil, additional sampling is needed to define the vertical extent of Pu 239 contamination in the Arroyo Seco channel and in Big Trees Park. This is necessary to protect the health of the public from potential exposure to Pu 239 that may exist at greater depths."

DOE/LLNL Comment: The health risk evaluation performed by the USEPA, the Radiological Health Branch of the CDHS, and agreed to in this ATSDR/CDHS Health Consultation state that even with the highest level of Pu 239 in the park used in a hypothetical worst case analysis of a maximally exposed child with a predilection for eating and inhaling dirt, the Pu is well below a level of health concern.

Agencies Response: *Since Big Trees Park and the Arroyo Seco Elementary School are areas where children play and other community members frequent, CDHS and ATSDR feel that there is a possibility soils deeper than 5 cm (about 2 inches) to be brought to the surface, whereby the public could then be exposed. This could easily happen a number of ways, such as children digging in the park, future landscaping changes or park improvements, or excavation of irrigation lines or other utilities throughout the park and the school.*

23. Health Consultation, p. 10, last paragraph:

re. Consultation assertion that past distribution of sewage sludge is a health concern that warrants further investigation.

DOE/LLNL Comment: Pu concentrations in the sludge were determined and the risk of using the sludge in residential applications was evaluated (Myers et al., 1975, Consultation Reference 22). This published work showed that there is no significant risk from using the sludge in a garden

even when assuming a worst-case scenario for treatment of the sludge with respect to inhalation (rototilling dry sludge and soil on a summer day) and ingestion (there is no uptake by the garden produce). Any sludge used as an amendment would by definition be diluted and the potential activity of any Pu in the sludge hypothetically available for exposure is thereby reduced.

*Agencies Response: CDHS does not believe that the "worst-case scenario" has been determined based on the levels used in the referenced report (Myers et al., 1975). The risk derived in the report was based on a Pu value of 4.4 pCi/g, which is much lower than the levels seen in sewage sludge during the years it was reportedly distributed. Levels of alpha activity have been shown to be as high as 297 pCi/g in the digester suspended sediment; even with the dilution from other soils, we cannot say that a health concern does not exist.*

### **Additional information supplied by DOE/LLNL**

DOE/LLNL Factual Accuracy Review of the report entitled, "Health Consultation, Lawrence Livermore National Laboratory Source of Plutonium in Big Trees Park Livermore, Alameda County"

Figures A-1 and A-2 show results of the January 1995 sampling of Big Trees Park for Pu 239/240 from all sampling locations except Location 1. Each plot in these figures shows results from a single location. All plots include results from split samples analyzed by the EPA National Air and Radiation Environmental Laboratory (NAREL) and the Lockheed Analytical Laboratory (LAL). LAL is the commercial analytical laboratory to which LLNL sent split samples. CDHS Radiologic Health Branch laboratory (RHB) results are included in the plots for the subset of locations that the CDHS chose to analyze.

Each plot contains two (LAL and NAREL) or three (LAL, NAREL, and RHB) vertical lines that indicate the result plus and minus the two sigma uncertainty as reported by each laboratory.

Horizontal reference lines are at 0.01 pCi/g, an estimate for the upper range of fallout background used in the Health Consultation, and at zero pCi/g.

The plots are separated into two groups. Group A includes locations where the NAREL result has a larger uncertainty than the other two laboratories, and the other laboratories' results are contained within the NAREL uncertainty range (see Figure A-1). Group B includes locations where the other laboratories' results are not entirely within the NAREL uncertainty range (see Figure A-2).

CDHS REFERENCES  
for DOE/LLNL Comments

1. Livermore Water Reclamation Plant. Letter to the Staff Toxicologist of the California Department of Health Services from the Water Resources Manager, (LWRP) re: City of Livermore records pertaining to LLNL plutonium release in 1967. 1997, September 17.
2. Lawrence Livermore National Laboratory. Letter to the Assistant Manager of the Livermore Water Reclamation Plant from LLNL, Department Head, Environmental Protection Department re: Plutonium at the Water Reclamation Plant. 1990 December 4.
3. United States Environmental Protection Agency. Letter to the U.S. Department of Energy and the Agency for Toxic Substance and Disease Registry re: Lawrence Livermore Big Trees Park 1998 Soil Sampling Plan. 1998, June 5.

## Lawrence Livermore National Laboratory Comments

The Lawrence Livermore National Laboratory (LLNL) recognizes the value that an independent, objective, and factual Health Consultation can bring to LLNL, the Department of Energy, and the general public. We hope that the enclosed comments will assist your efforts toward this end.

We appreciate CDHS having met with us on March 26, 1998 to discuss the December 18, 1997 DOE/LLNL written comments on the November 1997 Data Validation Draft report. (For the record, we would like to note that representatives from DOE/OAK, EPA, ATSDR, and the Site Team were present, in person or by telephone, and participated in the discussions.) Although CDHS indicated in that meeting their intention to modify the report in some areas in response to LLNL comments, CDHS also stated that LLNL (and presumably also other interested organizations) will not have another opportunity to review the Health Consultation after the public comment period ends and prior to its final release. For this reason, the enclosed comments address the February 9, 1998 Public Comment Release version of the Health Consultation.

Despite statements made by CDHS staff during the March 26 meeting, we remain concerned by the prospect that the final version of the Health Consultation will not reach conclusions based on an integrated interpretation of all pertinent data, but will instead, at best, present alternative conclusions based on various subsets, or possibly lean towards an interpretation based on a selected subset.

In addition to the enclosed written comments regarding the February 9, 1997 Public Comment Release, we are also resubmitting the DOE/LLNL December 18, 1997 comments and cover letter regarding the November 1997 DOE Data Validation draft of the Health Consultation, so that they will be part of the public record.

General Comments regarding the Public Comment Release:

- (1) We were pleased that ATSDR and California Department of Health Services (CDHS) agree with the assessment done in 1995 by the US Environmental Protection Agency and CDHS Radiological Health Branch (CDHS-RHB) that the highest level of Pu 239/240 found in the 1995 sampling of soil at Big Trees Park is not of a level of health concern.
- (2) Our primary concern is that the Public Comment Release draft version of the Health Consultation (like the Data Validation draft) makes interpretations and forms conclusions based on a selected subset of the available data, particularly when it is clear that the use of all of the data leads to different conclusions (see specific comment #13).
- (3) Our next greatest concern is a tendency, present in both the Data Validation draft and the Public Comment Release, to over-generalize. That is, the draft reports makes statements about the entire park that clearly are not supported by the data presented in the draft consultations. This

is the case even when attention is restricted to the selected subset that was used in both drafts. See specific comments #2, #13, #19, and #24.

(4) Since one of the proposed pathways by which plutonium reached the park involves sewage sludge, health risk assessments for use of sludge the public are relevant. The use of sewage sludge containing Pu was shown by an LLNL gardening/food uptake study using conservative exposure calculations (i.e., making worst case health protective assumptions) to not pose a significant health hazard.

We would like to see our comments reflected in the Final Draft which we understand is due shortly. Should the process be prolonged and additional information be placed in the document we would like to have the opportunity to meet with you so we can discuss how our comments have been addressed.

We appreciate CDHS/ATSDR attention to the DOE/LLNL data validation comments previously submitted (December 18, 1997). References in this document to data validation comments will be of the form, for example, "DV1" (which would be a reference to data validation comment number 1).

1. Health Consultation, p. 2 third paragraph, p.3, first full paragraph, and p. 5, first paragraph: "Plutonium levels in other nearby parks showed stratification in the soils in a different pattern than Big Trees Park; Big Trees soils may have higher concentrations at greater depths, rather than decreasing with soil depth."

"Two locations showed plutonium levels to be stratified in the top 5 centimeters of soils, decreasing with depth."

"Thus, in contrast with Sunflower and Sycamore Park, the Pu239 concentrations at Big Trees Park actually increase at deeper sample depths." and similar statements on p.3 (first full paragraph, "near Arroyo Seco where the plutonium concentration increased with depth").

LLNL Comment: The results at one of these two locations, Neighborhood Park, were  $0.007 \pm 0.008$  pCi/g (1 cm) and  $0.006 \pm 0.008$  pCi/g (5 cm). As indicated by NAREL on page A-3 of the 1994 NAREL report (the original source of these data; Health Consultation reference 2, dated August 15, 1994), these results are not significantly different. Therefore, these data are not evidence of stratification.

The statement "concentrations at Big Trees Park actually increase at deeper sample depths" is an over-generalization. It takes an observation about a single pair of samples in Big Trees Park and restates that observation as if it were a fact about the entire park. The statement should be modified to reflect that fact that a pattern of concentration increasing with depth is only a possibility, not a confirmed fact.



The 0-1 cm and 0-5 cm samples were collocated samples. That is, they were collected at distinct but nearby locations (Health Consultation reference number 2). It is completely unknown where in the 0-5 cm interval the plutonium was present; it could have been mostly in the 0-1 cm portion for example, or it could have been mostly in the 1-5 cm interval, or it could have been fairly evenly distributed throughout the 0-5 cm interval. Similarly, plutonium concentrations in the 1-4 cm interval of soil that was beneath the 0-1 cm samples (but wasn't collected) are completely unknown.

Since the 0-1 and 0-5 cm samples were collected at adjacent locations (rather than one above the other), the differences could easily be due to horizontal variation, rather than vertical variation. For example, grading operations (Health Consultation, pl2) would clearly move soil horizontally as well as vertically. The point is that the available data, from a single pair of samples, is nowhere near enough data from which to make generalizations that purport to describe the whole of Big Trees Park. Such generalizations can, and have, mislead the public and the press, as demonstrated by articles in local newspapers that have repeated the depth trend generalization as if were a fact. Such generalizations in the Health Consult should be corrected.

*Agencies Response: The text has been modified to reflect the comments and now reads, "At two locations, plutonium levels appeared to be stratified in the top 5 centimeters of soils, decreasing with depth."*

*"Thus, in contrast with Sunflower and Sycamore Park, the Pu 239 concentrations at Big Trees Park appear to increase with depth; however, due to the limited sampling it is not possible to make definitive conclusions regarding stratification of Pu 239."*

2. Health Consultation, p. 3, specific objective number 1:

"Provide an overview of existing information on plutonium in Big Trees Park."

LLNL Comment: The overview provided in this document is incomplete, because a substantial body of relevant information is neither used nor discussed. Specifically, the results from split samples analyzed by LAL and CDHS/RHB are not used or discussed in any significant way in this Public Comment Release Draft of the report, despite the fact that they are presented in Table 2 and Figure 3 of the Health Consultation. Furthermore, in most cases the LAL and CDHS analyses are in agreement, and the NAREL result is different from both of them. Therefore, this omission has a substantial impact on some of the conclusions in the Health Consult (See comment 13 for more details). The report should consider all available relevant data.

*Agencies Response: We have added a discussion of all the data sets to the health consultation, and the conclusions are based on consideration of all data.*

3. Health Consultation, p. 4, first paragraph in "Methods" section:

"...contamination... which had been first identified during a survey performed by LLNL in 1991..." (This was DV3)

LLNL Comment: Numerous site annual environmental reports comment on the Pu in the SE quadrant of LLNL. LLNL clearly identified Pu in the SE quadrant of LLNL in the 1971 site annual environmental report (UCRL-51242), 20 years before the 1991 date proposed in the Health Consultation. The SE quadrant was also sampled in 1974 and later years (see annual reports) and studied extensively in 1982-1983 (Buerer, "Taxi Strip cleanup", UCID20869, wherein the assessment and cleanup activities which were performed are discussed).

Note: copies of pertinent sections of several site annual environmental reports and a copy of the Buerer 1983 report which comment on contamination in part of the SE quadrant of LLNL were hand delivered to CDHS on March 26, 1998 during the meeting held at CDHS to discuss the DOE/LLNL comments on the November Draft of this Health Consultation. These annuals and the Buerer 1983 report had already been given to ATSDR prior to the development of this report and therefore were available for CDHS use.

Agencies Response: *Refer to our response to LLNL data validation comment #3 (DV3).*

4. Health Consultation, p. 4, second paragraph in "Methods" section:

"Pu 238 concentrations in the 1 cm. samples from the three locations ranged from 0.012 to 0.014 pCi/g (0.0004 to 0.0005 Bq/g) and are well above global fallout (background) levels (0.0005 to 0.002 pCi/g)."

LLNL Comment: The upper end of the background range for Pu 238 cited by CDHS came from a recent EPA draft document. However, the basis for this background value is unclear. The EPA draft document references NCRP 94. This report ("Exposure of the Population in the United States and Canada from Natural Background Radiation") contains no data specific to Pu 238 in soil. When contacting EPA for further information, they could not find the basis for the fallout background either.

Until the basis for the fallout background is known CDHS should refrain from asserting that the NAREL reported values exceed fallout.

Agencies Response: *We reviewed NCRP 94 and could not find the basis for the background reference either. For clarification we contacted the USEPA, Office of Air and Radiation, and spoke to the authors of the EPA draft document from which the value was cited. We were told that the value was obtained from DOE and it was acceptable for CDHS to cite as a background value. Therefore, the text has not been modified.*

5. Health Consultation, p.5, end of first partial paragraph:

"the USEPA recommended additional sampling in Big Trees Park (2), which the laboratory performed the following year."

LLNL Comment: We suggest that the subject quote be re-written to be more precise. LLNL responded to the NAREL with haste including public and regulatory agency participation. The sampling recommended by NAREL was performed as soon as possible after receipt of the

referenced EPA report. LLNL worked with the community, homeowners near Big Trees Park, and with representatives of the City of Livermore, Livermore Area Recreation and Parks Department, Livermore school district, the EPA, and CDHS-Radiological Health Branch (CDHS-RHB) in developing the sampling plan. The sampling was performed in January 1995 during the first opportunity afforded by winter weather with, as the consult mentions in the next paragraph, EPA and CDHS-RHB present. The EPA and CDHS-RHB took splits of the samples for their own independent analyses.

*Agencies Response: CDHS has adequately summarized the chronological chain of events based on information provided in the 1995 USEPA/NAREL report referenced by the comment and LLNL, Livermore Big Trees Park January 1995 Soil Survey Results. We do not feel that it is necessary to engage in a lengthy discussion about LLNL's response time. The health consultation has not been modified.*

6. Health Consultation, p. 5, last paragraph, third sentence:  
"is several orders of magnitude above the range normally attributed to the background..." (This was DV5).

LLNL Comment: Please note that the highest value reported is 2 orders of magnitude and not several orders of magnitude greater than the Consultation's fallout background value of 0.01 pCi/g. We understand that some will consider this to be a minor semantic quibble. It is not just a quibble; the use of "several" is an exaggeration that can mislead the public.

*Agencies Response: The text has been modified to reflect the comment and now reads, "The value of 1.02 pCi/g (0.03778 Bq/g) is above the range normally attributed to background..."*

7. Health Consultation, p. 5, last paragraph, first sentence:  
"Pu 239 concentrations, as reported in Table 2, ranged from 0.00035 to 1.02 pCi/g."

LLNL Comment: The range quoted in the text is not correct. Your Table 2 shows -0.0021 (i.e., clearly not detected) to be the lowest value reported.

*Agencies Response: The text has been modified.*

8. Health Consultation, p. 6, Radiological Evaluation, first paragraph.  
"In April, 1995 at USEPA's request, ATSDR reviewed these data from the Big Trees Park sampling events and concluded that the maximum concentration of Pu 239 found in the soil is not at a level of health concern (6) ... Because this review was not widely circulated, an explanation of its findings is included in this health consultation." (This was DV6).

LLNL Comment: Not stated in this draft Health Consultation is that the CDHS Radiological Health Branch agrees with the EPA (Health Consultation Reference number 5) and ATSDR radiological health evaluations. It would be beneficial to readers, and reassuring to the general

public, to name all of the public agencies that concur with the conclusion that "the maximum concentration of Pu 239 found in the soil is not at a level of health concern." It would also be worthwhile to state this very early in this Health Consultation, such as in the "Background and Statement of Issue" section. Please note that the EPA/CDHS-RHB/LLNL sampling results and the EPA/CDHS-RHB conclusions and health evaluation were widely circulated and publicly shared.

Agencies Response: 1) *The statement that the current levels of plutonium are not at a level of health concern has been added to the executive summary, and an explanation of the results of toxicological evaluations by USEPA and CDHS-RHB are added to the "Background and Statement of Issue" section.*

2) *We have omitted the phrase "because this review was not widely circulated." However, because this health consultation revisits this topic, and we anticipate new readers who will not be familiar with the previous reviews conducted, we thought it appropriate to include the toxicological evaluation in this document.*

9. Health Consultation, p. 6, Radiological Evaluation, second full paragraph through the ATSDR calculated organ doses:

"The estimated effective dose for a two- to three-year old pica child playing in the highest contaminated soil at the park for five days per week, 50 weeks per year was less than 1 millirem per year ... A pica child is a child with a craving for unnatural food, e.g., soils or ashes." (This was DV6).

LLNL Comment: We suggest that for accuracy you clarify for the readers the fact that the health risk calculation you performed using a pica child exposed to the highest measured value of Pu in the park is a worst case evaluation representing the maximally exposed individual at the single point of highest Pu value found only in one location. The result of this worst-case evaluation is a dose of less than 1 mrem/year, which is very small relative to the average natural background radiation in the United States of roughly 300 mrem/y, which should also be stated for reference, as should the number of pica children in the population. It is also well below the USEPA's proposed maximum allowable level for exposure to any maximally exposed member of the public of 15 mrem and the ICRP's recommended dose limit of 100 mrem/y (see Consultation Reference #3). Based on all of the available data (see comment 13 below), the level of Pu is even lower elsewhere in the park; doses calculated based on those Pu levels would be proportionally lower than the less than 1-mrem worst-case analysis. Therefore, the Consultation's health evaluation is even more extremely conservative for other locations in the park. It is not clear what is being explained or demonstrated by the data table. The purpose, whether to give examples of how the dosimetry modeling health-protectively calculates a higher dose for children than adults or to demonstrate that the results of the calculations are not of a level of health concern, should be clearly stated. We suggest that the weighting factors be included, to assist the reader in seeing how the whole body dose was calculated from the organ-specific doses.

Agencies Response: *The appropriate changes have been added to the text.*

10. Health Consultation, p. 8, first complete sentence:

"The USEPA's proposed radionuclide cleanup regulation... is not intended to decide if clean up at a particular site is warranted..." (This was DV8).

LLNL Comment: The USEPA's Preliminary Remediation Goal (PRG) "is a health protective screening level that was developed using health conservative exposure and risk assumptions" (US EPA Plutonium Fact Sheet, 1995, Consultation Reference 5). We agree that the PRG is not a proposed clean up level; it is in fact a screening value and can be a point of departure for negotiating clean up levels to a higher value if adequately health protective. Furthermore, values below the PRG are often cause for no further action at sites being investigated for contamination.

Agencies Response: *The section has been deleted from the text.*

11. Health Consultation, p.8, last sentence in first partial paragraph:

"These proposed regulations are not intended to be equated with a level of health concern." (This was DV9).

LLNL Comment: EPA conservatively equates an incremental health risk of one-in-a-million (10<sup>-6</sup>) with exposure at the PRG level. See comment 10 above.

Agencies Response: *The section has been deleted from the text.*

12. Health Consultation, p.8, Pathway (Route) Investigation, first sentence:

"Since the discovery of Pu 239 in Big Trees Park, there has been a great deal of community concern as to the source of the Pu 239." (This was DV10).

LLNL Comment: The concern has been expressed and promoted by a small but highly vocal minority. The residents around Big Trees Park (as represented by the Rhonewood Homeowners Association and members of the public attending LARPD and City of Livermore meetings where the results of sampling for Pu in the park were discussed), the City of Livermore, LARPD, and School District have not expressed concern about the source. Quite the contrary was determined by a Livermore City council committee and the LARPD. This is probably because LLNL has publicly stated that LLNL is the source and because the levels are, as the Health Consultation points out and as pointed out by the EPA and CDHS-Radiological Health Branch, not at a level of health concern using worst-case conservative assumptions. Inaccurate characterization of the degree of community concern does not serve the community well and may in turn cause anxiety and concern.

Agencies Response: *Refer to our response to LLNL data validation comment #10.*

13. Health Consultation, p. 8, Pathway (Route) Investigation, first paragraph, second and third sentences:

"Sixty eight percent of the split samples analyzed by NAREL in the 1995 survey contained Pu 239 concentrations above the upper end of the range ... considered to be attributed by global fallout. This indicates that there is an additional burden of Pu 239 throughout Big Trees Park which cannot be attributed to global fallout (2)." (This was DV11).

LLNL Comment: Reference 2 (cited by the third sentence in the first paragraph in the Pathway (Route) Investigation) is the 1994 EPA report describing results of confirmatory sampling of plutonium in the Southeast Quadrant of LLNL. Since the 1995 sampling in Big Trees Park had not yet taken place, the referenced EPA document (2) cannot possibly support the assertion in the third sentence (of which it is part), nor the 68% figure prior sentence.

Agencies Response: 1) *Citation of reference 2: The EPA document is referenced for the purpose of the background level, cited as 0.01 pCi/g. We have edited the text to clarify this.*

It is correct that 68% of the estimated activities reported by NAREL were above 0.01 pCi/g, if one ignores the counting uncertainties. However, many of the counting uncertainties indicated a likely range of true activities extending well below 0.01 pCi/g. This means that if the samples were reanalyzed, the result might very well be below 0.01. Therefore, the NAREL results are insufficient to conclude that the samples contain Pu 239 above 0.01 pCi/g. (The NAREL results, if considered out of context, without reference to the other splits, would indicate that these samples might be above 0.01 pCi/g; this is the most that can be said of them.) Further discussion of this topic is given below.

Even if 68% of the NAREL samples were to contain Pu 239 above 0.01 pCi/g, it would still be true that 32% do not, so that not all parts of the park would be above 0.01 pCi/g. Since "throughout" means, literally, "in all parts of," the statement "This indicates there is an additional burden ... throughout ..." is an over-generalization and is incorrect and should be revised to accurately reflect the data upon which it is based.

Twelve of the nineteen NAREL estimated activities are below their minimum detectable concentrations. Six of the nineteen NAREL analyses are non-detections (based on counting uncertainty). Two of the NAREL estimated activities are negative; these are non-detections no matter how one defines non-detection." Since some of the samples are clearly nondetections, it is impossible and incorrect to claim that Pu 239 is elevated throughout the park.

What follows is our major point in disagreement over the data as used and presented in the Draft Health Consultation.

It is not scientifically valid to evaluate radiological results without considering the counting error (also referred to as counting uncertainty). Consideration of error or uncertainty is fundamental in measurement processes-especially in measurement or analysis of radioactivity. For discussions of statistics in radiochemical measurements see:

Friedlander et al., 1981 (Nuclear and Radiochemistry, Wiley, New York, 1981, Chap. 9 "Statistical Considerations in Radioactivity Measurements").

ANSI N42.23,1995 (Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories, 1995, Section A.7.3, Interpretation of Individual Measurement Results);.

Wang, et al, 1975 (Radiotracer Methodology in the Biological, Environmental, and Physical Sciences, Prentice-Hall, New Jersey, 1975, Chap. 12 "Nuclear Statistics").

Altshuler and Pasternack,1963 (" Statistical Measures of the lower limit of detection of a radioactivity counter," Health Physics, 9:293,1963).

Currie, 1968 ("Limits for qualitative detection and quantitative determination-application to radiochemistry," Analytical Chemistry, 40:586,1968).

For general statistical discussions on measurements and errors see:

Wheeler and Lyday, 1989 (Evaluating the Measurement Process, SPC Press, Knoxville,1989, p. 22 "The Classification of Measured Items Relative to Specifications").

Miller and Freund, 1977 (Probability and Statistics for Engineers, Prentice-Hall, New Jersey, 1977, Chap. 6 "Sampling Distributions").

It is also invalid, as we show in the text below, to consider only one source of data when three sources of data are available (see the references just noted). The data for the Big Trees Park sampling can be found in documents cited in the Consultation. As a result of this scientifically invalid use in the Consultation of a partial data set, a number of assumptions, hypotheses, inferences, and conclusions throughout the Consultation should be reevaluated.

*Agencies Response: We have added a discussion of counting uncertainties to address this issue.*

The Consultation states several times that surface soil throughout the park contains levels of Pu 239 greater than can be attributed to global fallout (i.e. at levels above background concentrations).

In order for this assertion to be correct, it is necessary that there be samples collected throughout the park with Pu 239 concentrations definitely greater than background levels. Such data do not exist.

The basis for the assertion that Pu 239 is above background levels throughout the park appears to be the Consultation's "observation" that 68% (13 out of 19) of the split samples analyzed by NAREL were reported to contain Pu 239 above the 0.01 pCi/g value which the Consultation uses

as the upper limit of the range for global fallout background concentrations. The following discussion examines the question of how many locations are above fallout background.

There are three locations with concentrations definitely above background concentrations. There are not samples above background throughout the park.

We illustrate this first with examples from two specific sample locations (5 and 13), followed by a general discussion of all the available data.

#### Example 1 - Location 5:

At Location 5 (see Appendix A, Figure A-1), the US EPA National Air and Radiation Environmental Laboratory (NAREL) estimated concentration is 0.0111 pCi/g. This is above the 0.01 pCi/g "background concentration range" and is therefore one of the 13 samples considered by the draft Consultation to be "above background levels." However, the NAREL uncertainty estimate for this sample is 0.0115 pCi/g. This means that if NAREL were to reanalyze the sample, there would be a significant chance (probability) the reanalyzes result would be below 0.01 pCi/g. Therefore, it is impossible to conclude that this sample is definitely above background concentration.

It would be possible to suggest from the NAREL data alone that Pu data from Location 5 might be above background levels. However, there are additional data for Location 5. Location 5 is one of the locations where the CDHS-RHB took a split sample and had it analyzed by the CDHS-RHB laboratory. The CDHS-RHB result for this sample is  $0.004 \pm 0.003$  pCi/g. This is within the range of possible values indicated by NAREL ( $0.0111 \pm 0.0115$ , or from -0.0004 to 0.0226). Therefore, the NAREL and CDHS-RHB results are consistent with each other. The CDHS-RHB result shows that within the range of possible values given by the NAREL result, the most likely sub-range is 0.001 to 0.007 pCi/g, which is within the range of expected background concentrations. Not only is it impossible to conclude that Pu data from Location 5 are definitely above background levels, the data strongly indicate that the soil Pu concentrations from this location are within the range expected for background concentrations.

Finally, the split from the Location 5 sample that was sent to the Lockheed Analytical Laboratory (LAL), a commercial analytical laboratory, by LLNL has a result of  $0.0036 \pm 0.0023$  pCi/g. Out of three splits of a single well-mixed sample from a single location, two agree very closely, and are within the range expected for background concentrations, and one has a large uncertainty estimate whose range includes that of the other two. The conclusion is clear and inescapable: this location does not exhibit soil Pu concentrations above those expected from global fallout.

#### Example 2 - Location 13:

At Location 13 (see Appendix A, Figure A-2), the NAREL estimate is  $0.0301 \pm 0.0284$  pCi/g. This result was also counted by CDHS in the Draft Health Consultation as one of the 68% above background levels. In this case, the uncertainty range indicates only a small chance of the result being representative of background concentrations. By itself, this indicates probable, though not definite, evidence of the result being above expected background levels. However, the CDHS-



RHB and LAL results for this location are  $0.001 \pm 0.001$  and  $0.0012 \pm 0.0021$  pCi/g respectively. In this case, the overlap between the NAREL range and the other ranges is small. Perhaps the splits really were different, despite the mixing that took place before the sample was split. Or perhaps the NAREL result is in error due to cross contamination within that lab or for some other unknown reason. Whatever the reason, results from the other two labs agree with each other, have greater analytical precision, and do not agree with the results from NAREL.

All nineteen samples were collected for the purpose of being representative of a portion of the park in the vicinity of the sample location. Having been collected in an identical manner, each of the splits is equally representative. Therefore, in order to come to a conclusion about the area of the park the collective split samples represent, it is necessary to average them. This best represents the concentration to which an individual in that area might be exposed. The mathematically correct way to average measurements with varying degrees of uncertainty is to weight them by their uncertainty. When this is done, the estimated concentration at Location 13 is well below 0.01 pCi/g. The evidence that soil Pu levels at this location are above background is weak, at best, and far from definitive.

General discussion of all Big Trees Park data sets:

Appendix A, Figures A-1 and A-2 show estimated concentrations and uncertainty ranges from all three laboratories for all samples except those from Location 1. There is one horizontal line on each plot at 0.01 pCi/g and another at 0 (zero). It is clear from these figures that NAREL consistently has a very large analytical uncertainty compared to the other two laboratories (Location 10 is the only exception). In all cases but two, the NAREL uncertainty extends below 0.01 pCi/g. In nine of the fifteen cases, the NAREL uncertainty extends well below 0.01 pCi/g.

The analytical results generally fall into one of two cases:

- (1) A large NAREL uncertainty range that includes the LAL and CDHS-RHB results (Group A on Figure A-1).
- (2) A large NAREL uncertainty that does not include the LAL and CDHS-RHB results (Group B on Figure A-2).

In the first case, there is no contradiction between results from the different laboratories; the sensible thing to do is to use the more precise measurements. Nine out of fifteen samples (i.e., excluding the four Location 1 samples) fall into this case.

In the second case, it is possible that the splits really are different. The sensible thing to do is to average them; this best represents the concentration present in the environment and, by extrapolation, to which people in that area might be exposed. The mathematically correct way to average measurements that have uncertainty is to use the uncertainty in the calculation of the average. The other six samples fall into this case. Although one of the splits from a given sample may have exhibited concentrations above background levels, it does not follow that soils from that area of the park definitely have concentrations above background concentrations.

#### Summary of all Big Trees Park data sets

When all 19 samples are examined, taking into account their uncertainties, and combining results from splits, only three locations are found to exhibit soil Pu concentrations definitely above 0.01 pCi/g. These are Location 1 (4 samples, the smallest of which shows  $0.240 \pm 0.0204$  pCi/g), Location 7 ( $0.0526 \pm 0.0091$  pCi/g), and Location 8 ( $0.0217 \pm 0.0049$  pCi/g; see MacQueen, 1995, which is Reference 4 in the Consultation, for a complete discussion of all the sampling data, evaluated in a statistically valid and scientifically defensible manner).

Thus, the draft Health Consultation statements that soil throughout Big Trees Park contains Pu above 0.01 pCi/g, and therefore above expected fallout background concentrations, are incorrect and are contradicted by the data.

These Consultation statements should be corrected wherever they occur (for instance, see the second sentence in the next to the last paragraph on p. 9 and also the last sentence in the second paragraph on p. 10).

At the public Site Team meeting on 2/25/98 a member of the CDHS staff indicated, in response to this issue, that it would be necessary to explain the differences between the results reported by the different analytical laboratories. It is necessary to do more than just explain the differences. In order for this draft Health Consultation to be a complete, independent, and objective evaluation of plutonium in Big Trees Park, it will be necessary to evaluate the impact each of the laboratories' results has on the conclusions reached in the draft Health Consultation.

*Agencies Response: We have revised the text to reflect our use of all of the data sets since our assumptions, hypotheses, inferences, and conclusions are based on all available data.*

*We recognize that Lockheed Analytical Laboratories' results indicate that only 3 locations (4 points spread over 30 feet, plus two other unrelated locations), are clearly elevated. This information suggests to us that elevations above background are not confined to a single "hot spot" in the Park, and that the extent of elevated levels of plutonium is not confirmed at present. We have revised the text to be more specific since this is the basis for our recommendation of additional sampling.*

14. Health Consultation, p. 9, first partial paragraph, last sentence:

"Thus, it appears that Pu 239 levels in the sludge resulting from the 1967 release may not have been adequately characterized."

LLNL Comment: The quoted sentence and the paragraph of which it is part, reference a letter written by D. C. Sewell (LRL) to the AEC which summarized and documented the inadvertent release of Pu 239/Am-241 to the sanitary sewer and the assessment activities and meetings at the time. It appears that CDHS is asking in the quoted sentence and the preceding paragraph if such an inadvertent release of radioactivity would be characterized differently today with more samples collected and isotopic analyses performed than was done 31 years ago. The answer is simple: of course more sampling and more analyses would be performed by today's norms than was done in

1967. However, not stated in the Draft Health Consultation is the fact that release, summary hazards analysis, etc. were discussed in meetings with Livermore City officials, representatives of the US Atomic Energy Agency (which had oversight responsibilities for the then Lawrence Radiation Laboratory, Livermore site) and the State of California Department of Public Health. We have no indication from the City nor from the State that the work done in 1967 did not meet their satisfaction in 1967. It is worth pointing out the fact that evaluation at the time determined that the amount of plutonium released per unit time based on gross alpha and isotopic analyses of sewage sampled by a flow proportional sampler showed the activity or concentration to be less than one half of the 1967 drinking water standard for plutonium.

*Agencies Response: We were not asking if characterization today would differ from 31 years ago, as the comment suggests; what was relevant was the lack of currently available information, for whatever reason. It is not our intent to point out the past inadequacies of historic practices relating to the handling and use of radioactive and non-radioactive chemicals, but rather to assess the potential health implications which may have resulted. Assessing past, current, and future health impact from exposure to site related contaminants is one of the primary objectives of the ATSDR Public Health Assessment process. The text has not been modified based on the LLNL comment.*

15. Health Consultation, p. 9, second complete paragraph, third sentence:

"One possible scenario is that Pu 239 contaminated sewage sludge was used as a soil amendment during the development of Big Trees Park during the early 1970's." (This was DV13)

LLNL Comment: As pointed out in our December 1997 data validation comments, placement of Pu contaminated sludge in the park did not have to occur at the initial development of the park. It could have been brought in later and used as a soil amendment when planting trees in the park. We would argue that this is the most probable scenario based on sample values representative of the sludge.

Since the data validation comments were submitted, we have obtained blueprints and other plans from the 1969 to 1971 time period showing the locations and pattern in which ornamental trees were planned to be planted in Big Trees Park. The actual locations of the trees today do not match this pattern.

Aerial photographs for the 1967-1975 show the ornamental trees clearly present in 1975, possibly present in 1974, and not evident earlier.

Therefore, there remains some uncertainty about when the trees were planted, and by whom, and with what, if any, soil amendments.

Agencies Response: Refer to our response to LLNL data validation comment #13.

16. Health Consultation, p. 9, third complete paragraph, second sentence:

"Given the fact that the surface soil throughout the park contains elevated Pu 239 levels and in order for this scenario to have occurred, one must assume that residents deposited sewage sludge in a manner consistent with a random distribution throughout the park." (This was DV14).

LLNL Comment: As discussed and shown above in comment 13, it is not a "fact" that surface soil throughout the park contains elevated Pu 239 levels. Since the premise of the argument is false, the conclusions do not follow. Therefore the statement is not factual and should not say it is a fact. Furthermore, the Pu distribution in the park is not random: Location 1 is distinctly different from the rest of the park. Nor can anyone assume sewage sludge would be distributed randomly. The only samples found to have above 0.01 pCi/g in 1995 are from locations 1, 7, and 8. Locations 1 and 7 are among the ornamental trees along the lined, artificial drainage channel. The value seen at location 8 is consistent with amended soil having been mixed with native soils. The distribution found in the 1995 USEPA/CDHS-RHB/LLNL sampling is consistent with the use of sludge as a soil amendment.

Agencies Response: *The text has been changed.*

17. Health Consultation, page 9, third paragraph, last sentence:  
"In the absence of LWRP's sewage sludge distribution log book, this theory can be neither discounted nor verified." (This was DV15).

LLNL Comment: The values found during the 1995 sampling strongly argue for this theory. Lab employees visiting the LWRP in 1974 met with sewer plant employees and saw the log book.

Agencies Response: *Comment noted.*

18. Health Consultation, p. 10, first paragraph, seventh and eight sentences:  
"The annual wind rose ... indicates that Big Trees Park is located downwind from LLNL approximately 10% of the year (28). This suggests that a small percentage of aerial deposition from releases at LLNL may have occurred at Big Trees Park." (This was DV16).

LLNL Comment: We appreciate CDHS/ATSDR attention to DV16. However, the change from "approximately 15%" (in the data validation draft) to "approximately 10%" (in the public comment draft) is not appropriate. Our data validation comment (DV16) stated that wind blows from LLNL towards Big Trees Park less than 10% of the time. This was correct, but very conservative. The actual percentage indicated by the windrose cited by the Health Consult (reference 28) is about 2%. Please see Attachment A, a copy of the cited windrose, which has been annotated to indicate the basis for the 2% estimate.

The agencies response to this data validation comment stated, in part, "Whether or not Big Trees Park is located downwind from LLNL approximately 10% or 15% of the year is not the central issue being addressed. The Health Consultation is simply pointing out that it is possible for aerial deposition, from releases at LLNL, to have occurred at Big Trees Park a certain portion of the year." The Health Consultation is attempting to do more than point out that aerial deposition is

"possible." It is attempting to demonstrate that such deposition is "plausible," as is shown by the statement "... we have shown the plausibility that the Pu 239 discovered in Big Trees Park may be the result of both aerial deposition and..." (page 9, last two lines and page 13, Pathway Analysis). "Plausibility" is very subjective; however, the standard of evidence necessary to demonstrate plausibility is clearly greater than that needed to demonstrate possibility. If the question really was that of 10% vs. 15%, and the issue really was that of possibility, then we would agree that 10% vs. 15% is not significant. However, the issue is one of plausibility, and the question is that of 15% vs. 2%. At 2% of the year, what was "possible" becomes at least unlikely, if not implausible. The Health Consultation should be modified to recognize this.

We have examined meteorological data from 1979 through 1996 and found that winds blow toward the west almost entirely in the wet part of the year. We have examined air monitoring data from the B531 location, which is within the southeast quadrant, and found that resuspension occurs almost entirely within the dry part of the year. Therefore, there is very little redistribution of resuspended material from LLNL to areas west of LLNL.

Agencies Response: *The text has been modified.*

19. Health Consultation, page 10, second paragraph, first and fourth sentences:  
"Most of the samples collected from Big Trees Park have similar Pu 239 levels and the distribution is consistent with that of aerial distribution (Figure 3)." "...aerial dispersion is a plausible explanation for the above 'background' levels of the Pu 239 found throughout Big Trees Park with the exception of location #1." (This was DV17).

LLNL Comment: As discussed in comment 13, Pu 239 is not above background throughout the park. There is no need to provide a pathway hypothesis to explain results that are not above background.

The NAREL results, if considered by themselves without the counting uncertainties as is done by CDHS/ATSDR in the draft Consultation), are not similar to each other. Even excluding Location 1, they have a wide distribution, varying from less than zero to 0.0481 pCi/g. "Similar" is a subjective term; nevertheless, similarity of NAREL results fails to support the air deposition hypothesis because the NAREL results are not "similar."

Taking into account analyses of all of the splits, most of the locations in Big Trees Park do have similar Pu values (as pointed out in comment 13 and by MacQueen, 1995, Consultation Reference 4), and the distribution is consistent with aerial deposition of global fallout (again, see MacQueen, 1995, Consultation Reference 4).

Agencies Response: *Comment Noted. We have deleted the paragraph discussing similarities.*

20. Health Consultation, p. 11 through the top of p.12:  
"...plutonium-contaminated soil has been verified in the southeastern portion of LLNL and surface drainage from this area enters the Arroyo Seco (Figure 5)(29)" and regarding further text

asserting that arroyo sediments were a contributing source or the source of Pu at Location #1. (This was DV18).

LLNL Comment: As indicated in the data validation comments and discussed with CDHS and ATSDR on March 26, 1998, Arroyo Seco has not received surface runoff water from the southern portion of the SE quadrant of LLNL since prior to 1965 (see Figure 3.1-7 in the CERCLA Remedial Investigations Report for the LLNL Livermore Site, UCAR-10299). As pointed out in the December 1997 data validation comments, the site annual environmental reports for the calendar years 1986-89 (the Consultation Reference number 29 is the 1987 annual) were in error in stating that SE quadrant drainage flowed to Arroyo Seco. Furthermore, most of the SE quadrant has consistently drained to the north even prior to 1965 because of the surface topography - the site elevation drops off over 80 feet from the southeast corner of the site to the northwest (see Figure 3.112 of the CERCLA RI Report).

It's also worth noting that Buerer, 1983, indicates that the lined evaporation trays and ponds whose use resulted in soil contamination in the eastern quadrant of LLNL were used from about 1962 until 1976. For Pu to have gotten into runoff going to Arroyo Seco, it would have to have had occurred between 1962 and 1965. The Pu would then have to have settled out somewhere nearby or upstream of Big Trees Park until being moved from the arroyo bottom into the park. For this to have occurred with the 1970 construction of the new lined channel and realignment of the old arroyo channel into the newly lined portion, the hypothetical Pu in the sediments would have had to survive storm events with associated scouring, moving, and redepositing of sediments. Then, presumably in 1970 in connecting the old unlined arroyo with the newly excavated, concrete lined channel, some sediments from the natural channel may have been excavated and placed in the park.

It is very unlikely that such a string of events could occur with the result of as much as 1.02 pCi/g of Pu being placed in the park.

The two references (30 and 31) in these three paragraphs of the Consultation do not support the arroyo source assertion. The new channel for the concrete-lined portion of the arroyo was dug and lined prior to the filling of the old drainage channel through the park and the school (31). This generated excess dirt to be used as fill in the park and in the old drainage channel. Except for a very short portion of the arroyo east of the bridge over the arroyo, no excavation from the old arroyo channel needed to take place.

Furthermore, in contradiction with the health consultation statement, that the "only soils generated on-site (cut-areas) were used as fill materials", it appears from City survey maps for the park and school that fill was generated and put on the park site from making the road cuts for nearby streets (Kathy and Sandra Ways).

Agencies Response: *The health consultation has been modified to reflect historical surface water drainage.*

21. Health Consultation, p. 12, first paragraph:

"In the 1995 Soil Survey Report LLNL concluded that the source of the Pu 239 could not have come from the sediments out of the Arroyo Seco channel because the two samples collected from the channel bottom did not reveal plutonium concentrations above background (4)." (This was DV19).

LLNL Comment: As pointed out above, the conclusion that the arroyo is not the pathway to location 1 is supported by several lines of evidence. Historic surveillance sampling shows Pu in the Arroyo Seco sediments at levels consistent with global fallout. This, combined with the sampling done in 1995, plus the logic that digging and lining a new channel generates clean, uncontaminated fill further supports the conclusion that arroyo sediment was not the source of Pu.

Agencies Response: Refer to our response to LLNL data validation comment #19.

22. Health Consultation, p. 12, first paragraph:

"The shallower sampling methodology (1 cm and 5 cm) used in both the 1994 NAREL study and the LLNL 1995 Soil Survey of Big Trees Park was not, according to LLNL's own documents, the correct method to characterize sediments. Sampling should have been done at greater depths, if the sampling was to characterize sediments (29, 32)" (This was DV20).

LLNL Comment: The Big Trees Park sampling in 1995 was performed with a methodology agreed to and specified by EPA NAREL and the CDHS Radiological Health Branch. Since the 1995 sampling was in response to a NAREL recommendation to verify the NAREL 1994 0-5 cm Big Trees Park result, the sampling depth in 1995 was necessarily done to the same depth. Rather than criticizing the 1995 depth selection, the Health Consult should note that the depth was chosen for a specific and valid purpose, and with approval by the regulatory agencies (EPA and CDHS-RHB).

Agencies Response: Refer to our response to LLNL data validation comment #20.

23. Health Consultation, p.13, first paragraph, second sentence:

"...CDHS ... have shown the plausibility that the source of the Pu 239 discovered in Big Trees Park may have been the result of both aerial deposition and sediment distribution from the Arroyo Seco channel." (This was DV21).

LLNL Comment: CDHS has made serious scientific errors in trying to use the USEPA/NAREL data without considering the analytical uncertainties of the USEPA/NAREL data and without considering the independent analyses performed by CDHS Radiological Health Branch and by a commercial contract laboratory (see Comment 13 above). When the set of available data is used with accepted scientific methodology, it is clear that all of the Pu concentrations found in the 1995 soil sampling are consistent with global fallout background levels, except for those from 3 locations (Locations 1, 7, and 8). It is not plausible that air dispersion would deposit Pu in locations 7 and 8 only, and miss locations 2-6 and 9-16. Location 7, like location 1, is among the trees adjacent to the concrete arroyo channel, and therefore consistent with the soil amendment

hypothesis. Location 8 is not easily explained by any of the hypotheses, but is only slightly above the upper limit for background used in the Health Consult and therefore probably not indicative of significant contamination in its vicinity. Likewise, the history of the park and the physical realities discussed above do not support the arroyo sediments as a pathway or transport mechanism to Location 1.

*Agencies Response: Refer to our response to LLNL data validation comment #21.*

24. Health Consultation, p. 13, second paragraph:

"Because the previous investigations only sampled surface soil, additional sampling is needed to define the vertical extent of Pu 239 contamination in the Arroyo Seco channel and in Big Trees Park. This is necessary to protect the health of the public from potential exposure to Pu 239 that may exist at greater depths." (This was DV22).

LLNL Comment: This statement cites the only valid reason for sampling below 5 cm, namely, that it has not yet been done. However, there is no evidence at this time indicating that there is likely to be more contamination below 5 cm as implied by the Health Consult than above 5 cm. The Health Consult should acknowledge this fact.

*Agencies Response: Refer to our response to LLNL data validation comment #22.*

25. Health Consult, p. 13, third paragraph:

re. Consultation assertion that past distribution of sewage sludge is a health concern that warrants further investigation.

LLNL Comment: Pu concentrations in sludge have been measured, and the risk of using the sludge in residential applications has been evaluated (Myers et al., 1975, Consultation Reference 22). This published work showed that there is no significant risk from using the sludge in a garden even when assuming a worst case scenario for treatment of the sludge with respect to inhalation (rototilling dry sludge and soil on a summer day) and ingestion (there is no uptake by the garden produce). Any similar sludge use as an amendment would likely result in the sludge's being diluted by the activities associated with using soil amendments (e.g., rototilling and blending with other soil additives and soil) and the potential activity of any Pu in the sludge hypothetically available for exposure is thereby reduced.

*Agencies Response: We do not believe that the "worst-case scenario" has been determined based on the levels used in the referenced report (Myers et al., 1975). The risk derived in the report was based on a Pu value of 4.4 pCi/g. Levels of alpha activity have been shown to be as high as 297 pCi/g, albeit we are unsure if this is entirely plutonium or americium or naturally occurring alpha emitters, in the digester sludge; even with the dilution from other soils, we cannot say that a health concern does not exist.*



Additional information supplied by LLNL

LLNL Comments on the report entitled,  
"Health Consultation, Lawrence Livermore National  
Laboratory, Plutonium Contamination in Big Trees Park  
Livermore, Alameda County, California  
CERCLIS No. CA 2890012584"

Figures A-1 and A-2 show results of the January 1995 sampling of Big Trees Park for Pu 239/240 from all sampling locations except Location 1. Each plot in these figures shows results from a single location. All plots include results from split samples analyzed by the EPA National Air and Radiation Environmental Laboratory (NAREL) and the Lockheed Analytical Laboratory (LAL). LAL is the commercial analytical laboratory to which LLNL sent split samples. CDHS Radiologic Health Branch laboratory (RHB) results are included in the plots for the subset of locations that the CDHS chose to analyze.

Each plot contains two (LAL and NAREL) or three (LAL, NAREL, and RHB) vertical lines that indicate the result plus and minus the two sigma uncertainty as reported by each laboratory.

Horizontal reference lines are at 0.01 pCi/g, an estimate for the upper range of fallout background used in the Health Consultation, and at zero pCi/g.

The plots are separated into two groups. Group A includes locations where the NAREL result has a larger uncertainty than the other two laboratories, and the other laboratories' results are contained within the NAREL uncertainty range (see Figure A-1). Group B includes locations where the other laboratories' results are not entirely within the NAREL uncertainty range (see Figure A-2).