
# Vegetation and Foodstuff Monitoring

*S. Ring Peterson*

## Introduction

Lawrence Livermore National Laboratory has a vegetation and foodstuff monitoring program to comply with U.S. Department of Energy (DOE) guidance. This guidance (U.S. DOE 1991) states that periodic sampling and analysis of vegetation should be performed to determine if there is measurable, long-term buildup of radionuclides in the terrestrial environment.

LLNL has historically released tritium to the air during routine operations and, occasionally, by accident. Tritium is the only nuclide of interest in the LLNL vegetation and foodstuff monitoring program because tritium is the only radionuclide released from LLNL activities that occurs in detectable concentrations in vegetation and foodstuff. Tritium moves through the food chain as tritiated water (HTO) and can be rapidly assimilated into plant water and then incorporated into the organic matter of plants through photosynthesis. It can contribute to human radiation dose if it is inhaled, absorbed through the skin, or ingested via vegetables or via milk and meat from animals that are exposed to a tritiated environment.

LLNL has been monitoring tritium in vegetation to some extent since 1966 and has performed routine vegetation sampling in the vicinity of the Livermore site and Site 300 since 1971. The monitoring program is designed to measure changes in the environmental levels of radioactivity, to evaluate the environmental effect of LLNL operations, and to calculate potential human doses from tritium in the food chain.

In 1977, LLNL added wine to the LLNL monitoring program. Wine is the most important agricultural product in the Livermore Valley, with a retail value estimated conservatively at $140 million. Although the tritium concentrations in all wines are on average less than 0.2% of the EPA's drinking water standard, the sampling data indicate that Livermore Valley wines contain statistically more tritium than do wines from other California wine-producing regions.

In the past, other foodstuffs (cow milk, goat milk, and honey) leading to potential dose were also monitored for tritium. At present, however, honey and milk are no longer produced in the vicinity of LLNL, so tritium concentrations in only vegetation and wine are used to assess potential ingestion dose from tritium emitted during LLNL operations.

During 2002, LLNL collected and analyzed samples of herbaceous vegetation and wine. Potential human doses from these foodstuffs were calculated using the monitoring data and the dose models presented in Appendix B. In addition, as part of a continuing study, LLNL determined the potential tritium dose to the maximally exposed individual from a particular pine tree at the Livermore site. This tree serves as a diffuse source of tritium because it loses tritium to the air through evapotranspiration of tritium-contaminated water in the root zone. The dose from this tree (Location PINI in **Figure 11-1**) was calculated using the U.S. Environmental Protection Agency (EPA) model CAP88-PC.

## Methods

The methods used for monitoring vegetation and wine are presented in the following sections. All vegetation and wine sampling was conducted according to written and approved standardized procedures in the *Environmental Monitoring Plan* (Tate et al. 1999).

### Vegetation

In 2002, LLNL staff collected vegetation samples, usually annual grasses or small herbaceous plants, quarterly from 18 fixed locations in the Livermore Valley, San Joaquin County, and Site 300. LLNL collected approximately 100 to 200 g of vegetation with relatively high water content for each analysis; a sample of approximately equal size from the same location was also collected for archiving. Samples, delivered to LLNL's Chemistry and Materials Science Environmental Monitoring Radiological Laboratory, were kept frozen prior to processing. Water from the vegetation was collected using freeze-drying techniques (lyophilization), and the tritium concentration of the extracted water was determined by liquid scintillation counting.

Approximately 10% of the sites were sampled in duplicate to comply with quality assurance protocols. Duplicate samples were preserved, stored, processed, and analyzed with methods identical to those employed for all other samples.

Location maps are provided in **Figure 11-1** and **Figure 11-2**. Sample locations were selected to represent vegetation from locations near LLNL that could be affected by LLNL operations, background locations where vegetation is unlikely to be affected by LLNL operations, and areas of known or suspected LLNL-induced contamination. All sampling locations were the same as those in 2001.

The routine vegetation sampling locations are designated with permanent location markers. Consistent use of the same sampling locations allows LLNL to determine trends in data and to monitor areas of concern more closely. Vegetation sampling locations chosen by LLNL are places where ample living vegetation is most likely found. Sampling locations are distant from buildings or other obstructions that can cause unusual patterns of airflow. Irrigated or shaded areas are also avoided. Practical considerations, such as ease of access and personnel safety, also affected selection of sampling locations.

### Wine

In 2002, twelve bottles of wine from the Livermore Valley, six bottles of wine from different wine-growing regions of California (excluding Livermore), and four wines from different regions

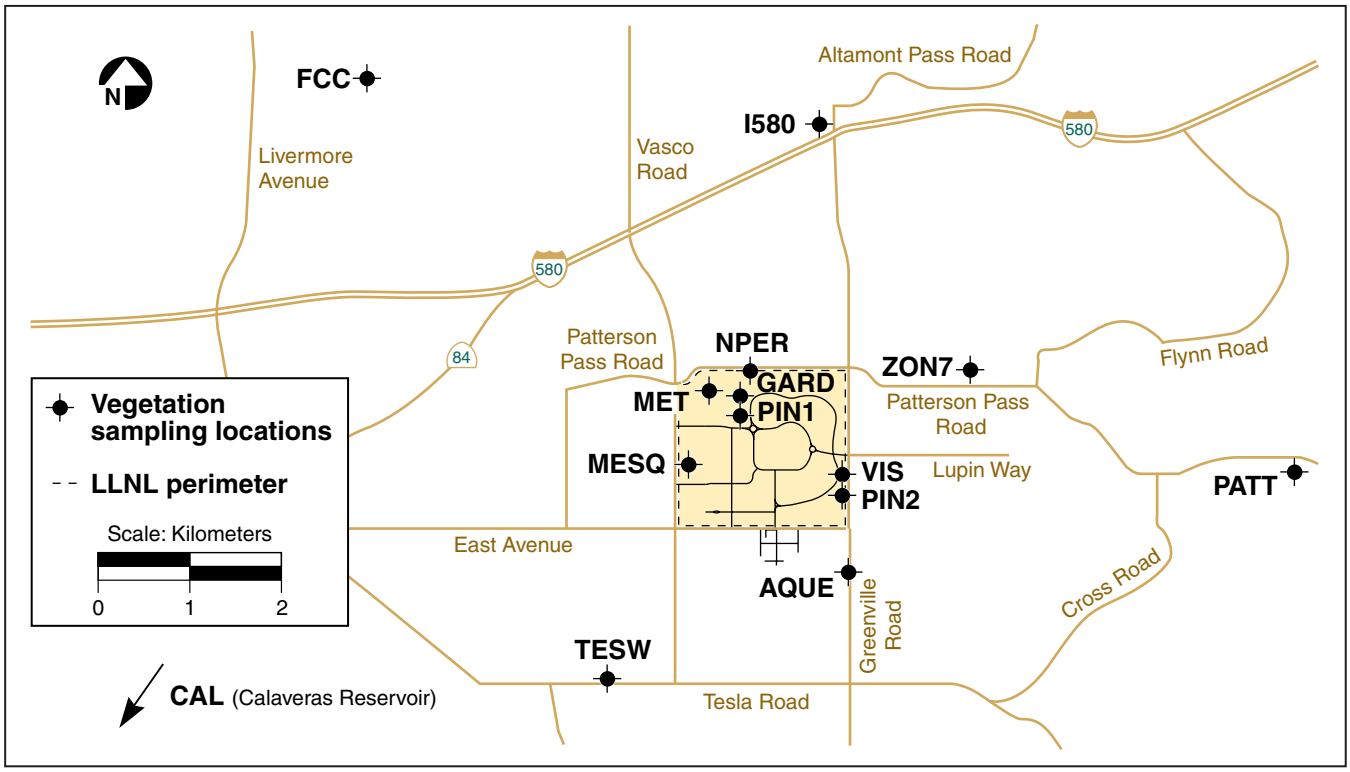


**Figure 11-1. Livermore site and Livermore Valley vegetation sampling locations, 2002**

of Italy, France, and Germany were collected and analyzed for tritium. An equal mix of red and white wines was selected to represent each area. Any estate-bottled wine from a designated area was considered representative of that area.

Selection of wines from a particular wine-growing region was based primarily on availability in local stores. The wines were purchased from local retailers to represent what the general public could buy and drink during 2002. Approximately 10% of the total complement of wines was sampled in duplicate to comply with quality assurance protocols.

LLNL analyzed wines for tritium using helium-3 mass spectrometry in the Analytical and Nuclear Chemistry Division's Noble Gas Mass Spectrometry Laboratory in the Environmental Radiochemistry Group. Using this highly sensitive method (Surano et al. 1992), the minimum detectable tritium concentration is about 0.056 Bq/L (1.5 pCi/L), well below measured concentrations in wine. With great care, a conventional scintillation detection system's sensitivity can reach about 1 Bq/L (27 pCi/L); this detection level, however, is not sensitive enough to detect small differences in wine samples.

## Results

The results of vegetation monitoring for the Livermore site and Site 300 and the results of wine monitoring are presented in the following sections.

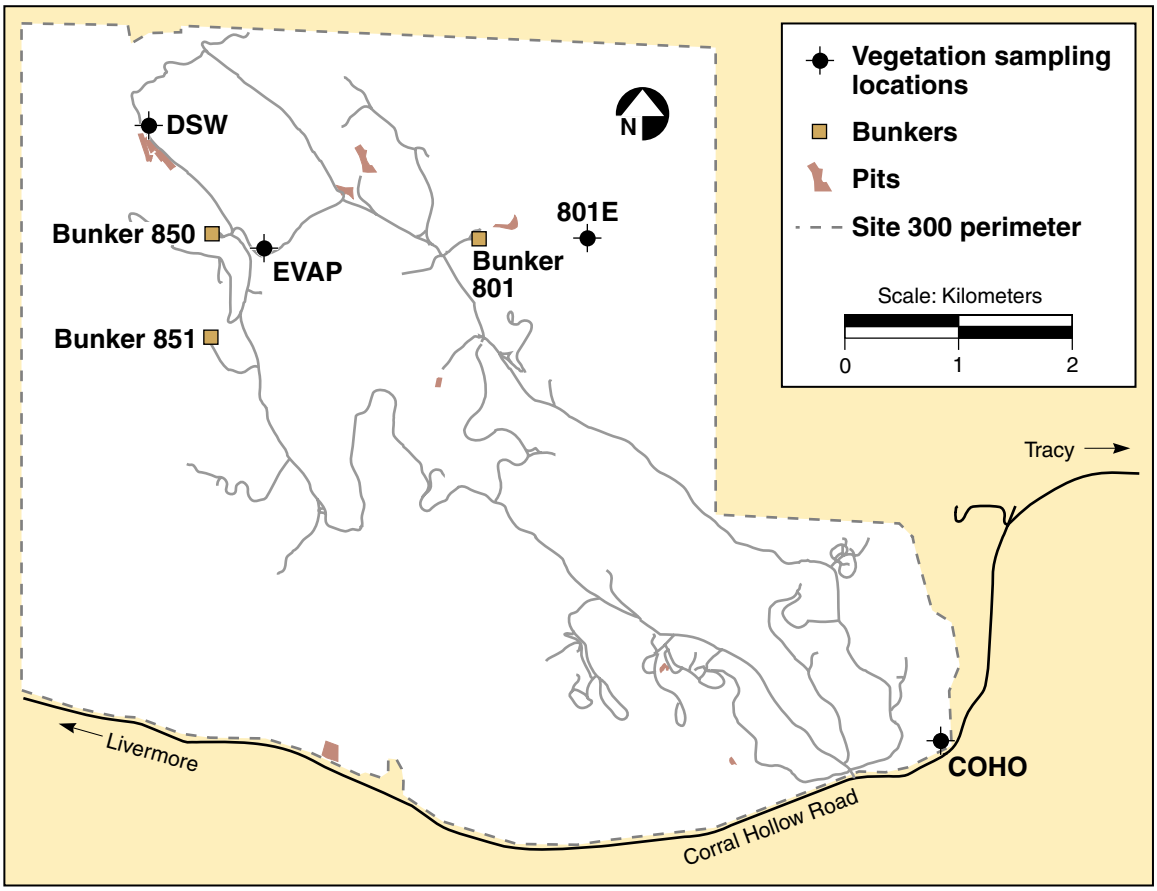


**Figure 11-2. Site 300 vegetation sampling locations, 2002**

## Livermore Site

### Vegetation

The Livermore site and Livermore Valley vegetation locations are divided into four groups for statistical evaluation:

- **Near:** locations on-site or within 1 km of the Livermore site perimeter. Near locations are AQUE, GARD, MESQ, NPER, MET, PIN2, and VIS.

- **Intermediate:** locations in the Livermore Valley 1–5 km from the Livermore site perimeter that are often downwind and, thus, potentially under the influence of tritium releases at the site. The Intermediate locations are I580, PATT, TESW, and ZON7.

- **Far:** locations unlikely to be affected by LLNL operations. One background location (CAL) is more than 25 km away. The other (FCC), although in the Livermore Valley, is unlikely to be affected by LLNL operations because it is more than 5 km from the Livermore site and generally upwind.

- **PIN1:** location of a pine tree rooted in an area of known tritium contamination on the Livermore site.

**Table 11-1** shows tritium concentrations for all vegetation collected for the LLNL vegetation monitoring program in 2002. For 2002, the data for tritium in vegetation were compared using Scheffé's *F* and Games/Howell multiple comparisons (Scheffé 1953; Games and Howell 1976). The Near group was found to be significantly different at the 5% level from the Far group, but not from the Intermediate group. The Intermediate group was also statistically different from the Far group. There was significant overlap in the ranges of values for some of the Near and Intermediate locations. Both the lowest and the highest concentrations were found in the Near locations, and two values for the Intermediate samples were higher than all but two of the Near samples.

**Figure 11-3** shows the 2002 medians of the tritium concentrations for PIN1, Near, Intermediate, and Far Livermore locations as a continuation of historic median concentrations from 1971 to 2001. The upturn in median values for the Intermediate group (**Figure 11-3**) is due to high values at ZON7. In general, the trend loosely linked to a small increase in emissions from the Tritium Facility (see Chapter 4), is towards slightly higher concentrations in vegetation in 2002 than in 2001. This is most noticeable in the Intermediate locations probably by chance, because quarterly vegetation sampling is insufficient to define annual average concentrations.

In 1997, PIN1, a pine tree growing in a known area of tritium contamination at the Livermore site, was monitored on a monthly basis to estimate emissions for compliance with National Emission Standards for Hazardous Air Pollutants (NESHAPs) (See **Chapter 13**). In 1998, the tree sampling was coordinated with the quarterly vegetation sampling. NESHAPs dose calculations to the maximally exposed individual (MEI), now based on quarterly observations, assume the tree to be a diffuse source of tritium.

To assess the contribution of soil water tritium to PIN1, LLNL also sampled a second tree (PIN2), which is not growing in tritium-contaminated soil. Concentrations of tritium in PIN2, like in all other vegetation sampled near the Livermore site (with the exception of PIN1), are from air and soil water in quasi-equilibrium with air. When samples from PIN1 were compared with samples from each Near location for 2002 using Scheffé's *F* procedure, concentrations of tritium in PIN1 were found to be significantly higher than concentrations at all other locations, including PIN2, at the 5% significance level.

### Wine

Data from the analysis of tritium in wine can be used to estimate the potential tritium dose received by consumers during the year of purchase. However, because wines purchased in 2002 represent vintage years 1997, 1998, 1999, and 2001, the 2002 sampling data cannot be used to indicate how LLNL's operations affected concentrations of tritium in wines produced from grapes grown in 2002. To analyze trends and help determine the impact of LLNL operations on tritium in wine for the year of harvest, LLNL corrects the wine concentrations for radiological decay that has occurred between the approximate date of the grape harvest and the date when the wine was analyzed in the laboratory. Comparisons can then be made of wine concentrations that represent the year when the grapes were exposed to the tritium.

The results from the 2002 wine tritium analyses are shown in **Table 11-2**. Tritium concentrations of Californian and European wines are within the range of those reported in previous years; the concentrations in Livermore wines are distinctly lower, on average. The data for the 2002 sampling year were analyzed using Scheffé's *F* and Games/Howell multiple comparisons. The results of the comparisons are the same as in previous years. Both analyses show that the tritium concen-

**Table 11-1. Concentrations of tritium in plant water (Bq/L) collected quarterly and estimated annual ingestion doses for each sampling location, 2002**

| | First Quarter | Second Quarter | Third Quarter | Fourth Quarter | Median | IQR[a] | Mean | Dose (nSv/y)[b] | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Mean[c] | Maximum |
| **Sampling locations within 1 km of the Livermore site perimeter** | | | | | | | | | |
| AQUE | 0.88 ± 2.0 | 2.5 ± 2.0 | 0.48 ± 2.0 | 2.1 ± 2.2 | 1.5 | 1.4 | 1.5 | 7.4 | 12 |
| GARD | 2.3 ± 2.0 | 0.58 ± 1.9 | –0.75 ± 1.9 | 1.4 ± 2.2 | 0.99 | 1.4 | 0.88 | 4.3 | 11 |
| MESQ | 2.5 ± 2.0 | –0.54 ± 1.9 | 0.34 ± 2.0 | 2.4 ± 2.3 | 1.4 | 2.3 | 1.2 | 5.9 | 12 |
| MET | 0.46 ± 2.0 | 0.88 ± 1.9 | 0.67 ± 2.0 | 7.4 ± 2.5 | 0.78 | 1.9 | 2.4 | 12 | 36 |
| NPER | 3.6 ± 2.1 | 1.6 ± 2.0 | 2.5 ± 2.1 | 5.7 ± 2.4 | 3.1 | 1.9 | 3.4 | 17 | 28 |
| PIN2 | 5.5 ± 2.2 | 7.5 ± 2.2 | 4.8 ± 2.2 | 3.5 ± 2.3 | 5.2 | 1.5 | 5.3 | —[d] | —[d] |
| VIS | 4.8 ± 2.2 | 4.9 ± 2.1 | 4.4 ± 2.2 | 4.5 ± 2.3 | 4.7 | 0.35 | 4.7 | 23 | 24 |
| PIN1 | 52 ± 3.7 | 77 ± 4.2 | 290 ± 7.5 | 12 ± 2.7 | 65 | 89 | 110 | 0.0089[e] | 0.024[e] |
| **Sampling locations 1–5 km from the Livermore site perimeter** | | | | | | | | | |
| I580 | 2.3 ± 2.0 | 1.2 ± 2.0 | 2.3 ± 2.1 | –0.19 ± 2.2 | 1.8 | 1.4 | 1.4 | 6.9 | 11 |
| PATT | 1.4 ± 2.0 | 1.3 ± 2.0 | 2.3 ± 2.1 | 0.77 ± 2.2 | 1.4 | 0.46 | 1.4 | 6.9 | 11 |
| TESW | 0.38 ± 2.0 | –0.10 ± 1.9 | 2.2 ± 2.1 | 3.8 ± 2.3 | 1.3 | 2.3 | 1.6 | 7.8 | 19 |
| ZON7 | 4.5 ± 2.1 | 2.7 ± 2.0 | 5.8 ± 2.2 | 6.7 ± 2.4 | 5.2 | 2.0 | 4.9 | 24 | 33 |
| **Sampling locations more than 5 km from the Livermore site perimeter** | | | | | | | | | |
| CAL | 0.26 ± 1.9 | 0.60 ± 1.9 | 0.91 ± 2.0 | –1.3 ± 2.1 | 0.43 | 0.81 | 0.12 | 0.59 | 4.5 |
| FCC | 0.22 ± 1.9 | 2.0 ± 2.0 | –0.44 ± 1.9 | 0.43 ± 2.2 | 0.33 | 0.77 | 0.55 | 2.7 | 9.8 |
| **Sampling locations at Site 300** | | | | | | | | | |
| COHO | 2.4 ± 2.1 | –0.025 ± 1.9 | 0.58 ± 2.0 | –0.31 ± 2.1 | 0.28 | 1.1 | 0.66 | 3.2 | 12 |
| 801E | 0.58 ± 2.0 | –0.13 ± 1.9 | –0.77 ± 1.9 | 1.40 ± 2.3 | 0.23 | 1.1 | 0.27 | 1.3 | 6.9 |
| DSW[f] | 45 ± 3.5 | 23 ± 3.0 | 2500 ± 21 | 2.3 ± 2.3 | 34 | 640 | 640 | 3100 | 12,000 |
| EVAP[f] | 37 ± 3.3 | 43 ± 3.3 | 120 ± 5.0 | –0.41 ± 2.2 | 40 | 35 | 50 | 250 | 590 |

Note: Radioactivities are reported as the measured concentration and an uncertainty (±2σ counting error). If the concentration is less than or equal to the uncertainty, the result is considered to be a nondetection. See Chapter 14.

a IQR = Interquartile range

b Ingestion dose is based on conservative assumptions that an adult's diet is exclusively vegetables with this tritium concentration, and that meat and milk are derived from livestock fed on grasses with the same concentration of tritium. See Appendix B.

c Doses are calculated based on mean rather than median concentrations because ingesting an equal mass of food quarterly is represented by the mean.

d Doses were not calculated because pine needles are not ingested by human beings. Concentrations from PIN2 are included with NEAR vegetation (**Figure 11-3**) because plant water tritium concentrations are similar among plant types.

e For this dose calculation, PIN1 is treated as a diffuse source of tritium (since pine needles are not eaten by human beings). Dose, calculated using CAP88-PC (see Chapter 13) is to the maximally exposed individual.

f These plants are rooted in areas of known subsurface contamination.

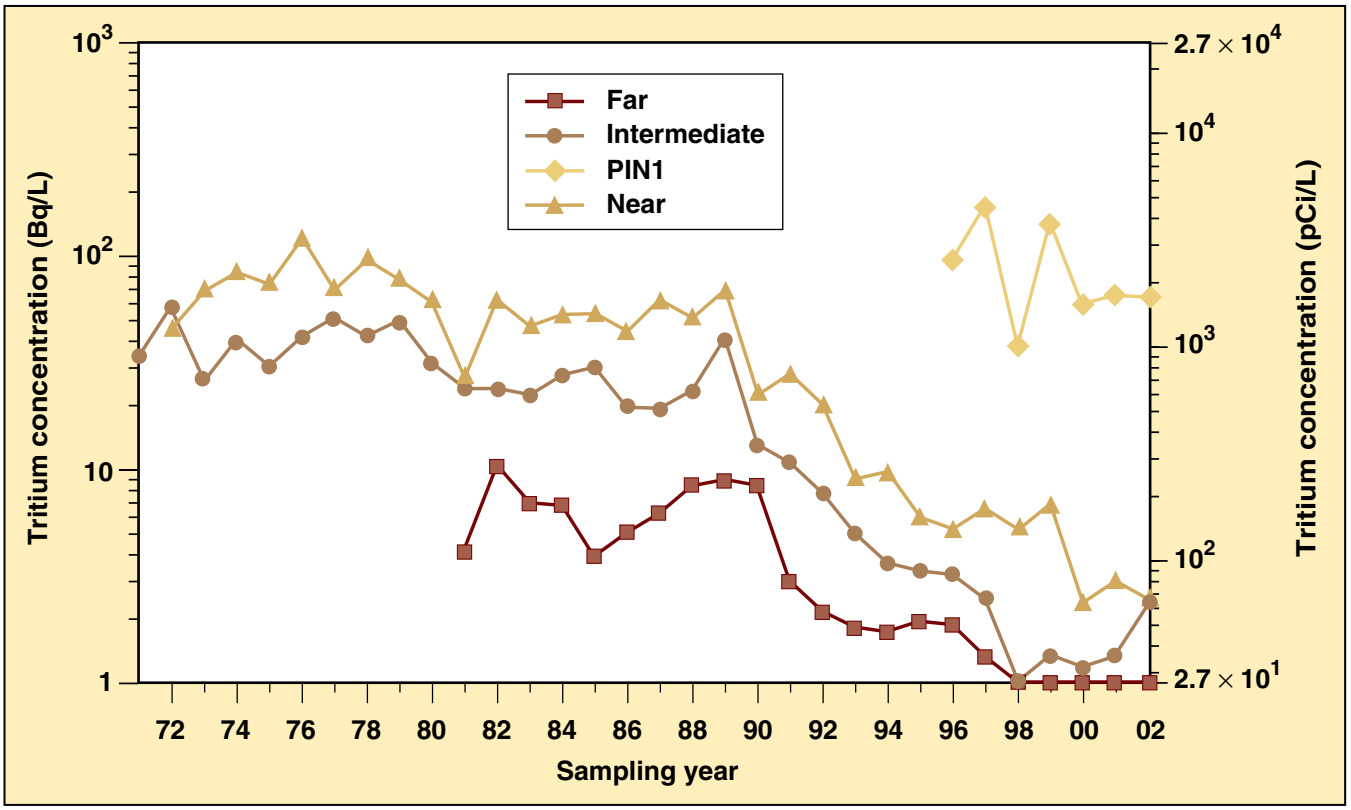


**Figure 11-3. Median tritium concentrations in Livermore site and Livermore Valley plant water samples, 1971–2002. When median values are below 1 Bq/L (well below detection limits), values are plotted as 1 Bq/L to eliminate meaningless variability.**

trations of Livermore Valley wines are higher than those of the six California wines at the 5% significance level. The Scheffé's *F* test, which can be used when the number of samples is fewer than six, also demonstrated that the California wines sampled have significantly lower tritium concentrations than the European wines sampled and that tritium concentrations in European wine are statistically indistinguishable from tritium concentrations in Livermore Valley wines.

There is more variability in the concentrations of Livermore Valley wines collected for 2002 than there has been in recent years. For 2002, the concentrations in Livermore Valley wines are both lower and higher than in 2001. The lower concentrations seen in wines collected in 2002 are all from grapes harvested in 2001; the higher concentration is from a bottle from grapes harvested in 1999.

Concentrations of tritium in wine corrected to vintage year are plotted in **Figure 11-4**. The downward trend for Livermore Valley wines continues. Using the Scheffé's F test, there is no significant difference in concentrations of California wines from 1991 through 2001.

**Table 11-2. Tritium in retail wine (Bq/L), 2002[a]**

| Sample | Area of production | | |
|---|---|---|---|
| | Livermore Valley | California | Europe |
| 1 | 0.71 ± 0.20 | 0.34 ± 0.19 | 0.88 ± 0.20 |
| 2 | 0.72 ± 0.20 | 0.42 ± 0.19 | 1.2 ± 0.22 |
| 3 | 0.75 ± 0.20 | 0.45 ± 0.19 | 1.3 ± 0.23 |
| 4 | 0.75 ± 0.20 | 0.50 ± 0.19 | 3.9 ± 0.43 |
| 5 | 0.83 ± 0.20 | 0.57 ± 0.19 | |
| 6 | 1.2 ± 0.22 | 0.76 ± 0.20 | |
| 7 | 1.2 ± 0.22 | | |
| 8 | 1.3 ± 0.22 | | |
| 9 | 1.4 ± 0.23 | | |
| 10 | 2.1 ± 0.28 | | |
| 11 | 2.6 ± 0.32 | | |
| 12 | 2.9 ± 0.35 | | |
| Median; IQR[b] | 1.2; 0.83 | 0.48; 0.13 | 1.3; 0.83 |
| Mean ± standard deviation | 1.4 ± 0.76 | 0.51 ± 0.15 | 1.8 ± 1.4 |
| Dose (nSv/y)[c] | | | |
| Mean[d] | 1.3 | 0.46 | 1.6 |
| Maximum | 2.6 | 0.68 | 3.9 |

Note: Radioactivities are reported here as the measured concentration and an uncertainty (±2σ counting error). If the concentration is less than or equal to the uncertainty, the result is considered to be a nondetection. See Chapter 14.

a Wines from a variety of vintages were purchased and analyzed in 2002. The concentrations reported are those at the time the bottle was opened.

b IQR = interquartile range

c This dose is calculated based on consumption of 52 L wine per year (see Appendix C).

d Doses are calculated on mean concentrations because ingestion intake is better represented by a mean than by a median.

## Site 300

### Vegetation

There are four monitoring locations for vegetation at Site 300 (**Figure 11-2**). Of these, 801E and COHO have the potential to demonstrate changes in atmospheric tritium concentrations. Vegetation from locations DSW and EVAP grows in areas of known groundwater contamination.

Plants can take up tritiated water from two sources: air moisture and soil moisture. When a plant's soil water is contaminated with tritium and there is little tritium in the air moisture, the tritium concentration in the plant water will be somewhat lower than that of soil water, but it will be much higher than the concentration in air moisture.

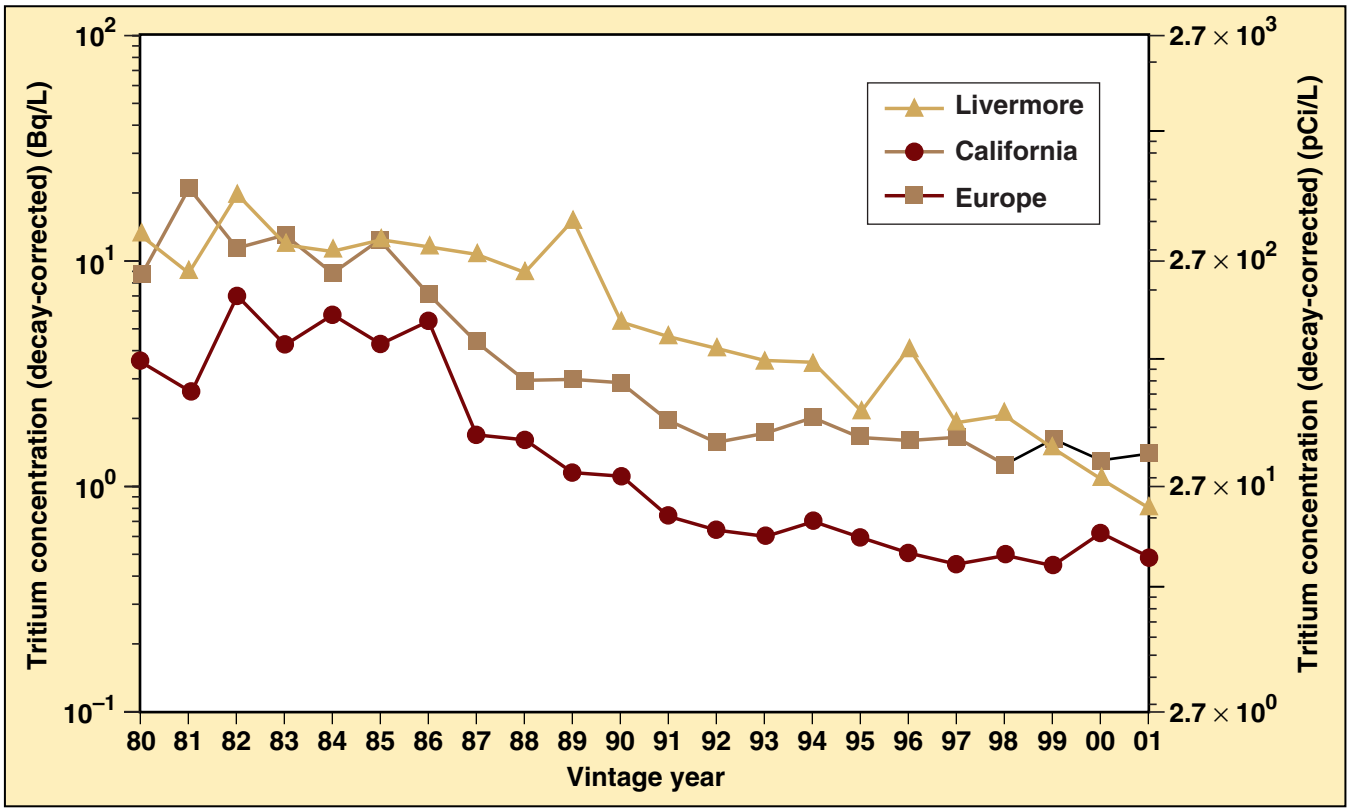


**Figure 11-4. Median tritium concentrations in retail wines decay-corrected from the sampling year to the vintage year**

Table 11-1 shows all tritium data for vegetation collected at Site 300 during 2002. Historic median concentrations for tritium at Site 300 sampling locations are shown in Figure 11-5. Results from 801E and COHO for 2002 were close to or below detection limits. Concentrations at locations EVAP and DSW were above detection limits for the first three quarters. The median concentrations at DSW and EVAP are similar; both are below those of 2001. As shown in Figure 11-5, median concentrations below 1 Bq/L (well below the limits of detection) are assumed equal to 1 Bq/L to avoid plotting meaningless differences.

The highest tritium result (2500 Bq/L) occurred at location DSW (see Table 11-1). This sampling location is adjacent to a landfill area that contains debris contaminated with tritium from past experiments. Tritium concentrations in vegetation are also above background levels at location EVAP, which is near a spring where groundwater flows near the surface and evaporates. Groundwater near EVAP is contaminated with tritium from Pit 3, Pit 5, and the firing table at Building 850. The DSW and EVAP locations are both within the East and West Firing Area (EFA/WFA) and the environmental restoration study areas of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (see Chapter 8).

Relatively high concentrations of tritium in plants at DSW and EVAP are observed only sporadically when the roots of the vegetation come in contact

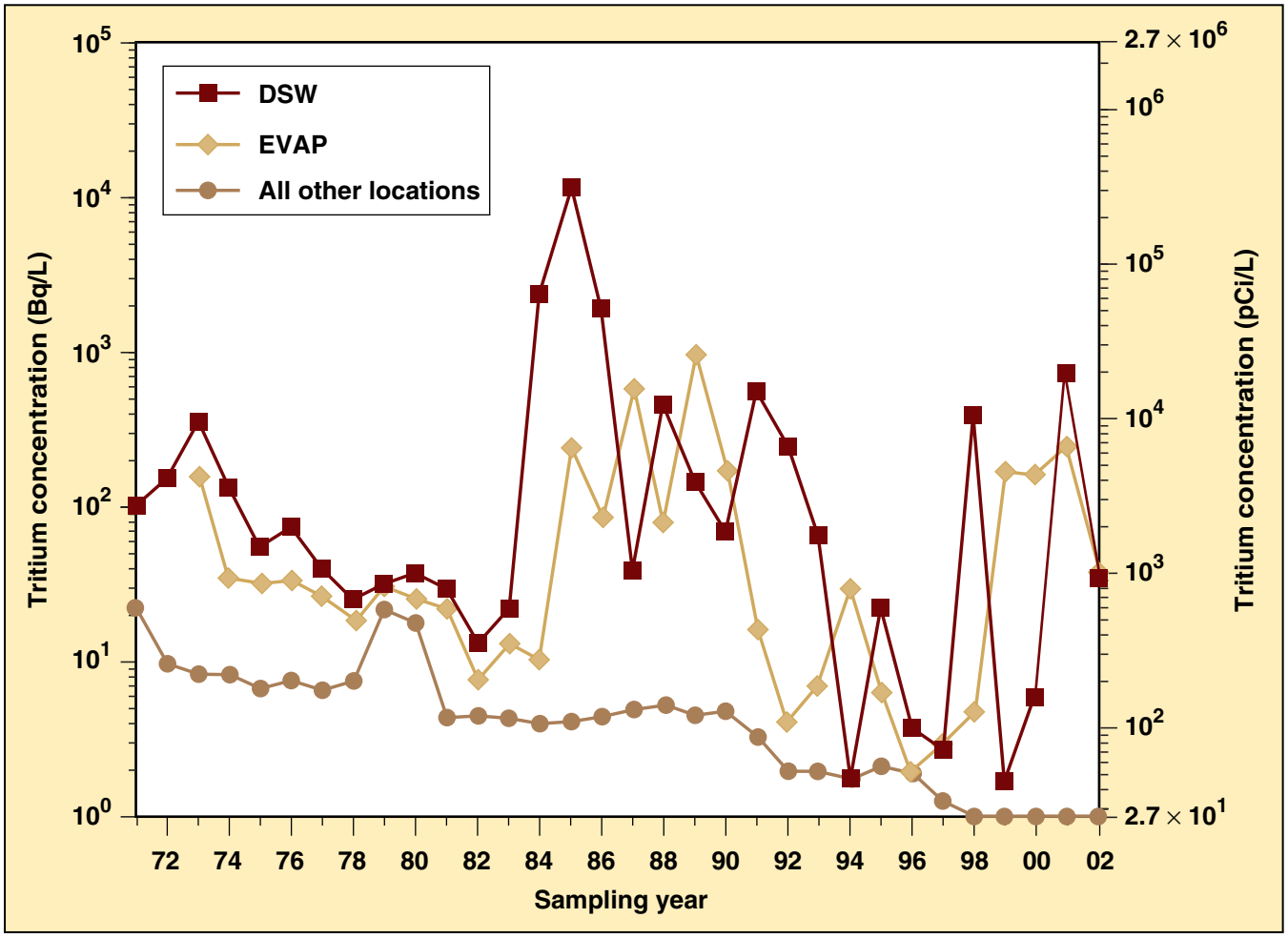


**Figure 11-5. Median tritium concentrations in plant water at Site 300 sampling locations, 1971–2002. When median values are below 1 Bq/L (well below detection limits), values are plotted as 1 Bq/L to eliminate meaningless variability.**

with contaminated groundwater. Evaluation of the 2002 data for Site 300 using Scheffé's *F* procedure yielded no significant difference between 801E, COHO, and EVAP, a result of the high variability of the data and the low number of data points. However, DSW was determined to be different from 801E and COHO at the 5% significance level.

## Environmental Impact

In 2002, the environmental impacts of LLNL operations on vegetation and wine, presented below, were small.

### Livermore Site Vegetation

LLNL impacts on vegetation in the Livermore Valley remained minimal in 2002. The effective dose equivalents, shown in **Table 11-1**, were

derived using the dose conversion factor ($1.73 \times 10^{-11}$ Sv/Bq) provided by DOE (U.S. DOE 1988) and the dose pathway model from U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 (U.S. NRC 1977). Appendix C provides a detailed discussion of dose calculation methods. The dose from ingested tritium is based on the conservative assumptions that an adult's diet (Table C-1, NRC maximum) consists exclusively of leafy vegetables with the measured tritium concentrations, as well as meat and milk from livestock fed on grasses with the same concentrations. In actuality, the vegetables consumed by an adult contain tritium at lower levels than those reported because most vegetables are imported from other areas. Similarly, tritium concentrations in food consumed by local livestock are at or below the concentrations in vegetation measured at the Intermediate and the Far locations. Nevertheless, based on these extremely conservative assumptions, the maximum potential dose from ingestion of vegetables, milk, and meat for 2002 for the Livermore Valley is 36 nSv/y (0.036 μSv/y or 0.0036 mrem/y).

Doses are calculated based on measured tritium in plant water without considering the contribution of organically bound tritium (OBT). Dose conversion factors of $1.8 \times 10^{-11}$ Sv/Bq for tritium in the plant or animal water (HTO) and $4.2 \times 10^{-11}$ Sv/Bq for OBT have been established by the International Commission on Radiological Protection (ICRP 1996). These conversion factors show the relative importance of ingested HTO and OBT to dose.

When vegetables are ingested, the dose from the HTO contribution is greater than the dose from the OBT contribution because the fraction of the vegetable that is organic matter is quite small (10–25%). For example, about 10% of the ingestion dose from leafy vegetables (about 10% dry matter) is contributed by OBT. OBT becomes increasingly important to dose when the fraction of dry matter increases. Pork, for example, has a dry-matter content of about 30–50% (Ciba-Geigy Ltd. 1981), and the resulting ingestion dose from pork is about half from OBT and half from HTO. The OBT in grain, which is 88% dry matter, contributes nearly 90% of the dose from ingested grain.

Given the different fractions of OBT in different foods, the importance of OBT to ingestion dose depends on what quantities of what kinds of foods are consumed. Accounting for a diet extremely high in OBT and for the relative biological effectiveness of the tritium beta possibly being greater than 1.0 would, at most, give an OBT contribution to dose twice that of HTO (U.S. Department of Health and Human Services 2001). Thus, conservatively, the maximum total tritium dose from ingestion of vegetables, milk, and meat from the Livermore Valley for 2002 cannot exceed 110 nSv/y (0.11 μSv/y or 0.011 mrem/y), which is well below any level of regulatory concern.

The dose values for PIN1 (shown in **Table 11-1**) were calculated in a different manner from those for edible vegetation because it is unreasonable to assume that any person is directly ingesting pine needles. The pine tree is treated as a diffuse source of tritium to the atmosphere via the contaminated transpirational stream. LLNL used an estimated tritium transpiration rate from the tree to estimate the Ci/y emitted by the tree that is used as the source input to the EPA regulatory model CAP88-PC. LLNL modeled air dispersion of the transpired tritium and calculated a resulting dose from inhalation, skin absorption, and potential ingestion from air concentrations at the location of the maximally exposed individual. This total dose is based on the conservative assumptions that 100% of the individual's time is spent at this location and that his/her diet consists exclusively of foods having the same tritium to hydrogen ratio as occurred in

air moisture. The resulting maximum dose for PIN1 of 0.024 nSv/y ($2.4 \times 10^{-5}$ µSv/y or $2.4 \times 10^{-6}$ mrem/y) is considerably lower than ingestion doses calculated directly from measured concentrations in vegetation because the tree is only an indirect source of air/vegetation contamination.

### Livermore Site Wine

No health standards exist for radionuclides in wine. However, all the wine tritium levels were far below drinking water standards. In fact, even the highest detected Livermore Valley value (2.9 Bq/L or 78 pCi/L) represents only 0.39% of the California drinking water standard (740 Bq/L or 20,000 pCi/L). Doses from wine consumption can be calculated according to methods for water ingestion, as described in Appendix C.

Based on the conservative assumption that wine is consumed at the same rate as the average consumption of water (370 L/year or about 1 L/day), the annual dose that corresponds to the highest detected 2002 Livermore Valley tritium value in wine is 19 nSv (1.9 µrem). Assuming a more realistic, yet high,* average wine consumption (52 L/year or 1 L/week), and the mean tritium values from the three sampling areas, the annual doses from Livermore, European, and California wines would be 1.3 nSv (0.13 µrem), 1.6 nSv (0.16 µrem), and 0.46 nSv (0.046 µrem), respectively.

## Summary

Very low concentrations of tritium may be found in foodstuffs grown near the Livermore site as a result of LLNL operations. A potential ingestion dose for 2002 that accounts for contributions from HTO and OBT in vegetables, milk, meat, and wine will realistically be less than 110 nSv (0.11 µSv or 0.011 mrem). This estimate is similar to dose estimates calculated using other assumptions (see Appendix C). This estimate is a factor of 27,000 lower than an annual background dose (~3000 µSv or 300 mrem) and a factor of 900 lower than the dose from a typical chest x-ray (100 µSv or 10 mrem) (Shleien and Terpilak 1984). Therefore, although tritium levels are slightly elevated near the Livermore site, doses from tritium ingestion are negligible.

In general, LLNL impacts on tritium concentrations in vegetation at Site 300 for 2002 were insignificant. With the exception of vegetation from previously identified sites of contamination, the tritium levels at Site 300 were comparable to those observed in previous years. The areas where tritium is known to be present in the subsurface soil are well delineated and localized.

The calculated maximum potential annual ingestion dose from vegetation at sampling location DSW (**Figure 11-2**), based on the maximum value of 2500 Bq/L (68,000 pCi/L), is 12 µSv (1.2 mrem). This dose, based on the conservative modeling assumptions described above, is theoretical—but nevertheless small— because vegetation at Site 300 is not ingested either by people or by livestock.

*. The California Wine Institute, December 2001, states that the average consumption of wine in the United States is 2.01 gal/y (7.6 L/y).