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Livermore Big Trees Park
1998 Soil Sampling Plan

July 31, 1998

Lawrence Livermore National Laboratory

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Environmental Protection Department

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1998 Soil Sampling Plan

July 1998

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Executive Summary

This sampling plan sets out the sampling goals, rationale, locations, and procedures for a plan to determine the extent of plutonium in soil above background levels in Big Trees Park and identify any possible pathways by which plutonium may have reached the park. The public is invited to witness the sampling at Big Trees Park. The plan has been developed by the U.S. Department of Energy (DOE) and Lawrence Livermore National Laboratory (LLNL) scientists with guidance from the Environmental Protection Agency (EPA), the Radiologic Health and Environmental Health Investigations Branches of the California Health Services Department (CDHS-RHB and CDHS-EHIB), and the Agency for Toxic Substances and Disease Registry (ATSDR). Input from citizens and community organizations was also received during an over-70-day public comment period.

Background

Plutonium was discovered in Big Trees Park in 1993 when the EPA was checking background plutonium values in the vicinity of LLNL. Only one soil sample collected at one location in the park definitively contained plutonium at a greater concentration than would have been expected from global fallout alone and at about 40% of the EPA's level of health concern. EPA was analyzing soil in the Livermore area because in 1991 LLNL had reported elevated concentrations of plutonium in soil in the southeast quadrant of its Livermore Site. In 1995, LLNL in collaboration with EPA, CDHS-RHB, the city, the school district, the homeowners association and Tri-Valley Citizens Against a Radioactive Environment, collected additional soil samples from Big Trees Park to verify the 1993 finding.

After this 1995 sampling, the EPA concluded that the plutonium was below the preliminary remediation goal (PRG), presented no health hazard, and required no further action. A draft health consultation prepared by CDHS-EHIB suggested sampling the park at greater depths than those sampled in 1995. LLNL volunteered to do so and to work with the regulatory agencies to assure that public concerns were met.

Big Trees Park

Big Trees Park is a 4.23-acre public park in the city of Livermore administered by the Livermore Area Recreation and Park District (LARPD) located about 1 kilometer west of LLNL. The park was initially constructed in 1971 and another 1.3 acres were added

in 1986. The original portion of the park is triangular in shape and bordered by Kathy Way on the south, by the concrete-lined Arroyo Seco on the northeast, and Arroyo Seco Elementary School on the northwest.

In 1970, the Arroyo Seco was rerouted and lined with concrete along the northern border of the park. The former channel was filled and is referred to in the plan as the "old channel."

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory, a DOE-owned facility is operated by the University of California as a national resource of scientific, technical, and engineering capabilities. Historically, its mission has focused on weapons development and national security, but has broadened over the years to include energy, the environment, biomedicine, technology transfer, and education.

The exact transport pathway of the plutonium to Big Trees Park at levels above those expected from global fallout is unknown. It is known that since the mid-1950s, LLNL released small quantities of plutonium to the sanitary sewer under strict DOE discharge limits. The sanitary sewage goes to the Livermore Water Reclamation Plant (LWRP) where it ends up in sludge after a period of time. During the early 1960s to mid-1970s, sludge was available to the community for use as soil compost or amendment. It is hypothesized that sludge containing very small amounts of plutonium was used by volunteers, not the City or Park district, when planting trees in certain parts of the park during that period. Other hypotheses not supported by any previous sampling or monitoring data by LLNL and regulatory agencies is that there may have been rare air and water pathways from the Lab.

Sample Collection Locations Test Potential Pathways

The sampling plan divides collection locations into eight sets or areas: Grid (150 samples), Arroyo Seco Channel (7), Old Channel (3-18), Ornamental Trees (18), Special Sampling at the 1995 sample locations (60), Disked Area (4), Playing Field (10), and Big Trees Park eastern extension (15). Samples will be collected at a variety of depths, depending on the unique characteristics of each location. The locations, numbers of samples, and depths have been selected with guidance from the EPA, CDHS-RHB, CDHS-EHIB, and ATSDR to assess the vertical and horizontal extent of plutonium and thereby attempt to identify the pathway by which plutonium reached the park.

Grid

The sampling grid consists of four radial lines and eight perpendiculars, with the origin of the radials being close to Location 1 sampled in 1995. Location 1 had the highest plutonium value in the analysis, although below the level of regulatory concern. Samples will be collected at the grid intersections at five depths between 0 and 40 centimeters. The rationale for any sampling grid is that it distributes the sampling locations randomly and precisely. The rationale for choosing a radial grid emanating from the area of highest known plutonium concentration is to determine the extent of the plutonium found above background in Big Trees Park.

Arroyo Channel

One soil sample will be taken at each of seven locations in the Arroyo Seco, six between LLNL and a location downstream of Big Trees Park and one upstream of LLNL. The samples will be collected at two depth intervals between 0 and 25 centimeters. Since the Arroyo Seco connects LLNL with Big Trees Park, it offers a potential water-borne pathway to the park. Analysis of these soil samples will evaluate the hypothesis of plutonium being transported down Arroyo Seco from LLNL in storm water.

Old Arroyo Channel

Soil samples will be collected from three locations in the old channel to further evaluate the water-borne hypothesis. If plutonium was carried down the arroyo before it was rerouted, then plutonium might still be present in the interface between the old channel bottom and the fill material. Sampling efforts will be directed toward finding the old channel and determining if it contains elevated levels of plutonium. Results will be used to evaluate the hypothesis of a past water pathway from LLNL to the park.

Ornamental Trees

Soil will be sampled at the bases of three ornamental trees. One of the pathway hypotheses is that plutonium arrived at Big Trees Park in processed sludge from the LWRP and was used as soil amendment to plant trees. There is no direct evidence that sludge was used as a soil amendment at Big Trees Park. Samples in this set will also be analyzed for Americium-241 because it is known that it was also released to the LWRP from LLNL. Sewage sludge also has a characteristic metals fingerprint, therefore samples from the ornamental trees set will be analyzed for heavy metals known to be concentrated by LWRP's water treatment procedures.

Special Sampling at 1995 Locations

Ten locations will be sampled around Locations 1, 7, and 8 of the 1995 sampling. These locations will be resampled at six depth intervals between 0 and 85 centimeters, for a total of 60 samples. Resampling may resolve discrepancies in results reported by the three sampling laboratories in 1995 and provide data relevant to the three hypothetical pathways: air, water, and sludge.

Disked Area

The disked area is an open field in the northern portion of the school property next to Big Trees Park. Four samples will be collected at depths between 0-15 centimeters in order to assess distribution of plutonium in the park.

Playing Field

The playing field is an open grass field north of the school grounds proper. Samples at two locations will be collected at depths between 0 and 40 centimeters, for a total of ten samples. These results will provide data on the spatial distribution of plutonium in soil.

Big Trees Park Eastern Extension

The eastern extension of Big Trees was constructed approximately 15 years after Big Trees Park. Three samples will be collected between 0 and 40 centimeters. Location 13 from the 1995 sampling was in this eastern extension. Resampling will resolve discrepancies in results reported by the three sampling laboratories in 1995.

Sampling and Handling Procedures

Surface and shallow samples will be collected with a hand-held coring device. A drill rig with the capability of coring will be used to collect deeper samples. The actual type of coring device used will depend on actual field conditions. Sampling will be witnessed by staff from LLNL and at least one regulatory agency. It will also be documented with photographic and video records. The exact location of all samples will be determined through use of a global positioning satellite system.

Every sample will be split into at least two portions: one for analysis and one to be archived. Some will be split into three or four samples depending on whether a field replicate and samples for ATSDR or EPA are required. Quality control samples will be collected at approximately 10% of the sample locations. Chain of custody and field

tracking forms will be maintained for all samples. The public is invited to witness the sampling activity.

Sample Analysis

Sample analyses will be performed by a certified analytical laboratory. Plutonium analyses will be performed using a measuring device called an alpha spectrometer that detects that the alpha particles associated with the radioactive decay of plutonium. Americium-241 analysis will be performed by directly analyzing the soil on a gamma spectrometer. Metals (chromium, copper, lead, nickel and zinc) samples will be analyzed using atomic adsorption spectroscopy. The sample size and analytical methods have been chosen to ensure that the detection limit (or level of sensitivity) is low enough to be able to distinguish whether the samples are elevated with respect to the background concentration of the constituent.

Responses to Public Comments

The first draft of the *Livermore Big Trees Park 1998 Soil Sampling Plan* was published April 10, 1998 and offered to the regulating agencies and public for comment. Organizations and private citizens commented for the record. Comments covered all aspects of the plan, but editorial quality, sampling locations and depths, history, analytes, and data interpretation were the categories that attracted the most comments. Suggestions were made that the document be more transparent to the lay reader, that other locations and depths be sampled, that more chemical elements be analyzed for, and that alternative methods be used to interpret the results. All of the comments and responses to the April 10 plan are addressed in this document.

Supplemental Information

Six appendices contain the following supplemental information:

- The EPA Plutonium Fact Sheet.
- A table of LLNL events with potential pertinent environmental impacts.
- Field sampling procedures.
- A discussion of the plutonium background in the Livermore Valley.
- Quality assurance and analytical methodology.
- Definitions of the acronyms used in the report.

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1. Introduction

This sampling plan describes the methodology to be used in the evaluation of plutonium (Pu) concentrations above background in Livermore's Big Trees Park. It was designed by the U.S. Department of Energy (DOE) and Lawrence Livermore National Laboratory (LLNL) scientists under the direction and oversight of the U.S. Environmental Protection Agency, Region IX (EPA) and the California Department of Health Services - Radiologic Health Branch (CDHS-RHB), under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

This plan and the associated sampling and analyses represent LLNL's voluntary response to community concerns voiced on the Agency for Toxic Substances and Disease Registry (ATSDR)/CDHS Environmental Health Investigations Branch (CDHS-EHIB) February 1998 draft Public Health Consultation (PHC). Elevated concentrations of plutonium were found in Big Trees Park in separate sampling events conducted by the EPA and LLNL in 1993 and 1995, respectively. EPA found no cause for health concerns or further action at that time.

This sampling plan addresses Recommendation 1 of the draft PHC: "CDHS and ATSDR recommend further sampling of Big Trees Park and the Arroyo Seco Creek sediments to determine the vertical extent of Pu-239 contamination." In addition, the plan also sets out guidelines for acquiring the data to evaluate the three pathways discussed in the Health Consultation (i.e., sewage sludge, water-borne/arroyo distributions, and aerial distribution).

1.1. Background

Big Trees Park is a Livermore Area Recreation and Park District (LARPD) park located approximately 1 km west of the LLNL Livermore Site (Figure 1). In 1993, a surface soil sample from the park revealed Pu-239+240 concentrations greater than those expected from global fallout from atmospheric weapons testing (NAREL, 1994; MacQueen, 1995).

In 1991, LLNL reported elevated levels of plutonium in the southeastern quadrant of the LLNL Livermore Site (DOE, 1991). In 1993, the EPA conducted a confirmatory soil sampling program to reevaluate the extent of plutonium in the soil (EPA, 1994). In the EPA's soil sampling reevaluation, they collected a soil sample at Big Trees Park and analyzed it for plutonium as a background sample. The result for Pu-239 was 0.164 picocuries per gram (pCi/g), which is less than EPA's Preliminary Remediation Goal (PRG) of 2.5 pCi/g for unrestricted residential use, but above estimated global

fallout concentrations. The EPA recommended that LLNL conduct follow-up sampling in Big Trees Park to verify the 1993 result. LLNL developed a sampling plan with input from the LARPD, local government officials, home owners, local school district officials, the EPA, and the CDHS-RHB. The follow-up sampling was conducted in January 1995 with oversight by the EPA and the State of California (LLNL, 1995; MacQueen, 1995). This sampling effort also included samples from the Arroyo Seco Elementary School, the bottom of Arroyo Seco, and one sample from a nearby apartment complex. The EPA summarized these plutonium investigations in a 1995 Fact Sheet (Appendix A).

ERD-LSR-98-0156

Figure 1. Map showing LLNL and Big Trees Park.

The 1995 sampling confirmed the 1993 EPA result, and found higher concentrations (ranging from approximately 0.2 to 1 pCi/g) at four locations around the 1993 sample location (referred to collectively as Location 1; Figure 2). These results established that there was an area where Pu-239 concentrations were above background concentrations expected from global fallout. Locations 7 and 8 had plutonium concentrations between those of Location 1 and the other 1995 locations. Location 7 was slightly above background (~0.05 pCi/g), but not as high as Location 1, and Location 8 was near the upper range of background concentrations (0.0215 pCi/g). LLNL issued a report summarizing the results (LLNL, 1995), and the EPA and CDHS-RHB concluded that no further action was necessary based on a risk assessment (EPA, 1995).

The 1995 samples were split and analyzed by two labs, Lockeed Analytical Services (LAS) and EPA National Air and Radiation Environmental Laboratory (NAREL), in all cases. A third lab (RHB) analyzed a lesser number of samples. Results from all three laboratories agree at the highest concentrations, but NAREL's values tend to disagree with results obtained by the other two laboratories at lower concentrations. The discussion in the previous paragraphs is based on the LAS and RHB results, and not the NAREL results because it appears that NAREL did not count the samples long enough to obtain accurate results

In 1997, CDHS-EHIB, working under a cooperative agreement with ATSDR to perform a Public Health Assessment of the LLNL Livermore Site, evaluated the data collected in 1993 and 1995 by EPA and LLNL. Their draft report stated: "ATSDR has concluded that Pu-239 found in surface soil at Big Trees Park is below a level of health concern." However, the report also recommended that additional sampling and analyses be performed. The report was released in February 1998 at a CDHS/Community/ATSDR Site Team meeting. At that meeting, several community members expressed opinions that additional sampling should be performed at Big Trees Park so that the community could better understand the source, extent, and risk associated with the plutonium detected in the park.

In March 1998, DOE/LLNL volunteered to collect additional samples in Big Trees Park to respond to community concerns. In April 1998, DOE/LLNL released a draft sampling plan with design guidance from EPA and CDHS-RHB. This draft plan was released to the Livermore community, the ATSDR Site Team, CDHS, EPA, the California Department of Toxic Substances Control (DTSC), ATSDR, and the Bay Area Regional Water Quality Control Board (RWQCB) for review and comment. Comments on the plan were received until June 22, 1998, 71 days after the release of the draft. DOE/LLNL have collaborated closely with EPA and CDHS to ensure that all comments are adequately addressed.

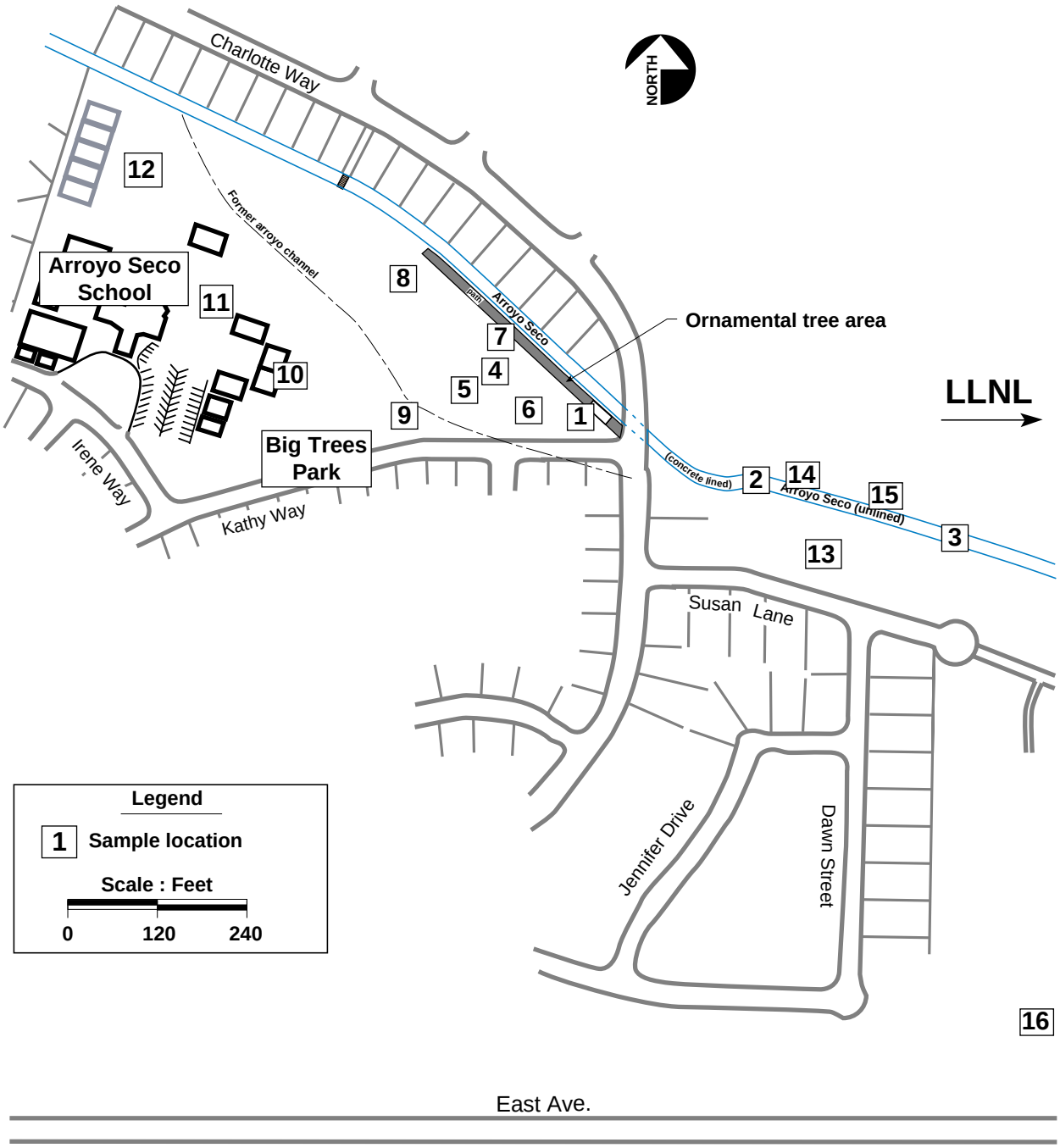

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Figure 2. Locations sampled in 1995.

1.2. CERCLA Process Related to this Sampling Plan

LLNL's Livermore Site was added to EPA's National Priority List (NPL) in 1987, and DOE, EPA, DTSC, and RWQCB entered into a CERCLA Federal Facility Agreement (FFA) in 1988. The FFA identified DOE as the party responsible for the assessment and cleanup of soil and ground water contamination resulting from DOE activities at the site. EPA, DTSC, and the RWQCB are the regulatory agencies tasked with oversight and approval of the cleanup.

ATSDR is mandated by Congress to investigate the past and present health effects of facilities on the National Priority List. These investigations include review of existing local public health data, facility release data, and environmental monitoring data. The results of the investigation of a facility are published in a report called a public health assessment. At a facility with several possible public health issues, each individual issue is evaluated in a document called a public health consultation (PHC). In both the public health assessment and the consultation process, ATSDR only reviews existing data. If additional data is needed or an action is recommended, the party responsible for the CERCLA site cleanup may be required to implement the actions with oversight and approval of the cognizant regulatory agencies (EPA and state and local agencies for the LLNL Livermore Site). Any actions undertaken are subject to the requirements of CERCLA.

The current ATSDR public health assessment process began at LLNL in 1992, and the first PHC was published in draft in February 1998 (CDHS/ATSDR, 1998). DOE/LLNL's decision to perform additional sampling was a proactive response to the draft PHC recommendation that additional assessment be performed in Big Trees Park. This sampling plan has been prepared following protocols and procedures to meet strict EPA standards, including Quality Assurance, sampling, and analytical procedures. DTSC and RWQCB have delegated their authority for approval to CDHS-RHB. This Draft Final sampling plan is the result of discussions between LLNL, DOE, EPA, CDHS-RHB, CDHS-EHIB and ATSDR and input from citizens and community organizations.

1.3. Purpose

As a result of the investigations undertaken to date, three hypotheses have been advanced to explain elevated plutonium concentrations in Big Trees Park. These are the water-borne/arroyo pathway hypothesis, the sludge pathway hypothesis, and the airborne pathway hypothesis (Section 3.1).

As discussions with EPA, CDHS-RHB, CDHS-EHIB, and ATSDR progressed, the following sampling plan objectives emerged:

1. Collect data intended to distinguish between the water-borne/arroyo pathway, the sludge pathway, and the airborne pathway hypotheses.
2. Assess the extent of contamination in terms of both surface area and vertical depth.
3. Collect some special purpose samples targeted at areas of interest.

Although further risk assessment is not specified in this plan, the results can be used for this purpose. Results of this effort will be used by regulatory agencies to determine if additional action is warranted.

2. Big Trees Park History

2.1. Physical Description

Big Trees Park is a 4.23-acre public park located in the City of Livermore, about 1 km west of the LLNL Livermore Site. The park was initially constructed in 1971, and although it is owned by the City of Livermore, it is administered by the Livermore Area Recreation and Park District (LARPD). The chronology of events at Big Trees Park, beginning with the acquisition of the land by the City of Livermore is summarized in Table 1. A similar table of potential pertinent LLNL environmental impacts is presented in Appendix B. The park is triangular in shape (Figure 2) and is bordered on the south by Kathy Way, on the northeast by the concrete-lined Arroyo Seco channel, and on the northwest by Arroyo Seco Elementary School. The eastern corner of the park is located at the intersection of Charlotte Way and Kathy Way. A turfed playing field and an unmaintained disked area are located in the northern portion of the park.

East from the main body of Big Trees Park, across Charlotte Way, is an eastern extension of Big Trees Park, which was constructed in 1986. This rectangular 1.3-acre extension is zoned for open space. The extension is bordered by the south bank of an unlined portion of Arroyo Seco.

As discussed in Section 1.3, the three primary pathways to be evaluated are the water-borne/arroyo pathway, the sludge pathway, and the airborne pathway. The water-borne pathway hypothesis considers the possibility that sediments excavated from the arroyo, which at one time may have carried water containing plutonium, were spread around the park during construction. The sludge hypothesis considers that sewage sludge containing plutonium was used as a soil amendment when ornamental trees bordering the northern boundary of the park were planted. The airborne hypothesis considers deposition from resuspension or emissions.

2.2. Soil from the Arroyo

The Arroyo Seco carries seasonal storm water runoff from the foothills on the eastern side of the Livermore Valley toward the west. It passes through the southwest corner of LLNL and continues downstream toward and along the northern edge of Big Trees Park. Some LLNL storm water runoff discharges into Arroyo Seco via the storm sewer

Table 1. Chronology of events at Big Trees Park.

Date	Activity	Source
July 17, 1969	Property, which becomes Big Trees Park, deeded to City of Livermore.	County Tax Assessor's map and Metroscan[a]
1970	New Arroyo Seco channel excavated and concrete-lined from just east of Charlotte Way to connect the already concrete-lined arroyo west of Big Trees Park.	Kaufman & Broad 1969, 1970
1970	Excavation of new concrete-lined arroyo generates approximately 9500 cubic yards of excess soil.	R. M. Galloway & Associates, 1970
1970	Excess soil generated from preparing road beds for street construction and lots for foundations was stockpiled in the park.	R. M. Galloway & Associates, 1970
1969–1970	Subdivision graded per city specifications.	Cooper-Clark & Associates 1969, 1970a, 1970b, 1970c
March 23, 1971	Concrete-lined portion of arroyo deeded to Alameda County Flood Control and Water Conservation District Zone 7.	County Tax Assessor's map and Metroscan
April and June 1971	Big Trees Park constructed per the terms of the LARPD for the installation of the irrigation system and turf. No imported fill or soils other than fertilizer were used in installing the irrigation system and turf.	LARPD, 1971
1972	No trees are apparent adjacent to the south side of the concrete-lined portion of the arroyo.	Aerial photograph, 1972
1970–1972	Arroyo Seco Elementary School constructed	Aerial photos of the area 1970 and 1972
1986	Play area and picnic tables upgraded. LARPD indicates that sand was brought in and gravel and soil from the older, smaller play area (dimensions not defined) was removed to make room for the larger play area.	Ingledue, 1998 LARPD drawing, 1986
1986	Big Trees Park eastern extension was constructed.	Ingledue, 1998 Aerial photograph, 1985
1988	Asphalt added to improve Big Trees Park paths.	LARPD drawing 1988
1993	EPA collects a background sample from Big Trees Park that exceeded global fallout background for this area.	NAREL, 1994
Oct.–Dec. 1994	LLNL meets and develops sampling plan with representatives of homeowners association near the park, City of Livermore, Livermore schools, LARPD, EPA, CDHS-RHB, and others.	MacQueen, 1995
Jan. 1995	LLNL samples Big Trees Park, Big Trees eastern extension, school yard, and vicinity. EPA and CDHS-RHB collect split samples of the soil for independent analyses.	MacQueen, 1995

a Commercial online service for determination of property ownership.

Table 1. Chronology of events at Big Trees Park (continued)

Date	Activity	Source
July 1995	LLNL report published and distributed. Pathway for plutonium from LLNL to park not definitive. All plutonium concentrations less than residential guideline.	
Sept. 1995	EPA fact sheet on plutonium published - "The levels of plutonium detected off site do not pose an unacceptable risk to local residents."	EPA, 1995
Feb. 1998	Regulatory agencies recommend that LLNL sample deeper. In response to regulator recommendations, LLNL develops a sampling plan with the cognizant regulatory agencies and stakeholder input.	McConachie, 1998

system. The Arroyo Seco channel between LLNL and Big Trees Park has flowing water for relatively short periods of time during and shortly after significant rainfall events but is dry for most of the year (Lunn, 1998). Water flow can be substantial after major storm events, which have been more frequent the last few years (including the 1997-1998 rainy season). LLNL staff have observed large volumes of water flowing during winter storms. Records of flood events in Arroyo Seco are not maintained, so definitive information about past overflows is not available. Flooding is rare according to unsubstantiated oral history.

Erosion of the banks at various locations within the channel between LLNL and Big Trees Park has been observed. The degree of erosion is variable. In 1997, a portion of the channel between Vasco Road and Big Trees Park was realigned about five feet to the south. During this realignment, the affected portion of the arroyo channel bottom was disturbed.

During residential development of the area in the early 1970s, a portion of the old arroyo channel was rerouted and lined with concrete. According to tract development blueprints, the old channel, which is now on the Arroyo Seco Elementary School grounds, was filled prior to the establishment of Big Trees Park in 1971. The section of the old arroyo under Charlotte Way and Kathy Way was filled in 1971. There is no LARPD record of when the old arroyo channel through the park was filled (Ingledue, 1998).

CDHS-EHIB hypothesize that the elevated level of plutonium found in the 1995 Big Trees Park samples may have arrived in soil excavated from the arroyo during the channel realignment and later used in the park as fill material (CDHS, 1998). A review of the City's engineering drawings and the aerial photos of the park and arroyo indicate

that the volume of material excavated from the old arroyo was probably fairly small. A larger source of fill would have been available from the grading activities elsewhere throughout Big Trees Park and the development of the adjacent housing tract.

Alameda County Flood Control and Water Conservation District Zone 7 (Zone 7) assumed title to the concrete-lined section of the channel in 1971, and staff report that essentially no maintenance has been required of this section. Zone 7 has conducted brush and vegetation removal from the portion adjacent to the Big Trees Park eastern extension.

2.3. Sludge Use at Big Trees Park

Big Trees Park is named for the large eucalyptus trees that are located throughout the park, the school, and Big Trees Park eastern extension. These trees were growing along the arroyo before the housing tract, school, and parks were developed.

Big Trees Park was initially constructed between April and June 1971 (Ingledue, 1997). According to the LARPD terms, no imported fill or soils other than fertilizer were to be used in installing the irrigation system and turf. No ornamental trees were planted by the LARPD contractor in 1971 along the south side of the arroyo channel in the vicinity of the area identified in 1995 as being the site of elevated plutonium concentrations. Trees adjacent to the south side of the concrete-lined section of the arroyo can be seen on aerial photographs by 1975.

While it is clear that the LARPD intended that no soil amendments be used in planting in the park, volunteers may have planted trees in the park along the arroyo using sanitary sewer sludge containing low levels of plutonium from the Livermore Water Reclamation Plant (LWRP) as a soil amendment

3. Sampling Strategy

Sampling strategy is based on choosing sampling locations and analytes that will provide data to satisfy the objectives of the sampling plan. Samples are to be collected at locations and depths that are believed to be unique to a particular pathway.

3.1. Sampling to Determine Contaminant Pathway

Knowing how plutonium got to Big Trees Park is not only important for historical reasons, but also provides reassurance that the pathway is no longer active. As discussed in Section 1.3, two primary hypotheses have been identified to explain the existence of elevated plutonium concentrations in Big Trees Park (Location 1): the water-borne/arroyo pathway hypothesis and the sludge pathway hypothesis (Sections 3.1.1 and 3.1.2, respectively). The aerial hypothesis is not a major element of the plan; however, some of the samples collected will aid in the evaluation of this hypothesis (Section 3.1.3). The sampling plan is summarized in Table 2.

3.1.1. Water-Borne/Arroyo Pathway

One way that traces of low-level plutonium might have reached Big Trees Park was by water-borne sediments carried from LLNL down the Arroyo Seco, which cuts across the southwestern corner of the LLNL site. Low-level plutonium contamination in the southeastern portion of the Livermore Site was first documented by LLNL in 1983 (Buerer, 1983). The activities responsible for the contamination occurred between 1962 and 1976. The possibility of water-borne mobilization of contaminated sediments from the southeastern portion of the site was proposed in the CDHS/ATSDR Public Health Consultation.

3.1.1.1. Hypothesis

According to this hypothesis, plutonium was transported from LLNL to Big Trees Park by the following sequence of events:

1. Surface water containing plutonium-contaminated sediment from the southeastern portion of LLNL entered Arroyo Seco via a storm sewer outlet in the southwest corner of LLNL.
2. The sediment was carried downstream approximately one-third mile to the area of Big Trees Park and deposited when the water receded.

Table 2. Big Trees Park sampling plan.

Sample set	Analytes[a]	Potential pathways	Depths (cm)	Number of locations	Number of samples
Current arroyo channel	Pu	Water	0-5 0-25	2 LLNL 1 SNL 2 Near park 2 (Downstream)	7
Old arroyo channel	Pu	Water	If identified: 1 at 0-5 If not identified: 6 at ±45	3	3 (18 Max)
Sludge/ ornamental trees	Am Pu Metals	Air Water Sludge	0-45 45-90 90-135	3 Pairs (6)	18
Extent of contamination/ grid	Pu Am	Air Water Sludge	0-5 5-10 10-20 20-30 30-40	30	150
Special sampling at 1995 Locations 1,7,8	Pu	Air Water Sludge	0-5 5-10 10-20 20-30 30-40 40-85	8 (Location 1) 1 (Location 7) 1 (Location 8)	60
Special sampling of disked area	Pu	Water Air	0-15	4	4
Special sampling of playing field	Pu	Air Water	0-5 5-10 10-20 20-30 30-40	2	10
Special sampling of Big Trees eastern extension	Pu	Air Water	0-5 5-10 10-20 20-30 30-40	3	15
				Total	**267[b]**
				Max	**282 [b]**

[a] Analytes are plutonium (Pu-239+240 and Pu-238), Americium-241 (Am), and metals (chromium, copper, lead, nickel, and zinc).

[b] Ten percent of the total number of samples will be collected, given a coded label, and sent to the analytical laboratory as blind samples for quality assurance. In addition, 11 locations will be selected for field replicates.

3. As part of the residential development of the area, a portion of the arroyo was rerouted into a concrete channel, and the banks of other parts of the arroyo were graded to make them less steep.
4. Excess soil from the bank improvements (including sediments containing plutonium left behind by receding water) was distributed in the park during grading operations.

It is uncertain whether the bank improvements of Steps 3 and 4 took place, and if so, when and where. The arroyo was rechanneled in 1970 (Table 1).

Sample locations unique to this pathway are the arroyo channel bottom and the park areas nearest the arroyo. Sampling in these locations is described in more detail in Sections 3.1.1.2 and 3.1.1.3.

3.1.1.2. Sampling in the Current Arroyo Channel

In the draft plan, sampling was proposed for the arroyo banks. However, as a result of discussions with EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, it was decided not to sample the banks, and instead take more samples at the Big Trees Park eastern extension. The current arroyo channel is unique to the water-borne/arroyo pathway, so samples will be collected in the current arroyo channel.

3.1.1.2.1. Sampling Rationale

Substantial erosion of the current arroyo channel has occurred over the past few years. Indirect evidence for the water-borne/arroyo pathway would be obtained if there is evidence of plutonium-contaminated sediment in the arroyo.

3.1.1.2.2. Sample Locations

The current channel will be sampled at 7 locations (Figure 3):

- Two locations between the storm sewer outlet and the surveillance monitoring location to compare the results with historical surveillance monitoring data.
- One location upstream of Sandia National Laboratory.
- Two locations upstream of the concrete channel near the eastern extension of Big Trees Park.
- Two locations downstream of the concrete channel.

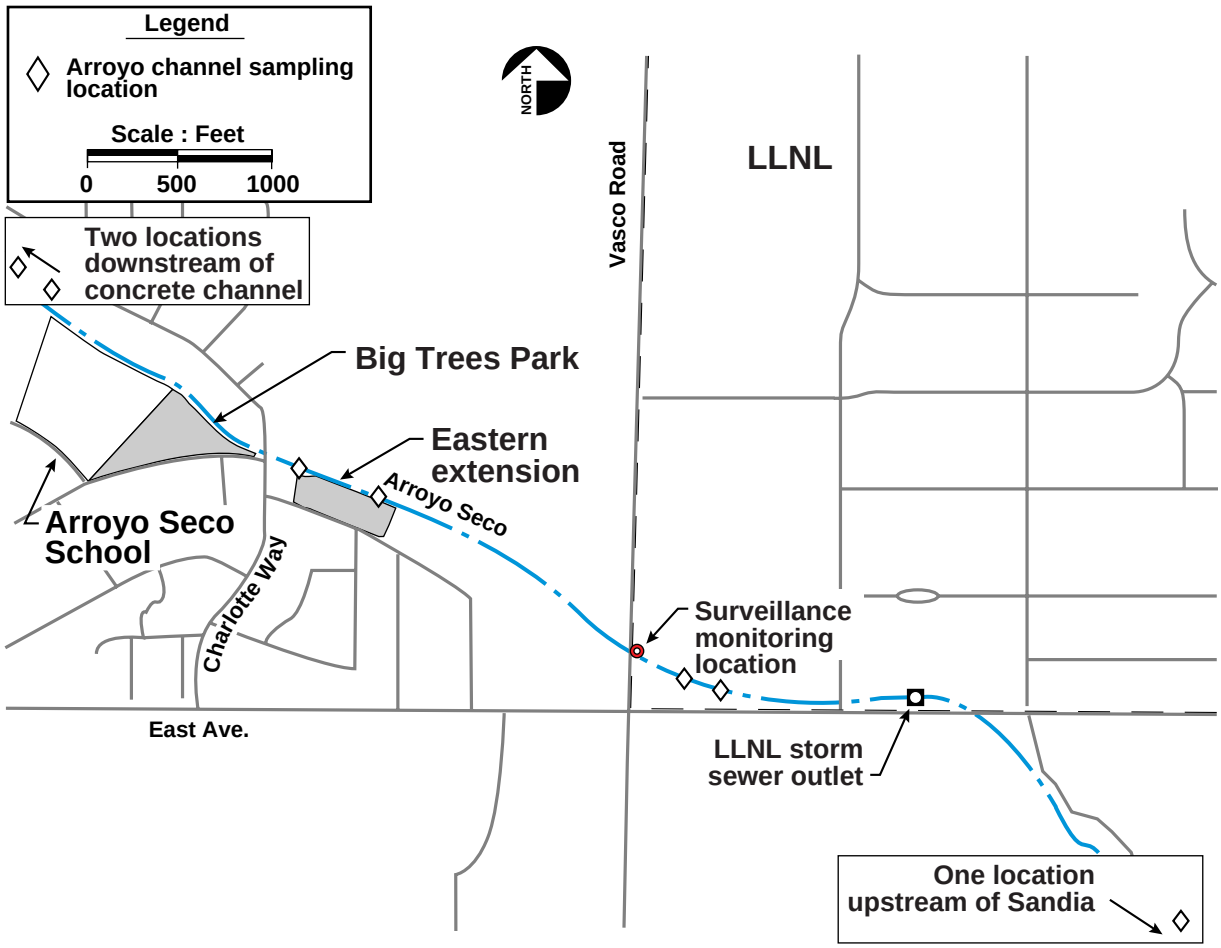

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Figure 3. Proposed Arroyo Seco sampling locations, 1998.

These sample locations were agreed during negotiations among DOE/LLNL, CDHS-RHB, CDHS-EHIB, EPA, and ATSDR.

For all channel locations, the precise locations of the arroyo samples will be points where sediment deposition appears to be the greatest, within roughly ± 3 meters of the pre-selected sampling locations. The sampling location may be in the center of the channel, or to one side, depending on where the sediment deposition appears greatest. Final sampling location decisions will be made in the field at the time of sampling.

3.1.1.2.3. Sample Depths

Upstream (east) of Vasco Road, sediment samples in the current arroyo will be collected at 0–5 cm, consistent with 1995 sampling and the recent LLNL surveillance monitoring (1993–present). At the two locations downstream of Big Trees Park and the two locations near the eastern extension of the park, sediment samples will be collected from 0–25 cm to determine if older sediments may still be present that contain plutonium.

3.1.1.2.4. Analytes

Samples will be analyzed for Pu-238 and Pu-239+240 to determine if this pathway is an explanation of why elevated plutonium has been detected at Location 1.

3.1.1.2.5. Data Analysis and Interpretation

Data will be compared to historical surveillance monitoring data. If Pu-239+240 concentrations within or above the range of Location 1 concentrations (0.164 to 1 pCi/g) are observed in the arroyo channel, then the water-borne/arroyo pathway hypothesis is plausible. If Pu-239+240 concentrations are below the Location 1 range, but the average concentration is consistently above annual surveillance monitoring results for the arroyo, the water-borne/arroyo channel hypothesis is possible but additional pathways (air) need to be considered.

3.1.1.3. Sampling in the Old Arroyo Channel

Another area that is unique to the water-borne/arroyo pathway hypothesis is the portion of the channel that was filled in 1970 and is now under a portion of the school property.

3.1.1.3.1. Sampling Rationale

If plutonium was in the channel sediments when the old arroyo was filled, sampling of the buried old arroyo channel sediments could provide evidence for this pathway.

3.1.1.3.2. Sample Locations

Three locations will be sampled from the old arroyo channel. The number of locations and samples was determined in discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR. In order to collect these samples, the following steps will be taken.

1. Locate the old arroyo channel. LLNL surveyors used the tract grading plan to locate the channel in May 1998.
2. Select three locations along the old arroyo channel to sample (Figure 4). Location distances are measured from the northernmost extent of the surveyed old arroyo channel, and depths of the former arroyo are estimated based on the original grading plan (Galloway and Associates)(Table 3).

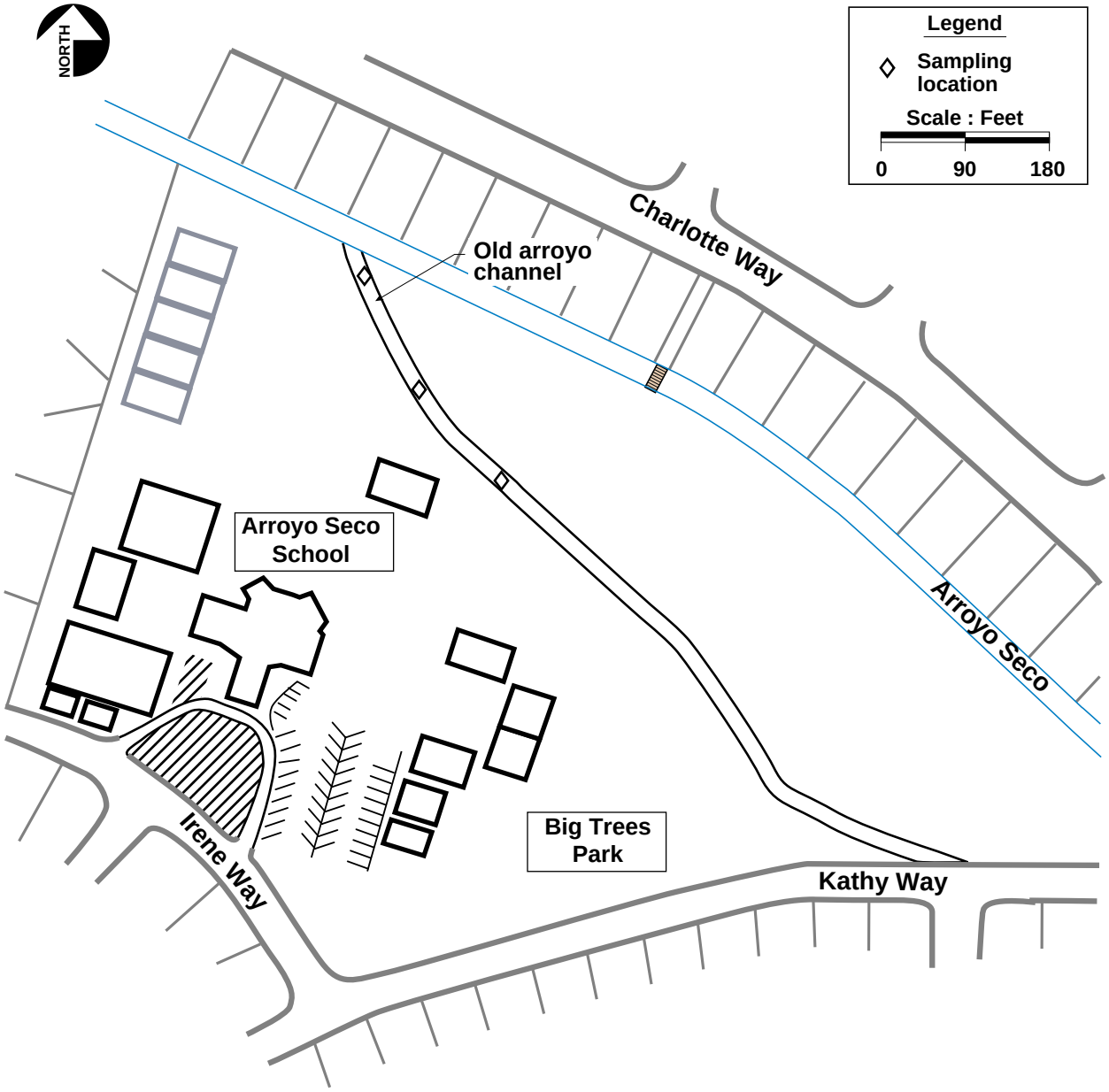

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Figure 4. Sampling area in the old Arroyo Seco.

3. Drill and extract soil cores deep enough to reach at least 45 cm below the estimated fill/sediment boundary (Figure 5).
4. Geologists from LLNL and the EPA will attempt to identify the fill/sediment boundary, based on the recovered cores. Identification is described in Appendix C: Field Sampling Procedures. Although the former channel/fill interface was apparent in a test borehole, there is no guarantee that the interface will be detected in the new boreholes.

3.1.1.3.3. Sample Depth Intervals

Depths to the old arroyo channel at the three sampling locations is presented in Table 3.

If the fill/sediment interface is identified, a sample will be collected from the first 0–5 cm below the contact. If the fill sediment boundary is not identified, six 15-cm segments centered over the estimated depth of the former channel bottom will be sampled to bracket the old sediment layer (Figure 5).

Table 3. Distances of locations and depths of samples to be collected from the old arroyo channel.

Sample	Distance (ft)	Estimated Depth (ft)
1	6	8 ft 3 in.
2	123	6 ft 2 in.
3	179	5 ft 3 in.

3.1.1.3.4. Analytes

The old arroyo sediments will be analyzed for Pu-239+240 and Pu-238, to determine if this pathway could be a source of elevated plutonium at Location 1.

3.1.1.3.5. Data Analysis and Interpretation

If Pu-239+240 concentrations within or above the range of Location 1 concentrations are observed in the old arroyo channel samples, then the water-borne/arroyo pathway hypothesis is possible.

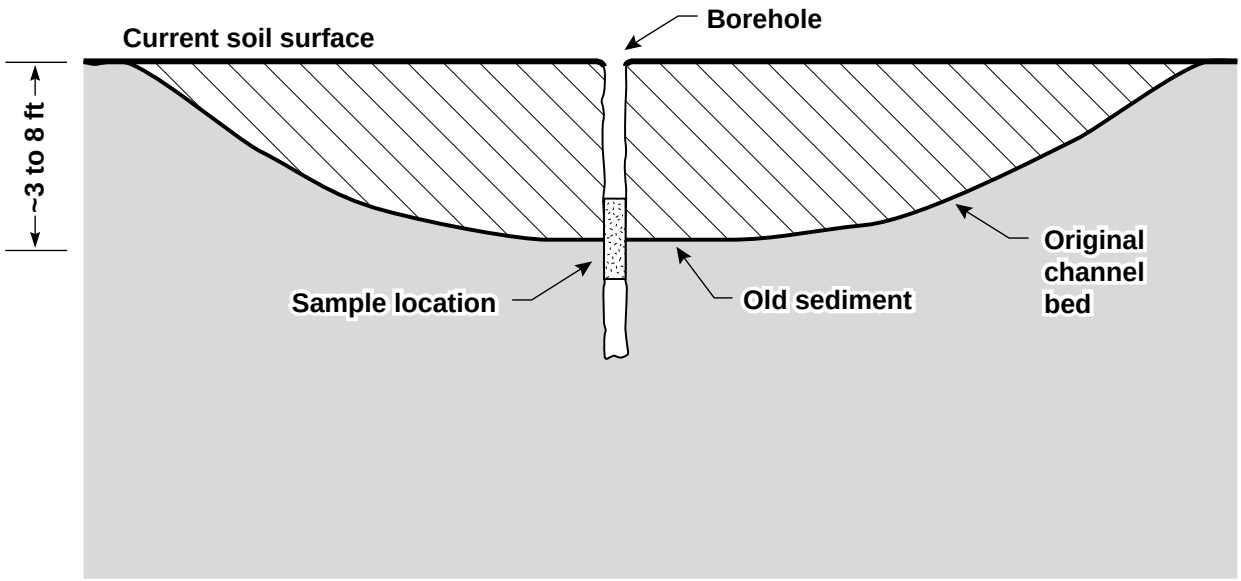

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Figure 5. Cross section of the old channel showing the original channel bed, old sediment, and sampling hole.

3.1.2. Sludge Pathway

This pathway suggests that sewage sludge containing Pu-239+240 from the Livermore Water Reclamation Plant (LWRP) was a component of a soil amendment used when ornamental trees were planted in Big Trees Park along Arroyo Seco. The probable source of plutonium in the sludge is a release to the LLNL sanitary sewer. Processed sewage sludge was free to the public for use as a soil amendment from the early 1960s to the mid 1970s. This has been confirmed by interviews with LWRP staff (CDHS/ATSDR, 1998). According to LWRP staff, 1 to 4 years passed from the time effluent entered the sewage treatment system until the sludge derived from it was available to the public. LLNL effluent reaching the LWRP prior to the 1967 release may have contained plutonium, but isotopic analyses were not conducted prior to 1960. All releases to the LWRP were below applicable regulatory limits at the time.

3.1.2.1. Hypothesis

According to this hypothesis, plutonium was transported to Big Trees Park by the following sequence of events:

1. Plutonium-contaminated effluent from LLNL reached the LWRP.
2. Contaminated sludge became available to the public.

3. Sludge from the LWRP was used as soil amendment while planting ornamental trees that run parallel to the concrete-lined portion of Arroyo Seco along the northern edge of Big Trees Park.
4. While trees were being planted, some sludge could have been spilled on the surface, and piles of sludge may have been stockpiled in the park near the trees for use as the amendment.

3.1.2.2. Sampling Rationale

The sampling locations unique to this hypothesis are the holes, or tree wells, in which the trees were planted, and to a lesser extent the surface area near the trees.

3.1.2.3. Sampling Locations

A variety of approaches were considered for selecting which trees to sample. After discussions with EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, it was decided to select three trees thought likely to have been planted during the appropriate time period. Trees near Location 1 that contains elevated concentrations of plutonium are obvious candidates, and a 1975 aerial photograph indicates that trees are present in the vicinity of Location 1.

A drill rig will be positioned as close to a tree as possible to collect soil samples from the old tree well. Logistical factors, such as the locations of limbs and roots, will determine the exact position of the drill rig and will be determined in the field at the time of sampling (Figure 6).

Paired with each tree well location is another location at least 1 meter beyond the irrigation berm that surrounds each tree. The second location needs to be far enough away from the tree well to not have been affected by soil amendment possibly introduced to the subsurface during tree planting. Following these general guidelines, the location will be precisely located in the field.

3.1.2.4. Sample Depth Intervals

At each location (both inside and outside the tree well), samples will be collected at three depths 0–45 cm, 45–90 cm, and 90–135 cm. The first two intervals are estimates of the depths of the holes that were probably dug to plant the trees. The deepest interval, 90–135 cm will provide a sample of soil that is believed to be beneath the depth of the tree well.

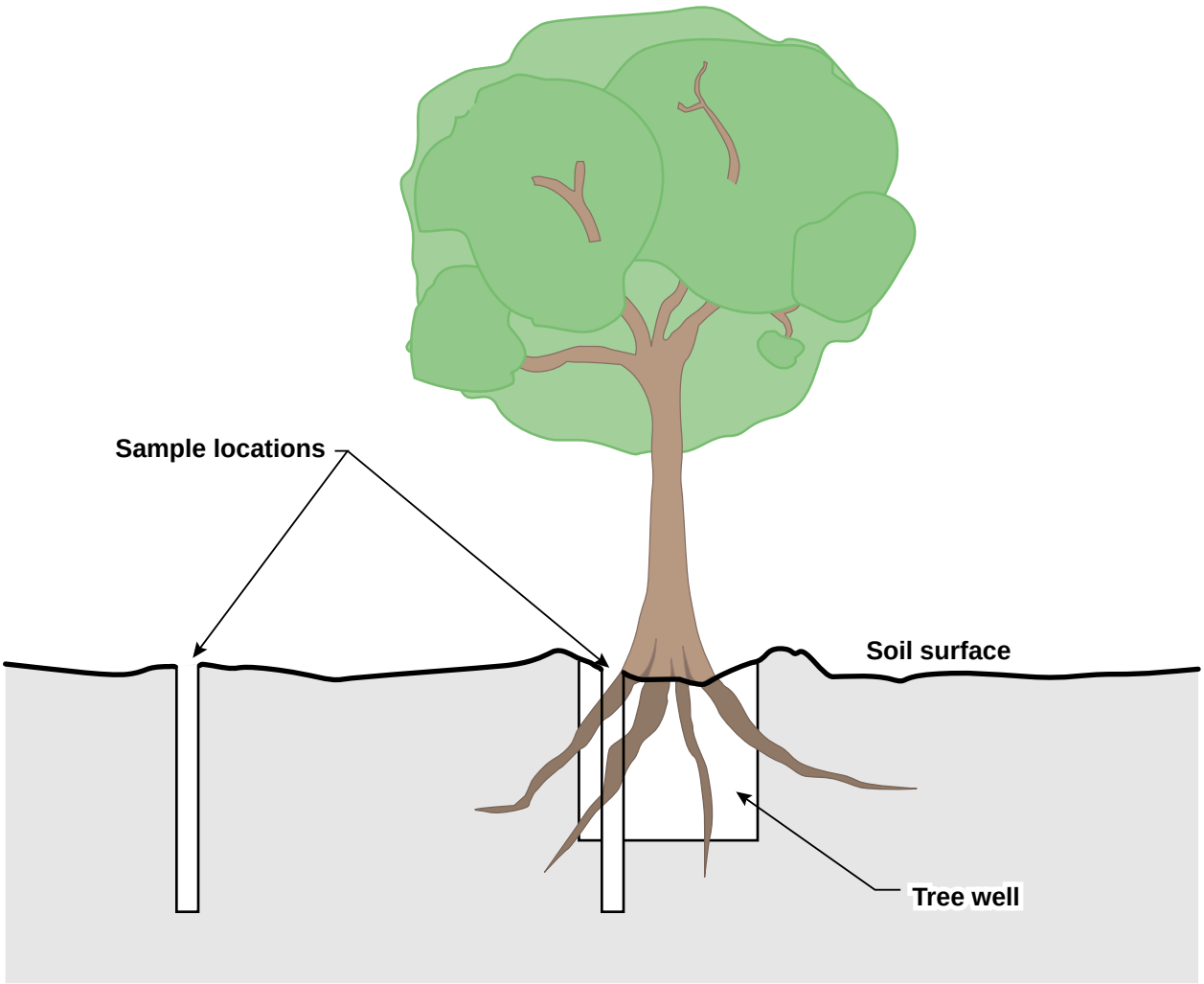

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Figure 6. Typical sampling holes around an ornamental tree.

3.1.2.5. Analytes

Samples will be analyzed for Pu-238 and Pu-239+240, Americium-241 (Am-241), and selected metals.

If the source of the plutonium at Big Trees Park is sewage sludge, there may be additional chemical constituents of the sludge detectable in the tree well. Such constituents might indicate the presence of sludge if they are in quantities sufficiently above the background levels for these constituents in soil. Samples will be analyzed for Am-241 because it was reported to be a constituent of some LLNL sewer releases.

Constituents that have been identified by the EPA as chemicals that are likely to be present in sewage sludge in a quantity sufficient to be regulated are arsenic, cadmium,

chromium, copper, lead, mercury, nickel, selenium, and zinc. These metals were identified based on the results of a 1990 National Sewage Sludge Survey of 208 publicly owned sewage treatment facilities in which sewage sludge samples were collected and analyzed for 412 analytes. Of these, chromium, copper, lead, nickel, and zinc may be discernible from background at Big Trees Park. The metals may be in sludge at concentrations of 100 to 1,000 parts per million (ppm), leading to the possibility that they may be detected after they are mixed with soil (Raven, 1997; Logan et al., 1997; Scora et al., 1997). The values for these metals also are high enough that they should be distinguishable from metals present in other fertilizers.

Further evidence that these may be appropriate metals to analyze is found in a study by Myers et al. (1976) of sludge from the LWRP that states: "Chemical content of the sludge was found to be within the normal range found in municipal sludges with some minor variations." They also reported concentrations of various chemicals and chemical compounds, among them, copper at 475 ppm. Other elements reported would not necessarily be distinguishable from background (Myers et al., 1976).

3.1.2.6. Data Analysis and Interpretation

If any pair of ornamental tree samples show that the sample from inside the tree well has a much greater concentration of Pu-239+240 than outside the tree well, then the sludge hypothesis is likely. Also, if the samples inside the tree well contain plutonium in the range of the 1995 Location 1 samples (0.2 to 1 pCi/g) and it's paired sample collected outside the tree well contains little or no Pu-239+240, this hypothesis is still likely.

The presence of elevated concentrations of Am-241 in the tree wells will be considered further evidence of this pathway.

Metal concentrations at levels typical of sewage sludge (Section 3.1.2.5) will confirm that sewage sludge was used and the presence of Pu-239+240 would confirm that the sludge was contaminated with plutonium.

3.1.3. Aerial Distribution Pathway

Another pathway that has been suggested for transmission of plutonium to Big Trees Park is aerial distribution. The draft PHC suggested that there was evidence of aerial deposition in Big Trees Park. This pathway is now believed to be unlikely, based on the limited distribution of plutonium detected at the park to date and that historical surveillance monitoring data does not show aerial distribution patterns of plutonium above background offsite.

3.1.3.1. Hypothesis

The hypothesis is that plutonium particles become airborne either by resuspension or emission, travel, and are deposited.

3.1.3.2. Sampling Rationale

Evidence that this pathway has affected Big Trees Park would consist of elevated concentrations of plutonium throughout the park. However, samples collected in 1995 do not indicate elevated concentrations throughout Big Trees Park. In addition, downwind sampling east of LLNL does not show concentrations close to any of the elevated concentrations at Big Trees Park. Therefore, it is extremely unlikely that airborne deposition of such elevated levels would occur selectively in Big Trees Park (e.g., Location 1). For these reasons, sampling specific only to this hypothesis is not planned. However, 0-5 cm results from locations other than Location 1 will be used to further evaluate this hypothesis.

3.1.3.3. Sampling Locations

Samples at 0-5 cm from all locations will be used to evaluate this hypothesis.

3.1.3.4. Sample Depth Intervals

Only surface samples (0–5 cm) will be used to evaluate the airborne pathway.

3.1.3.5. Analytes

Samples will be analyzed for Pu-238 and Pu-239+240 to evaluate this hypothesis.

3.1.3.6. Data Analysis and Interpretation

After the extent of the area containing elevated plutonium concentrations in Location 1 has been established, the remainder of the locations can be compared with surveillance monitoring data collected upwind of LLNL. In general, if many sample locations with high concentration values are observed across the park, then the aerial pathway is possible.

3.2. Sampling to Determine Extent of Contamination

The other goal of the sampling program it to determine the extent of plutonium contamination in the Location 1 area. This will be accomplished by establishing a sampling grid augmented with some special sampling, as discussed in Section 3.3.

3.2.1. Sampling Rationale

The proposed sewage sludge pathway hypothesis suggests that contaminated sludge from the LWRP was used as a soil amendment during planting of the ornamental trees that run parallel to the concrete arroyo channel. In this case, the expected pattern of results is that elevated concentrations will be near the ornamental trees along the edge of the channel. Elevated concentrations could also be associated with (a) some spillage nearby during the planting, and/or (b) a small elevated area where a pile of sludge might have been stockpiled when it was delivered to the park. Spills are likely to be small, scattered, and near the trees. The five highest concentrations from the 1995 sampling were near the ornamental trees (Locations 1 and 7). Under this hypothesis, elevated plutonium concentrations should only be detected at the surface, or in the tree wells.

The proposed water-borne/arroyo pathway hypothesis suggests that sediment from the arroyo was spread about by grading operations. This pathway would result in a somewhat random pattern of plutonium distribution both horizontally and vertically within the area that was graded. Plutonium would be more widespread than if it had arrived in soil amendments. The grading area is unknown, but would necessarily include Location 1.

Because both hypotheses support elevated plutonium concentrations around Location 1, or among the ornamental trees, sampling to determine the extent of contamination consists of a grid-like array of sample locations focused around Location 1. Because concentrations detected in 1995 are much lower away from Location 1, the sampling locations are spaced closer together near Location 1 (Figure 7).

Shallow (0-5 cm) grid samples will also be used to evaluate the airborne pathway hypothesis.

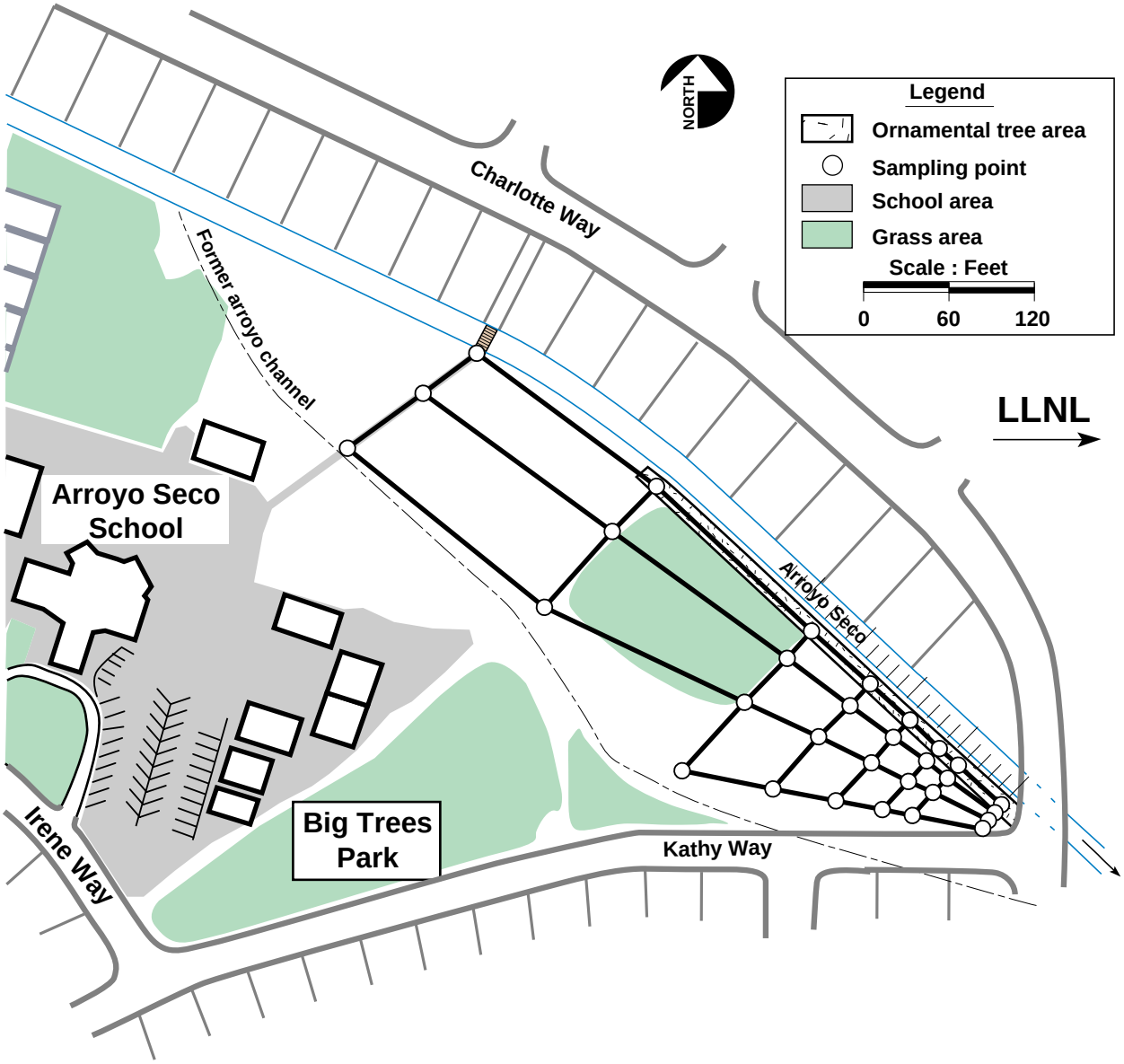

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Figure 7. Grid sample locations.

3.2.2. Sampling Locations

The grid consists of four radial lines, the first of which is parallel to and next to the concrete-lined arroyo channel, and eight cross lines perpendicular to the channel. A total of 30 locations will be sampled on the grid. The sampling grid is depicted in Figure 7.

The first radial is next to the arroyo and under the ornamental trees because Locations 1 and 7 are next to the arroyo and under the ornamental trees (Location 1 had the highest plutonium concentrations in 1995, Location 7 had the next highest concentration; Figure 2). The radials extend beyond Location 8, because Location 8 had the third highest concentration.

Moving south away from the arroyo, 1995 Locations 4, 5, and 6 appear to be within the range of background, so the radials are spaced to include these locations, but do not go much further south. As noted earlier, there was some variability in results between the three laboratories analyzing the 1995 results. However, the laboratory that used the lower detection limit and had higher precision at low levels reported all of these as within background. These findings indicate sampling should be focused inside these bounds.

During discussions with EPA, CDHS-RHB, CDHS-EHIB, and ATSDR it was decided to add eight additional locations near Location 1 to increase the sampling density (these are discussed in Section 3.3.1, Special Sampling). To facilitate spacing the sampling locations, these locations were also oriented perpendicular to the channel in the southeast corner of the park near Location 1. The purpose of the added locations is to ensure that the extent of contamination close to Location 1 is well defined.

Distances to the sample locations are measured from a fixed reference point close to the intersection of Charlotte Way and Kathy Way.

The first perpendicular is at a randomly selected distance from Location 1 to the southeast corner of the park. The next five perpendiculars between Location 1 moving west have a predetermined spacing, and a random starting point within the first 30 feet of Location 1 (30 feet was chosen because Location 1 is about 30 feet long). The predetermined spacings between these five perpendiculars are 20, 30, 45, and 60 feet, respectively. The gradually increasing spacing results in better coverage nearer to Location 1.

The sample locations are presented in Table 4, as distances in feet relative to the reference point.

Sample locations on the first radial are at the distances specified in Table 4, in the column headed “Distance along Radial 1 from reference point.” From sample locations on the first radial, sample locations on the second, third, and fourth radials are at the distances specified in their respective columns in the table, measured perpendicular to the concrete arroyo channel.

Table 4. Grid sample locations relative to grid starting point.

Perpendicular number	Distance along Radial 1 from reference point (feet)	Distance to Radial 2 (feet)	Distance to Radial 3 (feet)	Distance to Radial 4 (feet)
1	31	16	32	48
(Location 1 special)	~50[a]	16	34	58
(Location 1 special)	~80[a]	22	44	80
2	101	25	52	96
3	121	29	64	112
4	151	33	76	132
5	196	40	94	160
6	251	49	112	200
7	At path[b]	72	152	—
8	At bridge[b]	56	128	—

[a] Distances are approximate; exact location is to be found by re-locating the first and fourth points within 1995 Location 1 (Section 3.3.1)

[b] Distances to be located in the field

If a sample cannot be collected at a location due to logistical constraints (fences, tables, etc.), the sampling location will be moved to the nearest accessible location along the perpendicular line.

3.2.3. Sample Depth Intervals

DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR agreed to sample five depth intervals: 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm.

3.2.4. Analytes

All samples will be analyzed for Pu-239+240 and Pu-238. Surface samples will also be analyzed for Am-241, because the sludge pathway hypothesis suggests that sludge may have been spilled on the surface, and Am-241 was a component of the sludge.

3.2.5. Data Analysis and Interpretation

Initial data analysis will consist of inspecting the pattern of results and determining which of the expected patterns best matches the observed pattern (Section 3.2.1).

If the grid sample results indicate a well defined area with elevated plutonium concentrations, the distribution will be determined. These results would define the vertical and horizontal extent of contamination. Samples will be compared with historical background samples, as discussed in Appendix D: Background Data Summary.

3.3. Special Sampling

As a result of public comments and discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, special sampling efforts have been added to the previously discussed sets of samples: resampling of Locations 1, 7, and 8 from the 1995 sampling; the disked area; the playing field; and the park's eastern extension (Figure 8).

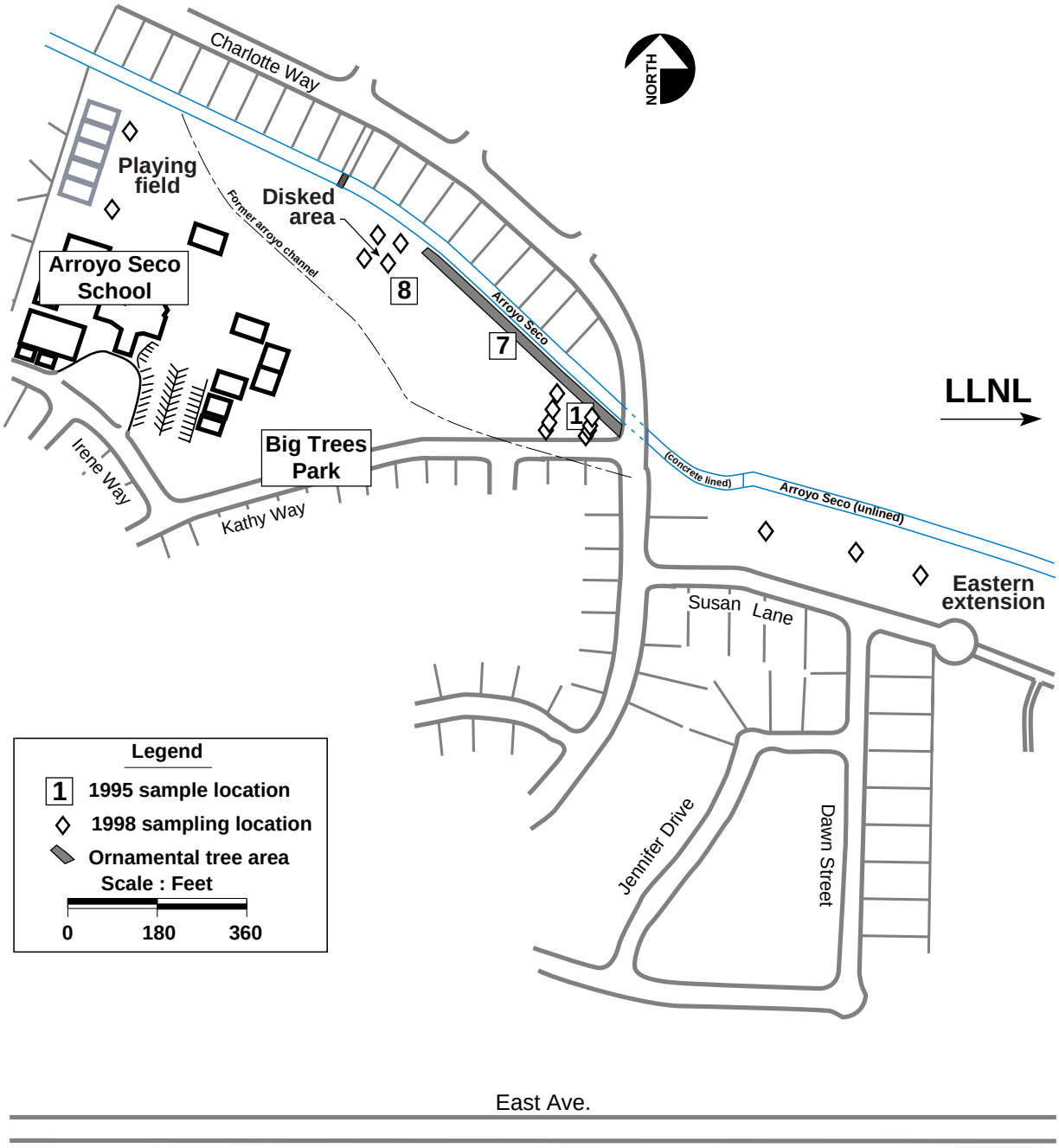

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Figure 8. Special sampling locations.

3.3.1. Special Sampling of Locations 1, 7, and 8

The highest concentrations measured in 1995 were at Locations 1 (0.2 to 1 pCi/g), 7 (0.05 pCi/g), and 8 (0.02 pCi/g).

3.3.1.1. Sampling Rationale

This sampling is being performed at the request of the respective agencies, to more thoroughly characterize these particular locations. EPA expressed interest in deeper sampling at Location 1, the 1995 1 pCi/g location. CDHS-EHIB expressed interest in deeper sampling at Locations 1, 7, and 8.

3.3.1.2. Sample Locations

Two locations at Location 1 will be resampled as part of the eight special sample locations requested near Location 1. Locations 7 and 8 from the 1995 sampling will be resampled.

The 1995 sampling locations will be re-located using notes from the 1995 Field Tracking Forms, photographs, and video records of the 1995 sampling event.

3.3.1.3. Sample Depth Intervals

Depth intervals will be 0-5, 5-10, 10-20, 20-30, 30-40, and 40-85 cm. The top five intervals are the same as the grid sample intervals.

3.3.1.4. Analytes

All samples will be analyzed for Pu-239+240 and Pu-238.

3.3.1.5. Data Analysis and Interpretation

Surface sample results can be compared with the 1995 results from these locations. Subsurface results will indicate the depth of contamination at these locations.

3.3.2. Special Sampling of Disked Area

The disked area is an open field on the northeast corner of the school property, next to the park. This area is disked annually, presumably for weed abatement, but otherwise appears to be unmaintained. A nearby resident attending a DOE/LLNL-hosted

presentation of the draft plan reported that children play in this area and suggested that the area be included in the sampling plan.

3.3.2.1. Sampling Rationale

Because the disking process increases the resuspension of soil particles (especially at the time of disking), this area is of interest.

3.3.2.2. Sample Locations

Four samples will be selected from locations, roughly equally spaced throughout the disked area. The number of samples and sample depths resulted from discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR.

3.3.2.3. Sample Depth Interval

After several years of disking, it can be reasonably assumed that soil has been thoroughly mixed. Therefore, the sample depth will be 0-15 cm which corresponds to the depth disked.

3.3.2.4. Analytes

Samples will be analyzed for Pu-239+240 and Pu-238.

3.3.2.5. Data Analysis and Interpretation

Because this is the first sampling of this area, the primary question is whether or not there are elevated levels of plutonium in this area.

3.3.3. Special Sampling of Playing Field

The playing field is an open field behind the school grounds proper. It does not appear to be used by the school as a play area for recess, but it is accessible to children as they travel to and from school. Location 12 from 1995 was in this area, and all three analytical laboratories reported values well within the range of background concentrations.

3.3.3.1. Sampling Rationale

CDHS-EHIB requested that this area be sampled again to increase the number of data points in this area.

3.3.3.2. Sample Locations

Two samples will be collected from random locations within this area. The number of samples and depths were the result of discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR.

3.3.3.3. Sample Depth Interval

The depths for these samples will be the same as those taken on the grid: 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm.

3.3.3.4. Analytes

Samples will be analyzed for Pu-239+240 and Pu-238.

3.3.3.5. Data Analysis and Interpretation

If results agree with the 1995 result, then the absence of contamination in this area will be known with greater confidence.

3.3.4. Special Sampling of the Big Trees Park Eastern Extension

The eastern extension of Big Trees Park was constructed in about 1986, approximately 15 years after Big Trees Park. It is adjacent to the arroyo, just upstream of where the arroyo enters the concrete channel east of Charlotte Way.

Location 13 from the 1995 sampling was in this eastern extension. Two of three laboratories reported results well within the range of fallout. The third laboratory reported a result above background, but with a high degree of uncertainty. This area is believed to be within background concentrations.

3.3.4.1. Sampling Rationale

CDHS-EHIB requested that this area be sampled again rather than sampling the banks of the arroyo as originally proposed.

3.3.4.2. Sample Locations

Three samples will be collected within this area, equally spaced along the length of this section of the park. The number of samples and the depths were the result of discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR.

3.3.4.3. Sample Depth Interval

The depths for these samples will be the same as those used on the grid, 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm.

3.3.4.4. Analytes

Samples will be analyzed for Pu-239+240 and Pu-238.

3.3.4.5. Data Analysis and Interpretation

If results agree with the 1995 result, then the absence of contamination in this area will be known with greater confidence.

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4. Sampling and Handling Procedures

4.1. Permits

The proposed soil sampling activities that will occur within Arroyo Seco are subject to Section 404 of the Clean Water Act. LLNL determined that the activities planned within the arroyo fall under Nationwide Permit (NWP) number 6: Survey Activities. The State Water Resources Control Board certified NWP number 6. However, under this permit, the discharger (LLNL) must notify the RWQCB of the planned activity. The submission of this sampling plan to the CERCLA Remedial Project Managers serves as notification to RWQCB. LLNL will provide a courtesy notification to the San Francisco District of the Army Corps of Engineers. LLNL discussed the proposed sampling activities with Warden Joseph Powell of the California Department of Fish and Game on March 27, 1998. Warden Powell determined that this activity would not significantly impact the streambed. Therefore the activity will not require a Streambed Alteration Agreement (Fish and Game Code Section 1601 et seq.).

The existence of an endangered species (the red-legged frog) approximately 2.0 km east of Big Trees Park, required that a special-status species survey be conducted along Arroyo Seco that would ensure that no endangered species or habitat was present. A red-legged frog survey was conducted on three occasions and it was determined that none of the conditions were present. Requirements for compliance with the National Environmental Policy Act (NEPA) have been evaluated.

In addition, permits were obtained from the City of Livermore and Zone 7 for the drilling and sampling activities, and the LARPD and the school district were notified.

4.2. Collection

Sample collection is summarized in this section and described in detail in Appendix C. Sample collection will be dictated by field conditions. Variances from the proposed sampling will be dependent on conditions encountered in the field.

Surface samples (0-5 cm) and the first subsurface sample (5-10 cm) will be collected using a hand-held coring device.

Subsurface samples (below 10 cm) will be collected using a drill rig.

Every sample will be split into at least two portions: one for laboratory analysis and one to archive. Some samples will be split four ways: one for the analytical lab, a field replicate, one for EPA or ATSDR, and one to archive. Adequate mass will be collected to achieve the analytical requirements.

4.3. Quality Control Samples

Quality Control (QC) samples will be collected at approximately 10% of the sample locations. Most of the locations will be selected randomly, however, at least one sample from the vicinity of Location 1 will be collected. QC samples will be labeled so that the analytical laboratory is unaware that they are QC samples.

In this sampling effort, ten locations will be randomly selected for field replicates. An additional field replicate will be selected from Location 1.

Performance Evaluation (PE) samples will be provided to each of the analytical laboratories on a single-blind basis. The samples will be identified as PE samples but the analyte concentration will be unknown to the laboratory. Multiple PE samples, subject to availability, will be sent to the analytical laboratories. The PE samples will consist of well documented traceable standards obtained from nationally recognized standards and/or intercomparison program sources (e.g., National Institute of Standards and Technology, and DOE Environmental Measurements Laboratory intercomparison program). These samples will have differing analyte concentrations within the expected analyte concentration range.

4.4. Documentation

All sample collection will be witnessed by staff from LLNL and the EPA if available. The Site Team, the regulatory agencies, and the public are encouraged to observe the sampling effort. Photographic and video records will be made. All sampling locations will be recorded using a Global Positioning System (GPS). Field tracking forms and chain of custody documentation will be maintained for all samples. Further details are in Appendices C and E.

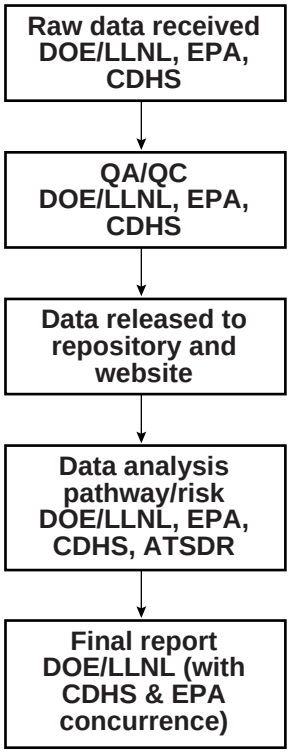
5. Reporting

5.1. Preliminary Data Distribution

The analytical laboratory will hold all results until all analyses are complete, and then, after internal review of the analytical QC results, will release results simultaneously to DOE, LLNL, EPA and CDHS-RHB. Data will then go through quality assurance/quality control (QA/QC) review in parallel by each agency. After QA/QC, the data will be distributed by DOE/LLNL and will be placed in the CERCLA information repositories and a website for public access (Figure 9).

CDHS, EPA, DOE and LLNL, with advice from ATSDR, will review the data for pathway analysis and "risk interpretation". The PRG will be used as a screening tool to determine whether further action or analysis is needed. Concentrations above the PRG do not automatically trigger remedial action. Generally, where environmental concentrations fall below this level, no further action or study is required. The PRG is intended to be associated with a one-in-one-million risk of a fatal cancer, but lack of data and/or scientific certainty necessitate the use of assumptions in its calculation. As a result, the value of the PRG is unavoidably somewhat uncertain. However, public health agencies tend to use assumptions and policies which are health protective, i.e., which would overestimate risk.

DOE and LLNL, with EPA and DHS concurrence, will publish a final report presenting and analyzing the data with respect to pathway analysis (Figure 9). DOE and EPA will also provide the community with a discussion of risk and uncertainty so that members of the public can make informed decisions for themselves.



ERD-LSR-98-0157

Figure 9. Figure distribution and analysis

6. Responsiveness Summary

The following responses address comments on the draft Livermore Big Trees Park (BTP) 1998 Soil Sampling Plan submitted by the California Department of Toxic Substances Control (DTSC) comments dated June 1, 1998; the Environmental Protection Agency Region 9 (EPA) comments dated June 5, 1998; the California Department of Health Services (CDHS) Environmental Health Investigations Branch (EHIB) comments dated June 10, 1998; the CDHS Radiologic Health Branch (RHB) comments dated June 12, 1998; the Western States Legal Foundation (WSLF) and the Greater San Francisco Bay Area Chapter of Physicians for Social Responsibility (PSR) comments dated May 21, 1998; T. Pritikin, citizen member of the LLNL Site Team and Hanford Health Effects Subcommittee, comments dated June 17, 1998; F. Owen Hoffman, of SENES Oak Ridge Inc., comments dated June 22, 1998; Tri-Valley CAREs (Citizens Against a Radioactive Environment) comments dated June 22, 1998; Kevin Reilly's comments dated May 18, 1998; Janis Turner's comments dated May 28, 1998; Stephanie Ericson's comments dated May 28, 1998; the Agency for Toxic Substances and Disease Registry (ATSDR) comments dated June 10, 1998; San Francisco Bay Regional Water Quality Control Board comments dated June 11, 1998; and Michael Ferrucci's comments dated June 22, 1998.

6.1. DTSC Comments and DOE/LLNL Responses

The Department of Toxic Substances Control (DTSC) has reviewed the subject plan dated April 10, 1998. We believe the work proposed by the Sampling Plan will adequately address the issue of whether plutonium occurs in soil at depths greater than that which was previously sampled and provide a better understanding of the pathway by which plutonium reached Big Trees Park. DTSC has limited jurisdiction over and experience with the characterization of sites where radioactive materials have been released. Therefore, we must defer to the other involved agencies which have expertise and/or jurisdiction in this area, the U.S. Environmental Protection Agency, the Department of Health Services, the Agency for Toxic Substances and Disease Registry, to evaluate the adequacy of the Sampling Plan as it relates to plutonium and other radioactive materials. As such, we believe it is not appropriate for us to comment on issues such as the laboratory analysis of soil/sediment samples for plutonium and background and health-protective levels of plutonium.

Comment noted.

The only specific comment we have on the Sampling Plan pertains to the written procedures which are to be prepared prior to sampling (Section 8, seventh bullet). On page 19 (second full paragraph), it is stated the written procedures will address safety issues for each type of sample.

A brief outline or summary any other topics that will be addressed in the written procedures needs to be included in the Sampling Plan

The Draft Final Livermore BTP 1998 Soil Sampling Plan now includes a Field Sampling Procedure as Appendix C.

6.2. EPA Comments and DOE/LLNL Responses

General Comments

Comment 1. *The sampling plan states that Lockheed Analytical Services (LAS) was used for the previous 1995 analysis of samples from Big Trees Park. It should be noted that this laboratory has since closed, and had been suspended in 1997 due to self-disclosure of inappropriate practices that effected data quality. It is not clear if there was a review of the 1995 data to rule out the possibility that inappropriate practices may have effected the 1995 data set.*

> According to a written communication from Lockheed to the LLNL Environmental Protection Department Assurance Manager, dated January 2, 1997, the sale of Lockheed Analytical Services (LAS) to SPL was effective December 29, 1996. The 1995 data set was not affected by the change of ownership. The analytical results from the 1995 sampling did not occur during the time period identified where inappropriate practices were used at LAS.

Comment 2. *The soil sampling plan should be expanded to include (1) a detailed discussion of action levels for each objective of the survey, (2) safety and health discussions related to the performance of the survey, and (3) methods of data interpretation for evaluating the results of the survey.*

> The Field Sampling Procedures (Appendix C) addresses safety concerns citing the LLNL Health and Safety Plan, the Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs) and LLNL Operational Safety Procedures. The Draft Final Livermore BTP 1998 Soil Sampling Plan includes a discussion of data analysis and interpretation in Chapter 3. Action levels have been defined by the EPA as Preliminary Remediation Goals (PRGs). The PRG is a screening tool used to determine whether further action or analysis is needed. Levels above the PRG do not automatically trigger a remedial action. PRGs are intended to be associated with a one-in-a-million risk of a fatal cancer. In this case, depending on the data collected, further actions could include removal of contaminated soil or No Further Action.

Comment 3. *EPA is not convinced the that three pathways outlined in this sampling plan are the only possible sources of the plutonium in Big Trees Park. EPA's original confirmation sampling that led to the discovery of elevated levels at Big Trees was focused on plutonium levels in the soil where the former evaporation pond had been at LLNL. The confirmation investigation found plutonium levels in the area as high as 12 pCi/g. LLNL has done considerable construction in the evaporation pond area over the past ten years and it is possible that some of the soil from this construction work found its way off site and ultimately to Big Trees Park.*

> LLNL Plant Operations personnel report that no soils from construction activities in the area could have found their way to Big Trees Park. Prior to any construction in the area, three radiological surveys were performed in 1978, 1981, and 1982. The 1982 survey resulted in the cleanup and disposal of approximately 3,000 cubic yards of soils. A portion of the soils were determined to be low level radioactive waste, and disposed of at the Nevada Test Site (Buerer, 1983).

Comment 4. *EPA recommends that DOE consult with Charles Phillips of Sanford Cohen and Associates Laboratory in Montgomery, Alabama. Mr. Phillips was the leader of the sampling team that collected the background sample from Big Trees Park during 1993 plutonium investigation at LLNL that proved to have an elevated level. We believe his participation would help to insure that the field sampling team gets the best information available on the original sampling locations beneath the ornamental trees.*

> LLNL consulted with Sanford Cohen and Associates prior to the 1995 sampling; the 1995 samples near the 1993 location were based on information received at that time. The 1995 sample locations were recorded on field tracking forms, photographs, and video.

Comment 5. *Since at this time there is no clear operational history concerning the plutonium, it would be prudent to expand the analyte list to include heavy metals and other radionuclides to compare to elevated levels of plutonium. If there is a correlation, it would be helpful to determine the location of sludge used as soil amendment, or other waste. Broad spectrum heavy metal analysis would require no more sampling effort but would expand the analytical costs for each sample. This cost would be outweighed by the ability to correlate and clearly define that each of the proposed pathways are truly being sampled.*

> DOE/LLNL have considerable operational history concerning the use of plutonium at LLNL as presented in Appendix B of the Draft Final Livermore BTP 1998 Soil Sampling Plan. All samples will be analyzed for plutonium. In addition, surface grid samples will be analyzed for americium-241 and samples around the ornamental trees will also be

analyzed for americium-241 and metals. Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents the sample sets, potential pathways, analytes, depths, and number of locations and analyses.

Comment 6. *The sampling plan is not linked to an umbrella quality assurance structure such as a Quality Assurance Project Plan. It is the position of EPA's QA Office that data generated without an approved QAPP is considered data of unknown quality. The requirement for a QAPP is specified in the Agency QA Order 5360.1, and further explained in "Requirements for Quality Assurance Project Plans for Environmental Data Operations" (EPA QA/R-5, August 1994), and "Multi-Agency Radiation Survey and Site Investigation Manual" (EPA 402-R-97-016, December 1997).*

Quality Assurance is now presented in Appendix E of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The Quality Assurance section has been modified from the Environmental Restoration's (ERD's) Quality Assurance Plan (1989) to more adequately address soil sampling.

Comment 7. *It is currently the understanding of EPA's QA Office, that due to time constraints, that an approved QAPP will not be used to oversee the quality of the data. If this occurs, the final technical report should address and document all elements of the EPA R-5 requirements as they were actually implemented, otherwise the data should be considered data of unknown quality.*

A Quality Assurance discussion is now included as Appendix E of the Draft Final Livermore BTP 1998 Soil Sampling Plan. Appendix E is based on ERD's approved Quality Assurance Project Plan (1989) and has incorporated EPA guidance since that date. The data collected will go through rigorous Quality Assurance/Quality Control by EPA, DOE/LLNL, and CDHS, which should verify the integrity of the data.

Comment 8. *It is recommended that the sampling plan provide a more detailed historical description of the contamination problem to provide better support for the conceptual models of the three proposed pathways. Attaching the 1995 EPA plutonium fact sheet and briefly summarizing it would satisfy some of the following information requests. Currently, the basis of the pathways must be abstracted from various sections of the plan. The sampling plan should address the following:*

The 1995 EPA Plutonium Fact Sheet has been included as Appendix A of the Draft Final Livermore BTP 1998 Soil Sampling Plan. Information contained in the Fact Sheet is expanded and summarized in Section 1 and Appendix B of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

a. The dates of possible releases from Lawrence Livermore or even other possible release sources;

A chronology of plutonium releases from LLNL and events at BTP are summarized in Appendix B and Table 1, respectively, of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

b. The quantity and scope of the radioactive elements that may have been released;

See response to EPA Comment No. 8a.

c. A rationale for limiting of contamination pathways to the three stated in the sampling plan;

A discussion of the rationale for investigating the three pathways is presented in Section 3.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The three pathways (air, sludge, and arroyo) are the only explanations for the elevated concentrations at Location 1 from the 1995 study that have seemed plausible.

d. A summary of how each potential pathway is linked to the list of potential releases;

Known releases are only linked to the sludge pathway, which is described in Section 3.1.2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

e. The quantity of sewage sludge used for soil amendment and the exact dates of transfer of the sludge;

As discussed in Section 2.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan, the Livermore Area Recreation and Park District did not intend for any soil amendments to be used when trees were planted in the park. However, LARPD does not oversee tree planting by private volunteers. Sanitary sewer sludge was made available for public and City use as a soil conditioner from at least 1961 to the mid-1970s.

f. The areas in which sewage sludge was used for soil amendment;

See response to EPA Comment No. 8e

g. The technique by which soil amendment occurred and how that relates to possible distribution of plutonium;

It is not known if soil amendments were used at BTP. If it was, it is expected to be mostly associated with the ornamental trees. Also see response to EPA Comment No. 8e.

h. Why plutonium is the only analyte of concern, while the sampling plan suggests that (Page 17) 241Am and 137Cs were also constituents of the sewage sludge, and 241Am, at least, is also known to be hazardous;

Samples collected around the ornamental trees will also be analyzed for chromium, copper, lead, zinc, and americium-241. In discussions with the EPA, CDHS-EHIB, CDHS-RHB, and ATSDR, it was agreed that 137Cs would not be indicative of a pathway.

i. The typical profile of LLNL sewage sludge for the list of possible indicator compounds (Page 17) at the time of release in terms of concentration;

A discussion about constituents commonly in sludge, and in the sludge of the Livermore Water Reclamation Plant (LWRP) is presented in Section 3.1.2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. In addition, historical information on sewer sludge is presented in the LLNL 1996 Environmental Report (LLNL, 1997).

j. Whether soils and/or sludge from sources other than LLNL were used for soil amendment;

It is not known if other sources provided soil amendments for use at BTP. Also see response to EPA Comment No. 8e.

k. Adequate description of the three pathways and how the data collected will support delineation of each proposed pathway; (For example, Figure 1 shows the proximity of LLNL to the area to be sampled with a prevailing wind direction that does not favor deposition on the city of Livermore but downwind of LLNL, if the air releases were from Livermore; further, Big Trees Park is also upwind of the proposed source. For this example, it would be helpful to have more information about the rationale for why the air pathway is believed to be reasonable and a clearer statement of the previous plutonium release history.);

Descriptions of each pathway, sampling rationale, sample locations, sample depth intervals, analytes, and data analysis and interpretation are discussed in Chapter 3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

l. The longitude and latitude of Livermore so that it is compatible with the provided description of background concentrations which are stated in terms of location latitude;

The latitude and longitude of the intersection of North Livermore and 1st Street is latitude 37 degrees 41 minutes 00 seconds, longitude 121 degrees 46 minutes 00 seconds. The latitude and longitude at a monument in the East Traffic Circle at the Livermore Site is latitude 37 degrees 41 minutes 15.882 seconds, longitude 121 degrees 42 minutes 0.448 seconds.

m. Background information for the site to include operational histories of activities in proximity that may have been a source of plutonium;

A chronology of plutonium releases from LLNL and events at BTP are summarized in Appendix B and Table 1, respectively, of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

n. Why Big Trees Park only was the location for previous investigation as the current migration pathways proposed for investigation suggest that Big Trees Park may not be the only receptor area;

As discussed in Section 1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan, EPA collected a sample in Big Trees Park in 1993 for background determinations. After detecting plutonium in a soil sample, the EPA recommended that LLNL conduct follow-up sampling at the park to verify the 1993 result. LLNL routinely monitors locations throughout the Livermore Valley each year as part of the surveillance monitoring program.

o. A description of how the problem became the focus of investigation;

The background leading to the current sampling proposed at Big Trees Park is discussed in Section 1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

p. A description of soil geology;

The soils are heterogeneous unconsolidated alluvial and fill material.

q. Description of the Arroyo Seco in terms of feed water, flow rates, etc.; and

The Arroyo Seco has flowing water for relatively short periods of time during and after significant rainfall events, and is dry for most of the year.

A discussion about the Arroyo Seco is now included in Section 2.2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

r. *A description of the conditions under which plutonium is mobile or not mobile (for example, is plutonium in acidic soil with high amounts of irrigation mobile.)*

The mobility of plutonium is dependent on many factors such as the pH, speciation, and composition (i.e., clay, inorganic and organic content) of the soil or sludge. Recent experimental work under near neutral pH conditions has shown that plutonium strongly sorbs (attaches) to minerals commonly found in soils, such as iron oxides, zeolites, and other silicates (Triay et al., 1996). We do not have data on these parameters for the soil at BTP or from sludge at the LWRP during 1961 - mid 1970s. Generally, domestic sludge is treated and stabilized before being made available as a fertilizer, and probably has a pH close to neutral.

Comment 9. *Pages 19 and 20 of the sampling plan indicate that the following major sampling plan elements still need to be prepared: a safety plan; written procedures for sampling; identification of sampling team members; written procedures in general; identification of specific sampling locations; development of a naming convention; and training sampling personnel on sampling procedures. It is recommended that these aspects of the sampling plan be provided in the next version of the plan.*

The Draft Final Livermore BTP 1998 Soil Sampling Plan contains the Field Sampling Procedure (Appendix C), which is in accordance with the Site Safety Plan for LLNL CERCLA Investigations, the LLNL Health and Safety Manual, the Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs), and LLNL Operational Safety Procedures.

Comment 10. *One potentially helpful clue for determining the source or sources of the plutonium present at Big Trees Park may be the ratios of Pu238 concentrations with respect to the Pu239/240 concentrations. A discussion of the isotopic ratios should be considered as a data evaluation strategy in the sampling plan.*

Because samples will be analyzed for both Pu-239+240 and Pu-238, these reported isotopic ratios will be available for analysis. Discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR resulted in a decision to also analyze for Am-241 in the surface grid samples and samples from the ornamental trees.

Specific Comments

Comment 11. *The sampling plan should explicitly state the organizational affiliation or name of the contractor, or if appropriate, of the samplers, that will be performing and overseeing the work.*

A discussion on quality assurance (Appendix E of the Draft Final Livermore BTP 1998 Soil Sampling Plan) identifies the entities for drilling, sampling, and laboratory analyses.

Comment 12. *Section 1. The sampling plan does not adequately explain the three proposed pathways of contamination. It is recommended that the expected characteristics of the data to be collected for each of the pathways be stated in summary form. For example, with the air pathway, it is not clear if there was a single release from LLNL or if there has been a long-term slow release. Further, it is not clear if a model was used to predict likely areas of air deposition based on release method, quantity, wind direction, etc. It is recommended that the rationale of this pathway be explained. With the Arroyo Seco pathway, it is not clear if there was single release or if there was a long-term release. In addition, it is not clear if the surface soil had been continually washed downstream and replaced with newly eroded soil over time, and hence, the contaminated soil, if it exists, may be located at points conducive to long-term collection of soil (for example bends or points of widening of the Arroyo Seco.) Further, if the plutonium releases occurred long ago, clarification should be provided as to why the contaminated sediments should still be in the channel, and if the former arroyo sampling is contingent on finding plutonium in the current channel.*

Additional explanation of the pathways is now discussed under the hypothesis headings in Chapter 3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The pathways include air deposition because the CDHS Public Health Consultation suggested this as a possible pathway, although annual monitoring indicates that airborne transport is not viable.

If there was a release to the arroyo long ago, it is very unlikely that those contaminated sediments would still be in the channel because the arroyo is a “losing” stream, meaning that erosion of the channel dominates over deposition. The arroyo channel sampling will be compared with LLNL's annual surveillance monitoring of the arroyo channel, which has not indicated releases of plutonium to the arroyo. The former arroyo will be sampled in addition to the other samples, and is not contingent on finding plutonium in the current channel.

Comment 13. *Section 1, page 3, number 2, bullet 2. The text states the three possible pathways for the plutonium in Big Trees Park, one of which is: "From LLNL via the sanitary sewer to sewage sludge used as soil amendment during planting of ornamental trees in the park." We suggest that the document clarify that other parts of the park are not suspected to be affected by plutonium-contaminated sewage sludge, based on the statement of a parks employee at the February 25, 1998 health advisory public meeting, unless other information has been found to counter this statement.*

> Section 2.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan discusses that the sewage sludge soil amendment may have been used when trees were planted, but would not have been used throughout the park. The Livermore Area Recreation and Park District has no records authorizing the use of soil amendments.

Comment 14. *Section 1, page 3, number 3. Objective number 3 is not consistent with the purpose of the survey described in the Introduction. The uses for the results of the survey could be reworded to make them clearer. It is recommended that the uses be worded as recommendations in the form of "if...then" statements. One of the uses of the results should include a recommendation for no further action.*

> The purposes of the sampling program have been clarified in Section 1.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. DOE/LLNL will work closely with EPA and the state agencies to determine if follow-up activities are necessary based on the results of this sampling.

Comment 15. *Section 2, page 4, para 3. It is stated that the samples collected at the grid locations will be used to determine if areas in the main body of the park other than Location 1 are <u>within</u> the range of fallout background plutonium concentrations. The sampling grid locations should be used to determine if any additional areas <u>exceed</u> background.*

> Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan includes data that can be used to determine areas that may exceed background.

Comment 16. *Section 2, page 4, para 4. The statement describing the precision requirements for identifying sample locations is very helpful. However, there are no quality control measurements described for evaluating the precision of identifying measurement locations in Section 5, QC Samples.*

> As discussed in Section 4.4 and Appendix C of the Draft Final Livermore BTP 1998 Soil Sampling Plan, a Global Positioning System (GPS) will be

used to identify specific sampling locations. Each time the GPS is used, Livermore City Monuments will be referenced. The GPS-generated coordinates will be used to ensure that the day-to-day GPS results are consistent and comparable.

Comment 17. *Section 2.1, page 4. Please clarify that the one private property location that will not be re-sampled is the sandbox, 1995 sampling location #16.*

The Draft Final Livermore BTP 1998 Soil Sampling Plan now states that only sample Locations 1, 7, and 8 from the 1995 study will be resampled.

Comment 18. *Section 2.1, pages 4, 5. This section should include a reference to Figure 1 and identify the location of the area that will not be resampled.*

Figures are now referenced in appropriate sections of the Draft Final Livermore BTP 1998 Soil Sampling Plan. All sample locations from the 1995 study are now shown on Figure 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan; however, only locations 1, 7, and 8 will be resampled.

The discussion of the potential for errors caused by the selected sampling scheme is very informative. The rationale for selecting sampling depth intervals is also helpful. After reviewing Appendix A, it appears that the majority of plutonium from fallout in undisturbed areas would be located in the top 30 cm. It seems that sampling the 5-50 cm interval would serve to dilute the plutonium from fallout, although grading operations would serve to mechanically mix the soil to provide a uniform concentration in this interval. It would be interesting to see this interval divided into two intervals: 5-25 cm and 25-50 cm. This information may be more appropriate for a follow-up investigation.

Sampling intervals have been revised in consultation with the agencies (EPA, CDHS-RHB, CDHS-EHIB, and ATSDR). The new sampling intervals are presented in Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Is there any information which might indicate that the park grounds were regraded as part of earlier refurbishment work? Such activities might have changed the distribution of surface soils and plutonium. Also, field investigations should attempt to determine whether soils and other "borrow" materials, other than sanitary sludge, were imported from other locations and used at the park. For materials that were imported, it might be possible to distinguish them from local natural soils. Such information should be recorded as part of field activities.

Additional information about the history of the park has been included in Chapter 2 and Table 1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The park site may have been graded in the early development of the park, which would have been at the same time that the adjacent housing tract was graded. Available information indicates that the park was not graded thereafter. Tract plans state that when fill was needed, only local fill was to be used.

In discussing the different mechanisms that might explain the presence of plutonium in surface soils, the sampling plan is silent on the impact of surface water runoff and entrainment of surface soils and sanitary sludge. This aspect might be an important consideration in assessing and interpreting sample results.

Information on surface runoff is not documented. However, the area containing elevated concentrations of plutonium is higher than the current arroyo indicating that surface water was not a significant transport mechanism for plutonium around the park.

Comment 19. *Section 2.2, pages 6, 7, Subset 1.*

This section should reference Figure 2. In Subset 1, the sampling of the present Arroyo Seco channel and banks is described. The discussions of the sampling locations in the channel are detailed and helpful, but the discussion of the location of the background sample upstream of Sandia National Laboratory should be expanded to provide a level of detail consistent with the other locations. The discussion of bank samples should also describe the number of samples and provide some discussion on locating the samples along the bank.

Section 3.1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan now describes that one sample will be collected upstream of Sandia National Laboratory. In agreement among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, samples will no longer be collected from the arroyo banks.

There should be some discussion of the rationale of the 5-25 cm sampling depth for sediment, especially since this depth is inconsistent with the other subsurface sampling activities where the samples are collected from 5-50 cm. The basis for describing this as a "reasonable maximum sampling depth" should be explained. Based on weather data, is there any history of the creek overflowing both before and after the creek was lined with concrete? In both cases, local floods might have had impacts on the redistribution of plutonium from sediments in surface soils. In sampling sediments, a point should be made that when sediment layers are readily discernible, a sample should be taken from each one, in addition to one spanning the prescribed sampling depth.

The Draft Final Livermore BTP 1998 Soil Sampling Plan includes depth intervals agreed to in discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, as discussed in Section 3.1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 20. *Section 2.2, pages 7, 8, Subset 2.*

In Subset 2, the location of samples in the former Arroyo Seco channel is described. This section should reference Figure 3.

Sample locations in the former arroyo are now discussed in Section 3.1.1 and shown on Figures 4 and 5 Draft Final Livermore BTP 1998 Soil Sampling Plan.

The method to be used for selecting six locations at random should be described.

As agreed among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, three samples will be collected from the former arroyo channel. One sample will be collected near each end of the accessible portion, and one sample will be collected in the middle. This is discussed in Section 3.1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Detailed instructions for selecting an appropriate interval to sample when the fill/sediment boundary is not identified should be provided or referenced to a detailed standard operating procedure (SOP).

Instructions for sampling the fill/sediment boundary is included in Appendix C, Field Sampling Procedure, of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

The requirement to collect a 25 cm core below the fill/sediment boundary is inconsistent with other sampling at this site. Two samples should be collected: the first from 0-5 cm below the boundary and the second from 5-25 cm or 5-50 cm to be consistent with either the sediment sampling or the subsurface soil sampling. A single 0-25 cm sample is expected to dilute the activity unnecessarily and reduce the probability of detecting plutonium at elevated concentrations.

This sampling intervals have been changed in the in the Draft Final Livermore BTP 1998 Soil Sampling Plan, as discussed in Section 3.1.1. For cores where the fill/sediment boundary is identified, the sampling interval is 0-5 cm below the contact. If the boundary is not identified,

samples are collected over 15 cm intervals, 45 cm above and below the estimated channel depth indicated in Table 3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The bracketing intervals are long enough to have a reasonable chance of including the actual boundary.

The plan relies on being able to adequately define the fill/sediment boundary, however, there are no criteria given for this identification, nor is there any description of the fill and sediment material.

The plan relies on the expertise of the geologists to identify the boundary. Estimated depths to the boundary at the three sampling locations are presented in Table 3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. Geologic information from the previously drilled test borehole that identified this boundary is also included in Appendix C.

Comment 21. *Section 2.2, page 8, number 4. We will do our best, but cannot guarantee that a registered geologist will be available during the time that the fill/sediment boundary of the former channel is investigated.*

Comment noted.

Section 2.3, page 8. The sampling plan requires looking for trees of the appropriate age, and includes a provision for coring of trees to determine age, for sampling. It is recommended that it be explicitly stated what age of trees are of concern.

The age of the trees that will be sampled are thought to have been planted between 1968 and 1975, as discussed in Section 3.1.2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The Draft Final Livermore BTP 1998 Soil Sampling Plan has been revised to select three trees from those of the specified age, as identified in a 1975 aerial photograph. No coring of trees to determine age is planned.

While sampling is performed inside and outside of the tree wells, it is not clear if there is a clear definition of inside and outside. Further, as it was not described how the soil amendment was performed, it is not clear if the sampling depths are appropriate.

Samples collected inside the tree wells will be obtained by positioning a drill rig as close as possible to the trees. The samples collected outside the tree wells will be at a distance of at least 1 meter from the irrigation berm that surrounds the trees. As discussed in Section 3.1.2.4 of the Draft Final Livermore BTP 1998 Soil Sampling Plan, the first two sampling intervals

are estimates of the depth that the holes were dug for the trees (down to 90 cm). The deepest interval, 90-135 cm, will provide a sample that is beneath the hypothetical tree well depth.

It is recommended that clarification be provided to address if the following issues may have an effect on the quality and type of data expected: probable increased watering of trees relative to locations near the trees; preferential routes of migrations that may have been made due to excavation for the tree wells; possible uptake of tree roots of plutonium; possible excretion of organic chelating agents by the tree roots that may increase mobility of plutonium near tree roots; and dilution of plutonium, if it exists in layered bands, to the point where the layers may be missed because 50 cm intervals are being taken.

Information on many of these issues is not available, but as discussed with the agencies (EPA, CDHS-RHB, CDHS-EHIB, and ATSDR), the new sampling depth intervals (Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan) will provide data to meet the goals of this sampling plan.

Comment 22. *Section 2.4, page 9. This section should reference Figure 5.*

It should be stated whether the samples are to be collected at the intersection of grid lines or at random locations within the boxes described by the grid.

It is stated that sample results are to be used to resolve three issues, but there is no discussion on how these issues will be resolved.

A figure showing a wind rose for this area would be useful. The figures all indicate that the park is upwind of LLNL so that transport by air would be highly unlikely. A wind rose for LLNL is provided in the reference Gallegos, 1995.

The samples will be collected at the grid line intersections, as described in Section 3.2.2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. A data analysis and interpretation discussion has been added for each type of sample in Chapter 3. A wind rose is included in Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 23. *Section 3.1, page 10. This section should refer to Figure 1. It is stated that the nineteen resampling locations are "sufficient to meet the goal of obtaining information about the plutonium concentration depth profile..." There is no discussion of why these nineteen samples are sufficient. (The objective stated in Section 1 is to determine if plutonium concentration increases with depth.) Judgment samples do not require a rationale for the number of*

measurements, but an explanation of why samples are collected in one area and not in another would be appropriate. If a secondary goal is to sample locations consistent with previous survey activities, this should be stated. Judgment samples should be compared directly with an action level. The action level should be stated in this section and the basis for selecting this action level provided.

> As agreed among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, samples will not be collected at the nineteen locations from the 1995 sampling, with the exception of 8 sample locations near the 1995 Location 1, and 1 sample location each from the 1995 sample Locations 7 and 8. The sample locations and depths are presented in Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 24. *Section 3.2, page 10. This section should refer to Figure 2.*

In this section it is stated that there are two decisions to be made using these samples. Decision 1 corresponds with Objective 1 for the survey, and Decision 2a corresponds with Objective 2. Decision 2b does not correspond to any of the previously stated objectives of the survey, although the results may be related to Objective 2.

> Decisions 1 and 2a in this section were eliminated in the Draft Final Livermore BTP 1998 Soil Sampling Plan. Decision 2b is now clarified in Section 3.1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Section 3.2.1 discusses the current Arroyo Seco channel depth profile. This section does not discuss the actual statistical tests that will be used to interpret the data. Because the depth profiles represent paired samples, the tests recommended in MARSSIM are not appropriate. A test for analyzing paired samples should be identified and used consistently for all analyses of depth profiles in this survey. The way the test is described herein, 8 of the 9 measurements would need to have subsurface concentrations significantly higher than surface concentrations to conclude that plutonium concentrations increase with depth. This should be acceptable for analyzing just the sediments in the current channel, but the analysis should be expanded to include all of the depth profiles measured on the site as well. The requirement that there be a significant difference between the surface and subsurface measurements implies that an extremely low detection capability is needed. In the next Subsection (3.2.2), it is stated that the expected geometric mean concentration is 0.001 pCi/g. MARSSIM recommends that the detection limit be at least half of this value, but Section 6 of this Plan states that the planned requirement is for five times this concentration. The consequences of using such a high detection capability compared to the expected result should be clearly explained.

Since submittal of the draft BTP Sampling Plan, it has been determined by EPA, CDHS-RHB, CDHS-EHIB, DOE/LLNL, and ATSDR that only surface samples at 0-5 cm will be collected in the arroyo, with four downstream samples being collected from 0-25 cm. Arroyo sampling is discussed in Section 3.1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Section 3.2.2 states that a plutonium concentration of 0.02 pCi/g would be considered an indication of significant on-going releases from LLNL. The basis for this value appears to be the required detection capability discussed in Section 6. If this is the case, a site-specific limit should be established based on the likelihood of contamination. If this is not the case then the basis for this value should be explained. The null hypothesis that the concentration is less than 0.001 pCi/g does not seem to be appropriate for results with a detection capability of 0.005 pCi/g.

As a result of discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, the number of samples for this part of the sampling effort is now a negotiated value. Therefore, the null and alternative hypotheses presented in the draft plan no longer have any bearing on the development of the sampling plan.

Discussions in this section (3.2.2) appear to refer to a less stringent evaluation of whether or not the plutonium concentration in the Arroyo exceeds 0.02 pCi/g. A more appropriate test would appear to involve evaluating the concentrations compared to 0.02 with an alpha of 0.01 (higher values of alpha would probably be acceptable for this analysis). MARSSIM recommends using the nonparametric Sign Test for this type of comparison, but the One-Sample t-Test or Wilcoxon Signed Rank Test described in Guidance for Data Quality Assessment (EPA QA/G-9, QA97 Version) may also be appropriate in certain cases. Data quality assessment should be used to evaluate the data collected to determine which test is appropriate.

The arroyo channel samples are being collected for the purpose of detecting contamination. As agreed among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, comparisons to background data will initially be focused on assessing the extent of contamination. Additional evaluations may be required subsequent to the initial comparisons.

Section 3.2.3 discusses the samples collected from the banks of the Arroyo. There is no indication whether these samples will be located randomly or using professional judgment. If the samples are random, they should be evaluated using the same test as the Arroyo channel samples described in Section 3.2.1. MARSSIM states that judgment samples should be individually compared to an action level. The rationale for selecting 0.1 pCi/g as considered above background (an action level?) should be defined more clearly. If the level is greater than

background for the sediments in the Arroyo is 0.02 pCi/g, it would seem to be appropriate to use the same background level for the banks.

> In discussions with EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, it was agreed that no samples will be collected from the banks of the arroyo in favor of sampling the Big Trees Park eastern extension. The arroyo channel sample locations and depths were also agreed on by EPA, CDHS-RHB, CDHS-EHIB, and ATSDR.

Comment 25. *Section 3.3, page 13. While Table 2 provides probabilities of finding plutonium for various conditions, this depends on adequate definition of the fill/sediment boundary, and an assumption about the degree of presence.*

In addition, we are not familiar with the use of the term prevalence and if there are any other underlying assumptions to validate Table 2. It seems reasonable that for the argument for the probability of finding plutonium to be valid, there must be equal chance for finding plutonium in any particular location. This does not seem likely if the assumption that plutonium is highly immobile and thus not likely to distribute itself over any given volume is true. It is recommended that further clarification of any assumptions for the probability analysis be provided.

> In consultation with EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, the sampling locations and depth intervals have been revised, and the degree of presence (prevalence) is no longer relevant to the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 26. *Section 3.3, page 13. The sampling plan states that soils in the former arroyo have been undisturbed since 1971, however, Section 2.3 (Soil samples near ornamental trees) suggests the sewage sludge pathway occurred in 1975. It is recommended that clarification be provided about the known plutonium releases to clarify the rationale for these pathways.*

> Sewage sludge may have been added as a soil amendment when planting trees in the park. These trees are not located in the path of the former arroyo.

Comment 27. *Page 14. We suggest that a section be added (possibly as Section 3.5) that provides a summary of all sampling locations, including the QA/QC samples. A table would also be very helpful.*

Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents a summary of sample set, analytes, potential pathways, depths, and number of locations and samples.

Comment 28. *Section 4, page 15. The notion of "background" values of plutonium in soil has certainly generated a lot of debate. The authors should cite background values from other areas (that are in fallout situations similar to the Bay Area) so that the reader can make comparisons to those background values that the LLNL references cite. Why are not the background values cited in the 1994 EPA/NAREL report on LLNL plutonium soil sampling referenced in this report? That document noted that worldwide fallout was in the range of .001-.01 pCi/g, a range with a low value that is an order of magnitude lower than that cited in this draft report. Explain if the sampling plan (number of samples in the arroyo, etc.) would change if this lower value (.001 pCi/g) were considered background.*

The 1994 EPA/NAREL report was not cited because it in turn cites the LLNL Environmental Report for 1991. The Draft Final Livermore BTP 1998 Soil Sampling Plan contains a more thorough discussion of the derivation that approximates the upper limit of fallout Pu-239 concentrations in the Livermore Valley (Appendix D). The 0.001 to 0.01 pCi/g range mentioned in the NAREL report represents a range of concentrations typical of fallout. It does not describe a range of possible values for the upper limit of fallout. The lower value in the cited range, 0.001 pCi/g, is within background, but not an upper limit for background.

Comment 29. *Section 4, page 15. The measured background of plutonium in sediment is significantly lower than the background concentration at the site (i.e., 0.001 pCi/g compared to 0.02 pCi/g). There is no discussion of this apparent contradiction. In addition, if the background is expected to be 0.02 pCi/g why state that 0.02 pCi/g in the current Arroyo Seco channel is an indication of an environmentally significant on-going release? This would seem to be the expected concentration in sediments as well as soil.*

Background concentrations are more thoroughly discussed in Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 30. *Section 5.2, page 16. In this section it is stated that at least eight field replicates will be collected. The method for homogenizing the samples should be described in detail. MARSSIM states that this process is difficult and expensive to perform and still provide double-blind samples to the analytical laboratory.*

The field geologists will homogenize all samples to the best of their ability. A description on the method for homogenization is included in Appendix

C, Field Sampling Procedures, of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 31. *Section 6, page 16. While we agree a single lab is acceptable to analyze the full suite of samples, EPA will not be recommending any single independent analytical lab. We will be taking split samples (10% of total numbers, locations TBD in the field). This is typical for our QA/QC verification and validation. We do agree that any split samples that are taken, by EPA or any other party, should be analyzed according to the same exact specified analytical protocols that LLNL uses for their analysis, and these protocols need to be specified in this plan. When DOE/LLNL selects a lab, provide justification for its selection.*

DOE/LLNL will be submitting samples for analyses to General Engineering Laboratories (GEL) in Charleston, SC, and the EPA and ATSDR will be submitting samples to Georgia Institute of Technology in Atlanta, GA. A description of the analytical methods and sample preparation is presented in Appendix E of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

GEL was used by LLNL's Environmental Protection Department during 1994-1995. During this time they were evaluated using many laboratory quality control samples, in which they performed very well. At the same time a detailed facility audit was conducted. Based on numerous documents (State certifications from CA and UT, Performance in national inter comparison performance evaluation programs, DOE's EML and MAPEP programs, EPA's EMSL, WP, and WS programs, QAP program including resumes, and audit reports from the Albuquerque and Oakridge DOE field offices) we felt confident in this laboratory because their state certificates were current, their inter comparison performance was excellent, their quality assurance program was good, and the audit reports were very detailed with deficiencies identified and corrective action responses.

Comment 32. *Section 6, page 17. The detection limit described in this section (.005 pCi/g) is not adequate for measuring samples at 0.001 pCi/g, which is the expected plutonium concentration in sediments stated in Section 3.2.2. The stated detection limit and measurement uncertainties are adequate for detecting plutonium at 0.02 pCi/g. The description of the method where 1-2 grams of soil will be processed by microwave digestion is not realistic considering the required detection limits. A leaching method similar to that described in Gallegos, 1995 is a more reasonable assumption.*

The analytical laboratory selected by ATSDR (and also EPA) for analysis of split samples has stated that they can achieve the required detection limit with 1-3 grams of soil, using total dissolution and microwave digestion.

Comment 33. *Section 7.1, page 18. The sampling plan states that foreign material (for example, glass, metal, rock) is not considered part of the sample, however, it is not clear if there is a more objective description. For example, is there a size at which rocks become sand and thus part of the sample?*

The discussion of sample sizes should consider the representativeness of the sample as well as the requirements of the analytical method. Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies (EPA/600/R-92/128, July 1992) provides guidance on determining appropriate sample sizes.

The procedure for homogenizing samples should be described in more detail or referenced to a specific SOP. There should be a discussion of reducing sample sizes when the samples are unusually large. Detailed written procedures should be consistent with the guidance provided in Guidance for Preparation of Standard Operating Procedures (SOPs) for Quality-Related Documents (EPA QA/G-6, November 1995).

The sample size, homogenization, and acceptable material are discussed in Appendix C of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 34. *Section 7.2, page 19. It is stated that the diameter of the area to be sampled for the top 5 cm will be determined based on the sample size requirements. A table showing diameters for various sample sizes, assuming a density of 1.5 g/cc, could be provided in this section.*

Adequate sample volume is required for analyses, so it will be determined in the field how best to satisfy these requirements. Generally, samples will be collected with standard hand augers or 2.5-inch split spoons.

Comment 35. *Section 7.3, page 19. It is stated that sampling tools have not been selected and that some test evaluations of techniques will be required to make a decision. This is inconsistent with Section 8, which states a drill rig will be used to sample the former Arroyo channel.*

Due to the depth of the former arroyo channel, it was known that a drill rig would be necessary for collecting these samples. The various sampling methods and equipment have now been tested to ensure that there are no problems associated with access or the ability to collect samples.

Comment 36. *Section 7.3, page 19. The sampling plan states that some test sampling will be necessary for the purpose of method evaluation and sampling procedure development; however, the test samples will not be analyzed. It is recommended that clarification be provided on the criteria for selection of methods and sampling procedures, especially since laboratory analyses will not be used.*

As discussed in the response to EPA Comment No. 35, it was the equipment that was tested to ensure that there were no problems associated with access or the ability to collect samples.

Comment 37. *Section 7.4, page 20. Examples of the field tracking form and the chain-of-custody documents should be included. Requirements for SOPs and data reporting should also be discussed in this section.*

Field tracking forms and a chain of custody form is included in Appendix C of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 38. *Section 7.4, page 20. DOE is the lead agency at the LLNL Main Site, and hence, is responsible for custody of its samples. Any agency, including EPA, will be responsible for their split samples.*

Comment noted.

Comment 39. *Section 8, page 20. This section states that sampling in the arroyo will be performed when it is sufficiently dry. There are no criteria provided for determining if the arroyo is sufficiently dry. If soil moisture measurements will be used (which seems unlikely) they should be described in this sampling plan. The preparation for sampling should also include selecting an analytical laboratory and evaluating the consistency of the products from the field sampling activities and the inputs to the analytical laboratory activities.*

No soil moisture measurements are proposed; the dryness of the arroyo was related to safely getting the equipment in and out of the arroyo. The arroyo needs only to be dry enough that the sampling personnel can safely do their work.

Comment 40. *Section 8, pages 20, 21. As much of the unresolved logistical questions in this section as possible should be included in the final version of this plan.*

Sampling Plans, Chain of Custody forms, Field Tracking Forms, Quality Assurance and a description of the field techniques to be followed have

been included in Appendices C and E of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 41. *Section 9.2, page 21. Permit issues need to be resolved before sampling starts and, if possible, put into this sampling plan.*

Section 4.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan discusses permits related to sampling at BTP.

Comment 42. *Section 10, page 22. Please provide detail on whether any statistical analysis will be done on the data, as was done in the 1995 Big Trees Park report. In addition, as lead federal agency, DOE/LLNL will be distributing the data, in some to be determined report format to the public.*

Statistical analyses may be performed once the data are available, but no specific analyses has been discussed with EPA, CDHS-RHB, CDHS-EHIB, and ATSDR.

Comment 43. *Section 11, page 22. The text states: "Past analysis of sanitary sewer sludge has detected plutonium concentrations up to 4 pCi/g". Please provide a reference for this data.*

This sentence is not in the Draft Final Livermore BTP 1998 Soil Sampling Plan, although information about the 4 pCi/g value can be obtained in Myers et al. (1975).

Comment 44. *Appendix A. The sampling plan references data for three sites to establish the maximum sampling depth. However, the relevance of the other site data to the current site was not established. In particular, a comparison of site-specific characteristics including rainfall, soil porosity, soil pH, and soil type, was not described. Further, the mode of deposition of plutonium at these sites was not addressed. Is the deposition at these sites considered similar to the hypotheses of Big Trees Park plutonium deposition?*

Appendix A in the draft BTP Sampling Plan pertained to a discussion of the proposed sampling intervals. In consultation with the agencies (EPA, CDHS-RHB, CDHS-EHIB, and ATSDR), the sampling intervals have been changed, and the former Appendix A is not included in the Draft Final Livermore BTP 1998 Soil Sampling Plan, although the new sampling intervals are included in the text.

Comment 45. *Appendix A. In addition, one of the referenced sites (Site C, Figure 6) seems to show spikes or bands of contamination at depths of 30 and 85 cm. The plutonium depth profile*

for Site C does not indicate attenuation of concentration to background with depth and could be interpreted to suggest significant mobility of plutonium. It is recommended further explanation be provided.

See response to EPA Comment No. 44.

Comment 46. *Appendix B should be expanded to document and justify the assumptions being made in developing the statistical methodology. For example, the text does not state the null hypothesis. In addition to EPA guidance, DOE/LLNL should refer to the confirmation sampling plan prepared by Weiss Associates for the LEHR Superfund Site.*

The MARSSIM statistical methodology is no longer part of the data analysis. Therefore, former Appendix B is not included in the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 47. *Appendix B. The DCGLw selected in this appendix is appropriate for determining if there are any risks to human health and the environment, but that is not one of the stated objectives of this survey. Based on the discussions in this sampling plan a more reasonable action level would be 0.02, which corresponds to fallout background levels of plutonium. In this case, it is recommended that the one-sample Sign Test be considered as an alternative. Using 0.01 for delta, 0.14 for sigma, and a reasonable value of 0.10 for alpha and beta, MARSSIM Table 5.5 recommends 30 samples, which is consistent with the proposed number of samples. In this case, where the potential action level is equal to the expected background, it may be better to demonstrate that the concentration is indistinguishable from background. Guidance on performing this type of analysis is provided in A Proposed Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys (NUREG-1505, December 1997).*

The objectives have been clarified in the Draft Final Livermore BTP 1998 Soil Sampling Plan, and the MARSSIM statistical methods are no longer part of the data analysis.

Comment 48. *Figure 1, Proposed Resampling of 1995 sample locations. The figure shows numbered sampling locations, however, it does not depict samples 16 through 19; it is recommended that these locations be explicitly depicted.*

The 1995 sampling consisted of 19 samples from 16 locations (four samples were collected from location 1). Location 16 from the 1995 study was outside the areas shown on Figure 1 of the draft BTP Sampling Plan. Sample location 20 in the Draft BTP Sampling Plan should have been labeled sample location 17. This is corrected on Figure 2 of the Draft Final

Livermore BTP 1998 Soil Sampling Plan. Only the Locations 1, 7, and 8 from the 1995 study will be resampled.

Editorial Comments

Comment 50. *The sampling plan does not adequately identify the organization preparing and responsible for the plan. For example, the plan is labeled with the "Environmental Protection Department," however, it is not clear if this is an organizational unit of the Department of Energy, the University of California, or Lawrence Livermore National Laboratory. It is recommended that a "Prepared by:" block be provided stating the organizational affiliation of the preparers and mailing address.*

DOE is responsible for the plan, which has been prepared jointly by DOE and LLNL scientists who work for the Environmental Protection Department.

Comment 51. *It is recommended that the sampling plan address what will be done with soil that is removed by the sampling process but not sent to the laboratory for analysis.*

As discussed in Appendix C of the Draft Final Livermore BTP 1998 Soil Sampling Plan, soil samples not sent to the laboratory for analysis will be archived at LLNL. Auger cuttings will be used to backfill the boreholes.

Comment 52. *It is recommended that a Health and Safety Plan (HSP) be developed. While not reviewed by EPA, a HSP must be referenced by or attached to every field sampling plan.*

LLNL has an existing Health and Safety Manual and an ERD Site Safety Plan that address the work proposed in this sampling plan. They are referenced in the Field Sampling Procedure (Appendix C of the Draft Final Livermore BTP 1998 Soil Sampling Plan).

Comment 53. *It is recommended that each of the graphs in Figure 6 be labeled with the corresponding site name.*

Figure 6 of the draft BTP Sampling Plan was related to the proposed sampling intervals. As discussed in the response to EPA Comment No. 44, the sampling intervals have been changed in negotiations among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR. Thus, Figure 6 of the draft BTP Sampling Plan is no longer included in the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 54. *It is recommended that a formal document control identification be used on each page of the sampling plan. For example, a block including Revision Date, Page # of total Pages.*

An identification header has been added to the Draft Final Livermore BTP 1998 Soil Sampling plan that states the document name, revision date, and page number of total pages.

Comment 55. *Section 2.2, page 6, para 4. Editorial comment. "....in the area where it passes through LLNL property)."*

This discussion has been revised in the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 56. *Section 7.4, page 20. The sampling plan states that field tracking forms will be used to record relevant notes and details, including descriptions of sampling location. It is recommended that bound field notebooks and videotape be used, especially since Section 2.1 of the sampling plan states that the previous 1995 sampling event did not record precisely the sampling locations, and the recollections of individuals had to be used for planning this sampling round.*

Field tracking forms are designed to expedite and ensure completeness of the information needed for each sample collected. We do not have bound field note books containing these forms, but the tracking forms and other pertinent paperwork will be filed together appropriately. The sample locations from the 1995 study were recorded on field tracking forms, photographs, and video. As stated in the draft BTP Sampling Plan, photographs, video, and a Global Positioning System (GPS) will be used to record sampling locations.

Comment 57. *It is recommended that an example chain-of-custody be attached to the plan.*

A chain-of-custody form has been included in Appendix C of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

6.3. CDHS/EHIB Comments and DOE/LLNL Responses

General Comments

Comment I. *<u>Choice and Scope of Objectives</u>. While it is good that objectives were stated, we believe these objectives could be reshaped to more accurately reflect the questions of interest. The primary objective could be to define the nature and extent of plutonium and other potential Lab-*

related contamination in Big Trees Park (vertically and horizontally). Objectives 1 and 3 are related, but too narrow as currently stated. The second objective could be to attempt to discern the pathway by which the plutonium entered the park; specifically, to find evidence that would strengthen or weaken each of the 3 pathways mentioned (distributed sewage sludge, aerial dispersion, arroyo sediments). Thus, objective 2 could be strengthened by being more specific.

The objectives have been redefined in Section 1.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment II. *Decision tree. It would be more understandable to any reader, including scientists, if clear, specific, and measurable objectives are stated that are tied to specific methodology and decision rules, with clear descriptions of what comparison(s) may be made, and what conclusions will be drawn depending on the outcome of the analyses. Currently, the objectives are stated, followed by a section on where different groups of samples will be taken and how, but what tests will be done, or exactly how this information will be used to draw conclusions is not stated. For example, see the table below as a guide:*

Objectives	Methodology	Analysis Plan	Interpretation	Actions
Obj. #1.		If result A, then interpretation X.	If result B, then interpretation Y.	
			If X, then action 1.	If Y, then action 2.
Obj. #2....				

The objectives are defined in Section 1.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The hypothesis, sampling rationale, and data analysis and interpretation are discussed in Section 3 for each sampling set. Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents a summary of the sample set, analytes, potential pathways, depths, and number of locations and samples. Conclusions drawn from the analyses will be made jointly by DOE/LLNL and the regulatory agencies.

Comment III. *Background levels. There is a need to define background levels and distribution of background levels. Several considerations need to be kept in mind.*

- *These samples should be taken from another location distant enough to be entirely unaffected by LLNL.*
- *An adequate number of samples is needed to provide information about distribution and variation.*

- *Background isotope ratios should be calculated based on measurements (analysis) of Pu-239,240 and Cesium-137 levels, either Pu-239,240 to Cs-137 or Pu-240 to Pu-239. Although absolute measurements will vary depending on factors such as rainfall, the ratio of these constituents is very specific and constant, making this a standard and much more precise methodology to determine whether contaminants resulted from global fallout or local processes.*

Background information should come from locations unaffected by a potential source, but also close enough to be comparable in terms of other factors such as rainfall, topography, large scale wind flow patterns, location relative to aboveground nuclear tests, etc. Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan contains a more thorough discussion of fallout background concentrations for Pu-239.

LLNL agrees that an adequate number of samples is needed to provide information about distribution and variation. This is also true for determining isotope ratios. To the best of our knowledge, the location nearest to LLNL, but outside of the Livermore Valley, for which isotopic ratio information exists, is Oakland (Hardy, 1975). There were only two samples in the Hardy study, not sufficient to provide information about distribution and variation. The assertion that "the ratio of these constituents is very specific and constant" needs to be fully assessed before it can be considered for use in interpreting isotopic ratio results. A variety of reports demonstrate substantial variation, both systematic and random, in measured isotopic ratios in the environment.

Comment IV. *Community input/process. We have heard LLNL representatives state a commitment to involving the Livermore community fully in this process, and we believe that adequate inclusion of the community groups and stakeholders in the design of the sampling plan is a critical step in assuring credibility and acceptance of the outcome. We further believe, based on the comments voiced at the Site Team Meeting on May 13, that an independent technical consultant should be made available to the community to review the plan. We strongly believe this is necessary for the plan to achieve credibility, and we believe it is in the Lab/DOE's best interest, acting as a good neighbor, to ensure this request is fulfilled. [Since this original writing, we are pleased to learn that USEPA has provided funding for this.]*

F. Owen Hoffman of SENES Oak Ridge, Inc. was funded to provide independent scientific review of the draft BTP sampling plan. His comments and DOE/LLNL responses are presented in Section 6.7.

New Information

Comment I. *Discovery of radiation sewer line breaks affecting the Arroyo Seco. Since the release of the Public Comment Draft, Plutonium Contamination in Big Trees Park, (February 9,1998), additional information has come to light on possible contaminants affecting the Arroyo Seco. CDHS staff have interviewed the former (1960-1991) Superintendent of the Livermore Water Reclamation Plant (LWRP). During the interview we were informed that the radiation laboratory sewer line was broken under the Arroyo Seco, for an indeterminate amount of time. To his best recollection, the break occurred during the early 1970's. CDHS has attempted to obtain information relating to this issue (sewerline drawings (locations), historic ruptures and repairs, etc.) from the City of Livermore. The City of Livermore has not been able to fulfill our requests. We feel that this issue is extremely relevant to the Arroyo sampling depths and locations, and would like this to be taken into account in determining the sample locations.*

After an investigation that included review of historical records and interviews with LLNL staff responsible for the construction and maintenance of sewer lines, it was determined the sewage line discussed in this comment was connected to an administrative building that was located outside the controlled area of LLNL therefore, this is not a likely pathway for plutonium to have traveled from LLNL to Big Trees Park.

Comment II. *Sewage Sludge Levels as high as 297 pCi/g. [Section 11, Next Steps, p. 22, 1st paragraph, 1st sentence: "Past analysis of sanitary sewer sludge has detected plutonium concentrations up to 4 pCi/gm."] Since the release of the public comment draft health consultation, "Plutonium Contamination in Big Trees Park, Livermore, California" (2/9/98), CDHS has obtained historic monitoring data of alpha activity in sewage sludge as high as 297 pCi/g at the Livermore Water Reclamation Plant (LWRP); this sludge was available and distributed to the public. Past attempts by CDHS to obtain this data from LLNL and LWRP have indicated that neither agency has this data available, so CDHS would be happy to share this information with these agencies, if desired.*

On March 26, 1998, LLNL obtained copies of Radiologic Health News from CDHS-RHB that cite this value for the LWRP sewage sludge. Similar values appear in Pleasanton and occasionally elsewhere in California. The Pleasanton measurements are believed to be due to a former commercial laundry facility that specialized in the laundering of clothing and other items from facilities such as nuclear power plants. These results were reviewed by a state agency, and no actions were taken at the time. The sludge in question is digester sludge, from a point earlier in the sewage treatment process, and not representative of the form of sludge that later became available to the public.

Specific Comments

Comment 1. Choice of Objectives (p 2); (see also general comment # I. above). ["Determine whether plutonium concentrations in soil increase with depth (below 0-5 cm interval sampled in 1993 and 1995)".] We believe this objective is narrower than the question of interest, which is to define the vertical extent of the contamination. CDHS has recommended and still recommends defining the vertical extent (limits) of the contamination in Big Trees Park and the Arroyo Seco. This should be done by sampling at frequent, discrete vertical locations until the vertical limits of the contamination have been identified. The sampling should not be conducted in a manner which averages concentrations over a long vertical section or interval.

If the authors have used the MARSSIM manual for guidance and development of the survey objectives, then CDHS suggests that the authors review the primary objectives of a characterization survey, in MARSSIM, and reword Objective 1 to be consistent with the guidance referenced for the development of the Livermore Big Trees Park 1998 Soil Sampling Plan. The first primary objective listed in MARSSIM, for the development of a characterization survey states, "determine the nature and extent of the contamination".

> In negotiations with EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, the sampling intervals have been modified to better define the vertical extent of contamination. The sample intervals are presented in Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 2. *Clarification of sample selection. [Section 2.1 Resampling of January 1995 sampling locations (pp.4-5) and Appendix A Concentration Depth Profile Examples (p.25). 1st paragraph of section, 1st sentence, "Samples will be collected at all locations that were sampled in 1995..."] 2nd paragraph of section, "Subsurface samples at increasing depths will be collected at each location" The sampling plan states that samples will be collected from 3 depth intervals, and Figure 1 shows 16 proposed (re) sampling locations, for a total of 48 samples. The sampling plan states that 19 samples are planned for this area, not 48, as implied by the text. CDHS is requesting clarification regarding this issue. It is unclear which samples overlap, also. An additional map should be provided with ALL proposed sample locations represented.*

> The 1995 sampling consisted of 19 samples from 16 locations (four samples were collected from location 1). Location 16 from the 1995 study was outside the area shown on Figure 1 of the draft BTP Sampling Plan. Figure 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan shows all 1995 sample locations; Locations 1, 7, and 8 will be resampled in this study.

Comment 3. *Sampling so "hot spots" will not be missed. [p.5, 4th paragraph, "Further discussion, examples, and references are given in Appendix A. Samples will be collected from the following depth intervals: 0-5cm...5-50cm...50-100cm".] Since the pathway is still unknown, the depth intervals should be more frequent in order to ensure adequate characterization of the soils below 5cm. Analysis of such a long interval (5-50), which provides an average concentration of the entire interval, may miss a "hot spot" section, which may be at a level of health concern to the public. Therefore, CDHS strongly recommends that samples be analyzed at discrete locations, at 10 cm intervals, starting from 5cm, (e.g. 0-5cm, 5-15cm, 15-25cm, 25-35cm, 35-45cm).*

Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan shows the new sample intervals that were agreed to by DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR. This provides an improved characterization of the soil.

Comment 4. Arroyo Seco Sample locations need modification. [Section 2.2 Arroyo Seco samples (pp.6-8). p. 6, 2nd paragraph (list of Arroyo sampling locations),

"• One upstream of LLNL (a sediment 'background' sample)

"• One upstream of Sandia National Laboratory (another sediment 'background' sample)

"• Nine equally spaced between LLNL and Big Trees Park."]

(background sampling locations): The sample planned "upstream of LLNL," which is directly downstream of Sandia should not be considered a "background location", because the Arroyo Seco receives all of Sandia's surface water and storm drain discharges. Likewise, with the sample planned upstream from Sandia National Laboratory (SNL). Figure 2 of the Sampling Plan shows the sample location to be in close proximity to SNL; creating the possibility for deposition in the Arroyo from aerial sources. CDHS recommends that "background" locations be chosen much further upstream, in areas less affected by operations at SNL and LLNL.

(Arroyo Seco sampling locations): At least 6 of the 9 sampling locations planned seem to be in areas where significant disturbance to the channel has occurred, due to recent improvements in the area. Thus, samples in such an area are unlikely to yield useful information, and should be relocated to areas downstream of Big Trees Park.

The sampling proposed in the arroyo is for determining if the storm water runoff outfall adjacent to East Avenue is releasing plutonium into the Arroyo Seco, as suggested in the Public Health Consultation. Concentrations downstream of the outfall will be compared to the

concentration upstream to determine if releases are occurring at the outfall.

The current arroyo sampling will be compared to LLNL's historical surveillance monitoring of the arroyo channel, which has not indicated releases to the arroyo. The winter of 1997-1998 had heavy rainfall, so most or all of what may be in the arroyo at this time was deposited this past winter.

The "recent improvements" discussed in this comment took place prior to the 1997-1998 winter. We agree that these samples are unlikely to yield useful information, but they were proposed in the interest of being thorough. Two samples will be collected downstream of Big Trees Park.

Comment 5. *Depth and spacing of Arroyo sediment samples. [p. 7, 3rd paragraph (discussion of sediment sample depths), "Sediment samples in the present arroyo and from its banks will be collected at two depths: 0-5cm....., 5-25cm. A reasonable maximum sediment depth. Sampling immediately below 0-5 cm sample prevents confounding of horizontal variation with the vertical variation".] "Hot spots" may be missed if the depth is not great enough, or if the interval of sampling involves averaging soil over too broad an interval. According to LLNL's own sediment sampling methodology, radionuclides are sampled and analyzed at a depth of 45 cm (LLNL, 1992 Environmental Report). To ensure adequate characterization of plutonium in the Arroyo Seco channel, CDHS strongly recommends that discrete samples be collected and analyzed at 10cm intervals to, and including, a depth of 45 cm.*

The sediment sampling method described in the 1992 Environmental Report is obsolete. A correct reference for sampling is the 1995 Environmental Monitoring Plan. As agreed with DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, seven samples will be collected in the Arroyo Seco channel. Three of the samples will be collected from 0-5 cm, and the four most downstream locations will be sampled from 0-25 cm. This is now discussed in Section 3.1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 6. *Grid analysis must be denser. [Section 2.4 Sampling Grid. p. 10, 1st paragraph, "Grid points are closer together at the southeast corner of the park, both because the park is narrower there, and because Location 1 (the only location from the 1995 sampling definitely exhibiting above background concentrations) is in the southeast corner".] The USEPA Data Quality Objectives for Remedial Response Activities, Volume 1-Development Process, references 10-ft interval grid line spacing for establishing a grid pattern. The grid is used to evaluate an air*

pathway, not point source determination, so a standardized grid should be used, not a biased (weighted more heavily in one area, based on prior knowledge) grid sample. The guidance suggests that if a preliminary investigation has already been conducted and a review of the data indicates a more intensive sampling is warranted, then sampling at the intersections of each 10 ft grid line is appropriate. CDHS suggests that a standard grid pattern be used with the same spacing intervals, going further into the park, including more comprehensive sampling in the playing field area, baseball area, and disked field. Currently, each of these comprise approximately the size of a grid block, which means that there would be one sample at each of four corners on the periphery of a block of 120 or more feet long. There are no samples planned currently for the playing field at all.

CDHS disagrees with the statement that Location 1 is the only location definitely above background; locations 7 and 8 are also elevated, and possibly others. The current grid does not include the park area on the other side of Kathy/ Charlotte Way (the eastern extension of the park).

Returning to the issue of a decision tree, the sampling plan is unclear about what type of analysis with the results of the grid information -- this should be stated.

To the best of our understanding, the choice of grid type (square, rectangular, triangular) has to do with hot spot detection efficiency, not the shape of the site, as discussed in the EPA guidance document "EPA Data Quality Objectives for Remedial Response Activities, Development Process." The grid proposed in the Draft Final Livermore BTP 1998 Soil Sampling Plan was agreed on by DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR.

As discussed in the Draft Final Livermore BTP 1998 Soil Sampling Plan, two samples will now be collected from the playing field (Section 3.3.3), four samples will now be collected from the disked area (Section 3.3.2), and three samples will be collected from the eastern extension of the park (Section 3.3.4).

The statement that Location 1 is the only location definitely above background was an error in the draft Big Trees Park Sampling Plan. Location 1 was definitely above background, Location 7 (in a position consistent with the sewage sludge pathway) was slightly above background, and Location 8 was near the upper range of background, and may or may not be higher than background. All other locations were well within the range of background.

The Draft Final Livermore BTP 1998 Soil Sampling Plan includes data analysis and interpretation sections for the various grid analyses (Section 3.2.5).

Comment 7. *Sampling Arroyo Banks -- not useful in disturbed areas. [Section 3.2.3 Arroyo Banks. p. 12, 1st paragraph, "The arroyo pathway suggests that plutonium above background should be present in the sediments deposited on the arroyo banks. In order for such sediments to be responsible for the levels seen at Location 1 the levels in the Arroyo banks should be at least as high as those seen at Location 1, ..."]. It is not clear what rationale is based on. CDHS has not suggested that "plutonium above background should be present in the sediments deposited on the arroyo banks". We do agree that depending upon where a sample is collected and in an undisturbed, unmodified area, there may the potential for deposition of contaminated sediments along a channel bank. However, this is not the case in the proposed sampling area of the arroyo banks. The arroyo banks have undergone significant disturbance and removal of native soils in the proposed sampling area. Thus, CDHS feels that the samples planned for this area may not provide the most useful information, and alternative sampling locations should be sought.*

As agreed among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, no samples will be collected from the arroyo banks.

Comment 8. *Other constituents. [Section 6 Laboratory Analyses. p. 17, 2nd paragraph, entire paragraph.] CDHS is pleased that the regulatory agencies are considering other constituents for analysis. This data will be useful not only for pathway development, but will also provide information on other contaminants which may be a potential health concern. A number of heavy metals and radiologic constituents may be sewer contaminants or have been released to the Arroyo Seco, so we recommend sampling be conducted for: arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc, Am-241, cesium-137, strontium-90, cobalt-60, gallium, and plutonium-238. Since there is a possibility that these constituents may have been released to the Arroyo, it is prudent to analyze for these constituents in the Arroyo Samples as well.*

The sampling plan is primarily an evaluation of plutonium contamination in Big Trees Park. LLNL's surveillance monitoring program already includes analyses for a variety of radioisotopes and metals in arroyo sediments. However, DOE/LLNL agreed that the surface grid samples will also be analyzed for americium-241 and samples around the ornamental trees will also be analyzed for chromium, copper, lead, zinc, and americium-241. Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents the sample sets, potential pathways, depths, number of locations, and analyses.

Comment 9. *Choice of MARSSIM Wilcoxon Rank Sum Test.* *We disagree with the use of the MARSSIM Wilcoxon Rank Sum test (which is not the Wilcoxon Rank Sum Test) in this situation. This is used for remediation and therefore considers a PRG, but this is inappropriate for health considerations or for evaluating how a contaminant got there. When analyses are called for of this data, it would be preferable to transform the data to a normal distribution (such as a logarithmic transformation), and conduct a t-test between a survey area and a reference area. The appropriate comparison should be between background from a reference area, and the levels in Big Trees Park, not using the PRG. We do not want to only test for a difference greater than the magnitude of the PRG between a hypothetical reference area and the park, either.*

Returning again to the issue of methodology and decision tree, we would appreciate it if the Lab clarified how it was planning to use the MARISSIM Wilcoxon Rank Sum Test in this situation (e.g. what would be the reference group?). What interpretation would be made regarding various answers?

> The MARSSIM statistical methodology is no longer part of the data analysis, and is not included in the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 10. *Plutonium levels in park are not uniformly low with the exception of location #1*. *It is inappropriate to state that the park has uniform concentrations of plutonium with the exception of #1. Locations #7 and #8 were high according to both labs used in the previous sampling effort, and additional locations were found high by the NAREL laboratory, although measurement uncertainty is a consideration. Also, it is inappropriate to use the current samples to determine what the standard deviation (measure of variability) would be for a reference group of values. Natural background will not have the degree of variability seen in these samples, so conclusions about the variability of natural background levels of plutonium should not be based on samples from Big Trees Park.*

> This comment pertains to Appendix B of the draft Livermore BTP 1998 Soil Sampling Plan, which discussed use of the MARSSIM Wilcoxon Rank Sum methodology. As discussed in the response to CDHS/EHIB Comment No. 9, the MARSSIM statistical methodology is no longer part of the data analysis, and is not included in the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 11. *Plutonium concentration profiles -- meaning of 4th possibility*. *[Appendix A, "A fourth possibility, not shown, is that of a relatively uniform concentration down to an unknown depth, with rapid decrease thereafter."] CDHS staff request information on why the "fourth possibility" is mentioned and not discussed in any detail. We are interested in knowing the pathway and the concentration depth profile which would pertain to this particular scenario.*

Appendix A in the draft BTP Sampling Plan pertained to a discussion of the proposed sampling intervals. In negotiations among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, the sampling intervals have been changed, and the former Appendix A is not included in the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 12. *Sewage sludge distribution. In addition to this current investigation of Big Trees park, an investigation should be conducted of the distribution of sewage sludge throughout the Livermore Valley, and other areas, to identify areas that may have received plutonium-contaminated sludge. The report should state that this topic will be pursued in an additional investigation and sampling effort.*

DOE/LLNL have asked the Livermore Water Reclamation Plant (LWRP) about the disposition of sludge from LWRP. The LWRP responded that they have no records indicating the disposition of sludge from 1961 to the mid-1970s.

Comment 13. *Additional locations. The investigation should include evaluating Sycamore Grove and Sunflower Park. For example, some of the 80 samples currently proposed just around tree roots in Big Trees Park could be more usefully changed to survey Sycamore Grove and Sunflower Park. This would clarify the question of the level of plutonium in these locations as well as help provide additional information on relevant to the 3 possible routes of contamination: sewage sludge, Arroyo sediments, or air deposition.*

This sampling plan's scope is limited to soil sampling at Livermore's Big Trees Park to assess the following:

1. Extent of elevated plutonium concentrations both laterally and vertically.

2. Possible pathways by which plutonium came to BTP.

3. Public risk associated with plutonium at BTP given current and future land uses.

If additional sampling outside of BTP is warranted, a sampling plan specifically designed to address that sampling will be written. DOE/LLNL will work closely with EPA and the state agencies to determine if follow-up activities are necessary based on the results of this sampling.

6.4. CDHS Radiologic Health Branch Comments and DOE/LLNL Responses

Comment 1. *Section 1.1 states that the objective for additional sampling at Big Trees Park is to "Determine whether plutonium concentrations in soil increase with depth..." Only two additional samples are being proposed for soil depths down to 100 centimeters, along with re-sampling of the surface sample of 0-5 cm. The limited number of depth samples cannot provide a statistically valid determination of this objective. Only a general sense of information about the presence of the plutonium in soil deeper than 5 centimeters may be obtained, not a determination of plutonium concentration depth profile. More segmented sampling would be appropriate.*

> The depth intervals have been changed to 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm for the grid sample. Samples collected from Locations 1, 7, and 8 from the 1995 sampling will be sampled at 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, and 40-85 cm.

Comment 2. *In addition to recording all sample locations with a global positioning system (GPS), as mentioned in Section 2, video recording and still photography should be used. The GPS should record longitude, latitude, and surface altitude. Additionally, the GPS should measure horizontal distances of all sample locations from the reference Location 1, the "hot spot".*

> As stated in the draft BTP Sampling Plan, photographs, video and a Global Positioning System (GPS) will be used to record sampling locations. The GPS records latitude, longitude, and altitude. The GPS itself does not measure distance from Location 1, but this distance can be calculated from the sample location coordinates.

Comment 3. *The depths proposed for the samples, i.e., 5-50 cm, 50-100 cm, and 100-150 cm is too wide and may mask significant activity due to sample volume dilution. Appendix A states that "if the concentration (of the 5 to 50 cm sample) is large enough to be of human health concern, it will be detected." The sampling plan does not provide verification of this statement.*

The 1995 sampling indicated plutonium concentrations up to 1 pCi/g for a sample of 0-5 cm depth. However an inclusive sample 5 to 50 cm deep that hypothetically has an activity of 9 pCi/g, greater than three times the USEPA's proposed Preliminary Remediation Goal of 2.5 pCi/g, may be a human health risk concern. Individual depth samples of 25-cm segments would be more informative.

> The sample depth intervals have been changed in agreement among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, agencies, as

presented in Chapter 3 and Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 4. *Section 2.2 proposes two upstream arroyo sediment background samples. The location of these samples should be selected such that to minimize the potential of plutonium concentrations due to air deposition, e.g., an undisturbed sheltered area. Please clarify whether if only these two background samples will be used to compare with the arroyo samples, or will the background range referenced in Section 4 be used to indicate elevated levels and confirmation of the pathway?*

The sampling proposed in the arroyo is for determining if the storm water runoff outfall adjacent to East Avenue is releasing plutonium into the Arroyo Seco, as suggested in the Public Health Consultation. The sample upstream of the outfall will be compared to concentrations downstream to determine if releases are occurring at this location.

Comment 5. *Section 4 states that the "reasonable upper bound for background concentrations (0.021 pCi/g) is two standard deviations above the mean upwind surveillance monitoring locations." Though individual results of 0.02 pCi/g of Pu-239/240 may be within the upper bound range of the mean upwind locations, a statistical test should be performed to verify that the mean sample population is not significantly different than the mean upwind surveillance monitoring locations. Will 0.02 pCi/g be used for determining if all soil samples as elevated or not?*

Because Big Trees Park is already known to contain elevated concentrations of Pu-239, such a statistical test may only to confirm what is already known. Until results are received and assessed, it is difficult to say whether there will be a subset of samples that is appropriate for such a test.

Comment 6. *Though not recommended for further action in the draft CDHS/ATSDR Health Consultation, additional analysis should be conducted for Pu-238, Am-241, Cs-137, Co-60, and H-3.*

As agreed to after discussions among DOE/LLNL, EPA, CDHS-EHIB, CDHS-RHB, and ATSDR, both the surface grid samples, and the samples collected around the trees will also be analyzed for americium-241.

Comment 7. *Section 10 states that the results will be held by the analytical laboratory until all analyses are complete, and that the laboratory, after review of the analytical QC results by appropriately qualified staff from the regulatory agencies and LLNL, will release results simultaneously to the regulatory agencies and LLNL." We believe that the analytical results*

should be held by the analytical laboratory until all analyses are complete, and then provided to EPA. Upon their review of the analytical QC results, EPA should then provide for the simultaneous distribution of all results to the other members of the Site Team.

> DOE/LLNL agree to let EPA or CDHS-RHB perform review of the analytical QC results first. DOE/LLNL will also perform a QC review once the data is provided. We agree that the entire set of results should be released simultaneously to all interested parties.

Comment 8. *The Data Quality Objectives (DQOs) are not clearly defined. There is inadequate discussion identifying the decision, the decision rule, and the limits on decision errors. As questioned earlier, what sampling results will indicate "yes" or "no" for each hypothesis? What will indicate that additional sampling at Big Trees Park is needed? Section 11 should be elaborated to clarify these DQO decisions. The Plan is adequate to address the general scope and procedures for performing a more thorough scoping survey, yet further review and discussion must be performed in order to reach any significant decision or action.*

> Because much of this sampling is for the purpose of characterization, not decision making, DQO elements such as specifying decision rules and limits on decision errors are not appropriate in all cases.

6.5. WSLF Comments and DOE/LLNL Responses

We are writing on behalf of the Western States Legal Foundation (WSLF) and the Greater San Francisco Bay Area Chapter of Physicians for Social Responsibility (PSR) to comment on the Lawrence Livermore National Laboratory's "1998 Big Trees Park Sampling Plan", by Kris Surano and Don MacQueen. As you know, WSLF Board Member, Patrice Sutton, MPH, and PSR Board Member Kathryn Smick, MD, are members of the Site Team convened by the California Department of Health Services (CDHS) to guide the work of the enhanced Public Health Assessment process being conducted by CDHS in a co-lead capacity with the Agency for Toxic Substances and Disease Registry (ATSDR).

Western States Legal Foundation (WSLF) is a non-profit, public interest organization located in Oakland, California. For the past 16 years, WSLF has monitored, analyzed, and challenged nuclear weapons programs at the Lawrence Livermore National Laboratory (LLNL) and other U.S. Department of Energy (DOE) nuclear weapons research, development, and testing and production sites. WSLF seeks to abolish nuclear weapons, compel open public environmental review of hazardous nuclear technologies, and ensure appropriate management of nuclear waste. The principle guiding WSLF's activities is advancement of the democratization of policies affecting nuclear weapons and related nuclear technologies and the protection of the environment

and the public health. WSLF works to involve citizens who work and live at the point where nuclear weapons programs have their social, ecological and public health impacts in decisions that affect their health. In addition to being an active member of the Site Team, other examples of WSLF' activities related to the CDHS/ATSDR Public Health Assessment include the fact that the 1992 site-wide Environmental Impact Statement prepared for LLNL was the product of an in-court settlement negotiated by WSLF attorneys. WSLF is also a consultant to a sub-committee of the federal Advisory Committee on Energy-Related Epidemiologic Research, a national forum that address public participation in research regarding the public health consequences of nuclear weapons production.

The Greater San Francisco Bay Area Chapter of Physicians for Social Responsibility (PSR), consistent with the mission and program of our national organization, is committed to the abolition of nuclear weapons and other weapons of mass destruction. As such, since the early 1980s, our chapter, representing approximately 2000 physicians and other health professionals has worked steadfastly against the design, production, deployment and use of nuclear weapons. We are equally committed to addressing the horrific legacy of environmental degradation and related public health issues that have been the consequence of over half a century of nuclear weapons work centered on the DOE weapons complex, including the LLNL. It is from this perspective that we offer our comments on the issues relating to plutonium in the Livermore area.

I. Public Participation

We are outraged by Lawrence Livermore National Laboratory's (LLNL) "Livermore Big Trees Park 1998 Soil Sampling Plan" dated April 10, 1998. LLNL developed the sampling plan outside of the open public process established by state and federal health agencies responsible for assessing the health effects of LLNL on the community.

LLNL developed and released its plan before the public comment period on the Big Trees Park Health Consultation had ended (LLNL released its plan at a news conference on April 14, 1998, and the Big Trees Park Health Consultation comment period ended April 15, 1998). The Lab excluded Site Team community members, stakeholders, and the California Department of Health Services Environmental Investigations Branch (CDHS/EHIB) from participating in the development of the plan. The Lab did not attend a May 5, 1998 Site Team meeting specifically convened to discuss the Lab's sampling plan. Based on the cover letter distributed with the sampling plan, the role of the Agency for Toxic Substances and Disease Control (ATSDR) is to "collate" the comments on the Lab's plan.

> The proposed sampling in Big Trees Park is being prepared under the Superfund (CERCLA) process. DOE/LLNL are using the public participation process established under Superfund to ensure public

comments are fully considered in the development of this plan. DOE/LLNL took the initiative to develop this plan early to respond to public concerns about plutonium in Big Trees Park rather than waiting until the Big Trees Park Health Consultation is completed. The draft sampling plan was developed after holding meetings with the various agencies to include their technical recommendations. The Draft Final Livermore BTP 1998 Soil Sampling Plan incorporates comments from EPA, CDHS-RHB, CDHS-EHIB, ATSDR, and other stakeholders. DOE/LLNL have also engaged in technical discussions with EPA Regional and Headquarters toxicological and radiation specialists in the development of this Draft Final Livermore BTP 1998 Soil Sampling Plan.

The two LLNL Site Team members were away on business and were not available to attend the May 5, 1998 Site Team Meeting. The Site Team was informed that these representatives had other commitments that week and offered to send someone to the meeting to give a presentation on the Big Trees Park sampling plan development and discuss recommendations of the Site Team. The offer was declined by CDHS/EHIB. The Senior Health Physicist with ATSDR and project manager responsible for the LLNL Health Consultations have been and continue to be actively involved in all sampling plan development activities. ATSDR and EPA will collect and analyze sample splits for analysis at an independent laboratory. Additionally, EPA will be involved in the data interpretation phase once the analytical results are available.

For public health 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." The Lab's controlling the environmental sampling or other community health activities runs counter to prevailing national sentiments on how to conduct credible, scientifically sound, research on the health impacts of the DOE nuclear weapons programs. In April 1998, a federal advisory committee of scientists convened to improve the quality and credibility of research related to populations affected by DOE nuclear weapons activities recommended:

"No agency responsible for exposures imposing risks on workers and the public should be entrusted with control over efforts to address the health consequences".[1]

Under Section 120 of the Superfund Amendments and Reauthorization Act (SARA) of 1986, DOE is given responsibility by Congress to clean up the site to meet regulatory established remediation goals. The goals are

> set by EPA and the State at levels that are protective of public health. DOE as the lead Federal agency and LLNL as DOE's contractor are responsible for characterizing the site and any offsite impacts, and ensuring that the health protective remediation goals are met. DOE/LLNL volunteered to prepare a sampling plan, submit the plan to the cognizant public agencies and community members for comment, address comments, and implement the sampling plan after comments are addressed/resolved. The Draft Final Livermore BTP 1998 Soil Sampling Plan was modified from the draft in conjunction with the regulatory agencies and responses to stakeholder comments. The study will be performed with active oversight of EPA and CDHS-RHB including taking sample splits and being involved in data interpretation.

In addition to the fact that the Lab is not a disinterested party to the results of current environmental sampling activities, the historical record demonstrates that the Lab is unqualified to control any public health activities. From February 26 to April 5,1990 the 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)"

The process by which environmental sampling and other follow-up to the Public Health Assessment is conducted should be transparent, independent, and timely, and should demonstrate the inclusion of an informed public in all follow-up decisions. Because follow-up 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 future efforts are the demonstrated inclusion of an informed public in a meaningful way in decision making related to the Public Health Assessment and follow-up. All follow-up activities must be conducted under the auspices of the Site Team convened by the state and federal public health agencies responsible for the Public Health Assessment. In addition to the California Department of Health Services Environmental Health Investigations Branch and the Agency for Toxic Substances and Disease Registry, the Site Team includes LLNL, regulatory agencies, community members and stakeholders. The Site Team process should allow for full participation of the community, through public meetings, and other outreach and education efforts.

The comments from the DOE Tiger Team report from 1990 did not apply to the LLNL CERCLA Environmental Restoration Program. The Environmental Restoration Division (ERD) program in 1990 was a stand alone, separately funded program being implemented under a CERCLA Federal Facility Agreement with EPA and the state of California and in compliance with all applicable state and federal regulations governing the assessment and cleanup of contamination.

Since the Tiger Team visit, LLNL has worked to upgrade its environmental operations to address all issues identified in the Tiger Team Report. A follow-up review determined that all issues specifically identified in the 1990 report had been resolved. In addition, the follow-up team noted LLNL's commitment to environmental stewardship and called the environmental program "excellent".

DOE/LLNL volunteered to develop this sampling plan and implement it with EPA. The plan was developed in consultation with EPA, CDHS, and other regulatory agencies and will be approved by EPA and CDHS before implementation, as was the 1995 sampling. In addition, DOE/LLNL either addressed community (including the Site Team) comments in the plan or respond to them in this Responsiveness Summary. The Draft Final Livermore BTP 1998 Soil Sampling Plan will be released to the public, and a community workshop will be held after the release to explain the plan. When the plan is implemented, ATSDR and EPA will collect split samples

as independent verification. Samples will analyzed by an independent, EPA-certified analytical laboratory. All agencies and the public are invited to witness the sampling. The final report will show the analytical results of all samples analyzed.

DOE should fund the services of an independent expert as a consultant to the LLNL Public Health Assessment process, including the environmental sampling plan. The contribution of an independent expert with 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 Public Health Assessment at LLNL. Dr. Owen Hoffman, of SENES, Oak Ridge, TN is an example of the type of consultant that is needed.

F. Owen Hoffman of SENES Oak Ridge, Inc. was funded to provide independent scientific review of the draft BTP sampling plan. His comments and DOE/LLNL responses are presented in Section 6.7. If ATSDR feels that the Livermore community needs an independent scientific consultant to provide additional review of technical documents, ATSDR can make the decision to use it's DOE public health assessment funds for that purpose.

II. Scope of Follow-up Environmental Sampling

The Lab does not adequately incorporate community concerns about the nature and extent of plutonium in the Livermore environment. The absence of input from the affected community and the public health agencies responsible for assessing the health impacts of LLNL has resulted in a plan to collect a large number of soil samples that may be unable to answer conclusively the larger questions posed by the CDHS/ATSDR Health Consultation on Big Trees Park. The objectives of the sampling plan must be clearly linked to the questions raised by the CDHS/ATSDR Health Consultation on Big Trees Park, i.e., by what pathways, and to what extent, did plutonium travel from the Lab into the Livermore community?

The goal of future environmental sampling and other follow-up activities must be to demonstrate with reasonable certainty whether or not there has been potential harm to community health by operations 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. 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.

Past radiological studies at BTP have resulted in the highest plutonium concentrations being 1.0 pCi/g, which is 40% of the Preliminary Remediation Goal (PRG) of 2.5 pCi/g. The PRG was established by EPA to be an acceptable risk level. This sampling plan's scope is limited to soil sampling at Livermore's Big Trees Park to assess the following:

1. Extent of elevated plutonium concentrations both laterally and vertically.

2. Possible pathways by which plutonium came to BTP.

3. Public risk associated with plutonium at BTP given current and future land uses.

If additional sampling outside of BTP is warranted, a sampling plan specifically designed to address that sampling will be written.

DOE/LLNL perform a variety of activities to determine public impact from LLNL Operations. The results of these activities are reported in the Annual Environmental Reports.

Leakage from Sanitary Sewer Lines

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 may also be a source of plutonium in Big Trees Park. A 1987 DOE study 2, 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 [Livermore Water Reclamation Plant]. 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 sewerlines." (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)

A soil and/or water pathway from exfiltration of hazardous materials from the LLNL sanitary sewer lines both on-site and off-site must be investigated. In addition to the Lab documents quoted above, CDHS reported in a May 5, 1998 Site Team meeting that a former Livermore Water Reclamation Plant employee recalled a rupture in the early 1970s of a sewer line from LLNL's Radiation Lab, and that the sewer line may run near Big Trees Park and the Arroyo Seco. The question, do, or have sanitary sewer lines ever run beneath Big Trees Park must be addressed prior to environmental sampling.

> After an investigation that included review of historical records and interviews with LLNL staff responsible for the construction and maintenance of sewer lines, it was determined that the sewage line discussed in this comment was connected to an administrative building that was located outside the controlled area of LLNL and flowed north along Vasco Road. This sewer line does not cross Arroyo Seco, and therefore, is not a likely pathway for plutonium to have traveled from LLNL to BTP.

Community members have recently observed activities that have resulted in considerable movement of soil in Big Trees Park. The soil and sediment in the Arroyo Seco channel has also been significantly disturbed in the past. These historical and apparently on-going disturbances to the soil in Big Trees Park will significantly confound the results of any environmental sampling plan if they are not properly accounted for. The plan should clearly consider these soil disturbances in deciding where soil samples are taken and how the results will be interpreted.

> DOE/LLNL are aware that soil disturbances, such as disking, occurred and that some of the proposed samples will be collected from disrupted areas. The locations in the Draft Final Livermore BTP 1998 Soil Sampling Plan have been discussed and agreed among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR. A discussion of collecting samples for background determinations from disturbed areas is included in Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

The long vertical sampling interval in the Lab's plan (5-50 cm) is the equivalent of a vertical composite sample. This long interval may result in an understanding of the "average" level of

plutonium in the sample, but it is an understanding of the range of plutonium levels that is of interest. Sampling for the "average" may result in missing any additional "hot spots" of plutonium that may be present in Big Trees Park.

The depth intervals have been changed to 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm for the grid sample. Samples collected from Locations 1, 7, and 8 from the 1995 sampling will be sampled at 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, and 40-85 cm.

Other Locations for Environmental Sampling

In addition to Big Trees Park, soil tested in 1994 at Sycamore Grove and Sunflower Street parks was 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 random soil samples at all three parks 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 our 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. Additional sampling must be conducted in Sunflower Street and Sycamore Grove Parks to demonstrate to the community with reasonable certainty 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 the USEPA's 1994 findings.

This sampling plan's scope is limited to soil sampling at Livermore's Big Trees Park to assess the following:

1. Extent of elevated plutonium concentrations both laterally and vertically.

2. Possible pathways by which plutonium came to BTP.

3. Public risk associated with plutonium at BTP given current and future land uses.

One of the objectives of this study is to further evaluate the three pathways (air, sludge, arroyo), all of which offer a different explanation for how plutonium may have been deposited at Big Trees Park.

If additional sampling outside of BTP is warranted, a sampling plan specifically designed to address that sampling will be written. DOE/LLNL will work closely with EPA and the state agencies to determine if follow-up activities are necessary based on the results of this sampling.

The statement that plutonium in Sycamore and Sunflower parks is above fallout is based on a comparison with values in an EPA draft document whose authors specifically stated, "Do not cite." In addition, the draft report clearly stated that the values were subject to change. The values are not directly based on measured values, but indirectly derived. The authors of this report have described these values to us in a phone conversation as generic, and not appropriate for use as a site specific background.

Soil sampling should be conducted 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.

DOE/LLNL collect soil samples as part of their routine surveillance monitoring program in locations around the laboratory, including east of the Livermore Site and at Site 300. These samples have not exceeded the Preliminary Remediation Goal (PRG) and are usually found to be comparable to background concentrations. The results of this routine monitoring are published in the Site Annual Environmental Report.

The sampling grid in Big Trees Park is insufficient. It should be denser, and a standard grid should be used, including more sampling of the playing field, disked area, and eastern extension of the park..

The grid location in the Draft Final Livermore BTP 1998 Soil Sampling Plan was agreed to among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR.

As discussed in the Draft Final Livermore BTP 1998 Soil Sampling Plan, eight additional locations will be sampled near Location 1 of the 1995 sampling effort (Section 3.3.1), four location will now be sampled in the disked area (Section 3.3.2), two locations will now be sampled in the playing field (Section 3.3.3), and three locations will now be sampled in the eastern extension of the park (Section 3.3.4).

Plutonium-Laced Sludge Grid

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. 3 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". 4

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. 5 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. ... "

An undated summary report of a May 1987 plutonium release 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 back ground) adjacent to LWRP may make it difficult to measure the impact of the recent sludge on the soil environment".

Follow-up must incorporate 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 . In the absence of a logbook or other credible evidence of where the plutonium-laced sludge went, community members should be offered the option of testing their household soil at no cost to them. 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. An air pathway from sludge piles at LWRP should be investigated.

The highest plutonium concentrations identified at Big Trees Park from soil sampling are about 1.0 pCi/g, less than half (40%) of the EPA established a Preliminary Remediation Goal (PRG) of 2.5 pCi/g. The PRG is a risk level which EPA considers acceptable. One of the objectives is to determine if the sewage sludge used as soil amendment during tree planting could have contained plutonium above an acceptable risk level. The areas that might reasonably contain soil sludge (around the ornamental trees) will also be analyzed for chromium, copper, lead, nickel, zinc, and americium-241.

The sampling plan's scope is limited to soil sampling at Livermore's Big Trees Park. The samples collected will help evaluate the air pathway as discussed in Section 3.1.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

If additional sampling outside of BTP is warranted, a sampling plan specifically designed to address that sampling will be written. DOE/LLNL will work closely with EPA and the state agencies to determine if follow-up activities are necessary based on the results of this sampling.

Methods and Analyses

There may be alternative methods for measuring environmental levels of plutonium that may be useful to follow-up efforts. 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 applicability of these and other potential approaches to environmental sampling for plutonium must be investigated and incorporated into the plan as appropriate.

> Because samples will be analyzed for both Pu-239+240 and Pu-238, these reported isotopic ratios will be available for analysis. Discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR resulted in a decision to also analyze for Am-241 in the surface grid samples and samples from the ornamental trees.

Plutonium may only be a tracer or indicator of other emissions of public health concern. This possibility must also be taken into consideration when planning future environmental sampling strategies. In addition to plutonium, soil samples should be tested for other radiologic chemicals and other possible contaminants such as lead, mercury, arsenic, cadmium, chromium, nickel, copper, zinc, etc.

> The surface grid samples will also be analyzed for americium-241, and samples collected from the ornamental trees will also be analyzed for chromium, copper, lead, nickel, zinc, and americium-241. Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents the sample sets, depths, number of locations, and analyses.

III. Interpretation of Results

The Lab's plan limits the investigation to the narrow issue of levels of plutonium in Big Trees Park. Even within the confines of this question, the Lab does not clearly indicate how the results of the soil samples collected will be interpreted. The Lab makes assumptions on behalf of the community as to what is "acceptable risk".

> DOE/LLNL defer to the EPA with respect to establishing risk based goals for remediation. DOE/LLNL do concur that the PRG is adequately protective of human health. A short description of process by which the PRG has been developed has been provided in this response to Owen Hoffman's Comment No. 4 (Section 6.7 of this Responsiveness Summary).

The Lab has redefined the problem of plutonium in the community by redefining global fallout levels to be double what the Lab and USEPA have stated it to be in the past (from 0.01 to 0.02 pCi/g), and 20 times higher than the lower range of global fallout levels cited in the CDHS/ATSDR Health Consultation (0.001 pCi/g). The effect of the Lab's raising the estimate of global fallout is to permit two to 20 times more contamination to be attributed to nuclear weapons testing rather than to Livermore-based Lab operations. In addition, global fallout levels used as a measure of "background" plutonium contamination levels must be defined from areas sufficiently distant from the Lab to be unaffected by LLNL/Sandia operations.

> Background information should come from locations unaffected by a potential source, but they also have to be close enough to be comparable in terms of other factors such as rainfall, topography, large scale wind flow patterns, location relative to above ground nuclear tests, etc. Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan contains a more thorough discussion of fallout background concentrations for Pu-239.

The plan does not, and must, clearly specify how the sampling methodology is linked to the objectives of the plan, and how the results will be analyzed and interpreted. For example, the Lab as a basis for further action or comparison specifies at least three concentrations of plutonium in soil: 1pCi/g, 2.5 pCi/g and 0.02 pCi/g:

Page 1. "If new surface soil sample results exceed the 1 pCi/g found in 1995 (for which risk estimates have already been performed), then regulatory agencies will have a basis for further actions necessary for determining whether or not plutonium concentrations pose an acceptable risk to human health or the environment."

Page 3. "The results of this effort [at Big Trees Park] may indicate that additional sampling is appropriate, or that measures need to betaken to protect public health (see section 11)." p22. Section 11: "The EPA has determined that for residential areas , plutonium concentrations in soil below the Preliminary Remediation Goal (PRG) of 2.5 pCi/g do not present an unacceptable risk to human health or the environment. The EPA has also determined that plutonium concentrations in soil above the PRG indicate that remediation is warranted (Gill 1998). Given these regulatory standards, if plutonium concentrations measured by this sampling effort are below the PRG, then it will be deemed that no unacceptable risk to human health or the environment exists at Big Trees Park and no further action is required. However, if concentrations above the 2.5 pCi/g value are detected, then DOE/LLNL commit, with regulatory agency concurrence, to removing soil exceeding the PRG and disposing of it in accordance with applicable state and federal regulations."

p15. "Some of the analyses of the results of this sampling effort will include comparisons with "background", that is, comparison with an estimate of what the plutonium concentrations in soil in Big Trees Park could be if there were no impact from LLNL operations. ... All three documents demonstrate that 239+240 Pu concentrations in soil as high as 0.02 pCi/g, and possibly slightly higher, are within the range of fallout background for the Livermore Valley."

> The three concentrations cited represent different conditions, actual measurements, the PRG, and background, and are not directly comparable. DOE/LLNL defer to the EPA with respect to establishing risk-based goals for remediation. DOE/LLNL do concur that the PRG is adequately protective of human health.

In another example, the plan specifies sampling nine locations in the present channel upstream of Big Trees Park. Are the chosen locations where the channel has been modified in the past or recently ? Why was a depth of 25 cm chosen ? CDHS reported that other LLNL sediment sampling identifies 45 cm as the appropriate depth.

> In the draft plan, 25 cm was chosen as an estimate of possible sediment depth. LLNL changed sampling depths 5 years ago in the belief that shallower sampling would do a better job of detecting releases from LLNL. The CDHS-EHIB statement that LLNL should still be using the 45 cm depth did not affect the validity of the method. In the Draft Final Sampling Plan, the sample depths vary from 5 to 25 cm as agreed to by DOE/LLNL and the regulatory agencies.

Consider the following statements in the Lab's plan:

p4. "The arroyo samples, set 2, will be collected for the purpose of determining if the arroyo pathway is the most plausible explanation for elevated plutonium concentrations in soil observed in Big Trees Park."

p 6. " Sediment samples will be collected from the present Arroyo Seco and its banks. The purposes of these samples are (1) to evaluate on-going arroyo-borne impacts, if any, of LLNL, and (2) to help decide whether the arroyo pathway is the most plausible explanation for the elevated plutonium concentrations in soil observed at Big Trees Park."

p10. "There are two decisions made to be made using these samples: (1)do plutonium concentrations increase with depth in arroyo sediments, and(2) are current plutonium concentrations in arroyo sediments large enough to indicate either (a) an on-going release at levels sufficient to account for the plutonium levels seen in Big Trees Park location 1, or (b) an on-going release at levels greater than that indicated by annual surveillance monitoring results.

p11. "The depth profile decision will be made by performing a statistical hypothesis test, comparing surface concentrations with subsurface concentrations. If there is no depth trend, then the differences between the surface and subsurface should be random, that is positive or negative with equal likelihood. ... po [the proportion of all possible sediment locations with subsurface plutonium concentration greater than surface plutonium concentrations] will be estimated from the analytical results by calculating the proportion of locations where the subsurface sample result is greater than the surface sample result and neither result is within the 2-sigma uncertainty range of the other. If the alternative hypothesis [there is a depth trend] is correct then most or all [defined as 90%] of the sediments in the arroyo should have plutonium concentrations increasing with depth.

The plan appears to be saying in the above statements that to prove that the Arroyo Seco is a pathway, 90% of all 9 samples collected the arroyo sediments should have subsurface plutonium concentrations greater than surface plutonium concentrations and that neither result can be within the 2-sigma uncertainty range of the other. On page 17, the Lab's plan states that the uncertainty for soil concentrations between 0.005 and 0.01 can be "less 100%". This appears to set an extremely high burden of proof for the Arroyo Seco pathway. On what basis has the Lab determined that most or all of the sediments in the arroyo should have plutonium concentrations increasing with depth if the arroyo is or has been a pathway ? If this is not what the Lab's plan is stating, please state clearly how the sampling results will be interpreted. Please specify what does it mean to prove the null hypothesis. Please state how a "depth trend" analysis of arroyo sediments can be useful in characterizing an arroyo pathway.

In the draft plan there were actually two distinct questions being addressed: do concentrations increase with depth, and are concentrations higher than expected. Only the latter has to do with the pathway question.

The subsurface arroyo samples in the draft BTP Sampling Plan were in response to the draft Public Health Consultation's assertion that plutonium concentrations may increase with depth in the park. Since submitting the draft BTP Sampling Plan, DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR have agreed to only collect surface samples from 0-5 cm in three locations, and 0-25 cm in four locations near the park, as presented in Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The 0-25 cm depth is at the request of CDHS-EHIB.

As a matter of statistical theory, the outcome of a formal statistical test is never to "prove" the null hypothesis. It is either "reject the null hypothesis" or "fail to reject the null hypothesis." With regard to "burden

of proof," it is intrinsic to the nature of statistical tests to require strong evidence before rejecting the null hypothesis.

Many community members expressed concern at the February 25, 1998 Site team meeting about the assumptions and conclusions of ATSDR's risk assessment of the hot spot in Big Trees Park. Although the community is concerned by the 1 pCi/g level of plutonium measured at this location, the Lab states that plutonium at two and one-half times this level (2.5 pCi/g) will indicate "... that no unacceptable risk to human health or the environment exists at Big Trees Park and no further action is required".

However, there is general agreement among scientists that there is no threshold dose of radiation below which cancers or genetic damage do not occur. Moreover, 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. In addition, 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 [1 pCi/g) 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.

A public process by which agreement can be reached as to what is the definition of "acceptable risk" must be initiated. All risk assessments used in the interpretation of environmental sampling results must clearly state an estimate of the number of people who will die from cancer over time from ingestion and inhalation of plutonium in soil at both the 1.0 pCi/g and the 2.5 pCi/g levels. All uncertainties in risk assessment methodology, especially surrounding the current scientific debate about exposure to low-level radiation, must be presented. All the assumptions on which the risk assessment is based must be presented to the public. The assumptions that dominate the uncertainty in the risk assessment should be clearly identified.

Based on EPA standards, CDHS-EHIB's assessment as well as national and international radiation protection standards, the risk from the concentrations of plutonium 239 found at BTP is clearly below 1-in-a-million cancer risk over the maximally exposed person's lifetime. Although each person may have their own threshold for tolerable risk, 1-in-a-million risk level is used by public health agencies as the action level

to determine the need for further analysis and/or remediation. The sampling will provide additional information to determine whether that conclusion is appropriate, but currently there is no information to support that the risk from plutonium at BTP represents a regulatory unacceptable risk to the public using the park.

IV. Funding

Recommended public health follow-up activities are an equal priority with "clean-up" at LLNL. It would be a perversion of the CDHS/ATSDR public health efforts if the community were to be told that they must choose between discovering the health impacts of the Lab and clean-up efforts, because DOE will not fund both activities at adequate levels. If not from "clean-up", where will the money come from? DOE is currently funding LLNL to build the most expensive element of the DOE "Stockpile Stewardship and Management" Program, a megalaser that will produce contained thermonuclear explosions, providing data for the "advance" of nuclear weapons science. Known as the National Ignition Facility, DOE estimates total construction and operational costs of the installation through a 30-year lifetime to be $4.5 billion. A $250,000 sampling plan is a "pittance" compared to the cost of the National Ignition Facility. The National Ignition Facility will cost taxpayers $17,124 every hour for the next 30 years. Therefore a $250,000 sampling program is equal to 14.6 hours of National Ignition Facility's lifetime cost.

DOE is funding the CERCLA cleanup program, ATSDR health assessment activities, and this additional sampling of Big Trees Park. DOE/LLNL will meet all CERCLA Federal Facility Agreement milestones in Federal Fiscal Year 1998 and also will attempt to complete the sampling at BTP this summer.

Finally, given the substantive nature of our comments, and the comments of other Site Team members and the public during the May 13, 1998 community meeting, it is crucial that a second draft of the sampling plan be developed and publicly reviewed prior to its implementation. It would be a travesty if, due to a failure to seek or to heed public input, substantial funds were expended to produce data that are not credible to the public, and fail to address community concerns.

Comments are incorporated into the Draft Final Livermore BTP 1998 Soil Sampling Plan, or are addressed in this Responsiveness Summary. A public workshop will held upon the release of the Draft Final sampling plan in which the public, the agencies (EPA, CDHS-RHB, CDHS-EHIB, and ATSDR), and the designers of the sampling plan will be free to discuss the content and issues associated with the plan.

6.6. Pritikin Comments and DOE/LLNL Responses

I. Purpose of the Proposed Sampling Plan

Comment l. *Expand Currently Stated Purpose: The stated purpose, as presently written, of the sampling plan, reads (see page 1 of draft Sampling Plan of 4/10/98):*

"The purpose of this 1998 sampling effort is two-fold: (l) to gain information about possible pathways by which plutonium reached Big Trees Park, and (2) to gain information about the possible presence of plutonium in soil deeper than 5 centimeters."

a. This purpose statement must be rewritten to include the following additional purposes:

(l) to assess levels of plutonium and potentially accompanying heavy metals and radionuclides present in Big Trees Park, and all other areas listed within the revised, publicly-responsive scope of the sampling plan (see revised scope of Sampling Plan, discussed below).

(2) to recommend follow-up assessment, by appropriate agencies, with independent oversight, of potential health impacts of exposure to offsite populations to contaminants found to be at levels above "acceptable risk" levels as defined through consensus of regulatory agencies and concerned public stakeholders. Note that this may not necessarily be the same "acceptable" risk level proposed by the Lab in its draft sampling plan.

This Sampling Plan must not serve, as currently drafted, to focus upon regulatory compliance without consideration of potential health impact of offsite exposures to contaminants found, through this sampling plan, to be at levels above "acceptable risk" as defined through a process involving open public discussion, acceptance, and input.

The scope of the Draft Final Livermore BTP 1998 Soil Sampling Plan was agreed on among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR. The objectives have been redefined and are presented in Section 1.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

DOE/LLNL defer to EPA with respect to establishing risk-based goals for remediation. DOE/LLNL concur with the EPA that the PRG is adequately protective of human health.

II. Scope of the Proposed Plan

In order for this sampling plan to be perceived as credible by the public, the scope of the plan must reflect the relevant concerns expressed by the public (both public site team members and the public at large), regulatory agencies, our citizens' independent consultant, and other stakeholders.

Comment l. *Re-title Sampling Plan as follows: "LAWRENCE LIVERMORE NATIONAL LAB 1998 OFF-SITE SOIL SAMPLING PLAN."*

The Title and scope of the plan should reflect the true scope of public concern, not just the narrow subcomponent of public concern currently expressed within the proposed title: "Livermore Big Trees Park 1998 Soil Sampling Plan."

> This sampling plan's scope is limited to soil sampling at Livermore's Big Trees Park to assess the following:
>
> 1. Extent of elevated plutonium concentrations both laterally and vertically.
>
> 2. Possible pathways by which plutonium came to BTP.
>
> 3. Public risk associated with plutonium at BTP given current and future land uses.

Comment 2. *Expand the analyte list to be sampled: The sampling plan should expand the analyte list to include heavy metals and other radionuclides which may accompany Pu- for which Pu may be a tracer (see as well EPA Sampling Plan recommendations, page 3). CADHS comments on draft sampling plan also recommend sampling for a number of heavy metals and radiologic constituents including: arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc, Am-241, cesium-137, strontium-90, cobalt-60, gallium, potassium-40, and plutonium-238. As stated within EPA comments on the draft sampling plan; "Broad spectrum heavy metal analysis would require no more sampling effort but would expand the analytic costs for each sample. This cost would be outweighed by the ability to correlate and clearly define that each of the proposed pathways are truly being sampled."*

note: As one of the stated purposes of the Sampling Plan is that of determining potential exposure pathways of contaminants in question, it may be helpful to determine ratios of Pu-238 with respect to Pu-239/240 concentrations in order to better differentiate fallout-derived contaminants from LLNL-originating contaminants. Discussion of the isotopic ratios should be included within data evaluation strategies to be employed (see discussion of Sample Data Interpretation, Section VI, below).

Surface samples collected on the grid will also be analyzed for americium-241. Samples collected at the ornamental trees will be also sampled for chromium, copper, lead, zinc, nickel, and americium-241.

Because samples will be analyzed for both Pu-239+240 and Pu-238, these reported isotopic ratios will be available for analysis. Discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR resulted in a decision to also analyze for Am-241 in the surface grid samples and samples from the ornamental trees.

Without a thorough study of both the expected ratio and its variability, interpretations of the ratio results will not be a reliable indicator of contamination. Such an study would have to be performed before the results of the sampling are analyzed, but is beyond the scope of this sampling plan.

Comment 3. *Sampling Plan Must Address Areas of Expressed Public Concern: for this sampling plan to be credible in the public eye, the plan must include appropriate sampling in the following locations, additional to Livermore's Big Trees Park:*

a. any other parks of public concern within Livermore proper.

b. any school grounds of public concern.

c. any other outdoor areas of public concern within Livermore proper where children frequent.

d. areas "downwind" of LLNL (i.e.-to the east)

e. areas in which Pu-laced sludge may have been distributed:

In conjunction with this sampling plan:

l) good faith efforts must be made to locate the sludge distribution book.

2) I advise consideration of a plan in which residents of Livermore Valley, who in good faith believe they or their predecessors at their residence may have received Pu-laced sludge for yard work, should be offered free or very, very low costs testing of soil from their yards.

(a) Livermore Valley residents certificate program: re the program suggested above, it might be extremely useful to homeowners if they could receive a certificate from the City or another official entity stating that their yard soil has been tested, and it is beneath a defined level of Pu and accompanying analytes concentration. This might

help address the issue raised by homeowners of plummeting property value- due to the fact that presently, homeowners if asked can only say that they do not know the concentration, if any, of these analytes, including Pu, within their yard soils.

(b) in the situation in which "x" (to be defined) amount of Pu (or other analytes) is found within the soil tested, soil will be replaced to a depth of "y" (depth to be defined), and (here's an interesting issue!) (here we will need some public policy discussion)- how will residents in this situation be reimbursed for yard damage, plant removal, etc?

f. areas in which sewage lines may have ruptured, resulting in potentially contaminant-laden leaks.

Additional sampling outside BTP: The sampling plan's scope is limited to soil sampling at Livermore's Big Trees Park If additional sampling outside of BTP is warranted, a sampling plan specifically designed to address that sampling will be written. DOE/LLNL will work closely with EPA and the state agencies determine follow-up activities are necessary based on the results of this sampling.

Sampling to "downwind" of LLNL: DOE/LLNL collect soil samples as part of their routine surveillance monitoring program in locations around the laboratory, including east of the Livermore Site and at Site 300. The results of this routine monitoring are published in the Site Annual Monitoring Report.

Areas where sludge has been distributed: DOE/LLNL have asked the Livermore Water Reclamation Plant (LWRP) about the disposition of sludge from LWRP. The LWRP responded that they have no records indicating the disposition of sludge from 1961 to the mid-1970s.

Sewer Lines rupture: After an investigation that included review of historical records and interviews with LLNL staff responsible for the construction and maintenance of sewer lines, it was determined that the sewer line discussed in this comment was connected to an administrative building that was located outside the controlled area of LLNL and flowed north along Vasco Road. This sewer line does not cross Arroyo Seco and therefore, is not a likely pathway for plutonium to have traveled from LLNL to BTP.

Comment 4. *Note: the "objectives" statement on page two of the draft sampling plan needs to be amended to includes all of the components of public concern, indicated above, within the definition of "scope."*

The objectives have been redefined, as presented in Section 1.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

III. Independent Contractor Should Carry Out Sampling Plan

It has been raised frequently in public discussion that it is inherently without credibility for the same entity (LLNL/DOE) which created the off-site contamination to be the entity carrying out the sampling plan for those contaminants.

The suggestion is that an appropriate independent entity be contracted to design and implement this sampling plan, within the budget currently allotted for this plan.

DOE/LLNL volunteered to develop this sampling plan and implement it with EPA. F. Owen Hoffman of SENES Oak Ridge, Inc. was funded to provide independent scientific review of the draft BTP sampling plan. His comments and DOE/LLNL responses are presented in Section 6.7. The Draft Final Livermore BTP 1998 Soil Sampling Plan has been designed with the significant contribution of EPA, CDHS/RHB, CDHS/EHIB, ATSDR and other organizations and individuals through written comments, meetings and/or telephone conferences. The plan will be implemented with EPA and CDHS/RHB specialists in the field during sample collection to observe operations. They will also collect split samples and send them to an independent laboratory for analyses. They will also be involved in the data analysis and interpretation.

IV. Historical/Background Information Within The Sampling Plan

The plan should provide detailed historical information regarding the dates of possible releases from LLNL, full range of potential contaminant/s in question, quantities of contaminants released, and probable pathways offsite. Logically, then, meteorologic patterns seen in the area should be described.

This section should also include a discussion of community and regulatory agency concerns which led to this 1998 Sampling Plan.

A chronology of plutonium releases from LLNL are presented in Appendix B of the Draft Final Livermore BTP 1998 Soil Sampling Plan. A windrose has been added to Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan to show meteorological wind patterns around LLNL. In addition, Chapter 1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents the background for this sampling plan, which

includes a discussion of regulatory conclusions and community concerns. The EPA Fact Sheet is also included as Appendix A.

V. Specifics of the Sampling Plan

Comment l. *Sampling Methods: It has been suggested that a combination of sampling techniques be employed. The currently suggested method of sampling involves a fairly lengthy core which is then mixed together, causing an averaging effect, and a dilution of any areas of higher concentration.*

a. It is recommended that two techniques be employed instead of the suggested long-interval homogenization method, or supplemental to the long-interval core homogenization method:

l) Alpha Track Analysis of an Intact Core- Dr. Hoffman provided some information on this technique, a method which could also provide substantial savings in cost over the method suggested in the plan.

2) slices of the core sample: it was also suggested by a number of people that, in order to avoid diluting the concentration of a core sample through homogenizing a longer interval sample, slices of the core should be analyzed at areas of concern.

As agreed among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, the sampling intervals have been revised to be shorter as presented in Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

To our knowledge, alpha track analysis is normally performed with soil spread out in a fairly thin uniform layer. Alpha track analysis of an intact core would employ a very different geometry, with alpha particles from different parts of the core traveling different distances to the recording film. This would greatly complicate the measurement of the tracks. Without considerably more research, we think this method is unlikely to provide useful results.

Comment 2. *Numbers of samples to be taken, location of samples: please refer to the scope of the sampling plan comments contained previously within my comments re geographic areas to be sampled. The question then becomes one of numbers of samples and depth of these samples. I defer to our consultant, and the stakeholder agencies for determination of the most appropriate placement and number of samples to be taken.*

Sample locations and number of samples have been determined in consultation with the regulatory agencies, and are presented in Chapter 3 and Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 3. *Recommendation Against Sampling Disturbed Areas: as advised within agency comments I have reviewed, areas which have been disturbed since previous sampling should not be sampled at this time, as results might be significantly misleading due to soil disturbance and resultant changes in concentration of any contaminants within these areas. These areas include parts of Big Trees Park, areas of the Arroyo, areas of the Arroyo Seco schoolyard (and, possibly other areas I have not been made aware of).*

Sampling in any area reflects the condition of the area at the time of sampling. DOE/LLNL are aware that soil disturbances, such as disking, occurred and that some of the proposed samples will be collected from disrupted areas. The locations in the Draft Final Livermore BTP 1998 Soil Sampling Plan have been discussed and agreed among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR.

Comment 4. *Samples within Arroyo Seco: it was difficult, as a member of the public, to understand the rationale behind the way the sampling grid or plan was developed for sampling within the Arroyo Seco. A more clearly presented rationale needs to be described.*

A discussion clearly describing the sampling grid is provided in Section 3.2.2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 5. *Analytic Labs: more than one lab should cross-check results of sample analysis. This is not currently recommended, to the best of my knowledge, within the draft sampling plan.*

The EPA and the ATSDR have informed us that they will be taking split samples. This is now discussed in Appendix C of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 6. *I would like to recommend that any members of the LLNL Site Team who may wish to be present during sampling be invited to do so.*

Members of the Site Team as well as any interested party are invited to be present during the sample collection but must abide by safety controls that will be in place. Additionally, EPA and CDHS/RHB will have personnel on-site during part or all of the sampling.

VI. Interpretation of Sample Analysis

Comment 1. *Reflecting the concerns voiced by members of the public and others, sample results should be interpreted in order to provide to the concerned public, regulatory agencies, and interested others, easily understandable information as to how the levels of analytes found might impact upon the health of those who may come in contact with these contaminants, in the case of a potentially completed exposure pathway. The raw data of sample results must be taken forward into health risk analysis, with full disclosure of uncertainties in the process.*

a. individuals with public health background would be most appropriate as authors of this component of the sampling plan (as vs authors geared to comply with regulatory agencies rather than with public health concerns).

The sample results and raw data will be made available to all interested parties. The Draft Final Livermore BTP 1998 Soil Sampling Plan was developed with the involvement of EPA, ATSDR, CDHS-EHIB, and CDHS/RHB and community input. The sampling plan will use the conservatively developed, risk-based PRG as a potential decision point that DOE/LLNL and the regulatory agencies will determine whether additional work is warranted at BTP. If no samples are found above the PRG for Pu-239, exposure is significantly less than 1-in-a-million cancer risk over the maximally exposed person's lifetime.

Comment 2. *With regard to this interpretation of sample analysis, the following should be provided:*

a. Possible health impact of additive exposure to contaminants, with "background" levels of these contaminants added in, rather than used as comparison levels.

l) note that this eliminates the problem of "background" levels being defined from within geographic areas close enough in to have been affected by LLNL or possibly, Sandia, operations.

By considering the (often varying) background levels as a component of overall estimated dose, and thereby, of estimated risk, health impact is more realistically assessed.

b. Special health concerns with regard to additive exposures to these contaminants of children, those with other special health considerations (i.e., those with impaired immune function).

c. Remediative action recommended (e.g. dose reconstruction, removal of contaminated soil, further sampling in certain areas, health advisories, signage in certain areas of Livermore)

Note: On page 1 of the draft Sampling Plan it states as follows: "there is no current health risk." This language should be removed from the draft sampling plan, because there is potential that humans may come in contact with the contaminants in question, and this requires a statement reflecting the fact that, with regard to ionizing radiation, there is no threshold below which the risk due to exposure is nil.

All regulatory and public health agencies agreed that the levels of plutonium found in Big Trees Park present an acceptable level of health risk.

We are not currently planning to perform a "Baseline Risk Assessment" for the park covering all materials of potential concern. There are many materials that could occur in BTP that could present risk to the community that are either naturally occurring or are due to anthropogenic activities not associated with LLNL operations. DOE/LLNL is responsible for, and is funded to perform assessment and remediation of materials that they have released.

If additional sampling outside of BTP is warranted, a sampling plan specifically designed to address that sampling will be written. DOE/LLNL will work closely with EPA and the state agencies to determine if follow-up activities are necessary based on the results of this sampling.

VII. Sampling Plan Appendices

Comment l. *Include glossary of terms, explanation of methodology (public friendly), and define all abbreviations used.*

An acronym list has been added in Appendix F of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 2. *Include all comments received from public members of the LLNL ATSDR Site Team, from all other agency and regulatory body members of the Site Team, from the citizens' independent consultant, and from the public. For each such comment, include the specific response to that comment.*

This Responsiveness Summary responds to all comments received from EPA, CDHS-RHB, CDHS-EHIB, ATSDR, and other stakeholders.

General Comments

I strongly recommend that the final Sampling Plan, once the next draft is reviewed and comments received and incorporated, should be presented in a public forum, and questions taken from those in attendance. It would be most useful if all members of the Site Team, LLNL authors of the Sampling Plan, and the independent consultant could be present to answer the public's concerns.

> We agree that the plan should be discussed in a public forum. DOE/LLNL plan to hold a Public Workshop to discuss the Draft Final Livermore BTP 1998 Soil Sampling Plan.

6.7. F. Owen Hoffman's Comments and DOE/LLNL Responses

Comment 1. *In general, the plan does not appear in its current form to support its stated objectives, namely, to determine the mechanisms as to how plutonium was transported from LLNL to Big Trees Park. My impression is that the sampling plan is currently designed to determine whether or not the concentrations of plutonium are below pre-established limiting values.*

Recommendation: The plan should be revised to clearly show how results obtained from the samples will be used to determine the mechanisms of offsite transport to Big Trees Park.

> The objectives have been redefined as identifying the pathway and extent of plutonium in BTP (Section 1.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan). A discussion is also included in Draft Final Livermore BTP 1998 Soil Sampling Plan for data analysis and interpretation of each sample set.

Comment 2. *Many of the citizens with whom I met on the evening of June 10th and the afternoon of June 11th, 1998 were concerned that the sampling plan was too narrowly focused. The plan is presently focused on identifying the pathways (air, sewage sludge, or Arroyo Seco sediment) by which plutonium may have been transported from LLNL to Big Trees Park. There is a general desire for a more comprehensive sampling plan that would provide comprehensive data from which public health agencies would be able to assess the nature and extent of off site exposures to Livermore residents resulting from present and historic operations at LLNL.*

Recommendation: A discussion should be included in the sampling plan to show how the results from this investigation will be included into an overall plan designed to characterize the nature and extent of off site contamination originating from LLNL over the history of its operation.

The plan should clearly define the questions it is designed to answer and the questions it cannot answer. For those questions related to the public health impact from past releases of contaminants from LLNL, the plan should reference what other activities are in place to address these broader issues of concern to the public.

> Risk management decisions will be primarily focused on comparison with EPA's most conservative risk-based standard, the Residential Preliminary Remediation Goal (PRG), for plutonium in soil. This PRG is discussed in Chapter 5 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. Public health impacts of LLNL operations are assessed and reported in the Site Annual Environmental Reports, Environmental Impact Statements, Public Health Consultations, epidemiological studies performed by state agencies, and various special studies.

Comment 3. *The sampling plan states that its purpose is to characterize the nature and extent of contamination of Pu and other LLNL radionuclides and chemicals that may have been transported to Big Trees Park. Samples may be analyzed for Pu-238, Cs-137, Am-241, Co-60 and metals typical of sewage sludge.*

If multiple contaminants exist in Big Trees Park, the assessment of potential health effects will be more transparent if the total health risk from exposure to multiple contaminants were estimated explicitly rather than merely comparing a measured soil concentration to a derived concentration limit.

Recommendation: Measurements of contamination in soil should be carried through to estimate the potential for inhalation and ingestion of plutonium and other contaminants. This process should be extended to include an estimate of tissue dose (in the case of radionuclides) and an overall estimate of the risk of adverse health outcomes.

For a health risk assessment the following estimates are needed:

(a) the average soil concentration for all contaminants detected in a defined area,

(b) the assumptions that determine the nature and extent of human exposure leading to ingestion or inhalation of contaminated material, or external exposure from radiation emitted from the soil surface

(usually for plutonium this requires an estimate of the ingestion of the soil over a specified period of time and the inhalation of contaminated surface dust resuspended into the atmosphere by wind or mechanical disturbance; for Co-60 and Cs-137, the external exposure from gamma radiation emitted from the soil surface will be important);

(c) the mathematical models and assumptions leading to an annual radiation dose rate to specific tissues (for plutonium, this will usually entail dose estimates for the bone, liver, and lung), and

(d) the mathematical models and assumptions associated with the translation of a tissue dose to a risk of an adverse health outcome for children and adults.

The models, assumptions, and uncertainties in the risk assessment should be discussed with members of the local community in a manner that is open and transparent.

Comment: I fully recognize that some believe this level of detail may be too technical or too detailed for public understanding and comprehension, yet it is precisely this level of detail that is the subject of public meetings and discussions at sites where efforts are underway to reconstruct public exposures due to past operation of DOE facilities.

Surface samples collected on the grid will also be analyzed for americium-241. Samples collected at the ornamental trees will be also sampled for chromium, copper, lead, nickel, zinc, and americium-241.

DOE/LLNL are assessing the pathway and extent of plutonium contamination in Big Trees Park. Risk management decisions will be primarily focused on comparison with EPA's most conservative risk-based standard, the Residential Preliminary Remediation Goal (PRG) for plutonium in soil. The PRG takes into account all pathways of exposure. Based on this development methodology, the PRG of 2.5 pCi/g will result in the maximally exposed person have an additional cancer risk of 1-in-a-million over their lifetime.

We are not currently planning to perform a “Baseline Risk Assessment” for the park covering all materials of potential concern. There are many materials that could occur in BTP that could present risk to the community that are either naturally occurring or are due to anthropogenic activities not associated with LLNL operations. DOE/LLNL is responsible for, and is funded to perform assessment and remediation of materials that they have released.

Comment 4. *The detailed assumptions associated with the derivation of the reference soil limit of 2.5pCi of Pu-239/240 per gram soil does not appear to have been discussed with local citizens. From the draft reports issued as part of the Rocky Flats dose reconstruction, the combined effect of the uncertainty in estimating the radiological dose to specific organs from an intake of Pu and*

the estimate of health risk resulting from this tissue specific dose is approximately a factor of 10 to 30 either side of a central estimate.

How has uncertainty in estimating human exposure, dose and risk been taken into account in arriving at the stated EPA Preliminary Remediation Goal of 2.5 pCi/g soil?

Is there a chance that a soil concentration of 0.2 pCi/g could result in a health risk exceeding a one in one million of excess cancer due to prolonged activities leading to a prolonged exposure in Big Trees Park?

Recommendation: The derivation of a meaningful Preliminary Remediation Goal should be based on a defensible estimate of health risk from potential exposure accounting for all sources of uncertainty. Because of the presence of uncertainty the Preliminary Remediation Goal should be stated as a range rather than a single value.

Comment: In making this recommendation, it is recognized that to date most CERCLA sites do not require a formal analysis of uncertainty in the estimate of health risk.

At some locations, however, EPA does allow for the analysis of uncertainty in the estimate of human exposures, but to date EPA has not engaged in formally estimating the uncertainty in the dose response (sometimes referred to as the "cancer slope factor").

Yet, for excess health risks estimated from the reconstruction of public exposures from releases of contamination due to the historic operation of facilities at DOE sites, a formal analysis of uncertainty has been mandated by the Centers for Disease Control and Prevention (Hanford, Savannah River, and Fernald), the State Departments of Health of Colorado and Tennessee (Rocky Flats, Oak Ridge), and the National Cancer Institute (Nevada Test Site).

> The PRG is a screening tool used to determine whether further action or analysis is needed. Levels above the PRG do not automatically trigger remedial action, nor designate a site as "dirty". Rather, concentrations in excess of the PRG indicate a need for further action or analysis, such as additional sampling and/or a site-specific risk assessment. Generally, where environmental concentrations fall below the PRG, no further action or study is required under CERCLA.
>
> The PRG is intended to be associated with a one-in-one-million risk, but lack of data and/or scientific certainty necessitate the use of assumptions in its calculation. As a result, the value of the PRG is unavoidably somewhat uncertain. However, when uncertainty is encountered in risk assessment calculations, EPA uses the more health protective assumptions which would err on the side of overestimating risk. This is especially true

of assumptions related to exposure. The PRG calculation uses a "reasonable maximum exposure" scenario, which means that 95 to 99% of the population would have less exposure, and therefore less risk, than that which is assumed in calculating the PRG.

Because the PRG is a screening tool based on the soil concentration that would generate a 1-in-a-million risk of lifetime cancer incidence using the default scenario parameter values, it is never expressed as a range of values. However, knowing the PRG for a particular contaminant, one could calculate the concentrations that would correspond to the CERCLA cleanup risk range, 10-4 to 10-6. For example, because Pu-239 has a PRG of 2.5 pCi/g, concentrations corresponding to the 10-4 to 10-6 CERCLA risk range would range from 250 pCi/g to 2.5 pCi/g.

More details on the derivation of PRGs and the assumptions used in the calculations are available from the following web site:

http://www.epa.gov/region09/waste/sfund/prg/index.html

Comment 5. *The plan gives the impression that a concentration 2.5 pCi per gram in a single sample will equal a lifetime health risk of one chance in one-million of excess cancer. This impression is incorrect.*

Health risk cannot (and should not) be estimated using information obtained from a single sample. The evaluation of health risk requires an estimate of an average concentration (with uncertainty) over a prescribed area likely to be utilized by children or adult members of the public on a continuing basis.

In it's current form, the sampling plan is not designed to provide information on the true but unknown average concentration within a defined area for a suite of contaminants that may have been released from LLNL. The sampling plan appears to be oriented to assure that concentrations are (a) below an established concentration limit, and (b) that measured concentrations are clearly above concentrations expected from global fallout.

Furthermore, an elevated concentration of a contaminant detected at depth in a soil or sediment profile, although indicative of a health risk in the past or a potential for risk in the future, will not be the same as if this elevated concentration were to occur presently on the soil surface.

Recommendation: If the sampling plan is to support a health risk assessment, the area in which individuals could be exposed on a continual basis should be defined and multiple samples taken in such a manner as to define the arithmetic mean concentration in this area and it's

uncertainty. It is highly unlikely that any individual will be chronically exposed to an area represented by a single soil sample.

> DOE/LLNL concur that a risk assessment would need to be based on an average of concentrations in the park. The sampling plan will use the conservatively developed, risk based PRG as a potential decision point that DOE/LLNL and the regulatory agencies will determine whether additional work is warranted at BTP. If no samples are found above the PRG for Pu-239, exposure is significantly less than 1-in-a-million cancer risk over the maximally exposed person's lifetime.

Comment 6. *The Big Trees Park Sampling Plan states on page 1 that:*

(a) "there is no current health risk", and

(b) the presence of contamination at other locations in Livermore will be addressed only after the sampling at Big Trees Park have been completed.

Recommendation: It is inappropriate to conclude that there is "no risk" when a carcinogenic contaminant is present in an environmental medium that could result in human exposure. The conclusion of "no risk", however, is not the same as the conclusion of "negligible" or "tolerable risk". The only time that the conclusion of "no" risk is justified is when it is known with a high degree of certainty that humans cannot come into contact with the contamination and when the presence of the contamination is clearly below an established threshold value. For ionizing radiation, there is no scientifically accepted threshold below which the risk is zero.

It is recommended that the process of assessing the nature and extent of LLNL contamination at other locations in Livermore begin prior to the completion of the Big Trees Park sampling effort.

> Based on EPA standards, CDHS-EHIB's assessment as well as national and international radiation protection standards, the risk from the concentrations of Pu-239 found at BTP is clearly below 1-in-a-million cancer risk over the maximally exposed person's lifetime. Although each person may have their own threshold for tolerable risk, 1-in-a-million risk level is used by public health agencies as the action level to determine the need for further analysis and/or remediation. The sampling will provide additional information to determine whether that conclusion is appropriate, but currently there is no information to support that the risk from plutonium at BTP represents a regulatory unacceptable risk to the public using the park.

Comment 7. *The logic behind the use of long depth intervals for subsurface sampling is not transparent. If a subsurface sample has a result of 0.2 pCi/g, what conclusions can be drawn? A soil core mixed to a depth of 5 to 50 cm will produce a concentration averaged over this interval. This averaging process may mask the presence of plutonium that exceeded concentrations of concern in an earlier surface deposit (for example, in the top 1 cm of soil) that was subsequently covered by new soil.*

Recommendation: The sampling plan should be revised to show how the results from subsurface soil sampling will be interpreted and how these samples will be used to determine the mechanisms of Pu transport to Big Trees Park. The plan should include the sampling of finer intervals when initial subsurface soil concentrations exceed some limiting value.

For a few locations, Alpha Track Analysis of an intact core, may prove useful, provided that the alpha tracks produced from soil plutonium can be distinguished or separated from the alpha tracks produced from naturally occurring alpha emitting radionuclides in soil.

> The sampling depths have been changed to shorter intervals. The depth intervals are now
>
> 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm for the grid sample. Samples collected from Locations 1, 7, and 8 from the 1995 sampling will be sampled at 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, and 40-85 cm.
>
> The Draft Final Livermore BTP 1998 Soil Sampling Plan discusses how the subsurface sampling results will be used to help determine mechanisms of plutonium transport to Big Trees Park.
>
> We appreciate the alpha track analysis suggestion. To our knowledge, alpha track analysis is normally performed with soil spread out in a fairly thin uniform layer. Alpha track analysis of an intact core would employ a very different geometry, with alpha particles from different parts of the core traveling different distances to the recording film. This would greatly complicate the measurement of the tracks. Without considerably more research, we think this method is unlikely to provide useful results.

Comment 8. *It is difficult to see how the statistical procedures adopted in Chapter 3.0 of the sampling plan relate to the stated objectives of the plan. Chapter 3.0 is extremely difficult to read and is not transparent.*

Recommendation: Chapter 3.0 should be revised to make the procedures more transparent and relevant to the objectives of the plan.

Eliminate use of the jargon of MARSIIM. The purpose of the Big Trees Park sampling plan is to characterize the nature and extent of plutonium concentrations in park soils and to determine the mechanisms leading to the transport of plutonium from LLNL to the park.

> The MARSSIM statistical methodology is no longer part of the data analysis and is not included in the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 9. *I have been informed by Don MacQueen of LLNL that the 9 sediment cores planned to be taken from Arroyo Seco will now be increased to 11 and that the spacing of these cores may be modified to a random spacing as opposed to a uniform downstream distance. The cores will still be taken at the nearest point to these randomly selected distances where sediment is observed to have accumulated in the creek bed. Some consideration could be given to increasing the number of background samples beyond the two locations presently described in the sampling plan.*

Recommendation: A discussion is needed to clearly explain how the results of these sediment samples will be analyzed and what conclusions will be drawn. If frequent storm events have scoured the creek bed, removing plutonium contaminated sediment that was initially released and deposited one to two decades ago, it is possible for stream bed sampling to produce inconclusive results. The sampling plan should discuss the potential for false negative findings due to frequent sediment scouring.

> It is unlikely that sediments deposited decades ago are still there. Section 3.1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents the data analysis and interpretation for samples collected from the Arroyo Seco. In consultation with the regulatory agencies, it has been determined that only one sample will be collected upstream of LLNL.

Comment 10. *It is not clear what methods will be used to distinguish Pu contamination from LLNL from Pu contamination from weapons fallout, other than a comparison of Pu concentrations in the soil and sediment cores with the upper end of the distribution of Pu concentrations known in the region to represent contamination from global fallout from atmospheric weapons testing of the 1950's and 60's (0.02 pCi/g). If other sampling procedures have been used to determine the variability fallout Pu for the Livermore region (i.e., the use of large area composite samples), this could bias the results towards a lower variability for fallout Pu than actually will occur when individual, non-composited soil cores are taken.*

Recommendation: It should be feasible to use ratios of concentrations of cesium-137 to plutonium-239/240 and plutonium-238 to plutonium-329/240, to distinguish Pu released from LLNL versus Pu present in 1960's weapons fallout. These isotope ratios may be useful to determine the presence of LLNL Pu even when concentrations are below the 0.02 pCi/g level.

The distribution (inter-sample variability) of Pu concentrations in surface soil due to weapons fallout should be determined using the same sampling procedures as used in the Big Trees Park sampling plan. If this is not feasible, a discussion should be included to indicate the potential for differences and/or interpretational biases due to the use of different sampling procedures.

A more complete discussion of the background concentrations of Pu-239 has been added in Appendix D of the Draft Final Sampling Plan.

Because samples will be analyzed for both Pu-239+240 and Pu-238, these reported isotopic ratios will be available for analysis. Discussions among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR resulted in a decision to also analyze for Am-241 in the surface grid samples and samples from the ornamental trees.

Without a thorough study of both the expected ratio and its variability, interpretations of the ratio results will not be a reliable indicator of contamination. Such an study would have to be performed before the results of the sampling are analyzed, but is beyond the scope of this sampling plan.

Comment 11. *It is not clear how the sampling of soil in the vicinity of the ornamental trees in Big Trees Park will be interpreted.*

Recommendation: The sampling plan should include a discussion as to how results from the sampling near the ornamental trees could be interpreted. What conclusions would be drawn if the concentration in the subsurface were within 30% of the concentrations at the surface? What conclusions would be drawn if the concentration at the subsurface was 10% of the concentration at the surface? What conclusions would be drawn if the surface was at background, and the concentration in the subsurface was equal to twice as large as the concentration at the surface?

The Draft Final Livermore BTP 1998 Soil Sampling Plan now describes the principles for interpreting the results (Section 3.1.2), but does not include specific interpretations based on percentages of concentrations.

Comment 12. *There is a need to modify and expand Section 11 of the sampling plan. If it is determined that the elevated levels of Pu in Big Trees Park came from the inadvertent dispersal*

of sewage sludge or from the upland disposal of contaminated creek sediment, what kind of follow-up activity will occur? Where else could Pu have been transported? Is it likely that there might be concentrations elsewhere in Livermore that exceed those monitored in Location #1 of Big Trees Park?

Recommendation: It is important that the sampling plan clearly indicate that the document is just the beginning of a larger effort, depending on the outcome of the results. Indications should be given as to the steps required to extend sampling to other locations if the results of sampling in Big Trees Park indicate that either the creek or sewage sludge were the predominant mechanism of transport. The failure to find concentrations in Big Trees Park that exceed 2.5 pCi/g should not be used as the criterion to determine that further sampling will be unnecessary elsewhere, unless it can be shown that the concentrations in Big Trees Park are clearly higher than is to be expected at any other location.

> This sampling plan and its field implementation is not necessarily the beginning of a larger effort. DOE/LLNL will conduct follow-on activities if the results of this sampling warrant additional work or if additional information indicates that LLNL operations have potentially impacted other areas at levels above health protective standards as developed by the cognizant regulatory agencies. The decision to conduct follow-up work will be made in the consultation the regulatory agencies.

Comment 13. *On page 5 of the plan, it is stated that, "even if plutonium is present in only part of a selected interval, concentrations high enough to be of human health risk concern should be detected." It is not totally clear that this is true.*

Recommendation: The sampling plan should provide a clear discussion as to how the presence of averaged concentrations in the subsurface soil will be deemed to be of no public health concern if they are below 2.5 pCi per gram. The presence of a highly contaminated thin (1 cm) section may be an indication of contaminated former surface soil that was later buried at depth by the subsequent addition of fresh top soil, but the presence of this thin section of former surface soil may not be detected by mixing the soil core to depths of 5 to 50 and 50 to 100 cm. Such a thin section may be important for determining past exposures of individuals who used the park for recreation and other activities.

> The depth intervals have been shortened, as presented in Chapter 3 and Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 14. *The sampling plan would be enhanced if specific information were provided on: (a) the date when the Arroyo Seco was filled and realigned should be given in the sampling plan,*

(b) the age of the ornamental trees selected for sampling, and (c) the precise locations of the samples taken on the Location 1 sampling grid.

The Draft Final Livermore BTP 1998 Soil Sampling Plan contains information on when the Arroyo Seco was filled (Section 2.2; Table 1), the age of the ornamental trees of interest (Section 3.1.2), and the sample location grid (Figure 7).

Comment 15. *If any one of the resampled January 1995 locations shows elevated levels of Pu, or other contaminants, what conclusions will be made, and what follow-up activity will there be? What conclusions will be drawn if Pu concentration in one subsurface sample is shown to be above background but below the 2.5 pCi per gram PRG?*

DOE/LLNL will work closely with the regulatory agencies to determine if follow-up activities are necessary based on the results from this sampling.

Comment 16. *Table 1 on page 11 of the sampling plan is incorrect and only applicable if samples are taken at random or from a randomized design within a defined area. The discussion on page 11 needs to be improved for transparency. There may be actual physical reasons why the subsurface sediments at one location may be elevated but not at others. I would suggest that each sample be evaluated separately and not subjected at this time to a statistical analysis unless the samples are randomized to characterize the average concentration in a defined reach of the arroyo.*

Equally spaced sample locations with a random starting point will be used to estimate the average concentration and its uncertainty. A statistical analysis is no longer part of the plan.

Comment 17. *Section 3.2.2 of the sampling plan: This section also needs to be rewritten for transparency. Is it not possible for concentrations of Pu in the Arroyo Seco much less than 0.02 pCi per gram to also be indicative of LLNL releases? Again, the use of isotope ratios could be useful in distinguishing releases from LLNL from releases from fallout of the 1960's. Again, the discussion should mention the fact that frequent sediment scouring events may make it impossible to detect Pu in the arroyo sediment even if this pathway was operable at some time in the past.*

The value of 0.02 pCi/g was selected in the draft BTP Sampling Plan as a value above which a false negative result from the statistical test was considered undesirable. The Draft Final Livermore BTP 1998 Soil Sampling Plan discusses sediment scouring in Section 3.1.1.2.1.

Comment 18. *Page 14 of the sampling plan: A 50% probability of not detecting plutonium concentrations when the Pu in the sediment of the former arroyo channel is associated with a prevalence of 10% or less, appears small. The number of samples should be increased to assure that even with a prevalence as low as 10%, there is a reasonably high probability of finding the contamination in the buried sediment. It is also not clear how the Wilcoxon Rank Sum test (as recommended in MARSIIM) is applicable to the objectives of this sampling plan.*

> In an agreement among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, seven samples will be collected in the arroyo channel. Thus, the Wilcoxon Rank Sum test is no longer relevant to this sampling plan.

Comment 19. *Page 15, Section 4 of the sampling plan: More discussion is needed on how measured concentrations of Pu in surface and subsurface soil and sediment will be distinguished from fallout sources of Pu. The use of a limit of 0.02 pCi per gram appears likely to lead to the conclusion that lower concentrations are clearly associated with fallout sources when this might not be the case.*

Reading the 1994 LLNL preprint from Gretchen Gallegos (UCRL-JC-118877), provided to me by Don MacQueen, on the surveillance monitoring of soils for radioactivity from 1976 to 1992, it is evident that 97.5% of all samples taken upwind of LLNL would be at or below 0.02 pCi per gram, and that 50% of these samples would be less than 0.0032 pCi per gram. It is also of interest to note that the samples of Pu taken downwind of LLNL are, in general, almost twice the values of the upwind samples, with 97.5% of the samples being equal to or less than 0.038 pCi per gram and 50% being at or below 0.0057 pCi per gram. These downwind soil samples are much more likely to contain Pu from airborne emissions from LLNL. Nevertheless, few of these samples exceed the level of 0.02 pCi per gram proposed in the Sampling Plan as required to distinguish LLNL originated Pu from the fallout background.

> The degree that the downwind concentrations have been increased is so small that the difference between upwind and downwind is barely detectable. In fact, it is only because LLNL has been conducting soil surveillance for over 25 years that the difference is measurable. A discussion of background samples is presented in Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 20. *Page 20 of the sampling plan: Given the need to assure the public of an open process, I recommend that any interested member of the public also be permitted to participate in the witnessing of the collection of samples.*

> As stated in Section 4.4 of the Draft Final Livermore BTP 1998 Soil Sampling Plan, the public is free to witness the collection of samples.

Comment 21. *Appendix B on page 27 of the sampling plan may not be appropriate for the stated purposes of this plan. MARSIIM is designed to survey sites that have already been remediated. Lognormal distributions of soil samples that span a range of almost a factor of 50 cannot be considered a "uniform" concentration. Therefore, the use of the Wilcoxon Rank Sum test is questionable.*

If the purpose is to determine the mechanisms with which Pu was transported from LLNL to Big Trees park, why choose a DCGLw of 2.5 pCi per gram? Why not a lower number, like 0.02 pCi per gram? In general, this section is difficult to review and cannot be readily understood by a trained professional. I recommend it be substantially rewritten so that it is transparent to a critical reviewer.

> The MARSSIM statistical methodology is no longer part of the data analysis and is not included in the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 22. *Figure 5 of the sampling plan. This figure should be replaced by one that shows the exact sampling locations on the grid. It is understood that the samples will occur at the nodes of the grid. The nodes should be marked explicitly and the sample locations given an identifying number. In general, the figures should be placed in the text where they are called out.*

> Figure 7 in the Draft Final Livermore BTP 1998 Soil Sampling Plan now clearly indicates that the sample locations are at the grid nodes. The sample location identifiers are described in the Field Sampling Procedures (Appendix C of the Draft Final Livermore BTP 1998 Soil Sampling Plan).

Comment 23.

As I mentioned last week during our meeting I feel that many of the issues might be lessened if the agency responsible for the sampling plan were not the same agency responsible for the presence of the contamination, and if the community could achieve consensus on a risk level for the presence of trace levels of contamination that could be considered to be acceptably small.

As I understand it, the risk level used by EPA in establishing the 2.5 pCi per gram Preliminary Remediation Goal (PRG) was a one chance-in-one-million life time risk of excess cancer. I am not sure the extent to which this acceptable risk level has been discussed among members of the Livermore Community.

I recognize that this risk level is the one often used by EPA for the evaluation of carcinogenic chemicals. A one-in-one million lifetime excess cancer risk is substantially smaller than the risk levels associated with most EPA regulations established to protect the public from exposure to

ionizing radiation. However, in no document that I reviewed were the assumptions used to determine the Big Trees Park PRG discussed, so I could not review the adequacy of this PRG with respect to a level of exposure, dose, and or health risk.

> As discussed in response to your first comment, DOE/LLNL volunteered to develop this sampling plan and implement it with EPA. DOE/LLNL defer to the EPA with respect to establishing risk-based goals for remediation. DOE/LLNL concur with the EPA that the PRG is adequately protective of human health.

6.8. Tri-Valley CAREs Comments and DOE/LLNL Responses

General Remarks

Process

As previously stated, Tri-Valley CAREs is concerned with the fact that LLNL took the lead in developing the initial sampling plan, and, in so doing, did not wait for public comments to the CDHS/ATSDR health consult on plutonium at Big Trees Park and in sludge used as soil amendment to be incorporated into a final report. Our concern stems, in part, because this way of proceeding left out potentially valuable and relevant comments that the CDHS/ATSDR received after the sampling plan's completion.

Subsequent discussion, postponements of the public comment due date, clarification of the nature of the sampling plan as a draft document and the eventual inclusion of an independent consultant for Tri-Valley CAREs and the community members of the Site Team into the sampling plan evaluation process, has permitted greater opportunities for wider input than would have occurred under the original schedule.

However, we remain concerned about LLNL's role in this and potential future sampling efforts to assist community environmental health investigations, whether those efforts are conducted under the auspices of CERCLA or not. We therefore wish to restate our strong belief that all such efforts should fully include the Site Team, and the public health agencies involved in the ongoing public health assessment.

We also reiterate our conviction that it is inappropriate for LLNL to take the lead in designing a sampling plan to investigate the very pollution it created. This view is supported by a high-level federal panel of scientists (ACERER) who advise on health research of community health impacts of the Department of Energy (DOE) nuclear weapons program. It recommends: "No agency

responsible for exposures imposing risks on workers and the public should be entrusted with control over efforts to address the health consequences."

We understand from our long history of commenting on CERCLA documents for the LLNL main site and site 300 cleanups that this is a different approach than EPA ordinarily takes, but it is one that must increasingly be considered by all public health and regulatory agencies. Moreover, we note that this particular draft sampling plan, in order to be considered adequate, must address not only the regulatory limits for plutonium and other elements in the soils and sediments, but also shed light on their potential pathways into Big Trees Park and thereby assist in the ongoing public health assessment process.

Despite the limitation regarding the responsible party as author of the plan, we are encouraged by two developments in the sampling plan review.

First, The procurement of funding for an independent technical consultant for Tri-Valley CAREs and the community members of the Site Team was an important element in allowing meaningful community input into the sampling plan design. Community site team members in particular have reported that the meetings with Dr. Owen Hoffman of SENES provided useful scientific clarification on a number of questions. Tri-Valley CAREs concurs. By thus enhancing the community representatives' understanding of the issues, they have been provided with an opportunity to exercise a more equal voice in decision-making about the sampling plan and to give input on how it relates to community health overall. This ultimately serves to support a well-designed sampling plan free of conflict of interest.

We wish to suggest that such funding be provided directly by the DOE to the community members of the Site Team in any future instances where the design of sampling or other investigatory scientific inquiries are to be reviewed by the Site Team and where such technical consulting can be of significant use to the Site Team's community members.

Secondly, we are pleased with the careful and thorough reviews of the plutonium sampling plan evident from the comments already submitted by CDHS-EHIB, ATSDR and US EPA. In general, we support their recommendations.

Our recommendations for "next steps" include the following:

First, that the next iteration of the sampling plan be a "Draft Final" plan and that a roundtable meeting of interested parties (e.g. Tri-Valley CAREs and members of the Site Team including community representatives and agencies) be convened to discuss it prior to its becoming finalized. Our second recommendation is related to the first. We request that the next iteration of the plan include all of the public comments received and responses to those comments. We object to the oft-used LLNL and DOE practice of providing only a "responsiveness summary" wherein multiple specific comments are "mooshed" together into a generic comment, often written by the

agency itself to (mis)represent the real comments, and then answered, leaving the reader no way of knowing whether the agency adequately responded to any specific, individual comment. Taken together, these two recommendations will ensure maximum transparency, allowing Tri-Valley CAREs and others to understand how and why specific comments were incorporated into the plan or rejected.

DOE/LLNL volunteered to prepare a sampling plan, submit the plan to the cognizant public agencies and community members for comment, address comments, and implement the sampling plan after comments are addressed/resolved. The original draft sampling plan was prepared after conceptual discussions with EPA and CDHS-RHB, submitted to all agencies and the public on April 10, 1998 for comment, the comment period closed 71 days later on June 22, 1998. Comments are addressed in this Responsiveness Summary, and where appropriate are included in the Draft Final Livermore BTP 1998 Soil Sampling Plan. A public workshop will be held upon the release of the Draft Final sampling plan in which the public, the regulatory agencies, and the designers of the sampling plan will be free to discuss the content and issues associated with the plan. Sampling will be performed as transparently as possible, with the public free to observe the sampling, with EPA and/or ATSDR taking split samples, and the analyses to be performed by an independent analytical company certified by EPA to perform the analyses. The data generated by the sampling will also be available to the community.

F. Owen Hoffman of SENES Oak Ridge, Inc. was funded to provide independent scientific review of the draft BTP sampling plan. His comments and DOE/LLNL responses are presented in Section 6.7. If ATSDR feels that the Livermore community needs an independent scientific consultant to provide additional review of technical documents, ATSDR can make the decision to use it's DOE public health assessment funds for that purpose.

Sampling Plan Clarity and Community Understanding and Participation

The plan's final draft should be written clearly in language ordinary citizens can understand. There are a number of places where technical language is confusing, even to a trained professional. There seems to be no reason why unnecessary jargon cannot be eliminated even in discussions of statistical analysis. Where jargon and acronyms cannot be eliminated they should be clearly explained.

We also agree with the comments of CDHS which recommend that a clearer exposition be included delineating clear, specific and measurable objectives and that these should be explicitly tied to methodology and decision rules on sampling results. The plan must clearly explain to professional and lay person alike what conclusions can be drawn from the range of sampling results, in terms of community health impacts -- past, present and potential future -- and what further investigatory actions should be taken.

In addition, we recommend that a clear discussion of the historical context of concerns surrounding the elevated levels of plutonium discovered in three parks and in sludge used for soil amendment be included in the plan along the lines suggested in US EPA's comments. We note in particular that dates of possible releases, any information known so far about the extent of sludge distribution as a soil amendment, and a delineation of a typical profile of LLNL sludge, if it exists, would assist in pursuing the stated objective of pathway/transport mechanism determination.

The sampling plan should also be placed in the context of the overall public health assessment as well as in the more narrowly defined CERCLA context. The goals of the broader health assessment investigation should be included and the role that this sampling effort plays within the investigation should be clearly stated.

The final draft plan should be widely distributed to allow greater community input. To the extent the Internet is part of this distribution, the document should be more easily accessible from the Internet than is true for the present sampling plan.

DOE/LLNL has prepared an Executive Summary of the sampling plan that explains both the historical and regulatory context of the sampling plan, describes the purposes and scope of the plan and provides a “layman's” description of the plan. In addition, a chronology of the events relating to the releases of plutonium by LLNL and the investigations at Big Trees Park are also included in Appendix B and Table 1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Risk management decisions will be primarily focused on comparison with EPA's most conservative risk-based standard, the Residential Preliminary Remediation Goal (PRG) for plutonium in soil. The PRG, which is developed using very conservative exposure scenarios, takes into account all pathways of exposure. Based on this development methodology, the PRG of 2.5 pCi/g will result in the maximally exposed person have an additional cancer risk of 1-in-a-million over their lifetime.

The Draft Final Livermore BTP 1998 Soil Sampling Plan will be distributed to the agencies and community members, and will be available on the Internet.

Risk Analysis, and Risk Uncertainty and Acceptable Risk

We concur with the recommendation by Owen Hoffman, Ph.D., (see his comment #3) that a clear and complete exposition of health risk analysis, including a presentation of analytic methodologies and their assumptions, which underlie EPA's PRG (preliminary remediation goal) needs to be included in the sampling plan. This is because, to date, such a discussion has not been presented to the community. Yet it is vital to a true understanding of what our present state of knowledge can tell us about health risks.

Moreover, as Dr. Hoffman also recommends, the uncertainty associated with any such risk analysis should be transparently presented, particularly since such uncertainty typically has a wide range. We also concur that the health risk from multiple contaminants, if discovered at Big Trees Park, should be estimated cumulatively.

We hope that this information can provide a meaningful basis for interested members of the community as a whole to understand, publicly discuss, and to come to individual and collective conclusions about, the level of risk they may decide is "tolerable," "negligible," or "acceptable."

Finally, we note that health risks of exposure to radiation at low levels may be greater than recognized by current regulatory standards that ATSDR uses to assess risk. For example, a 1997 UCLA study of cancer mortality among workers exposed to radiation on the job at the DOE's Santa Suzanna Field Laboratory ETEC facility found that the excess cancer mortality among workers exposed to "low dose" radiation on the job was at least six to eight times greater than the risks previously assumed by current regulations.

DOE/LLNL defer to the EPA with respect to establishing risk-based goals for remediation. DOE/LLNL concur with the EPA that the PRG is adequately protective of human health. A short description of process by which the PRG has been developed has been provided in this response to Owen Hoffman's Comment No. 4 (Section 6.7 of this Responsiveness Summary).

Scope of the Sampling

There is compelling evidence that plutonium traveled from the Lab into the community by more than one route. Samples of surface soil at Sycamore Grove and Sunflower Street parks revealed higher than background levels of plutonium, as published by EPA in 1994. While the Lab

contends the sample readings are inaccurate, this cannot be assumed. We recommend the following:

- *These parks should be resampled. Some of the plutonium found in Big Trees Park may have come there from air emissions at the Lab. The Sycamore Grove and Sunflower Street plutonium contamination, if confirmed, strongly suggests the same pathway. However, since the prevailing winds blow eastward, the greatest amounts of plutonium from air emissions are most likely to be found east of the Lab.*
- *A commitment to sample areas east of the Lab should be made. Since preparatory work needed to select the best sampling locations may take time, including a review of routine and accidental releases, and wind and weather patterns, actual sampling can occur later, but a commitment to undertake this work should be made now.*
- *Plutonium-laden sludge has been distributed to the community as soil amendment. The amount of contamination in the sludge and the extent of its distribution are not presently known. Estimates by the Lab stand at half a gram of plutonium. The draft CDHS/ATSDR health consult on plutonium suggests the analyses conducted by LLNL may have been inadequate, and that the amount of plutonium present in the sludge could have been even greater. This plan should review what information is known, and make a clear commitment to assist in developing a community sampling plan in coordination with public health agency efforts to uncover historical records that may reveal additional, if not complete, information about the distribution of the contaminated sludge.*

We strongly recommend that the plan make soil sampling available free of charge to residents who suspect their property may have been contaminated. In this, we concur with the letter to this effect already sent by EPA. Such a plan should also consider providing participating Livermore homeowners with certificates from the City or other official entity validating that their soil has been tested and shown to be below specified concentrations of plutonium and accompanying analytes. Should elevated levels of plutonium (or other analytes) over a specified limit be found in residential, commercial or public property, LLNL/DOE should fund the removal of contaminated soil and replace it with uncontaminated soil.

The statement that plutonium in Sycamore and Sunflower parks is above background levels is based on a comparison with values in an EPA draft document whose authors specifically stated, “Do not cite.” In addition, the draft report clearly stated that the values were subject to change. The values are not directly based on measured values, but indirectly derived.

The authors of this report have described these values to us in a phone conversation as generic, and not appropriate for use as a site specific background.

DOE/LLNL collect soil samples as part of their routine monitoring program in locations around the laboratory, including east of the Livermore Site and at Site 300. The result of this routine monitoring are published in the Site Annual Environmental Report.

The use of sludge as a soil amendment is discussed in Section 2.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The date of release from LLNL is presented in Appendix B.

This sampling plan's scope is limited to soil sampling at Livermore's Big Trees Park to assess the following:

1. Extent of elevated plutonium concentrations both laterally and vertically.

2. Possible pathways by which plutonium came to BTP.

3. Public risk associated with plutonium at BTP given current and future land uses.

If additional sampling outside of BTP is warranted, a sampling plan specifically designed to address that sampling will be written. DOE/LLNL will work closely with EPA and the state agencies to determine if follow-up activities are necessary based on the results of this sampling.

Funding

The DOE is responsible for funding the Public Health Assessment as well as cleanup activities of LLNL. Both efforts stem from the Lab's placement on the EPA's NPL, commonly called the Superfund list. Such funding for cleanup and health assessment activities is a pittance compared with LLNL's latest nuclear weapons project, the National Ignition Facility, which will cost at least $5 billion overall. We make the following recommendation:

- *DOE must fund both cleanup and ATSDR/CDHS-directed health activities at adequate levels and not ask the community to choose between discovering the health impacts of the Lab and cleaning up the Lab's pollution.*

DOE is funding the CERCLA cleanup program, ATSDR health assessment activities, and this additional sampling of Big Trees Park. DOE/LLNL will meet all CERCLA Federal Facility Agreement milestones in Federal Fiscal Year 1998 and also will attempt to complete the sampling at BTP this summer.

Specific Comments

Objectives

We concur that comments from CDHS-EHIB to the effect that some of the plan's objectives are too narrow and should be restated as they suggest.

We also agree that the objectives need to be clearly linked to choice of sampling methodology and interpretation of results. We recommend including a table such as the one they present in their comments.

Finally, the sampling plan does not appear to support the second objective -- to evaluate the likelihood of various pathways or transport mechanisms contributing to soil contamination by plutonium and possibly other radionuclides. For example, the use of the PRG of 2.5 pCi/g may be relevant to remediation actions, but it is irrelevant to understanding how the contamination got to Big Trees Park.

We also note that should sampling results suggest that a water pathway, through Arroyo Seco, be (one of) the likely pathway(s) of plutonium contamination, this would suggest the need to for follow-up activities to explore the transport mechanisms by which the Arroyo Seco was contaminated.

The objectives have been redefined to better evaluate the various pathways as presented in Section 1.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents the sample sets, analytes, potential pathways, depths, and number of locations and samples.

DOE/LLNL will conduct follow-on activities if the results of this sampling warrant additional work or if additional information indicates that LLNL operations have potentially impacted other areas at levels above health protective standards as developed by the cognizant regulatory agencies. The decision to conduct follow-up work will be made in the consultation with the regulatory agencies.

Background Levels of Plutonium

The decision to use 0.02 pCi/g as a yardstick by which to determine whether soil samples are above background level (resulting from global nuclear testing fallout) is insufficiently justified. Moreover, we believe it is an inappropriately high number. Since it is out of step with the benchmark used in earlier sampling of Big Trees Park (0.01 to 0.001 pCi/g), any decision to make this change should be carefully scrutinized and must be fully supported by the facts.

The previous "benchmark" represents a range of typical, or frequently occurring, values, not an absolute upper limit. Additional discussion of background concentrations has been included in Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Please note Dr. Hoffman's comment #19 to the effect that 97.5% of monitoring soil samples taken upwind of LLNL from 1976 through 1992 are at or below 0.02 pCi/g and that 50% of these samples would be less than 0.0032 pCi/g. We also note that other data, including a 1973 report by LLNL staff, suggest that the appropriate background level for Livermore is at or near the lowest levels referenced in Dr. Hoffman's comments.

The 1973 report discussed in this comment provides information about the range of typical concentrations. The degree that the downwind concentrations have been increased is so small that the difference between upwind and downwind is barely detectable. In fact, it is only because LLNL has been conducting soil surveillance for over 25 years that the difference is measurable. A discussion of background samples is presented in Appendix D of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Moreover, as has been suggested by others, radionuclide ratios (such as cesium and strontium to plutonium) may provide additional measures to determine fallout background levels, and should be included in determining background levels.

We would also like to see a discussion of how fallout background levels may vary with depth in undisturbed soil. Presumably fallout background levels result mainly in surface contamination.

Therefore, shouldn't background levels for lower depths -- below 5 cm, 25 cm, and 50 cm -- be considerably lower?

> A discussion of background levels is presented in Appendix D of the Draft Final Big Trees Park Sampling Plan.

We note that LLNL often attempts to mask the severity of its potential effect on the surrounding environment by discussing Lab-generated radioactive pollution merely as a percentage of background, rather than listing it quantitatively (e.g. number of picocuries released or discovered). Thus, the change proposed by LLNL from the DOE-derived range of 0.01 to 0.001 pCi/g used by EPA in the 1994 confirmatory sampling report to the substantially higher number -- 0.02 pCi/g -- is not just an academic question. LLNL has a "political," public relations motive for desiring a very high number. The number ultimately chosen to reflect background must, in our view, be adequately justified.

> The DOE-derived range used by the EPA in the 1994 confirmatory sampling report is a range for annual average concentrations, not individual sample results. Background concentrations for the purposes of comparison in the interpretation of the data resulting from this sampling plan will be determined based on peer-reviewed technical literature.

Vertical Aggregation of Samples

We share concerns expressed by CDHS-EHIB, ATSDR, EPA and Dr. Hoffman that averaging concentrations over long vertical intervals may lead to inadequate characterization of the soil contamination. We strongly concur with recommendations to take samples from more frequent discrete vertical locations, as well as using alpha track analysis for some samples as a supplementary tool.

As Dr. Hoffman states, "The presence of highly contaminated thin (1 cm) section may be an indication of contaminated former surface soil that was later buried at depth by the subsequent addition of fresh top soil," a contamination he notes which could be masked by mixing soil over a 50 cm vertical spread.

> The sampling intervals have been shortened as presented in Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. The depth intervals for grid samples are now 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm. Samples collected from Locations 1, 7, and 8 from the 1995 study will now be sampled at 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, and 40-85 cm.

> To our knowledge, alpha track analysis is normally performed with soil spread out in a fairly thin uniform layer. Alpha track analysis of an intact core would employ a very different geometry, with alpha particles from different parts of the core traveling different distances to the recording film. This would greatly complicate the measurement of the tracks. Without considerably more research, we think this method is unlikely to provide useful results.

However, if sections of 10 cm, for example, is definitively demonstrated to be too cost prohibitive for all locations, we recommend that a second reserve sample be taken at all locations and, as Dr. Hoffman suggests, whenever a vertically aggregated sample demonstrates a level of contamination above a certain limit, such discrete sampling methods then be employed. For this approach to be viable and acceptable to the community, it would be necessary to include a full discussion of how that limiting number would be determined. We note, too, that for Tri-Valley CAREs this would represent our minimum acceptable, or "fall-back," position. As noted above in the section of our comments labeled Funding, the amount of money devoted to public health and CERCLA activities relative to the funding for nuclear weapons activities at LLNL is so minuscule (about 2%, generally totaling $22 million or less, of the $1 billion annually received by LLNL from DOE goes to fund all Superfund cleanup activities) that we remain unconvinced by LLNL crying poor when it comes to doing an adequate sampling job.

Our first and foremost recommendation remains that the samples, or an appropriately large subset thereof, be stratified at 5 to 10 centimeter intervals. If it is a subset that is to be stratified at lesser intervals, we recommend that a second, reserve, sample be collected in the other locations.

> Sampling intervals have been shortened as agreed among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, as presented in Table 2 of the Draft Final Livermore Big Trees Park 1998 Soil Sampling Plan.
>
> DOE is funding the CERCLA cleanup program, ATSDR health assessment activities, and this additional sampling of Big Trees Park. DOE/LLNL will meet all CERCLA Federal Facility Agreement milestones in Federal Fiscal Year 1998 and also will attempt to complete the sampling at BTP this summer.

Analysis of Other Contaminants

We concur with recommendations to analyze a broader suite of radioactive and metal constituents. This will allow a greater understanding of the total impact of any contamination

on the health of the community. It will also help in determining the sources and transport mechanisms of the contaminants, including the determination of fallout background components through analyzing radionuclide ratios and the possible contribution of plutonium-laden sludge to the discovered soil contamination. (See CDHS-EHIB comment #8.)

We support CDHS-EHIB's recommendations to analyze samples for arsenic, cadmium, chromium, copper mercury, nickel, lead, zinc, Am-241, cesium-137, strontium-90, cobalt-60, gallium, and plutonium-238.

> Surface samples collected on the grid will also be analyzed for americium-241 and samples around the ornamental trees will also be analyzed for chromium, copper, lead, zinc, and americium-241. Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents the sample sets, potential pathways, depths, and number of locations and analyses.

Soil and Sediment-Disturbing Activities

There has been evidence of considerable soil and sediment disturbing activities in the past. They seem to continue to the present with construction activities at Arroyo Seco School disturbing soil around at least one sampling location. Moreover, CDHS-EHIB reports that six out of nine sampling locations in Arroyo Seco "seem to be in areas where significant disturbance to the channel has occurred...."

As noted in Tri-Valley CAREs' comments on the CDHS/ATSDR health consult, our members who live around Big Trees Park have noticed a series of substantial changes to the physical surfaces at the park and along Arroyo Seco between LLNL and the park. (See our comment #B-8 of April 15, 1998 for key details.)

In the case of Arroyo Seco, even where human activities have not disturbed the soil, possibly-contaminated sediment may have been washed away from rain. The sampling plan should locate additional sediment samples to areas undisturbed by human activity.

The sampling plan should include a discussion about the possible impacts of changes in soil and sediment composition due to human or natural activities on the sampling results and how to interpret these results.

> The arroyo sample locations have been revised in agreement among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR (see Figure 3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan). Two samples will now be collected downstream of Big Trees Park, as is discussed in

Section 3.1.1.2.2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. Impacts due to collecting disturbed samples are discussed in Appendix D.

Future Soil Disturbances and Interpretation of Results

As already noted, a number of areas of concern have already been disturbed, complicating sampling design and result interpretation as well as causing the possible (re)suspension of plutonium particles into the air.

When sampling results are analyzed (re: risk assessment), we suggest that three scenarios be considered:

1) *that the soil remain essentially undisturbed by human activity;*

2) *that the topsoil is disturbed by such activities as sports play and children digging in the dirt; and*

3) *that the soil is disturbed by such activities as construction, modification to the park foliage and/or play equipment. This is particularly important with regard to any "hot spots" found at depth.*

We further note that particle size is relevant to risk analysis. We understand that tenth micron particles -- the size that might most logically be disproportionately present in emissions from LLNL plutonium stacks due to the transparency of HEPA filters at that size -- tend to hang in the air for long periods of time. Moreover, regarding the inhalation pathway, they are among the particle sizes tending to stick in the lung when inhaled.

We agree that anyone who performs risk assessments using soil sample results from this sampling plan should take into account the factors described above.

Ornamental Trees Sampling

We concur with CDHS-EHIB that some of the 80 samples proposed for the roots of ornamental trees in Big Trees Park might more usefully be located in other locations, such as Sycamore Grove and Sunflower Parks, or by extending the areas in the proposed grid sampling.

The sampling plan's scope is limited to soil sampling at Livermore's Big Trees Park. If additional sampling outside of BTP is warranted, a sampling plan specifically designed to address that sampling will be written.

DOE/LLNL will work closely with EPA and the state agencies to determine if follow-up activities are necessary based on the results of this sampling.

Expansion of Sampling Grid

We concur with the extension and adjustments recommended by CDHS-EHIB to the proposed sampling grid in Big Trees Park.

As presented on Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan, four samples will now be collected in the disked area, two samples in the playing field, and three samples in the eastern extension of the park.

Sewer Line Break

Consideration of a possible fourth pathway for investigation should be considered in light of the new information discovered by CDHS-EHIB suggesting a sewer line from LLNL had been broken for an indeterminate length of time under the Arroyo Seco.

The possibility of sewage leaks was noted by a 1987 DOE study which noted that hazardous and radioactive constituents may escape the sewer lines through cracks caused by seismic activity, acid releases, and negligent construction. They state the potential of "thousands of gallons" of waste to percolate into the ground through such cracks of "the LLNL on-site sanitary sewer system, the SNLL system, and the trunk line carrying the combined waste waters to the LWRP."

After an investigation that included review of historical records and interviews with LLNL staff responsible for the construction and maintenance of sewer lines, it was determined that the sewage line discussed in this comment was connected to an administrative building that was located outside the controlled area of LLNL and flowed north along Vasco Road. This sewer line does not cross Arroyo Seco and therefore, is not a likely pathway for plutonium to have traveled from LLNL to BTP.

MARSSIM Wilcoxon Rank Sum Test

A clear explanation of this test and the rationale for using it is not presented, making it impossible for a lay person to evaluate this part of the sampling plan. However, we note that comments from other agencies suggest that it is not appropriate for this investigation. We also note that it uses the PRG in its statistical methodology which we find suspect, since the PRG, as previously stated, is relevant to remediation efforts, not health risk assessment and contaminant pathway determination.

The MARSSIM statistical methodology is no longer part of the data analysis and is not included in the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Inaccurate Statements

The plan on page 1 inaccurately states that "there is no current health risk" from the surface soil plutonium discovered in Big Trees Park thus far. This statement should be changed to reflect the public health agencies' conclusion that the contamination levels are below a level of health concern or action.

This statement is not included in the Draft Final Livermore BTP 1998 Soil Sampling Plan. Based on EPA standards, CDHS-EHIB's assessment as well as national and international radiation protection standards, the risk from the concentrations of Pu-239 found at BTP is clearly below 1-in-a-million fatal cancer risk over the maximally exposed person's lifetime. Although each person may have their own threshold for tolerable risk, 1-in-a-million risk level is used by public health agencies as the action level to determine the need for further analysis and/or remediation. The sampling will provide additional information to determine whether that conclusion is appropriate, but currently there is no information to support that the risk from plutonium at BTP represents a regulatory unacceptable risk to the public using the park.

The plan also suggests that "if plutonium concentrations measured by this sampling effort are below the PRG, then it will be deemed that no unacceptable risk to human health or the environment exists at Big Trees and no further action is required." (p. 2, emphasis added)

We wish to note that the community has yet to be engaged in a discussion about acceptable risk, including the possibility of future human and other activities that cause the resuspension of plutonium particles into the air. We further note that risk uncertainty suggests a range, rather than a single number for the PRG. (See Dr. Hoffman's comment #4.)

DOE/LLNL defer to the EPA with respect to establishing risk-based goals for remediation. DOE/LLNL concur with the EPA that the PRG is adequately protective of human health. A short description of process by which the PRG has been developed has been provided in this response to Owen Hoffman's Comment No. 4 (Section 6.7 of this Responsiveness Summary).

Finally, as pointed out by CDHS-EHIB, assertions in the plan suggesting that only one location in Big Trees park demonstrated higher than background levels of plutonium are simply untrue.

> The statement that Location 1 is the only location definitely above background was an error in the draft Big Trees Park Sampling Plan. Location 1 was definitely above background, Location 7 (in a position consistent with the sewage sludge pathway) was slightly above background, and Location 8 was near the upper range of background, and may or may not be higher than background. All other locations were well within the range of background. Locations 1, 7, and 8 will be resampled in this 1998 study.

6.9. Kevin Reilly's Comments and DOE/LLNL Responses

The plutonium contamination at Big Trees Park in Pleasanton, CA, is being investigated by the LLNL. Many of us from the communities around LLNL believe that the contamination came from LLNL and should be investigated by an impartial, independent agency, preferably with a public health track record. As a Registered Nurse, I believe that independent investigations are about the only way the public can gain access to meaningful information and trust that the answers we get will be truthful. I frequent Del Valle Regional Park nearby and have visited Shadow Cliffs Regional Park (also nearby) and plan to spend more time at Sunol and Ohlone Regional Wilderness areas. Will these areas also be evaluated and found to have been contaminated? I don't believe for a minute that folks at LLNL would want us to know.

This community must have representation on both the sampling plan development and the technical group contributing to plan development and evaluating sample results. We are sick of the LLNL public relations game. If they think we are going to stand by and watch as they use our tax dollars to construct a new multi-billion dollar boondoggle (the NIF) while they haven't finished cleaning up the mess from their previous projects and continue to stonewall community neighbors who have valid public health concerns about many of the activities at LLNL, they are surely mistaken.

If in fact the belief is that plutonium-laden sludge was distributed throughout the area as soil amendment, any sampling plan must include soil-sampling free of charge to residents and businesses who suspect contamination. The Department of Energy, as the historical oversight agency, must pay for all aspects of the sampling plan.

Finally, I hope I never hear an agent from the U.S. government say that the plutonium samples found do not constitute a threat to the public. If I do, I hope they proceed to eat the soil at Big Trees Park as a show of good faith!

DOE/LLNL's goal is to ensure the sampling results are both scientifically valid and accurate. The sampling, drilling, and analytical work is being contracted to qualified consultants. The Draft Final Livermore BTP 1998 Soil Sampling Plan was developed in conjunction with EPA, CDHS/RHB, and ATSDR. Representatives of EPA and CDHS/RHB will be in the field to observe sample collection and take splits. EPA and ATSDR will collect sample splits along with LLNL to be sent to an independent laboratory for analysis. The data resulting from the sampling will be analyzed by LLNL, EPA, CDHS-EHIB, CDHS-RHB, and ATSDR.

The sampling plan's scope is limited to soil sampling at Livermore's Big Trees Park. If additional sampling outside of BTP is warranted, a sampling plan specifically designed to address that sampling will be written. DOE/LLNL will work closely with EPA and the state agencies to determine if follow-up activities are necessary based on the results of this sampling.

DOE is funding the CERCLA cleanup program, ATSDR health assessment activities, and this additional sampling of Big Trees Park. DOE/LLNL will meet all CERCLA Federal Facility Agreement milestones in Federal Fiscal Year 1998 and also will attempt to complete the sampling at BTP this summer.

6.10. Janis Turner's Comments and DOE/LLNL Responses

I urge you to contract with an agency other than LLNL to design and implement the testing of Big Trees Park (Livermore) for plutonium contamination. I am concerned that LLNL has too much of an interest in the outcome of this soil analyses to remain neutral when analyzing (and acquiring) data.

F. Owen Hoffman of SENES Oak Ridge, Inc. was funded to provide independent scientific review of the draft BTP sampling plan. His comments and DOE/LLNL responses are presented in Section 6.7. If ATSDR feels that the Livermore community needs an independent scientific consultant to provide additional review of technical documents, ATSDR can make the decision to use it's DOE public health assessment funds for that purpose.

6.11. Stephanie Ericson's Comments and DOE/LLNL Responses

On behalf of the community members of the LLNL Public Health Assessment Site Team, I am responding to your letter of May 22, 1998. In this letter you state that DOE/Oakland is unwilling to provide funding for an independent consultant to assist community Site Team members and interested persons in the Livermore community to evaluate and comment on LLNL's proposed sampling plan for Big Trees Park and Arroyo Seco.

We would like to request that you reconsider your decision, and specifically request an amount between $7300 to $8300 for this purpose. This amount corresponds to an estimate received from a highly recommended independent consulting firm, SENES, with extensive technical expertise and experience working with community groups. This amount covers 40 hours of consulting and travel expenses for their lead consultant who would meet with Site Team members and other interested persons. The range reflects uncertainty in airfare, but I believe we would be able to keep costs closer to the lower end of that range.

We believe the consultant costs to be reasonable and a small price to pay to assure that the sampling results and analysis have scientific credibility with the community.

Indeed, these costs are very small in comparison to the projected costs of the sampling, which from what I've read and heard, is expected to cost between $250,000 to $350,000. Why would DOE and LLNL wish to spend over a quarter of a million dollars without first establishing to the community the sampling plan's scientific validity through an independent scientific review of this kind?

The requested consulting funds are even smaller in comparison with such projects as the National Ignition Facility which is now expected to cost upwards of $5 billion over its lifetime, according to the DOE's FY99 budget request to Congress.

You say that government regulatory agencies can provide adequate independent review. However, even though different branches of the U.S. government may enjoy some independence from each other, it is not the same as a community chosen independent consultant.

In addition, as you are well aware, not only members of the Site Team, but also members of the public at the last Site Team meeting, called for funding an independent scientific review of the sampling plan.

The importance of providing communities with financial wherewithal to contract with independent technical experts has been recognized at other DOE sites around the country where this practice has been implemented, as was mentioned at the meeting.

Moreover, this approach has been applied here at LLNL as well; Tri-Valley CAREs receives limited funding to cover technical consulting costs regarding soil and ground water remediation efforts at LLNL's Main Site and Site 300. It is unfortunate that US EPA apparently feels that the money provided to it by DOE is insufficient to permit it to increase technical assistance funds to Tri-Valley CAREs to under write public health consulting for the Site Team as well.

This issue of independent scientific review will not go away, but will remain in any public discussion of sampling for plutonium and other radionuclides at Big Trees Park, Arroyo Seco and elsewhere. We urge you to reconsider your decision on this matter.

> F. Owen Hoffman of SENES Oak Ridge, Inc. was funded to provide independent scientific review of the draft BTP sampling plan. His comments and DOE/LLNL responses are presented in Section 6.7. If ATSDR feels that the Livermore community needs an independent scientific consultant to provide additional review of technical documents, ATSDR can make the decision to use it's DOE public health assessment funds for that purpose.

6.12. ATSDR Comments and DOE/LLNL Responses

General Comments

Comment 1. *The sampling plan should contain additional discussion of the quality control and quality assurance plan to ensure the precision and accuracy of the measured results. The Section 5 in the plan does not adequately address these issues*

> Appendix E of the Draft Final Livermore BTP 1998 Soil Sampling Plan describes quality assurance.

Comment 2. *A more detailed discussion of the methods to be used in the laboratory should be either discussed or referenced.*

> A description of analytical methods and sample preparation for General Engineering Laboratories and Georgia Institute of Technology are included in Appendix E of the draft in BTP Sampling Plan.

Comment 3. *A more detailed discussion (in layman's terms) of the statistical analysis to be used would assist the public in their understanding of minimum detectable activity and 2 sigma error.*

Statistical tests may be conducted on the data once it is available. DOE/LLNL are willing to discuss details of any statistical analysis at a public meeting, if requested.

Comment 4. *A table with the number of samples to be collected at each location is desirable.*

Table 2, which presents the number and depth intervals of samples to be collected at each location, has been added to the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 5. *A brief discussion of biased samples should be given to explain how this sampling event differs from the 1995 sampling event.*

A brief comparison of the 1995 sampling design with the present one has been added to Sections 3.2 and 3.3.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Specific Comments

Comment 1. *Page 5 - discussion of sample depths (applicable at other locations within the document). Although we understand the laboratory objective of determining if plutonium (Pu) concentration increases with depth, ATSDR is concerned that such a large sampling interval may mask any variations in Pu with depth. We recommend that a split spoon sampling procedure be used. One half of the sample can be analyzed in toto; whereas, the other part of the spilt spoon can be segmented into 5 to 10 centimeter segments. Since the Pu analysis only requires a few grams for microwave digestion, this change should not require any additional material.*

The sampling intervals have been revised agreed among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR. The depth intervals are now 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm for the grid sample. Samples collected from Locations 1, 7, and 8 from the 1995 sampling will now be sampled at 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, and 40-85 cm.

Comment 2. *Page 7 - background sampling upstream of Sandia Nation Laboratory (SNL). Under normal circumstance, a sediment sample collected upstream is a good indicator of background levels of materials to be analyzed. However, the predominant wind direction is toward the upstream direction. If this is the case, and based on DOE Tiger Team concerns with airborne Pu releases, ATSDR recommends that three sediment samples be collected upstream at*

different distances from SNL to ensure no atmospheric deposition has occurred via the air pathway.

The sampling proposed in the arroyo is to determine if the storm water runoff outfall adjacent to East Avenue is releasing plutonium into the Arroyo Seco, as suggested in the Public Health Consultation. Concentrations downstream of the outfall will be compared to the concentration upstream to determine if releases are occurring at this location.

Comment 3. *Sampling of the bank nearer to the main body of the park. Understanding that this would assist in the determination of vertical distribution of Pu in the park soils, we would also recommend that the far bank be sampled. This could serve as a background reference. If the soils in the park received Pu contaminated materials after the arroyo was constructed, no contamination should be found on the far bank. If Pu is found in the far bank statistically above background levels, then perhaps additional scenarios for contaminant migration would need to be developed.*

In agreement among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, samples will not be collected along the arroyo banks.

Comment 4a*. Page 8 - use of LLNL licensed surveyors. ATSDR recommends that a team consisting of LLNL as well as a city or county surveyor be used.*

The LLNL surveyors used for locating the old arroyo are licensed surveyors and located the old arroyo to the best of their professional abilities. One test borehole drilled where the old arroyo was sighted located the interface of the fill with the old arroyo sediment boundary.

Comment 4b. *Page 8 - select six locations. Besides the random locations within the original channel, consideration should be given to collect a sample at the junction of the original channel and the existing channel.*

The junction of the original and existing channel is believed to be close to where the arroyo enters the concrete channel, which was sampled last time, or is currently inaccessible under concrete. New sample locations are presented in Section 3.1.1 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 5. *Page 9 - second line. Please consider adding the following: "and if the possibility for contaminated sludge use at other locations exist."*

In addition to the sludge being in the tree wells, there is the possibility that sludge was spilled as people carried it in wheelbarrows or where a pile of sludge might have been stockpiled. This discussion has been added to Section 3.1.2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 6. *Fourth paragraph (Logistics...). In this case, one can see the situation where potentially contaminated soils were replaced with clean soils. In this case, negative results still do not answer the question.*

Empty tree wells will not be sampled. Only trees believed to potentially have been planted with sludge will be sampled.

Comment 7. *Section 2.4 sampling grid. In your Figure 5, showing the grid construct, one can see that from the intersection of Kathy Way with Charlotte Way to the point between the roses and "compacted bare soil" represents a triangle. The remaining grid locations roughly represent a rectangle. The MARSSIM manual recommends using different formula when evaluating a non rectangular area versus a rectangle.*

In an agreement among DOE/LLNL, EPA, CDHS-RHB, CDHS-EHIB, and ATSDR, the sample locations have been relocated. The guidance on grid construction is not relevant to the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 8. *Page 16 - Laboratory QC samples. The number of samples representing each type of sample discussed in the QC portion should be stated.*

As described in Section 4.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan, collocated samples will be collected at approximately 10% of the sample locations, 10 locations will be randomly selected for field replicates, one sample from Location 1 of the 1995 study will be collected for a field replicate, and two performance evaluation samples will be sent to the analytical laboratory.

Comment 9. *Laboratory Analyses. Because ATSDR will be receiving a number of the samples for analyses, this should be discussed as to the percentage of the samples to be split (10 percent), how the determination as to what samples are to be shipped are chosen, and how the chain of custody will be maintained. ATSDR also recommends that besides Pu speciation, Sr-90 determinations and full gamma spectroscopy be performed on the samples. As for procedures to be used, ATSDR in discussions with the laboratory that will analyze the samples, recommends that the procedure be altered somewhat. The current procedure calls for the precipitation of Pu*

with neodymium fluoride onto filter paper. Our laboratory informs us that a better yield and more stable results can be obtained with electroplating of the Pu onto a planchet. Furthermore, the electroplated samples are more stable (with respect to storage) than storage of filter paper. The separation of Sr-90 can be obtained from the same ion exchange column and this would involve a few extra steps. The gamma spectroscopy would indicate other potential radioactive substances present in soil; however, inclusion of this analytical procedure requires much more sample volume than possibly available, because composite samples are not to be collected as mentioned on page 18 of the sampling plan.

The ATSDR will determine which samples they want to collected for splits. The chain of custody procedures that DOE/LLNL will use are described in the Environmental Restoration Division's Standard Operating Procedure 4.2, "Sample Control and Documentation" (Dibley and Depue, 1998). Also, a chain of custody form is included in Appendix C of the Draft Final Livermore BTP 1998 Soil Sampling Plan.

Comment 10. *Page 19 - last paragraph. In the "test sampling" efforts discussed, cores that are removed during the test efforts are to be re-inserted in the bore holes. ATSDR recommends that the testing be performed in an area with similar geological parameters or on the opposite bank of the arroyo.*

The test boreholes were drilled at BTP to ensure that all physical conditions were similar to proposed activities described in this sampling plan.

6.13. RWQCB's Comments and DOE/LLNL Responses

The Regional Water Quality Control Board (RWQCB) has received the subject document. As we have mentioned in the coordination meeting March 24, 1998, the RWQCB would defer to the California Department of Health Services to review the soil sampling plan and other plutonium related issues at Big Trees Park in the future.

Comment noted.

6.14. Michael Ferrucci's Comments and DOE/LLNL Responses

I have reviewed the comments of the United States Environmental Protection Agency and the California Department of Health Services regarding the Big Tress Park 1998 sampling plan. In addition, I have taken into account the comments and concerns received from the public at our

LLNL Site Team meetings. I have also considered the comments made by Dr. Owen Hoffman, and independent consultant and other site team and community members.

In general, I agree with Dr. Hoffman's analysis of the sampling plan and support his recommendations. I have made only a few comments to express my additional concerns.

The plan in its current form does not appear to support its stated objectives, namely, to determine the mechanisms as to how plutonium was transported from LLNL to Big Trees Park. The plan is clearly designed to determine whether or not the concentrations of plutonium are below pre-established limiting values. However it does not explain how determination of Pu levels will contribute to the understanding and determination of mechanisms responsible for the translocation of Pu offsite. The plan should state how these test results will be used in an overall plan to characterize the nature and extent of historical LLNL off site contamination.

> The objectives have been redefined and are presented in Section 1.3 of the Draft Final Livermore BTP 1998 Soil Sampling Plan. A discussion is also included in Draft Final Livermore BTP 1998 Soil Sampling Plan for data analysis and interpretation of each data set. Historical offsite sampling results are presented in the LLNL Annual Environmental Reports.

Given the fact that the source of contamination remains unknown, there is no information on the particle size of the measured activity. While it is likely that the contamination consist of small particles, it has been suggested that we perform an alpha track survey to identify the density of plutonium contamination.

> To our knowledge, alpha track analysis is normally performed with soil spread out in a fairly thin uniform layer. Alpha track analysis of an intact core would employ a very different geometry, with alpha particles from different parts of the core traveling different distances to the recording film. This would greatly complicate the measurement of the tracks. Without considerably more research, we think this method is unlikely to provide useful results.

I am in agreement with the comments made by Kathy Setian, Remedial Project Manager at the EPA's Federal Facilities Cleanup Office in San Francisco. In her comments dated June 5, 1998, Ms. Setian suggests that there may be another pathway that should be considered. She specifically mentions a former LLNL evaporation pond area. This is the first that I have heard of this possible source of contamination. She also recommends that DOE consult with Associated Laboratory in Montgomery Alabama. This laboratory conducted sampling in the original investigation of Big Trees Park in 1993 and they may be able to provide valuable information regarding sampling locations beneath the ornamental trees.

LLNL Plant Operations personnel say that no soils from construction activities in the area could have found their way to Big Trees Park. Prior to any construction in the area, three radiological surveys were performed in 1978, 1981, and 1982. The 1982 survey resulted in the identification, cleanup and disposal of approximately 3,000 cubic yards of soils. A portion of the soils were determined to be low level radioactive waste, and disposed of at the Nevada Test Site (Buerer, 1983). In addition, more information is described in a discussion of the East Taxi Strip in the CERCLA Remedial Investigation report (Thorpe, 1990).

The draft BTP Sampling Plan discusses conducting sampling in the 1995 sampling locations, not the 1993 sampling location. LLNL consulted with Sanford Cohen and Associates prior to the 1995 sampling; the 1995 samples near the 1993 location were based on information received at that time. This 1998 study will resample Locations 1, 7, and 8 from the 1995 study.

I think that there is consensus among the site team members and others that we should expand the analyte list to include heavy metals and other radionuclides to compare to elevated levels of plutonium. I concur that if there is a correlation, further investigation of the sewer sludge pathway is warranted.

In addition to plutonium, the surface grid samples will now be analyzed for americium-241 and samples around the ornamental trees will now also be analyzed for chromium, copper, lead, zinc, and americium-241. Table 2 of the Draft Final Livermore BTP 1998 Soil Sampling Plan presents the sample sets, potential pathways, depths, number of locations, and analyses.

DOE/LLNL will work closely with the EPA and the state agencies to determine if follow-up activities are necessary based on the results of this sampling

It is my opinion that we are making progress in this public health assessment, I want to commend the CDHS, ATSDR, EPA, LLNL, and my fellow site team members for all of their contributions. Unfortunately, I am disappointed in the level of participation by the City of Livermore in this investigation. I urge city officials to get involved and support the efforts of the above mentioned agencies and those of the site team.

Comment noted.

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Appendix A: Lawrence Livermore National Laboratory Plutonium Fact Sheet (Prepared by the EPA)

This appendix can be obtained by contacting Bert Hefner at the LLNL Public Affairs Department, P.O. Box 808, Livermore, CA 94550, (925) 424-4206

Appendix B: Chronology of Potential Environmental Impacts from LLNL

Date	Activity	Source
1950-1952	California Research and Development constructs but does not operate a Materials Test Accelerator on site to produce plutonium and tritium.	DOE, 1982
1952	LLNL, then called Lawrence Radiation Laboratory, established for nuclear weapons and energy research. Plutonium brought onsite from other U.S. facilities.	DOE, 1982
November 8, 1960	Curium cave fire: A few µCi of curium in a cave were released but confined to area of Building 251. Some Pu-238 may have been present as a decay product of Cm-242. No monitoring impact.	DOE, 1982
1962-1976	LLNL uses solar evaporation ponds in SE quadrant to evaporate water and thereby reduce the volume of liquid radioactive waste for offsite disposal.	Buerer, 1983
March 26, 1963	Nuclear excursion (U-235) in Building 261 -"Only small amounts of short-lived gaseous fission products were released from the experiment room." No plutonium was involved.	DOE, 1982
September 13, 1965	A plastic bag containing some plutonium and Pu-plated pieces caught fire as it was being moved to a metal can. It was immediately extinguished. No detectable plutonium escaped the building, and procedures were changed to prevent reoccurrence.	DOE, 1982
May 25-June 15, 1967	32 mCi of Pu-239/Am-241 inadvertently released over 3 weeks to sanitary sewer; assessment of release was given to City of Livermore, State Department of Public Health, and U.S. Atomic Energy Commission. Total from prior 3 yrs showed gross alpha activity comparable to the 1967 plutonium release (all below regulatory limit).	Sewell, 1967 McConachie, 1998 Silver, 1998
1971-1972	LLNL expands valley-wide environmental sampling to additional locations and includes plutonium isotopic analyses. LLNL identifies plutonium in soil due to onsite evaporators and at the Livermore Sewage Treatment Plant (LWRP) due to releases below regulatory limits to the sanitary sewer.	Gudiksen et al., 1973
1973	LLNL finds plutonium in air sampler downwind of the evaporation ponds on the east side of site (the total for the year was less than the derived concentration guide limit). LLNL modifies solar evaporation method to reduce wind dispersal, and reports this in Site Annual Monitoring Report.	Silver et al., 1974
Date	**Activity**	**Source**

Date	Activity	Source
1974	LLNL samples SE quadrant of site where solar evaporation was conducted – confirming release from evaporation process - all values less than regulatory limit.	Silver et al., 1975
1975	LLNL publishes "Evaluation of the Use of Sludge Containing Plutonium as a Soil Conditioner for Food Crops." Sewer sludge from LWRP containing about 2.8 pCi of Pu-239 per gram of sludge used. Conditions selected to maximize exposure to plutonium in the sludge through resuspension and in plant content to approximate the maximum potential hazards due to the inhalation and ingestion pathways. In the study, the maximum credible dose commitments from use of contaminated sludge as a soil conditioner were about 0.04% of the annual maximum permissible dose.	Myers et al., 1976
March 11, 1979	21 sacks containing 43 μCi of Americium went to Eastern Alameda County Disposal Site. The material was located and recovered. A program of training and improved supervision was adopted to prevent misplacing radioactive waste.	DOE, 1982
1980	CDHS samples soil to E, ENE, and NE downwind of LLNL and finds no significant offsite plutonium.	Toy, 1988
April 8, 1980	Over pressurized argon supply line to glove box in Building 332 bursts glove and contaminates room releasing 3 μg (0.19 μCi) of Pu-239 to the environment becasue of improperly installed HEPA filters and failure to perform the required filter tests. Operations in the facility were stopped until similar glove boxes were inspected for adequate pressure relief mechanisms and all air filters were tested for proper installation and performance. Release not seen on perimeter or offsite air monitors nor in soil samples.	Toy et al., 1981 DOE, 1982 Silver, 1998
April 16, 1980	Flash fire involving ethanol from an ultrasonic cleaner occurrs in a sample preparation glove box in Building 332. Pressure forces the top of the glove box out of its retaining clips and releases a small amount of plutonium to the laboratory. None released to the outside environment.	Holland, 1988 DOE, 1982 Silver, 1998
May 1987	LLNL releases approximately 1 mCi of plutonium to the sanitary sewer at a concentration above routine levels but still about 1000 times below the regulatory discharge limit.	Gallegos et al., 1992
1991	LLNL conducts extensive soil sampling (195 samples in less than 1/4 mi. sq.) in SE quadrant of Lab in response to DOE Tiger Team comment. All values less than regulatory limit.	SAER, 1991
1993	EPA resamples SE quadrant (reported by the EPA in September '94) - finds good agreement with the 1991 work. One location on site exceeds the industrial cleanup goal (this soil was exhumed. A "background" sample from Big Trees Park exceedes global fallout background for this area.	NAREL, 1994

Date	Activity	Source
October-December 1994	LLNL meets and develops sampling plan with representatives of homeowners association near the park, City of Livermore, Livermore schools, LARPD, EPA, CDHS-RHB, and others.	MacQueen, 1995
January 1995	LLNL samples Big Trees Park, Big Trees eastern extension, school yard, and vicinity. EPA, CDHS-RHB and others present. EPA and CDHS-RHB take splits of the soil samples for independent analyses.	MacQueen, 1995
July 1995	LLNL report published and widely distributed. Pathway for plutonium from LLNL to park not definitive, but data from park and valley-wide monitoring suggest use of sanitary sewer sludge containing plutonium. (Airborne and arroyo storm runoff pathways are not supported by the data.) All results less than residential guideline.	MacQueen, 1995
September 1995	EPA fact sheet on plutonium published - "The levels of plutonium detected off site do not pose an unacceptable risk to local residents."	EPA, 1995
February 1998	Regulators recommend LLNL sample deeper sampling. In response to regulator recommendations, LLNL develops a sampling plan with the cognizant regulatory agencies and stakeholder input.	McConachie, 1998

Appendix C: Field Sampling Procedures

This Field Sampling Procedures describes Lawrence Livermore National Laboratory's procedures for collecting subsurface environmental samples for the Big Trees Park study in Livermore. The development and design of this sampling plan is based on the U.S. Environmental Protection Agency (EPA) Data Quality Objectives (DQO) process (EPA, 1994). The written approval of this plan by the LLNL Drilling Program Coordinator is required prior to performing the work.

C-1. Background

During past surface sampling (0-5 centimeters) events at Big Trees Park, a few samples were found to contain plutonium (Pu 239+240) concentrations greater than can be attributed to global fallout (NAREL, 1994; MacQueen, 1995). In 1995, regulatory agencies determined there was not an unacceptable health risk from this surface-soil plutonium, and that no further action was necessary (Gill, 1995; EPA, 1995). An additional evaluation in 1998 (CDHS/ATSDR, 1998) agreed that there is no unacceptable current health risk.

However, there is continuing interest from the public and regulatory community about possible human health risks from soil deeper than 5 cm and about how the plutonium reached Big Trees Park. This sampling effort has two purposes: (1) to gain information about possible pathways by which plutonium reached the park, and (2) to gain information about the extent of elevated plutonium in the soil.

C-2. Scope of Work

The scope of work includes hand-sampling using a hand coring device at depths between 0–10 cm (0–15 cm in the disked area; up to 25 cm in the arroyo) and auger drilling 66 shallow boreholes at depths ranging from 10 cm to 300 cm. Hand-sampling and hand-auger coring sampling equipment shall generally be used for near surface samples, and a truck- or trailer-mounted auger rig using a hammer driven split-spoon sampler (7.4 cm outside diameter by 45.7 cm in length) through hollow-stem augers shall generally be used to collect deeper sediment samples.

The sample locations are discussed in Section 3 of the Sampling Plan. The various types of samples are divided into eight sample sets, as discussed below.

C-2.1. Grid Samples

Grid samples shall be collect at a total of 30 locations selected from coordinates established on a grid with its origin beginning closest to southeast corner of the park. Samples shall be collected to total depths of 40 cm.

C-2.2. Current Arroyo Channel Samples

A total of seven current arroyo channel samples shall be collected from various locations along the existing arroyo. Locations near LLNL and upstream of Sandia National Laboratory will be collected to a depth of 5 cm. Two locations near the eastern extension of the park, and two locations downstream of the park will be collected to depths of 25 cm.

C-2.3.Park's Eastern Extension

Three samples will be collected in the area of the parks eastern extension to total depths of 40 cm.

C-2.4.Former Arroyo Channel

Three shallow boreholes shall be drilled at locations behind the Arroyo Seco Elementary School (Livermore School District Property) along the center of the old arroyo channel to depths ranging from 100 cm to 300 cm.

C-2.5. Ornamental Tree Samples

Two shallow boreholes shall be drilled adjacent to each of the three selected ornamental trees to depths of approximately 135 cm. At each tree, one borehole shall be drilled as close to the tree trunk as possible, inside the "well" of the tree, and the other shall be at least 1 meter beyond the irrigation berm that surrounds each tree.

C-2.6. Special Sampling Locations

There are three special sample locations:

- Location No. 1 from the 1995 study, with associated areas. These will consist of eight boreholes, sampled in the same manner as the other grid samples but collected to a total depth of 85 cm each.

- Location No. 7 from the 1995 study. This borehole will be sampled to total a depth of 85 cm.
- Location No. 8 from the 1995 study. This borehole will be sampled to total a depth of 85 cm.

C-2.7. Disked Area

Surface soil samples shall be collected at four locations in the unlandscaped "disked" area behind the Arroyo Seco Elementary School (Livermore School District Property) to depths of 15 cm.

C-2.8.Playing Field

Surface soil samples shall be collected at two locations on the playing field located directly behind the Arroyo Seco Elementary School (Livermore School District Property) to depths of 40 cm.

C-3. Procedures

C-3.1. Standard Operating Procedures

All work shall be conducted in accordance with the following procedures:

- Site Safety Plan for LLNL CERCLA Investigations.
- The LLNL Health and Safety Manual (LLNL, 1998).
- The Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs) (Dibley and Depue, 1998).
- LLNL Soil and Arroyo Sediment Sampling SOP (EMP-S-S); Operations and Regulatory Affairs Division, Terrestrial and Atmospheric Monitoring and Modeling Group (Attachment C-1).
- LLNL Operational Safety Procedure No: O-121 (Livermore Site Off-Site Ground Water Investigation Activities) (Attachment C-2).
- Quality Assurance Management Section; U.S. EPA Region 9 Field Sampling Procedures for Private and State-Lead Superfund Projects (Document Control No. 9QA-06-93).

C-3.2. Lithological Descriptions

The soils are heterogeneous unconsolidated alluvial and fill material. The drilling geologist shall describe the sediments on the borehole log following the Unified Soil Classification System (USCS) and include descriptions of any debris or other foreign materials observed in the sample.

C-3.3. Sample Collection Procedure

Surface samples (0–5 cm), the first subsurface samples (5–10 cm), and four of the arroyo samples (0–25 cm) shall be collected in accordance with procedures set forth in the LLNL Soil and Arroyo Sediment Sampling SOP (Attachment C-1).

C-3.3.1. Surface Samples

The surface samples will be collected from a surface area 23 cm in diameter using a 7.25-cm coring device. This area will be delineated by placing a guide over the center of the chosen site. The entire top 5 cm of this area will be removed and bottled as described in the SOP (Attachment C-1).

C-3.3.2. First Subsurface Core Samples

Once the entire top 5 cm is removed from the area within the guide, the next 5 cm will be collected using the same method. Depending on the soil moisture and consistency, it may be necessary to place a gloved hand over the end to the auger so that soil does not fall back into the hole.

Each sample will also be removed from the sampling area and bottled as described in the SOP (Attachment C-1).

C-3.3.3. Hammer Driven Split-Spoon Core Samples

These samples shall be collected in accordance with the LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedure (SOP) 1.2, Borehole Sampling of Unconsolidated Sediments (Soil) (Dibley and Depue, 1998).

C-3.4. Sampling Intervals

The prescribed sample depth interval collected by hand sampling, or split-spoon core sampling shall be considered, for sampling purposes, a single sample. For each discrete

depth interval, the cored sample shall be put into a decontaminated stainless-steel bucket and mixed thoroughly prior to being divided into multiple sample containers.

Each sample container shall be labeled with its unique sample number, sealed and stored for transport under appropriate Chain-of-Custody (COC) to the analytical laboratory. COC procedures set forth in SOP 4.2 (Sample Control and Documentation) will be followed. An example of a COC form is presented in Attachment C-3.

C-3.5.Former Arroyo Sample Locations

From the surface, collect, assess and continuously log the cored sediments using hammer-driven split-spoon sampler until the interface between the old arroyo and the fill material is identified. Care should be taken to center a core run over the estimated depth to the base of the channel from Table C-1. The geologist should look for features indicative of the interface (lithologic change, color change, texture change, flat lying rocks, debris, plastic, wood fragments, etc.). If the interface is not obvious, core 45 cm deeper than anticipated. In a test borehole previously drilled, the interface was identified by the observation of a lithologic change, a color change, and a texture change (coarse, loosely consolidated silty-sand, light colored to fine-grained, firm, dark colored, clayey-silt). Rocks were observed immediately above the contact, some were flat lying.

If the interface is identified, collect one sediment sample from each borehole 0-5 cm below the contact that coincides with the interface of the old arroyo bed and the overlying fill material (depth is estimated in Table C-1.) If the interface is not identified, collect samples over 15 cm intervals, 45 cm above and below the estimated channel depth from Table C-1. Following the examination and description of the core by the drilling geologist, each sample will be put into a stainless-steel bucket and mixed thoroughly. The entire 15 cm of soil collected in the split-spoon sampler shall be considered (for sampling purposes) a single sample.

Table C-1. Distances of locations and depth of samples to be collected from the former arroyo channel.

Sample	Distance (ft)	Estimated Depth of Channel (ft)
1	6	8 ft 3 in
2	123	6 ft 2 in
3	179	5 ft 3 in

C-4. Survey of Sample Locations

Each proposed sample location will be marked on the ground using white spray paint prior to drilling. Each location will be identified using global positioning system (GPS) technology. The use and data processing of the GPS is discussed in Attachment C-4. The positions of each borehole will be identified in latitude, longitude, and altitude on special Field Tracking Forms (FTFs) (Attachment C-5).

C-5. Underground Utility - Buried Line Locator

Each proposed borehole location will be cleared by the underground utility line locator prior to drilling.

C-6. Equipment Use and Storage

The drill rig, support vehicles and all equipment used during daily field activities shall be transported to the park each morning from LLNL and return to be stored at LLNL at the end of each work day.

C-7. Drilling-Derived Waste

C-7.1. Soils

Auger cuttings will be used to fill each borehole upon completion. Any boreholes that are short on fill material will be brought to the surface with clean fill.

C-7.2.Equipment Decontamination Water

All equipment coming in contact with the soil will be decontaminated using deionized water and low-phosphate detergent prior to reuse. All water from this decontamination process will be contained in a 5-gallon carboy or DOT 17 rated 55-gallon drum until the results of analysis determine if the water can be discharged to sewer or handled in a different manner.

Augers, split-spoon samplers, sample mixing buckets, mixing spoons, and core trays shall be steam cleaned prior to initial use. During the drilling and sampling, the split-spoon samplers, sample mixing buckets, mixing spoons and core trays shall be washed in a solution of deionized water and a low-phosphate detergent and triple rinsed in deionized water prior to re-use. Augers, split-spoon samplers, sample mixing buckets, mixing spoons and core trays shall be steam cleaned prior to use in another borehole.

Rinsate from the steam cleaner and decontamination station shall be put into 55-gallon DOT 17 rated drums, labeled appropriately and transported back to LLNL each evening. When a drum is 2/3 full, it shall be entered into the Waste Accumulation Area (WAA) for profiling prior to determining its ultimate disposition.

C-8. Soil Samples

C-8.1. Standard Samples

The samples will be divided as determined by the number of samples necessary for laboratory analysis. All samples shall be put into 500-ml plastic containers, labeled accordingly and sealed with Chain-of-Custody (COC) seals prior to being stored inside a locked vehicle at the worksite. A signed COC document shall accompany each set of samples, and the sample shall be released under signature to the receiving entity representative on the day of collection.

For each sample interval, a minimum of two sample containers shall be filled, labeled and sealed. One of those samples will go to the analytical laboratory and the other will be archived at LLNL.

Additionally, whenever EPA or ATSDR choose to collect a duplicate, a third sample container shall be filled. When EPA or ATSDR collect a duplicate sample, collect an additional sample for analysis at the LLNL onsite laboratory.

C-8.2. Blind Split Samples

Ten percent of the total number of samples shall be collected and given a coded identifier and sent to the analytical laboratory as blind split samples. These samples will be randomly selected; however, at least one sample in the vicinity of Location 1 from the 1995 study will be collected as a blind split sample. In addition, ten locations will be randomly selected for field replicate. An additional field replicate will be selected from Location 1.

C-9. Sample Quantities

Every sample will be split into at least two portions: one for the analytical laboratory and one archive. Additional samples may be needed for field replicates or splits for the EPA or ATSDR. Analysis for Pu and Am requires 100 g of soil, for a total of 400 grams when four splits are required. Adequate mass will be collected to achieve the analytical requirements.

C-10. Sample Labeling Convention

Proper labeling conventions are described below. A drill rig will be used to sample all boreholes greater than 10-cm deep except in the current arroyo and in the disked area, so all surface samples will be collected first then the drill rig will move to those locations.

C-10.1. Grid Samples

Thirty locations spaced on a grid

Depth	Label Convention
0 - 5 cm	L-G(xx,yy grid coordinate)-D0.5CM-SO
5 - 10 cm	L-G(xx,yy grid coordinate)-D5.10CM-SO
10 - 20 cm	L-G(xx,yy grid coordinate)-D10.20CM-SO
20 - 30 cm	L-G(xx,yy grid coordinate)-D20.30CM-SO
30 - 40 cm	L-G(xx,yy grid coordinate)-D30.40CM-SO

(xx indicates radial number, 01 through 04 (01 is closest to concrete arroyo channel)

yy indicates perpendicular number, 01 through 8 (01 is closest to southeast corner of park)

C-10.2. Arroyo Channel (current channel)

Three Locations (2 at LLNL, 1 at SNL)

Depth	Label Convention
0 - 5 cm	SSS-AS-101-D0.5CM-SO through SSS-AS-103-D0.5CM-SO

C-10.3. Arroyo Channel (current channel)

Four Locations (2 near park, 2 downstream)

Depth	Label Convention
0 - 25 cm	SSS-AS-104-D0.25CM-SO and SSS-AS-107-D0.25CM-SO

C-10.4. Park Eastern Extension

Three Locations

Depth	Label Convention
0 - 5 cm	L-BTPE-01-D0.5CM-SO through L-BTPE-03-D0.5CM-SO
5 - 10 cm	L-BTPE-01-D5.10CM-SO through L-BTPE-03-D5.10CM-SO
10 - 20 cm	L-BTPE-01-D10.20CM-SO through L-BTPE-03-D10.20CM-SO
20 - 30 cm	L-BTPE-01-D20.30CM-SO through L-BTPE-03-D20.30CM-SO
30 - 40 cm	L-BTPE-01-D30.40CM-SO through L-BTPE-03-D30.40CM-SO

C-10.5. Former Arroyo Channel

Three locations

Depth	Label Convention
0 - 5 cm	B-FAS-01-D0.5CM-SO through B-FAS-03-D0.5CM-SO
@ 120-300 cm BLS	B-FAS-01-D120.300CM-SO through B-FAS-03-D120.300CM-SO

C-10.6. Ornamental Trees

Six locations at 3 trees (inside tree well and outside tree well, per tree)

C-10.6.1. Inside Tree Well

Depth	Label Convention
0 - 45 cm	L-Tree_____I-D0.45CM-SO
45 - 90 cm	L-Tree_____I-D45.90CM-SO
90-135 cm	L-Tree_____I-D90.135CM-SO

C-10.6.2. Outside Tree Well

Depth	Label Convention
0 - 45 cm	L-Tree_____O-D0.45CM-SO
45 - 90 cm	L-Tree_____O-D45.90CM-SO
90-135 cm	L-Tree_____O-D90.135CM-SO

C-10.7. Special Sampling Areas

Three locations (identified in 1995 study as locations #1, #7, #8)

C-10.7.1. Special Sampling Location 1

Eight sample locations

Depth	Labeling Convention
0-5 cm	L-LOC1S-01-D0.5CM-SO through L-LOC1S-08-D0.5CM-SO
5-10 cm	L-LOC1S-01-D5.10CM-SO through L-LOC1S-08-D5.10CM-SO
10-20 cm	L-LOC1S-01-D10.20CM-SO through L-LOC1S-08-D10.20CM-SO
20-30 cm	L-LOC1S-01-D20.30CM-SO through L-LOC1S-08-D20.30CM-SO
30-40 cm	L-LOC1S-01-D30.40CM-SO through L-LOC1S-08-D30.40CM-SO
40-85 cm	L-LOC1S-01-D40.85CM-SO through L-LOC1S-08-D40.85CM-SO

C-10.7.2. Special Sampling Location 7

One location

Depth	Labeling Convention
0-5 cm	L-PATHN-02-D0.5CM-SO
5-10 cm	L-PATHN-02-D5.10CM-SO
10-20 cm	L-PATHN-02-D10.20CM-SO
20-30 cm	L-PATHN-02-D20.30CM-SO
30-40 cm	L-PATHN-02-D30.40CM-SO
40-85 cm	L-PATHN-02-D40.85CM-SO

C-10.7.3. Special Sampling Location 8

One location

Depth	Labeling Convention
0-5 cm	L-DISK-02-D0.5CM-SO
5-10 cm	L-DISK-02-D5.10CM-SO
10-20 cm	L-DISK-02-D10.20CM-SO
20-30 cm	L-DISK-02-D20.30CM-SO

30-40 cm	L-DISK-02-D30.40CM-SO
40-85 cm	L-DISK-02-D40.85CM-SO

C-10.7.4. Disked Area

Four sampling locations

Depth	Labeling Convention
0-15 cm	L-DISKED-01-0.15CM-SO through L-DISKED-04-0.15CM-SO

C-10.7.5. Playing Field

Two locations

Depth	Labeling Convention
0-5 cm	L-PLAYYD-01-D0.5CM-SO through L-PLAYYD-02-D0.5CM-SO
5-10 cm	L-PLAYYD-01-D5.10CM-SO through L-PLAYYD-02-D5.10CM-SO
10-20 cm	L-PLAYYD-01-D10.20CM-SO through L-PLAYYD-02- D10.20CM-SO
20-30 cm	L-PLAYYD-01-D20.30CM-SO through L-PLAYYD-02-D020.30CM-SO
30-40 cm	L-PLAYYD-01-D30.40CM-SO through L-PLAYYD-02-D30.40CM-SO

C-11. Chain of Custody

Instructions placed on the attached COC should include:

- Samplers name
- Name of employer
- Name of the study area
- Unique sample name/number (borehole and depth specific using agreed upon sample numbering convention)
- Date and time sample was collected
- Number of sample containers
- Type/size of sample container
- Required analysis
- Required turn-around-time
- Special instructions/comments
- Signature and date when sample was transferred to recipient

C-12. Analytes

C-12.1. All Samples

Soil samples collected for LLNL analysis should be marked on COC as:

- **AS:PUISO** (Pu 239+240) requesting a limit of sensitivity of 0.005 pCi/g and submitted to **General Engineering Laboratories (GEL) in Charleston, South Carolina** for analysis with a **14-day** turn-around-time.
- All analytical results should be reported to Don MacQueen, Kris Surano, Bob Bainer and Rick Blake.

C-12.2. Grid Samples

In addition to plutonium analyses, surface soil samples collected at the grid for LLNL analysis should also be marked on COC as:

- **AS:AMISO**: Americium (Am-241) requesting a limit of sensitivity of 0.005 pCi/g and submitted to **GEL Laboratory** for analysis with a **14-day** turn-around-time.

C-12.3. Tree Samples

In addition to plutonium analyses, soil samples collected around the ornamental trees for LLNL analysis should also be marked on COC as:

- **TTLC:** (Total Metals in Soil) specify chromium, copper, lead, nickel, and zinc submitted to **GEL Laboratory** for analysis with a **30-day** turn-around-time.
- **AS:AMISO**: Americium (Am-241) requesting a limit of sensitivity of 0.005 pCi/g and submitted to **GEL Laboratory** for analysis with a **14-day** turn-around-time.

Attachment C-1:

LLNL Soil and Arroyo Sediment Sampling SOP

Attachment C-1 can be obtained by contacting Bert Hefner at the LLNL Public Affairs Department, P.O. Box 808, Livermore, CA 94550, (925) 424-4206.

Attachment C-2:

LLNL Operational Safety Procedure No. O-121

Attachment C-2 can be obtained by contacting Bert Hefner at the LLNL Public Affairs Department, P.O. Box 808, Livermore, CA 94550, (925) 424-4206.

Attachment C-3:

Chain of Custody

Chain-of-Custody Record

☐ ORAD/TSG ☐ TAMM (air only)
☐ ORAD/EOG ☐ Other _____

page ___ of ___

Laboratory:

Sample Group Description:

Analyst:

Sample Identifier (site - location - no. - medium)	Date	Total Containers	Analyses Requested and # Containers per Analysis										Lab Use Only / Fax No.: / REMARKS
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													
- - -													

Release Number or ProCard:	TRR:

DISPOSITION OF COPIES (after signatures)
Goldenrod: Returned to TSG DMT by sampler with courier signature or airbill no.
Pink: Signed and returned to TSG DMT by laboratory upon receipt of samples.
Canary: Retained by laboratory.
Green: Retained and filed by analyst.
White : Archived with data by TSG DMT.
ALL SIGNATURES MUST BE MADE ON WHITE COPY

Relinquished by Sampler:	Date/Time	Received by:	Date/Time
Relinquished by:	Date/Time	Received by Courier at LLNL:	Date/Time
Relinquished by Courier to Lab:	Date/Time	Received at Laboratory:	Date/Time
Data relinquished from Lab:	Date/Time	Data received by Analyst:	Date/Time
Data relinquished by Analyst:	Date/Time	Data received by Data Management:	Date/Time

ORAD: WGMG/TAMM/TSG/EOG
Lawrence Livermore National Laboratory
P.O. Box 808, L-629
Livermore, CA 94551

Form QAP-8
Rev. 9
January 1998

Attachment C-4:

Global Positioning System

Global Positioning System

The Global Positioning System (GPS) will be employed in pre-sample planning and during the sampling event to assist in identifying the park boundary, its features, and specific sampling locations. The GPS, which is Model Pathfinder ProXR, with TDC2 data collector is manufactured by Trimble Navigation Ltd. and has an accuracy of 50 cm. This accuracy is obtained using a link between the data collector and at least four satellites. Data collected with the GPS will be referenced each time using known waypoints (Livermore City Monuments). These waypoints have been identified and surveyed by LLNL Surveyors.

The real time GPS positions (in latitude and longitude) will be obtained and recorded on the Field Tracking Form (FTF). All collected GPS positions will be stored in the GPS rover unit for data transfer once back from the field. Once data is transferred to the office computer, it will be post-processed using Trimble's MCORR 400 differential correction engine to improve its accuracy. Once sampling is completed the GPS data will be used to produce a map detailing the locations of all samples collected within the park.

Attachment C-5:

Field Tracking Forms

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: **GRID SAMPLES**

Date Sampled: _____ **Log book number** _____

Sample Identifier (xx,yy grid coordinate)	Time Sampled	Depth	
L-G____-D0.5CM-SO	_____	(____cm)	QA Identifier _____
L-G____-D5.10CM-SO	_____	(____cm)	QA Identifier _____
L-G____-D10.20CM-SO	_____	(____cm)	QA Identifier _____
L-G____-D20.30CM-SO	_____	(____cm)	QA Identifier _____
L-G____-D30.40CM-SO	_____	(____cm)	QA Identifier _____
			_____

Samplers Initials: _____

GPS File name: _____

_____

GPS Coordinates

_____ **North**

_____ **West**

_____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: CURRENT ARROYO CHANNEL

Date Sampled: _____ **Log book number** _____

Sample Identifier **Time Sampled** **Depth**

SSS-AS-___-D____CM-SO _____ (_____cm) QA Identifier _____

GPS Coordinates

Samplers Initials: _____ _____ **North**

GPS File name: _____ _____ **West**

_____ _____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: PARK EASTERN EXTENSION

Date Sampled: _____ **Log book number** _____

Sample Identifier	Time Sampled	Depth	
L-BTPE-___-D0.5CM-SO	_____	(_____cm)	QA Identifier _____
L-BTPE-___-D5.10CM-SO	_____	(_____cm)	QA Identifier _____
L-BTPE-___-D10.20CM-SO	_____	(_____cm)	QA Identifier _____
L-BTPE-___-D20.30CM-SO	_____	(_____cm)	QA Identifier _____
L-BTPE-___-D30.40CM-SO	_____	(_____cm)	QA Identifier _____

GPS Coordinates

Samplers Initials: _____ _____ **North**

GPS File name: _____ _____ **West**

_____ _____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: FORMER ARROYO SECO

Date Sampled: _____ **Log book number** _____

Sample Identifier	Time Sampled	Depth	
B-FAS-___-D0.5CM-SO	_____	(_____cm)	QA Identifier _____
B-FAS-___-D____CM-SO	_____	(_____cm)	QA Identifier _____
B-FAS-___-D____CM-SO	_____	(_____cm)	QA Identifier _____

GPS Coordinates

Samplers Initials: _____ _____ **North**

GPS File name: _____ _____ **West**

_____ _____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: **TREES (inside of tree well)**

ampled Date: _____

Log book number _____

Sample Identifier	Time Sampled	Depth	
L-TREE____I-D0.45CM-SO	_____	(____cm)	QA Identifier _____
B-TREE____I-D45.90CM-SO	_____	(____cm)	QA Identifier _____
L-TREE____I-D90.135CM-SO	_____	(____cm)	QA Identifier _____

Samplers Initials: _____

GPS File name: _____

_____

GPS Coordinates

_____ **North**

_____ **West**

_____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: **TREES (outside of tree well)**

Sampled Date: _____

Log book number _____

Sample Identifier	Time Sampled	Depth	
L-TREE____O-D0.45CM-SO	_____	(____cm)	QA Identifier _____
L-TREE____O-D45.90CM-SO	_____	(____cm)	QA Identifier _____
L-TREE____O-D90.135CM-SO	_____	(____cm)	QA Identifier _____

Samplers Initials: _____

GPS File name: _____

_____

GPS Coordinates

_____ **North**

_____ **West**

_____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: **SPECIAL SAMPLING LOCATION #1**

Date Sampled: _____ **Log book number** _____

Sample Identifier	Time Sampled	Depth	
L-LOC1S-___-D0.5CM-SO	_____	(_____cm)	QA Identifier _____
L-LOC1S-___-D5.10CM-SO	_____	(_____cm)	QA Identifier _____
L-LOC1S-___-D10.20CM-SO	_____	(_____cm)	QA Identifier _____
L-LOC1S-___-D20.30CM-SO	_____	(_____cm)	QA Identifier _____
L-LOC1S-___-D30.40CM-SO	_____	(_____cm)	QA Identifier _____
L-LOC1S-___-D40.85CM-SO	_____	(_____cm)	QA Identifier _____

GPS Coordinates

Samplers Initials: _____ _____ **North**

GPS File name: _____ _____ **West**

_____ _____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: **SPECIAL SAMPLING LOCATION #7**

Date Sampled: _____ **Log book number** _____

Sample Identifier	Time Sampled	Depth	
L-PATHN-___-D0.5CM-SO	_____	(_____cm)	QA Identifier _____
L-PATHN-___-D5.10CM-SO	_____	(_____cm)	QA Identifier _____
L-PATHN-___-D10.20CM-SO	_____	(_____cm)	QA Identifier _____
L-PATHN-___-D20.30CM-SO	_____	(_____cm)	QA Identifier _____
L-PATHN-___-D30.40CM-SO	_____	(_____cm)	QA Identifier _____
L-PATHN-___-D40.85CM-SO	_____	(_____cm)	QA Identifier _____

GPS Coordinates

Samplers Initials: _____ _____ **North**

GPS File name: _____ _____ **West**

_____ _____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: **SPECIAL SAMPLING LOCATION #8**

Date Sampled: _____ **Log book number** _____

Sample Identifier	Time Sampled	Depth	
L-DISK-___-D0.5CM-SO	_____	(_____cm)	QA Identifier _____
L-DISK-___-D5.10CM-SO	_____	(_____cm)	QA Identifier _____
L-DISK-___-D10.20CM-SO	_____	(_____cm)	QA Identifier _____
L-DISK-___-D20.30CM-SO	_____	(_____cm)	QA Identifier _____
L-DISK-___-D30.40CM-SO	_____	(_____cm)	QA Identifier _____
L-DISK-___-D40.85CM-SO	_____	(_____cm)	QA Identifier _____

GPS Coordinates

Samplers Initials: _____ _____ **North**

GPS File name: _____ _____ **West**

_____ _____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: **DISKED AREA**

Date Sampled: _____ **Log book number** _____

Sample Identifier **Time Sampled** **Depth**

L-DISKED-___-0.15CM-SO _____ (_____cm) QA Identifier _____

GPS Coordinates

Samplers Initials: _____ _____ **North**

GPS File name: _____ _____ **West**

_____ _____ **Altitude**

_____ **Datum**

Comments:

1998
Big Trees Park Soil Sampling
Special Field Tracking Form

Lab	COC #

Category: PLAYING FIELD

Date Sampled: _____ **Log book number** _____

Sample Identifier	Time Sampled	Depth	
L-PLAYYD-___-D0.5CM-SO	_____	(_____cm)	QA Identifier _____
L-PLAYYD-___-D5.10CM-SO	_____	(_____cm)	QA Identifier _____
L-PLAYYD-___-D10.20CM-SO	_____	(_____cm)	QA Identifier _____
L-PLAYYD-___-D20.30CM-SO	_____	(_____cm)	QA Identifier _____
L-PLAYYD-___-D30.40CM-SO	_____	(_____cm)	QA Identifier _____

GPS Coordinates

Samplers Initials: _____ _____ **North**

GPS File name: _____ _____ **West**

_____ _____ **Altitude**

_____ **Datum**

Comments:

Appendix D: Background Data Summary

Above-ground weapons testing, primarily in the 1960s, has resulted in a world-wide distribution of plutonium isotopes. The actual plutonium concentration in any particular location depends on the latitude, longitude, meteorology, and topography of the location. LLNL has conducted weapons research using plutonium since the early 1950s. Consequently, the best estimate of background levels of the Livermore Valley is one based on sampling of the Livermore Valley in areas not affected by LLNL operations.

LLNL measures radionuclides in soil and sediment samples in the Livermore Valley in support of its environmental surveillance monitoring effort. Soil and sediment sampling are conducted according to written, standardized procedures contained in *the Environmental Monitoring Plan* (Tate et al., 1995). Samples are collected from undisturbed areas near permanent sampling location markers. These areas generally are level, free of rocks, and are unsheltered by trees or buildings. The sampling technician chooses two 1-m squares from which to collect the sample and records how far away and in what direction from the permanent marker the sample is collected. Each sample is a composite consisting of 10 subsamples that are collected with an 8.25-cm-diameter stainless steel core sampler at the four corners and the center of each square. Since 1976, all soil subsamples have been collected from the top 5 cm because surface deposition from the air is the primary pathway for potential contamination and resuspension is the most likely exposure route. Since 1993, the sediment samples have also been collected 5-cm deep, because surface deposition is the most likely pathway for potential contamination, and resuspension (not migration through the groundwater) is the most likely exposure route to offsite populations.

Selection of samples to represent background

Not all surveillance monitoring samples can be appropriately called background samples. Some samples are collected in areas of known contamination. Others are collected in locations downwind of the Livermore site in areas likely to be affected by the resuspension of known low-level plutonium-contaminated soils in the southeast quadrant of the Livermore Site. Samples collected in areas of known contamination, for example, the Livermore Water Reclamation Plant, are not included in any calculations of background. Samples downwind of the Livermore Site are eliminated based on whether or not they are in the prevailing downwind directions (E through N or SW to SSW), see Figure D-1. A map showing the locations sampling locations is provided in Figure D-2.

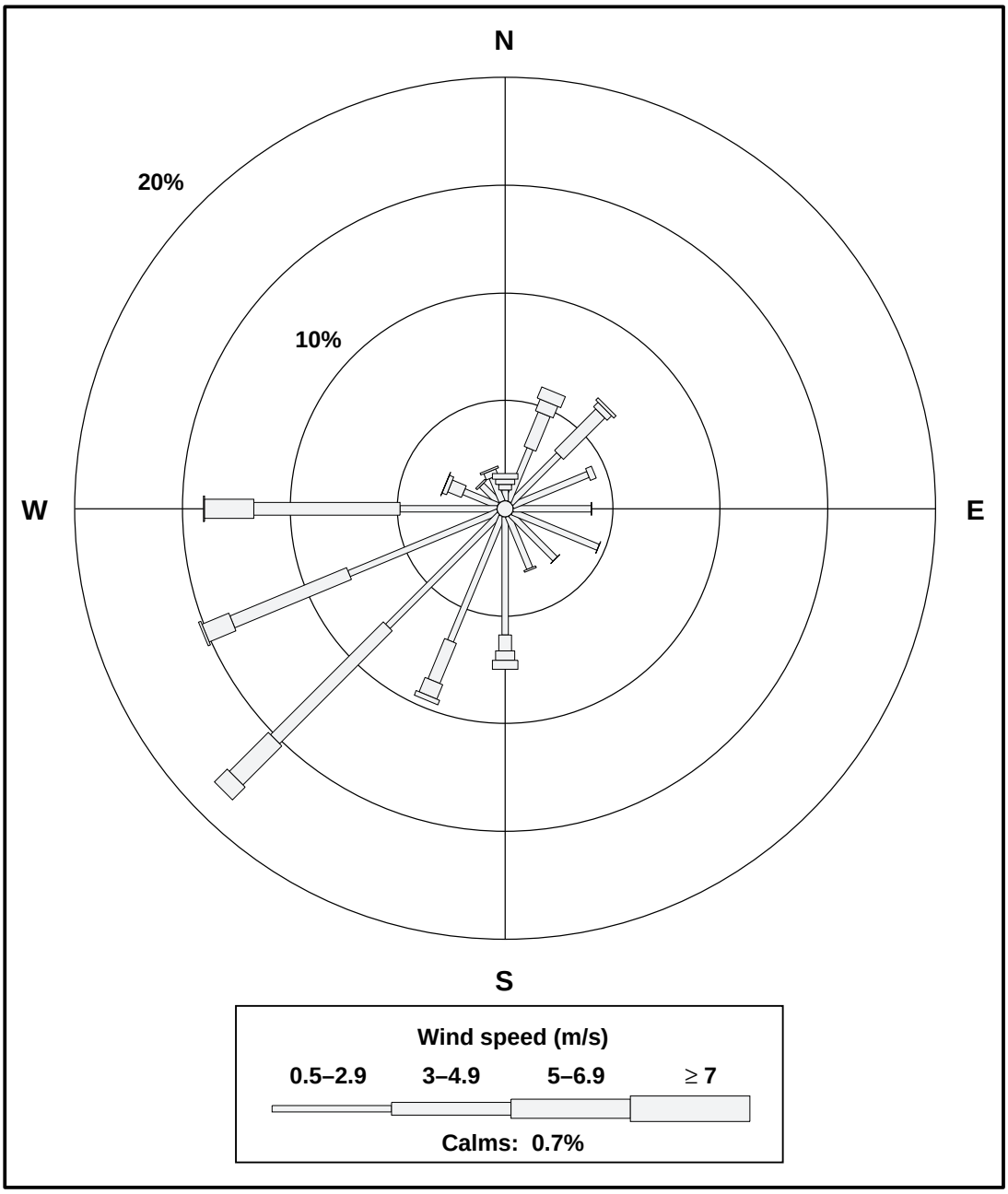

Figure D-1. Windrose showing the average annual wind speed, frequency of occurrence, and direction from which the wind is blowing at the Livermore Site, 1997.

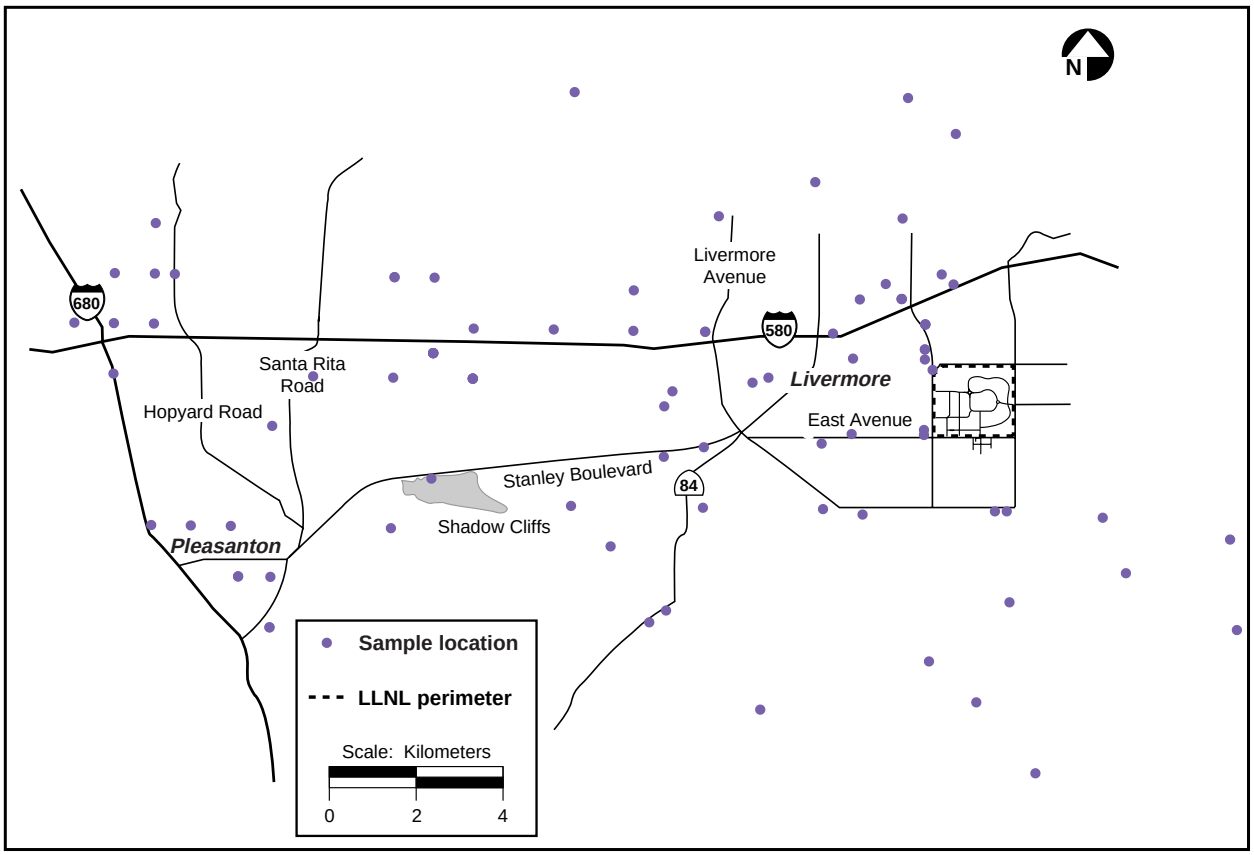

Figure D-2. Map of soil sampling locations in the Livermore Valley.

In addition, only samples collected at the depth interval of interest are used for individual calculations. For example, soil samples collected before 1976 were collected at varying depths from 0-1 to 0-30 cm. Soil samples collected in 1976 and later were collected at 0-5 cm deep. Use of consistent sampling depths is important because air deposition is the primary source of the contamination. Therefore, most of the contaminant is found at or near the ground surface. If varying depths are used, the amount of contaminated soil is diluted by varying amounts of lesser or uncontaminated soils, leading to inconsistent quantification of the amount of contamination per gram of soil.

Table D-1 at the end of this Appendix provides a listing of all samples considered to be background, including their approximate latitude and longitude, and measured Pu-239+240.

Applicability

There are some differences between how the surveillance samples are collected compared to how we intend to collect the samples at Big Trees Park. The first of these differences is that the surveillance samples are composites of 10 subsamples, which are separated by up to 2 meters, but the Big Trees Park samples are not composited. Compositing provides an average value for the entire sample interval. It also reduces the overall variability among samples. Use of composite sample data for evaluation of background concentration will reduce the variability, thereby reducing the calculated estimate of the upper bound of background (either 95% UCL for 95th percentile, 80% UCL for 95th percentile, or geometric mean plus two geometric standard deviations). The net result is a conservative, that is, low, estimate of background soil concentrations.

In addition, although every attempt is made to obtain surveillance samples from undisturbed soils, occasionally disturbed areas are sampled. For example, an open field may look like an undisturbed area, but may have been plowed a few years earlier. The inclusion of disturbed sites serves to make the estimate of central tendency lower, meaning that a location exhibiting above-background concentrations, might not really be above background. An additional complication is that most of Big Trees Park soil is disturbed. However, the nature and extent of the disturbance, that is, how thorough or how deep the mixing might be, is unknown. Consequently, a background value based on undisturbed soil may be slightly higher than the Big Trees Park soil, but there is no way this can be quantified, and the any difference should be small.

A further reason for using the upwind environmental surveillance samples as background samples is that they show no trend with time. The lack of trend with time indicates that the samples are all from the same sample population and that there are no environmental or other influences on the soils that would skew the statistical estimates derived from the data.

Finally, it should be noted that the upwind data are composed of multiple samples at the same general locations as well as single samples at multiple locations. These samples have been evaluated to determine if any bias has been introduced. A Tukey-Kramer HSD (Honestly Significantly Different) test was conducted on all pairs of locations, and no significant differences were found. In addition, the data were evaluated for trends by latitude and by longitude; again, no significant differences were found. Visual inspection of the medians of the data plotted by location showed no pattern of high values, and all locations with a single value greater than 0.01 pCi/g and more than one analysis also had a value reported less than 0.01 pCi/g. Consequently, there is no bias introduced by including data from multiple samples of the same locations with single samples at multiple locations.

Statistical Analysis of Background Data

The surveillance soil background data set is lognormally distributed. Figure D-3 is a histogram of the natural logarithms of the data. Visually, the data shows a bell-shaped curve typical of the normal distribution. Statistically, the logarithms of the data pass the Shapiro-Wilke W Test for normality if the two lowest values (which are much lower than all other data points) are omitted from the set. The untransformed data do not visually appear to be a normal distribution nor do they pass the statistical test for normality.

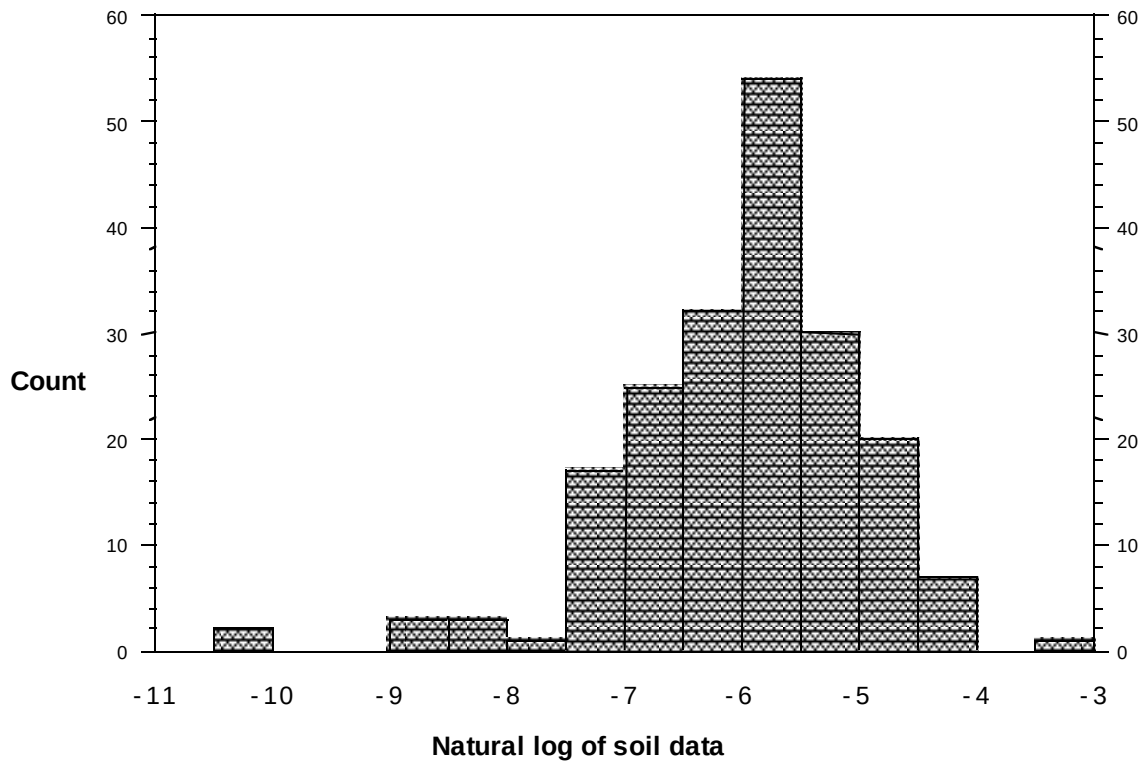

Figure D-3. Histogram of natural logorithms of the background soil data.

Because the data are lognormally distributed, any estimates of central tendency and variation are made on the log-transformed data. As a result, the geometric mean and the geometric standard deviation are the appropriate measures of the central tendency and the variation. In addition, the two lowest points are omitted from these calculations. The geometric mean of the data is 0.0026 pCi/g and the geometric standard deviation is 2.4. The upper 2-sigma value for background is 0.015 pCi/g. The 95% upper confidence level (UCL) for 95th percentile is 0.013 pCi/g, and the 80% UCL

for 95th percentile is 0.012 pCi/g. It is conservative to use an estimate of the 95th percentile to represent the upperbound of fallout, or as a screening level, because approximately 5 percent of fallout data will be considered above background. Similarly, an estimate of the 80th percentile is even more conservative because 20 percent of fallout background data will be considered to be above background. The UCL calculations are made following the method stated in G. J. Hahn and W. Q. Meeker, *Statistical Intervals-A Guide for Practioners*, John Wiley & Sons, Inc., New York, 1991, Chapter 4, Methods for Calculating Statistical Intervals for a Normal Distribution.

Comparison with Other Plutonium Data

It is important to compare the upwind surveillance data to data from other sources to determine whether the data are a reasonable estimate of background concentrations.

LLNL also has collected data for its Experimental Test Facility, Site 300, which is located 20 km east of the Livermore Site. Although the topography of Site 300 is different from the Livermore Site, and the rainfall is less, plutonium has not been used at Site 300, so the plutonium analytical data for the site is representative of fallout. The geometric mean of the Site 300 data is equal to the geometric mean of the upwind data, 0.0026 pCi/g, and the geometric standard deviation is 2.6. These data reinforce our choice of locations as upwind and unaffected by LLNL Livermore site operations.

In 1975, Hardy reported two plutonium-in-soil results for Oakland, CA, at 0.8 mCi/km^2. These data, which were acquired from samples collected 30 cm deep, can be compared to the LLNL upwind surveillance data if assumptions are made about the density of the soil, the fraction of the total fallout present in 0- to 5-cm depth, and the effect of variation in rainfall on deposition. Assuming a soil density of 1.6 g/cm^3, that 70% of the plutonium is found in the 0- to 5-cm depth, and that deposition is directly proportional to differences of rainfall with the Livermore Valley receiving about 70% of the amount of rain that falls on Oakland, the estimated Pu-239+240 in soil from the Hardy data is 0.0049 pCi/g. Table D-2 provides an example of how varying the assumption on how much plutonium is in the 0- to 5-cm depth effects the result. The value 0.0049 pCi/g is between the geometric mean and the UCL calculated for upwind data and supports the upwind calculation as an estimate of background.

A national average of 2 mCi/km^2 is reported in the Agency for Toxic Substances and Disease Registry (ATSDR) Public Health Statement on plutonium on the Internet (http://atsdr1.atsdr.cdc.gov:8080/ToxProfiles/phs9021.html [address on July 7, 1998]). The same assumptions to convert this value to pCi/g as were used to convert the Hardy data, yielding an estimate of 0.018 pCi/g. This value, is approximately 7 times higher than the geometric mean of the LLNL upwind data, also suggests that environmental

conditions in Livermore resulted in fallout depositions below the national average, and that the LLNL background estimate adequately accounts for regional differences due to geography, meteorology, and topography.

Although less specific than regional or national estimates of fallout, world-wide estimates of fallout by latitude also provide a comparison point for determining the reasonableness of the use of upwind data to estimate background. One estimate of Pu-239+240 in soil for 30-40 degrees north latitude (Livermore is approximately 37.6 degrees north latitude) is 1.8 ± 0.6 mCi/km^2. The same assumptions to convert this value to pCi/g as were used to convert the Hardy data, yielding an estimate of 0.011 ± 0.005 pCi/g for the average for the range of latitudes. This value is approximately 4 times higher than the geometric mean of the upwind data, and suggests that environmental conditions in Livermore resulted in fallout depositions that are also below the average for the 10-degree range of latitude.

Table D-1. Samples considered to be background, taken at 0- to 5-cm deep, including their approximate location and measured Pu-239+240 in pCi/g.

Location identifier	Sample date	Pu-239+240 activity	Latitude	Longitude
L-100-SO	7/1/76	7.10×10^{-3}	37.71	–121.91
L-100-SO	5/18/78	1.03×10^{-2}	37.71	–121.91
L-100-SO	5/21/80	2.00×10^{-4}	37.71	–121.91
L-100-SO	5/21/80	3.00×10^{-4}	37.71	–121.91
L-100-SO	4/30/81	4.40×10^{-3}	37.71	–121.91
L-100-SO	3/20/86	3.70×10^{-3}	37.71	–121.91
L-100-SO	5/5/87	5.00×10^{-3}	37.71	–121.91
L-100-SO	5/5/87	5.00×10^{-3}	37.71	–121.91
L-101-SO	4/30/81	5.20×10^{-3}	37.64	–121.88
L-107-SO	5/25/79	2.20×10^{-3}	37.664	–121.732
L-108-SO	5/7/82	3.70×10^{-3}	37.627	–121.703
L-111-SO	5/14/82	1.10×10^{-3}	37.7	–121.81
L-126-SO	7/1/76	6.40×10^{-3}	37.71	–121.85
L-126-SO	5/6/83	1.09×10^{-2}	37.71	–121.85
L-128-SO	3/20/86	7.00×10^{-4}	37.7	–121.91
L-130-SO	4/30/81	3.40×10^{-3}	37.66	–121.89
L-133-SO	4/30/81	3.00×10^{-4}	37.64	–121.88
L-134-SO	7/1/76	1.20×10^{-3}	37.66	–121.91
L-134-SO	5/14/82	1.00×10^{-3}	37.66	–121.91
L-134-SO	3/20/86	9.00×10^{-4}	37.66	–121.91
L-134-SO	5/5/87	1.30×10^{-3}	37.66	–121.91
L-136-SO	6/5/84	5.00×10^{-3}	37.677	–121.772
L-136-SO	3/6/85	9.00×10^{-4}	37.677	–121.772
L-136-SO	5/5/87	7.40×10^{-3}	37.677	–121.772
L-138-SO	6/27/77	6.80×10^{-3}	37.67	–121.84
L-138-SO	3/20/86	2.70×10^{-3}	37.67	–121.84
L-138-SO	5/5/87	1.10×10^{-3}	37.67	–121.84
L-139-SO	5/25/79	2.40×10^{-3}	37.635	–121.715
L-139-SO	4/30/81	3.10×10^{-3}	37.635	–121.715
L-139-SO	3/7/85	3.00×10^{-3}	37.635	–121.715
L-139-SO	3/20/86	3.20×10^{-3}	37.635	–121.715
L-139-SO	5/5/87	2.70×10^{-3}	37.635	–121.715
L-140-SO	6/7/84	5.70×10^{-3}	37.642	–121.785
L-141-SO	5/15/78	2.90×10^{-3}	37.665	–121.805
L-141-SO	4/30/81	5.30×10^{-3}	37.665	–121.805
L-141-SO	5/6/83	9.50×10^{-3}	37.665	–121.805

Table D-1. (continued)

Location identifier	Sample date	Pu-239+240 activity	Latitude	Longitude
L-142-SO	6/27/77	2.70×10^{-3}	37.7	–121.74
L-143-SO	6/23/76	3.20×10^{-3}	37.71	–121.727
L-143-SO	5/15/78	1.60×10^{-3}	37.71	–121.727
L-143-SO	3/6/85	1.80×10^{-3}	37.71	–121.727
L-143-SO	3/6/85	1.40×10^{-3}	37.71	–121.727
L-144-SO	6/5/84	2.60×10^{-3}	37.691	–121.756
L-144-SO	6/5/84	2.40×10^{-3}	37.691	–121.756
L-148-SO	6/5/84	2.30×10^{-3}	37.657	–121.795
L-149-SO	6/5/80	6.00×10^{-4}	37.665	–121.772
L-149-SO	5/6/83	5.70×10^{-3}	37.665	–121.772
L-149-SO	5/6/83	5.70×10^{-3}	37.665	–121.772
L-150-SO	5/22/80	3.00×10^{-4}	37.71	–121.85
L-151-SO	6/27/77	3.20×10^{-3}	37.71	–121.84
L-151-SO	5/15/78	2.80×10^{-3}	37.71	–121.84
L-151-SO	5/6/83	1.90×10^{-3}	37.71	–121.84
L-151-SO	3/20/86	3.60×10^{-3}	37.71	–121.84
L-151-SO	5/5/87	3.10×10^{-3}	37.71	–121.84
L-153-SO	5/7/81	3.60×10^{-3}	37.7	–121.772
L-153-SO	6/7/84	4.60×10^{-3}	37.7	–121.772
L-154-SO	4/30/82	8.00×10^{-4}	37.675	–121.782
L-155-SO	5/14/82	1.10×10^{-3}	37.7	–121.79
L-155-SO	5/6/83	3.00×10^{-3}	37.7	–121.79
L-155-SO	3/6/85	1.00×10^{-3}	37.7	–121.79
L-158-SO	5/14/79	1.13×10^{-2}	37.71	–121.92
L-159-SO	5/22/80	5.60×10^{-3}	37.723	–121.769
L-161-SO	6/20/77	4.20×10^{-3}	37.68	–121.735
L-161-SO	5/25/79	2.80×10^{-3}	37.68	–121.735
L-161-SO	5/25/79	3.50×10^{-3}	37.68	–121.735
L-162-SO	5/21/82	6.00×10^{-4}	37.695	–121.735
L-162-SO	5/6/83	3.00×10^{-3}	37.695	–121.735
L-162-SO	6/5/84	4.50×10^{-3}	37.695	–121.735
L-163-SO	6/27/77	1.30×10^{-3}	37.72	–121.91
L-163-SO	5/18/78	1.20×10^{-3}	37.72	–121.91
L-164-SO	5/14/79	2.60×10^{-3}	37.71	–121.905
L-164-SO	4/30/81	7.00×10^{-4}	37.71	–121.905
L-164-SO	5/14/82	7.00×10^{-4}	37.71	–121.905
L-164-SO	5/14/82	7.00×10^{-4}	37.71	–121.905
L-164-SO	5/5/87	2.00×10^{-4}	37.71	–121.905

Table D-1. (continued)

Location identifier	Sample date	Pu-239+240 activity	Latitude	Longitude
L-166-SO	5/14/82	2.00×10^{-4}	37.65	–121.88
L-166-SO	5/6/83	6.20×10^{-3}	37.65	–121.88
L-264-SO	5/5/87	1.00×10^{-3}	37.71	–121.71
L-271-SO	5/25/79	1.80×10^{-3}	37.697	–121.717
L-271-SO	3/20/86	7.00×10^{-4}	37.697	–121.717
L-275-SO	6/17/77	4.70×10^{-3}	37.665	–121.696
L-275-SO	5/25/79	3.00×10^{-3}	37.665	–121.696
L-275-SO	5/7/81	4.00×10^{-3}	37.665	–121.696
L-275-SO	5/21/82	3.30×10^{-3}	37.665	–121.696
L-275-SO	5/6/83	7.90×10^{-3}	37.665	–121.696
L-275-SO	3/5/85	2.20×10^{-3}	37.665	–121.696
L-545-SO	5/7/81	1.13×10^{-2}	37.712	–121.713
L-56-SO	6/25/76	2.50×10^{-3}	37.695	–121.84
L-56-SO	5/18/79	3.00×10^{-3}	37.695	–121.84
L-56-SO	5/7/81	1.60×10^{-3}	37.695	–121.84
L-56-SO	5/14/82	2.00×10^{-3}	37.695	–121.84
L-56-SO	5/14/82	2.30×10^{-3}	37.695	–121.84
L-56-SO	5/6/83	3.30×10^{-3}	37.695	–121.84
L-56-SO	3/6/85	2.90×10^{-3}	37.695	–121.84
L-56-SO	3/6/85	4.90×10^{-3}	37.695	–121.84
L-56-SO	5/5/87	1.20×10^{-3}	37.695	–121.84
L-56-SO	5/5/87	1.00×10^{-3}	37.695	–121.84
L-60-SO	5/15/78	6.00×10^{-4}	37.695	–121.84
L-60-SO	5/15/78	7.00×10^{-4}	37.695	–121.84
L-64-SO	6/17/77	8.50×10^{-3}	37.702	–121.717
L-64-SO	5/8/78	3.30×10^{-2}	37.702	–121.717
L-64-SO	5/5/87	1.60×10^{-3}	37.702	–121.717
L-72-SO	5/7/81	1.60×10^{-3}	37.723	–121.723
L-72-SO	5/14/82	1.50×10^{-3}	37.723	–121.723
L-72-SO	3/20/86	3.20×10^{-3}	37.723	–121.723
L-796-SO	6/5/80	3.50×10^{-3}	37.665	–121.699
L-796-SO	3/6/85	2.10×10^{-3}	37.665	–121.699
L-80-SO	6/5/80	4.60×10^{-3}	37.66	–121.64
L-80-SO	3/5/85	5.70×10^{-3}	37.66	–121.64
L-803-SO	6/12/80	6.40×10^{-3}	37.697	–121.717
L-803-SO	3/20/86	7.30×10^{-3}	37.697	–121.717
L-81-SO	5/7/81	1.20×10^{-3}	37.644	–121.695
L-81-SO	4/30/82	1.27×10^{-2}	37.644	–121.695

Table D-1. (continued)

Location identifier	Sample date	Pu-239+240 activity	Latitude	Longitude
L-83-SO	5/25/79	1.55×10^{-2}	37.664	–121.672
L-83-SO	5/7/81	7.10×10^{-3}	37.664	–121.672
L-84-SO	3/5/85	2.60×10^{-3}	37.653	–121.666
L-85-SO	6/5/80	3.40×10^{-3}	37.642	–121.638
L-85-SO	3/20/86	3.20×10^{-3}	37.642	–121.638
L-87-SO	5/18/79	8.50×10^{-3}	37.74	–121.71
L-87-SO	5/18/79	7.60×10^{-3}	37.74	–121.71
L-87-SO	5/7/82	2.00×10^{-3}	37.74	–121.71
L-87-SO	3/20/86	4.00×10^{-3}	37.74	–121.71
L-97-SO	8/19/71	1.20×10^{-2}	37.7	–121.83
L-97-SO	5/14/79	6.70×10^{-3}	37.7	–121.83
L-99-SO	5/22/80	3.30×10^{-3}	37.69	–121.85
L-99-SO	5/5/87	2.20×10^{-3}	37.69	–121.85
L-CHUR-SO	7/21/97	4.26×10^{-3}	37.7306	–121.7203
L-ERCH-SO	4/30/81	7.00×10^{-4}	37.612	–121.688
L-ERCH-SO	7/15/91	3.60×10^{-3}	37.612	–121.688
L-ERCH-SO	5/14/92	6.79×10^{-3}	37.612	–121.688
L-ERCH-SO	5/14/92	6.68×10^{-3}	37.612	–121.688
L-ERCH-SO	6/18/93	2.91×10^{-3}	37.612	–121.688
L-ERCH-SO	6/30/94	4.76×10^{-3}	37.612	–121.688
L-ERCH-SO	7/19/95	2.43×10^{-3}	37.612	–121.688
L-ERCH-SO	6/14/96	1.53×10^{-3}	37.612	–121.688
L-FCC-SO	6/17/76	3.90×10^{-3}	37.73	–121.745
L-FCC-SO	5/18/79	2.80×10^{-3}	37.73	–121.745
L-FCC-SO	3/20/86	1.60×10^{-3}	37.73	–121.745
L-FCC-SO	3/20/86	9.00×10^{-4}	37.73	–121.745
L-FCC-SO	4/26/88	3.00×10^{-3}	37.73	–121.745
L-FCC-SO	5/17/89	4.22×10^{-3}	37.73	–121.745
L-FCC-SO	5/17/89	4.12×10^{-3}	37.73	–121.745
L-FCC-SO	5/11/90	2.88×10^{-3}	37.73	–121.745
L-FCC-SO	5/9/91	2.72×10^{-3}	37.73	–121.745
L-FCC-SO	5/13/92	2.52×10^{-3}	37.73	–121.745
L-FCC-SO	6/14/93	2.66×10^{-3}	37.73	–121.745
L-FCC-SO	6/28/94	2.23×10^{-3}	37.73	–121.745
L-FCC-SO	7/18/95	2.08×10^{-3}	37.73	–121.745
L-FCC-SO	6/11/96	2.54×10^{-3}	37.73	–121.745
L-FCC-SO	7/21/97	2.09×10^{-3}	37.73	–121.745
L-HOSP-SO	5/21/82	5.90×10^{-3}	37.625	–121.757

Table D-1. (continued)

Location identifier	Sample date	Pu-239+240 activity	Latitude	Longitude
L-HOSP-SO	5/6/83	9.80×10^{-3}	37.625	–121.757
L-HOSP-SO	3/7/85	3.60×10^{-3}	37.625	–121.757
L-HOSP-SO	5/5/87	1.24×10^{-2}	37.625	–121.757
L-HOSP-SO	4/26/88	1.11×10^{-2}	37.625	–121.757
L-HOSP-SO	5/17/89	9.41×10^{-3}	37.625	–121.757
L-HOSP-SO	5/11/90	7.52×10^{-3}	37.625	–121.757
L-HOSP-SO	5/9/91	2.68×10^{-3}	37.625	–121.757
L-HOSP-SO	5/9/91	1.21×10^{-2}	37.625	–121.757
L-HOSP-SO	5/13/92	3.75×10^{-3}	37.625	–121.757
L-HOSP-SO	6/16/93	3.20×10^{-3}	37.625	–121.757
L-HOSP-SO	6/29/94	1.90×10^{-3}	37.625	–121.757
L-HOSP-SO	7/19/95	3.57×10^{-3}	37.625	–121.757
L-HOSP-SO	6/14/96	1.13×10^{-3}	37.625	–121.757
L-HOSP-SO	7/21/97	5.21×10^{-4}	37.625	–121.757
L-MESQ-SO	3/20/86	4.20×10^{-3}	37.695	–121.717
L-MESQ-SO	4/26/88	2.80×10^{-3}	37.695	–121.717
L-MESQ-SO	5/17/89	1.72×10^{-3}	37.695	–121.717
L-MESQ-SO	5/14/90	1.74×10^{-3}	37.695	–121.717
L-MESQ-SO	5/9/91	1.52×10^{-3}	37.695	–121.717
L-MESQ-SO	5/13/92	6.80×10^{-4}	37.695	–121.717
L-MESQ-SO	6/17/93	1.09×10^{-3}	37.695	–121.717
L-MESQ-SO	6/28/94	7.30×10^{-4}	37.695	–121.717
L-MESQ-SO	6/27/95	1.10×10^{-3}	37.695	–121.717
L-MESQ-SO	6/10/96	9.94×10^{-4}	37.695	–121.717
L-MESQ-SO	7/22/97	1.15×10^{-3}	37.695	–121.717
L-MET-SO	4/26/88	4.00×10^{-3}	37.693	–121.715
L-MET-SO	5/17/89	1.96×10^{-3}	37.693	–121.715
L-MET-SO	5/14/90	1.08×10^{-3}	37.693	–121.715
L-MET-SO	5/8/91	1.56×10^{-3}	37.693	–121.715
L-MET-SO	5/13/92	1.38×10^{-3}	37.693	–121.715
L-MET-SO	6/14/93	1.23×10^{-3}	37.693	–121.715
L-MET-SO	6/28/94	2.50×10^{-3}	37.693	–121.715
L-MET-SO	7/18/95	1.34×10^{-3}	37.693	–121.715
L-MET-SO	6/10/96	1.52×10^{-3}	37.693	–121.715
L-MET-SO	7/22/97	1.22×10^{-3}	37.693	–121.715
L-RRCH-SO	6/5/80	2.30×10^{-3}	37.747	–121.722
L-RRCH-SO	6/5/80	1.80×10^{-3}	37.747	–121.722
L-RRCH-SO	7/15/91	3.43×10^{-5}	37.747	–121.722

Table D-1. (continued)

Location identifier	Sample date	Pu-239+240 activity	Latitude	Longitude
L-RRCH-SO	5/14/92	7.58×10^{-3}	37.747	–121.722
L-RRCH-SO	6/14/93	4.02×10^{-5}	37.747	–121.722
L-RRCH-SO	6/30/94	7.35×10^{-3}	37.747	–121.722
L-RRCH-SO	7/18/95	8.35×10^{-4}	37.747	–121.722
L-RRCH-SO	6/17/96	5.70×10^{-3}	37.747	–121.722

Table D-2. Estimation of Pu-239+240 activity in soil based on Hardy (1975) data for Oakland, CA, varying the value for the fraction of Pu-239+240 in the 0- to 5-cm depth.

Parameter						
Pu-239+240 fraction	1	0.9	0.8	0.7	0.6	0.5
Deposition (mCi/km^2)	0.8	0.8	0.8	0.8	0.8	0.8
Depth (cm)	5	5	5	5	5	5
Soil density (g/cm^3)	1.6	1.6	1.6	1.6	1.6	1.6
Rainfall adjustment	0.7	0.7	0.7	0.7	0.7	0.7
Estimated activity (pCi/g)	0.0070	0.0063	0.0056	0.0049	0.0042	0.0035

Appendix E: Quality Assurance

1.1. Project Organization

The Livermore Site Environmental Restoration Project (ERP) is part of the Environmental Restoration Program and Division (ERD) that belongs to the Lawrence Livermore National Laboratory (LLNL) Environmental Protection Department (EPD). LLNL is operated by the University of California for the U.S. Department of Energy (DOE). The Big Trees Park soil sampling study is performed under the existing Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process in accordance with the Livermore Site Federal Facility Agreement (FFA). Figure E-1 shows the soil sampling investigation relationship to EPD, LLNL, DOE, the regulating agencies, and the ERP subcontractors.

1.1.1. DOE Oakland Operations Office

The DOE office is responsible for oversight of investigation and cleanup activities under the CERCLA process for the Livermore Site.

1.1.2. Regulating Agencies

The sampling plan was developed in response to a Health Consult performed by the California Department of Health Services-Environmental Health Investigations Branch (CDHS-EHIB) in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). The sampling plan activities are performed under CERCLA in accordance with the Livermore Site FFA. Signatories to the FFA are DOE, the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board - San Francisco Bay Region (RWQCB). The DTSC and the RWQCB have deferred their oversight role of the Big Trees Park soil sampling study to CDHS-Radiologic Health Branch (RHB). Therefore, regulatory oversight is primarily the responsibility of EPA and DHS-RHB.

1.1.3. LLNL Site Manager for Laboratory Site Operations

The Laboratory Site Operations office has administrative responsibility for Environmental Protection Department.

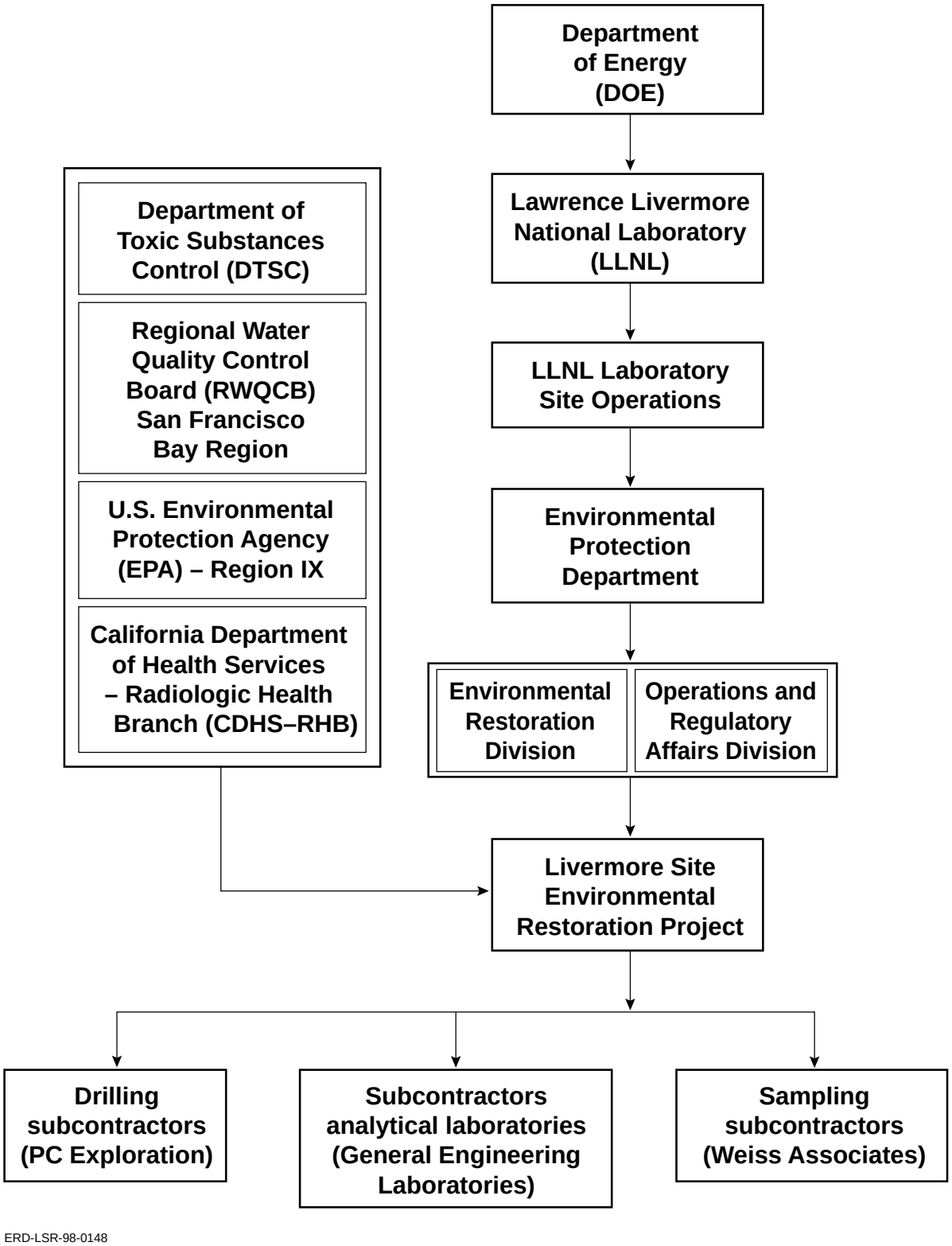

Figure E-1. Relationship of the parties participating in Big Trees Park soil sampling.

1.1.4. Environmental Protection Department

EPD ensures that LLNL meets its environmental responsibilities as set by environmental legislation, DOE orders, and other applicable regulations for environmental regulatory matters.

1.1.5. Environmental Restoration Division (ERD)

ERD will be involved in the investigation and implementation of the sampling plan, and will maintain direct communication with regulatory agencies.

1.1.6 Operations and Regulatory Affairs Division (ORAD)

ORAD will conduct the surface sampling.

1.1.7. Project Subcontractors

Subcontractors are responsible for implementing the sampling plan procedures and soil analyses to ensure precision, accuracy, completeness, and representativeness of the data as required by EPD. The drilling subcontractor will be PC Exploration of Roseville, CA; the field geologist subcontractor will be Weiss Associates of Emeryville, CA; and the analytical laboratory will be General Engineering Laboratories of Charleston, SC.

1.2. Background

Big Trees Park is a Livermore Area Recreation and Park District (LARPD) park located approximately 1 km west of LLNL. Surface (0-5 cm) soil in a small portion of the park was found to contain plutonium 239+240 concentrations greater than can be attributed to global fallout (NAREL, 1994; MacQueen, 1995).

In 1995, regulatory agencies determined there was not an unacceptable health risk from this surface-soil plutonium, and that no further action was necessary (Gill, 1995; EPA, 1995). An additional evaluation performed in 1998 (CDHS/ATSDR, 1998) also indicated that there is no current unacceptable health risk.

1.3. Problem Definition

There is continuing interest from the public and regulatory community about possible human health risks from soil deeper than 5 cm and about how the plutonium reached Big Trees Park. Therefore, the purpose of this 1998 sampling effort is two-fold: (1) to

gain information about possible pathways by which plutonium reached Big Trees Park, and (2) to gain information about the extent of elevated plutonium in the park.

1.4. Project Description

This sampling plan's scope is limited to soil sampling only at Livermore's Big Trees Park. The sampling will consist of a combination of surface and depth sampling to adequately assess the vertical and horizontal distribution of elevated levels of plutonium detected in soils in 1993 and 1995 sampling events.

1.5. Quality Objectives and Criteria for Measurement Data

The development and design of this sampling plan is based on the EPA Data Quality Objectives (DQO) process (EPA, 1994a).

The DQO process consists of seven steps:

1. State the Problem.
2. Identify the Decision.
3. Identify Inputs to the Decision.
4. Define the Study Boundaries.
5. Develop a Decision Rule.
6. Specify Limits on Decision Errors.
7. Optimize the Design for Obtaining Data.

1.5.1. Stating the Problem

The problem is stated in Section 1.3.

1.5.2. Identifying the Decision

Three specific decisions to be made are:

1) To determine if the presence of elevated plutonium concentrations in Big Trees Park (at Location 1 from the 1995 study) can be explained by the water-borne/arroyo pathway hypothesis.
2) To determine if the presence of elevated plutonium concentrations in Big Trees Park (at Location 1 from the 1995 study) can be explained by the sewage sludge pathway hypothesis.

3) To determine if the presence of elevated plutonium concentrations at Big Trees Park can be explained by the air pathway hypothesis.

In addition, this study will assess the extent of the area containing elevated concentrations of plutonium (Location 1 from the 1995 study).

The three pathways (air, sludge, and arroyo) are the only explanations for the elevated concentrations of plutonium from the 1995 study that have seemed plausible.

1.5.3. Identifying Inputs to the Decision

Inputs to the specific decision consist of analytical results from sampling locations unique to each pathway hypothesis. These are described in Sections 3.1.1, 3.1.2, and 3.1.3 of the Draft Final Livermore Big Trees Park 1998 Soil Sampling Plan. Input to the assessment of extent of contamination is described in Section 3.2.

1.5.4. Defining the Study Boundaries

The sampling scope is limited to soil at Big Trees Park, the eastern extension of the park, the playing fields, disked area, the Arroyo Seco, and the former arroyo channel.

1.5.5. Developing a Decision Rule

The decision rules for the pathway hypothesis decisions are discussed in sections 3.1.1, 3.1.2, and 3.1.3 of the Livermore Big Trees Park 1998 Soil Sampling Plan.

1.5.6. Specify Limits on Decision Errors

The numbers of samples collected for the purpose of making the pathway and extent decisions were determined during discussions with EPA, CDHS-RHB, CDHS-EHIB, and the ATSDR. These discussions did not specifically consider limits on decision errors.

1.5.7. Optimize the Design for Obtaining Data

The design for obtaining data was finalized during discussions with EPA, CDHS-RHB, CDHS-EHIB, and the ATSDR. Samples were placed in areas believed most likely to provide useful information.

1.6. Training

Personnel supporting the sampling investigation are trained to ensure that they have the skills and knowledge necessary to perform their work assignments in a safe, competent, and environmentally sound manner. The drillers, samplers and field geologists are Superfund Amendments and Reauthorization Act / Occupational Safety and Health Administration (SARA / OSHA) certified. In addition, all personnel supporting this sampling investigation are trained to conduct their work in accordance with the Site Safety Plan for LLNL CERCLA Investigations, the LLNL Health and Safety Manual, the Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs), ORAD's Environmental Monitoring Program's Soil Sampling Procedure, and LLNL Operational Safety Procedures.

1.7. Documentation and Records

1.7.1. Information Included in Reporting Packages

The data reports received from the subcontracted analytical laboratory for the project will include:

1) Case Narrative.
2) Chain of Custody (COC) Documentation.
3) Summary of Analytical Results.
4) Summary of Quality Control (QC) Sample Results.

1.7.1.1. Case Narrative

A Case Narrative, on letterhead of the analytical laboratory will include:

- LLNL's sample identification (ID).
- Corresponding laboratory ID.
- Analysis as requested by LLNL on the COC for each sample and the methodology used.
- Indication of whether holding times were exceeded.
- Description of any occurrence that may have affected sample integrity or data quality.

- Detailed description of all problems encountered during sample handling and analysis and how they affect the sample results especially when associated QC sample analyses are outside of acceptance limits.
- Statement saying all calibration acceptance criteria were met, or if not, an explanation.
- Date of report.
- Authorization by lab director or designee for release of data.

1.7.1.2 COC Documentation

A completed COC will be included with the results. The analytical laboratory will supply appropriate and accurate receiving and relinquishing signatures and dates.

1.7.1.3 Summary of Analytical Results

Results for each sample must include:

- Project ID, if applicable.
- COC number.
- Document control number, if present.
- LLNL's sample ID as found on the COC.
- Laboratory sample ID (e.g., log number).
- Sample QC batch number.
- Sample collection date as indicated on the COC.
- Date the laboratory received the sample.
- Sample matrix.
- Filtration code, if applicable.
- Date and time of sample extraction.
- Sample extraction method, if applicable.
- Analysis request code as indicated on the COC.
- Analysis method.
- Date and time of analysis.
- Analyte name.

- Analyte parameter code.
- Analytical results (analyte concentration or activity in the sample) and units.
- Reporting limit flag, a symbol used to indicate whether the analytically determined value is less than the reporting limit.
- Analytical uncertainty (error) at two sigma deviation, where applicable.
- Calculated value (analytically determined value), where applicable.
- Dilution or concentration factor of the samples.
- The reporting limit.
- ID of the instrument used for analysis.
- The analytical chemist's ID.
- Data qualifier flags, if any, and their definitions.
- Any applicable notes or comments.
- California and/or Utah State Certification Number, where applicable.

1.7.1.4 Summary of QC Sample Results

The analytical laboratory will report the results for the QC samples for each batch of samples. A summary of QC sample results will be provided for each analysis and will include:

- Method blank results and reporting limits.
- Surrogate or tracer yield recoveries, when applicable, and corresponding control limits.
- Sample duplicate results, when applicable, precision expressed as relative percent difference (%RPD), and corresponding control limits.
- Matrix spike (MS) and matrix spike duplicate (MSD) results, sample result before spike, spike amount, percent recoveries, %RPD, laboratory sample ID for sample used for matrix spikes, and corresponding control limits.
- Laboratory control samples or standards (LCS) results, percent recovery, and control limits.

In addition, the following elements are required for all QC sample analyses:

- QC batch number.
- Date and time of analysis.
- Instrument ID.
- Analyst ID.
- Analysis request code.
- Analysis method.
- Analyte name.
- Analyte parameter code.
- Units.
- Matrix.
- Error, where applicable.
- Data qualifier flags, if any, and their definitions.
- QC sample ID.

The analytical laboratory will also deliver electronic versions of the results described above in a format specified by LLNL's ERD. Data and information in the electronic data deliverable will match the data and information in the hard results exactly.

All raw sample and QC hard copy data are considered Quality Assurance (QA) records and must be maintained for the life of LLNL. The analytical laboratory shall retain all related project information for a minimum of 3 years, after which the laboratory may turn it over to LLNL for storage.

1.7.2. Field Operation Records

Daily field logs will be prepared by the field geologist to document all activities that occur each day. Field tracking forms, photographs, video, and a Global Positioning System will be used to record sampling locations.

2. Measurement/Data Acquisition

2.1. Sampling Process Design

The sampling process design is described in the Draft Final Livermore Big Trees Park 1998 Soil Sampling Plan.

2.2. Sampling Methods

Surface soil sampling will be conducted by the LLNL Operations and Regulatory Affairs Division (ORAD) per the requirements of ORAD procedure EMP-S-S, "Soil and Arroyo Sediment Sampling."

Drilling and subsurface sampling will be conducted in accordance with the ERD Standard Operating Procedures (SOPs) 1.1, "Field Borehole Logging;" SOP 1.2, "Borehole Sampling of Unconsolidated Sediments and Rock;" SOP 1.3, "Drilling;" SOP 4.1, "General Instructions for Field Personnel;" and SOP 4.2, "Sample Control and Documentation" (Dibley and Depue, 1998).

2.3. Sampling Handling and Custody Requirements

Sample custody procedures are described in ERD SOP 4.2, "Sample Control and Documentation." This SOP describes the methodology of sample control and documentation applicable to field logbooks, sampling data collection forms, chain-of-custody records, and sample identification labels. ERD SOP 4.3, "Sample Containers and Preservation," contains holding time information, as well as the appropriate sample volume, container, and preservation techniques. Additional sample handling and shipping information can be found in ERD SOP 4.4, "Guide to the Handling, Packaging, and Shipping of Samples."

2.4. Analytical Methods Requirements

The analytical laboratories will analyze for the specific analytes of interest as identified in Table 2 of this document. The laboratories will perform and document their standard sample preparation (which generally includes drying, grinding, sieving, and ashing).

This will be followed by

- Extraction of plutonium from the prepared sample by total dissolution with a combination of nitric, hydrofluoric, and hydrochloric acids in the presence of Pu-242 tracer.
- Isolation of plutonium by anion exchange and electrodeposition onto a stainless steel disc for determination by alpha spectrometry.

The major difference between the General Engineering Laboratories (GEL) method and the Georgia Institute of Technology Environmental Resources Center (GIT) method is the sample size. GEL uses 10-15 gram aliquots of the prepared sample, while GIT uses 1 to 3 gram aliquots of the prepared sample. A smaller soil sample can create greater variability in the analytical results.

Soil will be analyzed directly for americium-241 by gamma spectrometey, a technique by which americium can be directly measured without sample processing because gamma particles are not subject to the penetration limitations that alpha particles are.

Metals (chromium, copper, lead, nickel, and zinc are the metals associated with sewage sludge) samples will be analyzed by atomic adsorption spectroscopy. Samples will be leached with acid to dissolve the metals. The collected leachate will then be analyzed using an atomic absorption spectrometer.

The analytical laboratories must perform analyses with a minimum detectable activity (MDA) of at most 0.005 pCi/g. Total propagated uncertainty should be approximately 10% for soil concentrations above 0.1 pCi/g, approximately 20% for soil concentrations between 0.01 pCi/g and 0.1 pCi/g, and less than 100% for soil concentrations between 0.005 pCi/g and 0.01 pCi/g. Uncertainties less than 100% for soil concentrations between 0.001 pCi/g and 0.005 pCi/g are possible, but will not necessarily be achieved in all cases. This performance standard approximates the performance achieved by two of the laboratories that analyzed the 1995 samples from Big Trees Park (MacQueen, 1995). The more precise analyses from the 1995 sampling had 2-sigma uncertainties of approximately ±0.005 pCi/g when the estimated sample concentration was about 0.02 pCi/g.

2.5. Quality Control Requirements

2.5.1. Field QC

There are many measures that need be taken to ensure the quality of the sampling and analysis effort. The QC checks that ERD has implemented are the collection of equipment blanks to check the effectiveness of decontamination procedures, trip blanks and field blanks which identify contamination that occurs during sample collection and transportation, and the collection of collocated samples. When collocated samples are collected, processed, and analyzed by the same organization, they provide intra-laboratory precision information for the entire measurement system including sample acquisition, homogeneity, handling, shipping, storage, preparation and analysis. When collected, processed, and analyzed by different organizations, these QC checks provide inter-laboratory precision information for the entire measurement system. Additional information regarding these type of QC checks can be found in ERD SOP 4.9, "Collection of Field QC Samples." In addition, 10 locations will randomly be selected for field replicate samples to assess variability due to sample inhomogeneity and analytical variability. An additional field replicate will be collected from Location 1.

2.5.2. Analytical QC

The analytical laboratory that will analyze samples for the this project is required to perform and document certain internal QC checks. These checks will vary according to the specific analytical method, but generally include the analysis of one method blank, matrix spike and spike duplicate or sample duplicate, and a laboratory control standard per batch of twenty samples. In addition, initial instrument calibration data, continuing calibration data, extraction blank data, surrogate recoveries, retention time windows, method detection limit determinations, laboratory QC control charts, and gas chromatograph/mass spectrometer (GC/MS) tune data may also be reported. At a minimum, these items are kept at the laboratory and reviewed upon request or during an audit of the analytical laboratory facilities. Analytical QC checks required by ERD are explained in ERD SOP 4.6, "Validation and Verification of Nonradiological Data Generated by Analytical Laboratories," and ERD SOP 4.11, "Validation and Verification of Radiological Data Generated by Analytical Laboratories."

2.6. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

ERD field instruments are maintained as directed by the manufacturer. The maintenance procedures and required documentation are described in ERD SOP 4.8,

"Calibration / Verification and Maintenance of Measuring and Test Equipment (M&TE)."

ERD ground water monitor wells and related equipment are maintained according to ERD SOP 2.12, "Ground Water Monitor Well and Equipment Maintenance."

The analytical laboratory has internal procedures that describe the maintenance and corrective actions performed for analytical instrumentation.

2.7. Instrument Calibration and Frequency

ERD field instruments are calibrated by the manufacturer and verified according to ERD SOP 4.8, "Calibration / Verification and Maintenance of Measuring and Test Equipment (M&TE)." This SOP also describes the corrective action steps required when an instrument is outside of acceptance criteria.

The analytical laboratory internal calibration procedures include frequency and standards for the calibration of their analytical instrumentation.

2.8. Inspection/Acceptance Requirements for Supplies and Consumables

All supplies and consumables required by ERD are procured by the ERD Resource Managers per LLNL procurement regulations. ERD personnel order the materials or equipment from the ERD Resource Managers and specify the technical and quality requirements. When the order is received, ERD personnel determine if the item meets the specified requirements. The graded approach is used to determine the level of testing required.

2.9. Data Acquisition Requirements for Non-Direct Measurement Data

Data from non-measurement sources, such as literature files, and computer databases and programs, are essential elements of project implementation and decision making. Use of these data are managed in accordance with the policy presented in this section.

Information collected will be documented to indicate its source. Documentation will, as appropriate, include author or individual contacted; source title; identification of periodical or journal; standard, guideline, or report number; identification of publisher or originating organization; page location; and date. Documentation must be sufficient to allow other individuals to easily obtain or verify the information.

Whenever possible, complete copies of articles, data compilations, maps, reports, and photographs will be included in the project files. If this is not feasible, copies of title pages and pertinent sections should be included with complete source documentation. Regulations, standards, guidelines, and textbooks, which are generally not project specific, may be obtained and kept in the project library if they are of an unique nature.

Personal communications, such as interviews or correspondence, will be documented in the form of trip reports, meeting notes, or memoranda, and the resulting documentation included in the project files. Documentation will provide, as appropriate, the date and the name, organization, address, telephone number, and credentials of individuals contacted. A request should be made for formal written confirmation of critical data obtained verbally to serve as final documentation.

As necessary, an estimation of the quality/credibility of the information will be made. The collection of information must be consistent with the quality objectives of the project. Particular attention should be given to information that is collected that is not published from a peer reviewed source, or collected under the controls of a documented quality assurance program. This may include, but is not limited to, personal interviews, internal reports and memoranda, or newspaper articles. Any limitations or potential reservations for the accuracy or credibility of acquired information that could affect project quality should be clearly identified.

Computer software documentation, such as reference manuals and users' guides, are maintained and easily accessible to users. Computer hardware/software configurations are installed, tested, and maintained as described in the EPD Computer Security Plan. Software developed or modified for the project is documented and tested according to EPD's Software Quality Assurance (SQA) policy.

2.10. Data Management

The Information Systems Management Group has developed a data management system of data storage based on projected retrieval needs of the data users. The data elements needed by the data users are captured to provide a consistent data set available to all users of a specified data quality. The key goal of the system was to provide project personnel with timely access to the data while ensuring safe archival. This section will describe the structure and flow of data in the data management system used by ERD to store and archive data.

2.10.1. Structure and Flow of Data Through the Data Management System

The structure is based on a relational database named EPDData. EPDData handles sample tracking, sample location, media, analytical results, and some geological information. This production database is maintained on a Sun Sparc 20 with OpenIngres relational database software. Applications are developed on a separate Sun Sparc Station before implementation on the production database. Two read-only, date-stamped, archive databases are also on a separate Sun Sparc 20. These two read-only databases are copied from the production database twice a week.

The flow of data, both hard copy and electronic, follows a model which tracks information from sampling plan through storage to archiving. The process of the data management includes COC tracking of the sample, analytical result receipt, the application of quality control procedures, and the electronic use of data in decision support tools, such as risk assessment and compliance monitoring.

A sample plan is developed to establish the frequency, method and location of samples to be taken. Field log books and COC forms confirm the collection of samples as dictated by the plan. A document control number is assigned to the samples based on the field log book used. A carefully controlled system of field log book labeling permits electronic tracking of an environmental sample from field collection through analytical result receipt as well as tracing back to the log book for any given analyte, should details of sampling conditions be needed. Samples are sent on to analytical laboratories where they are given unique log numbers. A software application, Sample Planning and COC Tracking (SPACT), tracks the flow of the sampling information. The important fields in each SPACT record are document control number, analytical laboratory, analytical lab log number, sampling location identification, sampling date, and the analysis requested. Several dates tracked are: receipt of COC form and analytical results, and date of entry. SPACT also tracks invoice information. SPACT records are updated according to the receipt of official printed analytical results and invoices based on the document control number and sampling location. A data record is marked complete only when all analytical results have been received. Thus, completion of a record confirms that all requested analyses have been performed and reported.

Analytical results are stored in separate, but correlated, relational database tables based on sampling location, log number, and date. These tables are accessed by the MONITOR application and are related to SPACT tables by identical fields: document control number, sampling location, sampling date, analytical laboratory, and requested analysis. Additional information collected for each sample and analyte includes requester, project, sample media, sample type, units, error, detection limit, dilution

factor, and dates of extraction, analysis, and entry, together with comments and special notes. Sources of data in these database tables include geologic borehole logs, surveyor reports, field measurements, laboratory measurements, calculated or reduced data, and test conclusions. Types of data to be stored have included descriptive sample location information, such as coordinates, elevations, lithology, and screened intervals of monitoring installations, as well as measurements and analytical information, including physical and chemical parameters, media identification, and ground water elevation measurements.

Data verification and validation are achieved through a combination of methods. Hand entered data are run through a series of computerized verifications that check for duplication, empty fields, and reported results not consistent with reported detection limits. Data are also thoroughly checked by a second person before being formally added to the database. Electronically delivered laboratory data are groomed by filling in empty fields and ensuring consistency in fields such as sample location, project, media, and type. Computerized verifications are also run on electronic data and a second person checks sample descriptor fields before data are formally added to the database. Random audits are done to verify electronically delivered results against official printed results. Analytical results in the database are reviewed and validated by qualified chemists. Original hard copies of data are stored in file cabinets in numerical order by laboratory for easy access.

The MONITOR application also contains fields dedicated to QC. Such fields include flags indicating analytical result qualification and data quality category. The result qualifier flags are absent from a routine report, but may be included to show dilution greater than 1, compound detection in method blanks, or any of several other conditions.

The database, previously known as the MONITOR database, was originally developed on a VAX 6310 with VMS operating system using INGRES relational database software. A second database was added to serve the SPACT needs. In 1993, the databases were merged into one database, EPDData, accessed by different software applications. In 1996, the database was migrated over to the UNIX operating system.

The integrated centralized data management system has many advantages. The use of such a system promotes and provides a consistent data set of known quality, which is available to all. Single entry for multiple use allows quality assurance and quality control to be performed equally for all data.

3. Assessment/Oversight

3.1. Assessments and Response Actions

Data will be reviewed and analyzed by DOE/LLNL and the regulatory agencies for quality control and validation, and an appropriate response action will be determined.

3.1.1. Performance Evaluation Samples

Performance Evaluation (PE) samples will be provided to each of the analytical laboratories on a single-blind basis. The samples will be identified as PE samples but the analyte concentration will be unknown to the laboratory. Multiple PE samples, subject to availability, will be sent to the analytical laboratories. The PE samples will consist of well documented traceable standards obtained from nationally recognized standards and/or intercomparison program sources (e.g., National Institute of Standards and Technology, and DOE Environmental Measurements Laboratory intercomparison program). These samples will have differing analyte concentrations within the expected analyte concentration range.

3.2. Reports to Management

A final report will be issued which will consist of a summary of the work performed, including chemical analyses.

4. Data Validation and Usability

4.1. Data Review, Validation, and Verification Requirements

Analytical results from field and laboratory QC samples will be reviewed to verify that the results can be used for the intended purposes. Summary statistics of the field replicate samples will be calculated in order to assess variability due to sample homogeneity (or lack thereof) and analytical variability.

The MDAs and analytical uncertainties of the reported data will be compared with the requirements specified in Section 2.4. Data whose MDAs do not meet those requirements will not be useable for comparisons with background. Data with estimated activities greater than 0.005 pCi/g and two-sigma analytical uncertainty greater than 100% will not be useable for comparisons with background.

4.2. Validation and Verification Methods

The ERD QC Chemist will review the analytical results received from the analytical laboratory. During this review, the QC Chemist will verify that the analytical laboratory's internal QC data is within acceptance limits, blanks are clean, and dilutions, units and reporting limits are correct. The ERD's data validation procedures are described in ERD SOPs 4.6 and 4.11.

The ERD QC Chemist will initiate Data Qualifier Flags for analytical data that is suspect, outside acceptance criteria, or requires additional qualification. The analytical sample results will be qualified based on the associated QC data and other information that accompany the results. The QC Chemist will work with the laboratories to identify and correct any problems with data or service. The data qualifier flags used by ERD were adapted from the Contract Laboratory Program data qualifier flags (EPA, 1994b).

4.3. Reconciliation with User Requirements

All documentation will be reviewed (e.g., field tracking forms, chain of custody, etc.) to verify that samples were collected in the correct locations and in the correct manner.

Appendix F: Acronyms

ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BTP	Big Trees Park
CDHS	California Department of Health Services
CDHS-EHIB	CDHS Environmental Health Investigations Branch
CDHS-RHB	CDHS Radiologic Health Branch
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CES	Chemistry and Materials Sciences Environmental Services
COC	Chain of custody
DOE	United States Department of Energy
DOT	United States Department of Transportation
DQO	Data Quality Objective
DTSC	California Environmental Protection Agency, Department of Toxic Substances Control
EPA	United States Environmental Protection Agency
EPD	Environmental Protection Department (LLNL)
ERD	Environmental Restoration Program and Division (LLNL)
ERP	Livermore Site Environmental Project
ES&H	Environmental, Safety, and Health
FFA	Federal facility agreement. A negotiated agreement that specifies required actions at a federal facility as agreed upon by various agencies (e.g., EPA, RWQCB, DTSC, and DOE).
FTF	Field Tracking Form
GEL	General Engineering Laboratories
GIT	Georgia Institute of Technology
GPS	Global positioning system

LARPD	Livermore Area Recreation and Park District
LAS	Lockheed Analytical Services
LLNL	Lawrence Livermore National Laboratory
LWRP	Livermore Water Reclamation Plant
MDA	Minimum detectible activity
MDC	Minimun detectible concentration
NAREL	National Air and Radiation Environmental Laboratory
NEPA	National Environmental Policy Act.
NWP	Nationwide Permit
ORAD	Operations and Regulatory Affairs Division (LLNL)
PHC	Public Health Consultation
PRG	Preliminary Remediation Goal
QA	Quality assurance
QAC	Quality Assurance Coordinator
QC	Quality control
RHB	Radiologic Health Branch
RWQCB	Regional Water Quality Control Board
SOP	Standard Operating Procedure
SPACT	Sample Planning and COC Tracking
TAMM	Terrestrial and Atmospheric Monitoring and Modeling (LLNL)
TSG	Technical Support Group (LLNL)
UCL	Upper confidence level
Zone 7	Alameda Flood Control and Water Conservation District

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