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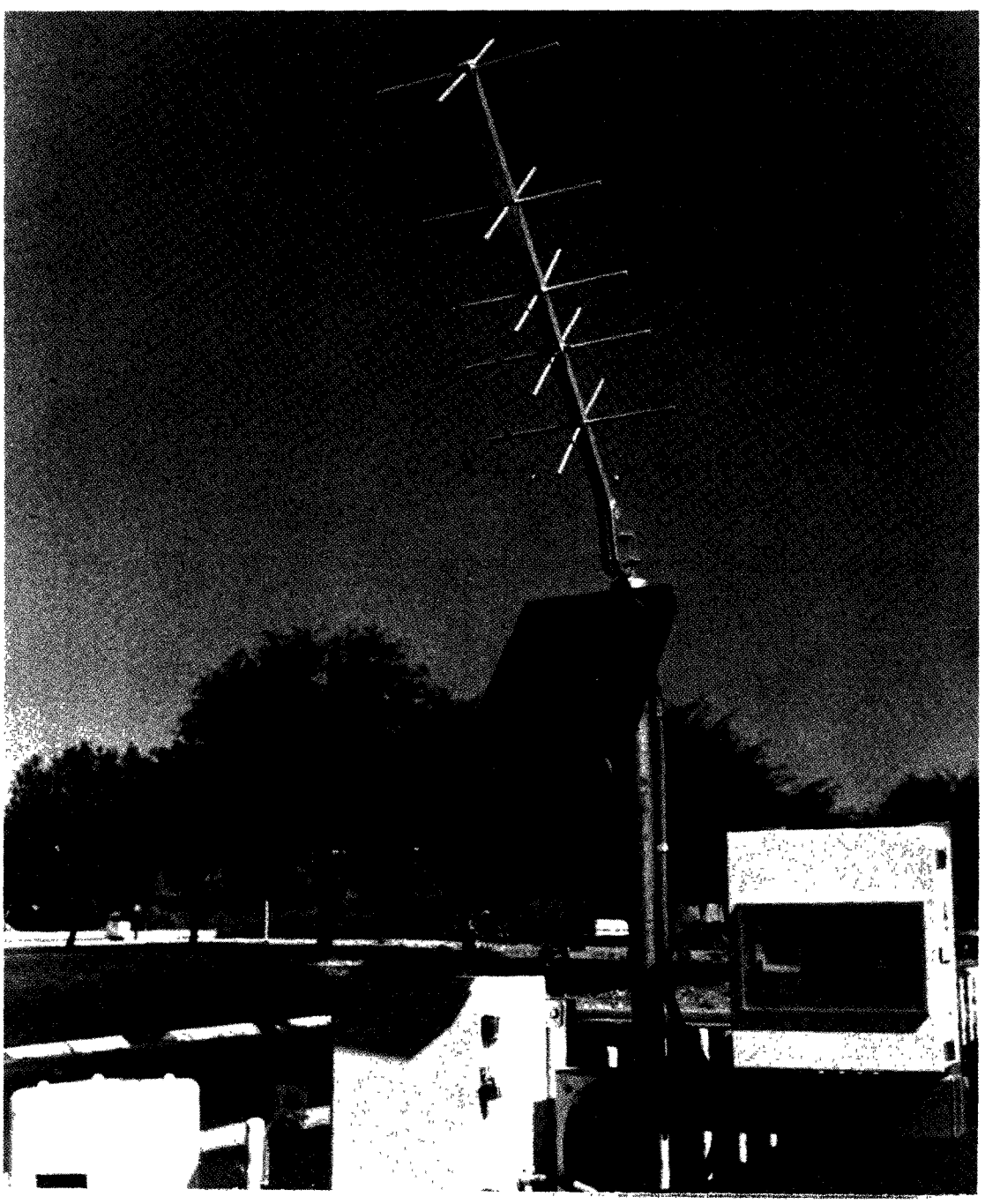
EPA

Offsite Environmental Monitoring Report

Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1989



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Offsite Environmental Monitoring Report

Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1989

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ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
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List of Abbreviations, Acronyms, and Conversions

ABBREVIATIONS

ALARA — As Low as Reasonably Achievable
ALI — Annual Limit on Intake
ASN — Air Surveillance Network
AVG — Average
BOMAB — Bottle Mannequin Absorber
Bq — Becquerel, one disintegration per second
CFR — Code of Federal Regulations
CG — Concentration Guide
Ci — Curie
CMS — Community Monitoring Station
CP-1 — Control Point One
CY — Calendar Year
d — day
DAC — Derived Air Concentration
DOE — U.S. Department of Energy
DOE/NV — Department of Energy, Nevada Operations Office
DQO — Data Quality Objectives
DRI — Desert Research Institute
EG&G — EG&G Energy Measurements
EML — Environmental Monitoring Laboratory
EMSL-LV — Environmental Monitoring Systems Laboratory, Las Vegas
EPA — U.S. Environmental Protection Agency
eV — electron volt
g — gram
GOES — Geostationary Operational Environmental Satellite
Gy — Gray, equivalent to 100 rad (1 J/kg)
GZ — Ground Zero
hr — hour
HTO — tritiated water
keV — One thousand electron volts
L — liter
LTHMP — Long-Term Hydrological Monitoring Program
m — meter
MeV — One million electron volts
MDC — Minimum Detectable Concentration
MSL — Mean Sea Level
MSN — Milk Surveillance Network
NIST — National Institute of Standards and Technology
NGTSN — Noble Gas and Tritium Surveillance Network
NRD — Nuclear Radiation Assessment Division
NTS — Nevada Test Site
Pa — Pascal - unit of pressure
PIC — Pressurized ion chamber
QA — Quality Assurance
QC — Quality Control
R — Roentgen
REECo — Reynolds Electrical and Engineering Corporation
RNM — Radionuclide Migration
rad — unit of absorbed dose, 100 ergs/g
rem — dose equivalent, the rad adjusted for biological effect
SAIC — Science Applications International Corporation
S.D. — Standard deviation
SI — International System of Units
SOP — Standard Operating Procedure
Sv — Sievert, equivalent to 100 rem
TLD — thermoluminescent dosimeter
USDI — United States Department of Interior
WHO — World Health Organization
WSNSO — Weather Service Nuclear Support Office

PREFIXES

a	atto	=	10^{-18}
f	femto	=	10^{-15}
p	pico	=	10^{-12}
n	nano	=	10^{-9}
μ	micro	=	10^{-6}
m	milli	=	10^{-3}
k	kilo	=	10^{3}
M	mega	=	10^{6}

CONVERSIONS

Multiply	by	To Obtain
Concentrations		
μCi/mL	10^{9}	pCi/L
μCi/mL	10^{12}	pCi/m^3
SI Units		
rad	10^{-2}	Gray (Gy = 1 Joule/kg)
rem	10^{-2}	Sievert (Sv)
pCi	3.7×10^{-2}	Becquerel (Bq)

Abstract

This report describes the Offsite Radiation Safety Program conducted during 1989 by the Environmental Protection Agency's (EPA's) Environmental Monitoring Systems Laboratory-Las Vegas (EMSL-LV). This laboratory operates an environmental radiation monitoring program in the region surrounding the Nevada Test Site (NTS) and at former test sites in Alaska, Colorado, Mississippi, Nevada, and New Mexico. The surveillance program is designed to measure levels, and trends of radioactivity, if present, in the environment surrounding testing areas to ascertain whether the testing is in compliance with existing radiation protection standards, and to take action to protect the health and well being of the public in the event of any accidental release of radioactive contaminants. Offsite levels of radiation and radioactivity are assessed by sampling milk, water, and air; by deploying thermoluminescent dosimeters (TLDs) and using pressurized ion chambers (PICs); and by biological monitoring of both animals and humans. To implement protective actions, provide immediate radiation monitoring, and obtain environmental samples rapidly after any release of radioactivity, personnel with mobile monitoring equipment are placed in areas downwind from the test site prior to each test. Comparison of the measurements and sample analysis results with background levels and with appropriate standards and regulations indicated that there was no radioactivity detected offsite by the various EPA monitoring networks and no exposure above natural background to the population living in the vicinity of the NTS that could be attributed to NTS activities. Trends were evaluated in the Noble Gas and Tritium, Milk Surveillance, TLD, and PIC networks, and the Long-Term Hydrological Monitoring Program. All evaluated data were consistent with previous data history, with the one exception of some slightly elevated results which occurred due to the accident at Chernobyl, U.S.S.R in April 1986. Population exposure came from naturally occurring background radiation which yielded an average dose of 93 mrem/yr, and worldwide fallout which accounted for about 0.04 mrem/yr.

Chapter 1. Introduction

C. A. Fontana

The U.S. Atomic Energy Commission used the Nevada Test Site, between January 1951 and January 1975, for conducting nuclear weapons tests, nuclear rocket engine development, nuclear medicine studies, and for other nuclear and non-nuclear experiments. Beginning in mid-January 1975, these activities became the responsibility of the U.S. Energy Research and Development Administration. Two years later this organization was merged with other energy-related agencies to form the U.S. Department of Energy (DOE).

Atmospheric weapons tests were conducted periodically at the Nevada Test Site from January 1951 through October 1958, followed by a test moratorium which was in effect until September 1961. Since then all nuclear detonations at the NTS have been conducted underground, with the expectation of containment, except for the above ground and shallow underground tests of Operation Sunbeam and in cratering experiments conducted under the Plowshare program between 1962 and 1968.

Prior to 1954, an offsite radiation surveillance program was performed by personnel from the Los Alamos Scientific Laboratory and the U.S. Army. Beginning in 1954, and continuing through 1970, this program was conducted by the U.S. Public Health Service. Since 1970, the EPA has provided an offsite Radiological Safety Program, both in Nevada and at other nuclear test sites, under interagency agreements with the DOE or its predecessor agencies.

Since 1954, the objectives of the offsite radiation surveillance program have included: the measurement and documentation of the levels and trends of any radiation or radioactive contaminants in the environment in the vicinity of nuclear testing areas; and the determination as to whether the testing is in compliance with radiation protection standards, guidelines and regulations. Offsite levels of radiation and radioactivity are assessed by gamma-ray measurements using pressurized ion chambers and thermoluminescent dosimeters; by sampling air, water, milk, food crops, other vegetation, and animals, and by biological assay procedures.

Before each nuclear test at the Nevada Test Site, EPA radiation monitoring technicians are stationed in offsite areas most likely to be affected by an airborne release of radioactive material. These technicians use trucks equipped with radiation detectors, samplers, and supplies and are directed by two-way radio from a control center at the Nevada Test Site.

Hours before each test, the Weather Service Nuclear Support Office personnel (WSNSO) and, if requested, an aircraft gathers meteorological data for use by the Test Controller's Advisory Panel in judging the safety of executing the test. Another aircraft carries radiation detectors and is in a pattern over Yucca Lake at test time to track the radioactive effluent if a release should occur. Radioactive cloud sampling and analysis can also be performed aboard the aircraft. Data relating to the location of the radioactive effluent would be used to move the field monitoring technicians on the ground to positions along the path of the effluent to initiate protective action for the public, and to perform radiation monitoring and environmental sampling (EPA88C).

Beginning with operation Upshot-Knothole in 1953, a report summarizing the monitoring data obtained from each test series was published by the U.S. Public Health Service. For the reactor tests in 1959 and the weapons and Plowshare tests in 1962, data were published only for the tests in which detectable amounts of radioactivity were measured in an offsite area. Publication of summary data for each six-month period was initiated in 1964. In 1971, the Atomic Energy Commission implemented a requirement (AEC71), subsequently incorporated into Department of Energy Order 5484.1 (DOE85), that each agency or contractor involved in major nuclear activities provide an annual comprehensive radiological monitoring report. During 1988, Order 5481.1 was superseded by the General Environmental Protection Program Requirements (Order 5400.1) (DOE88) of the Department of Energy. Each annual report summarizes the radiation monitoring activities of the U.S. Environmental Protection Agency in the vicinity of the Nevada Test Site and at former nuclear testing areas in the United States. This report summarizes those activities for calendar year 1989.

Included in this report are descriptions of the pertinent features of the Nevada Test Site and its environs; summaries of the dosimetry and sampling methods; a delineation of analytical and quality control procedures; and the results of environmental measurements. Where applicable, dosimetry and analytical data are compared with appropriate standards and guidelines for the external and internal exposure of humans to ionizing radiation.

Although written to meet the terms of the interagency agreement between the U.S. Environmental Protection Agency and the Department of Energy as well as the requirements of Order 5400.1, the data and information contained in this report should also be of interest and use to the citizens of Nevada, Utah and California who live in the areas downwind of the Nevada Test Site. State, federal and local agencies involved in protecting the environment and the health and well-being of the public, and individuals and organizations concerned with environmental quality and the possible release of radioactive contaminants into the biosphere, may also find the contents of this report of interest.

Chapter 2. Summary

C. A. Fontana and Nuclear Radiation Assessment Division

SECTION 2.1. PURPOSE

"EPA is charged by Congress to protect the nation's air and water systems" (EPA89). This policy applies to radioactive contamination of the biosphere and accompanying radiation exposure of the population. To accomplish these goals and to ensure compliance with the DOE policy of keeping radiation exposure of the general public as low as reasonably achievable (ALARA), the EPA's Environmental Monitoring Systems Laboratory in Las Vegas conducts an Offsite Radiological Safety Program around the DOE's Nevada Test Site (NTS). This program is conducted under Interagency Agreement between EPA and DOE. The main activity at the NTS is the testing of nuclear devices, however, other related projects are conducted as well.

The principal activities of the Offsite Radiological Safety Program are: routine environmental monitoring for radioactive materials in various media and for radiation in areas that may be affected by nuclear tests; protective actions in support of the nuclear testing program; and gathering information to direct protective actions where needed. These activities are conducted to document compliance with standards, to identify trends, and to provide information to the public. This report summarizes these activities for the calendar year 1989.

Section 2.1.1. Air Surveillance Network (ASN)

In 1989, the air surveillance network consisted of 31 continuously operating air sampler locations surrounding the NTS and 78 standby stations operated one or two weeks each quarter. At least one standby air sampler is located in each state west of the Mississippi River. During 1989, no airborne radioactivity related to current nuclear testing at the NTS was detected in any sample from the ASN. Other than naturally occurring ^{7}Be, the only activity detected by this network was ^{238}Pu which was attributed to worldwide fallout.

Section 2.1.2. Noble Gas and Tritium Surveillance Network (NGTSN)

The noble gas and tritium sampling network (NGTSN) consisted of 20 offsite sampling stations (outside of the NTS and Nellis Air Force Base Range) in 1989. During 1989, no NTS-related radioactivity was detected at any network sampling station. As in previous years, results for xenon and tritium were typically below the minimum detectable concentration (MDC), as expected. The results for krypton, although exceeding the MDC, were within the range of values expected due to statistical variations that occur when sampling at background levels.

Section 2.1.3. Milk Surveillance Network (MSN)

The milk surveillance network consisted of 27 locations within 300 kilometers of the NTS and 106 standby milk surveillance network (SMSN) locations in the contiguous states west of the Mississippi River, except Texas (Texas is sampled by state radiological laboratories). Samples from two locations each in the SMSN and MSN contained minimum detectable amounts of tritium. Eighteen of the 236 analyses for radiostrontium were above the sample MDC, and the concentrations were comparable to those obtained by other laboratories.

Section 2.1.4. Biomonitoring Program

Tissue samples are collected annually from cattle, deer and bighorn sheep and samples of garden vegetables are collected every two to three years for analysis of radioactivity. The gamma emitting radionuclide most frequently found in the edible portion of the sampled animals is ^{137}Cs. However, its concentration has been near the MDC since 1968. Strontium-90 in samples of animal bone remain at very low levels as does $^{239+240}Pu$ in both bone and liver samples. Elevated tritium concentrations were found in samples from deer that drank from a contaminated source on the NTS.

Section 2.1.5. Thermoluminescent Dosimetry (TLD) Program

External exposure is monitored by a network of thermoluminescent dosimeters at 135 fixed locations surrounding the NTS and by TLDs worn by 65 offsite residents. No apparent net exposures were related to NTS activities. With one exception, there were no apparent net exposures above natural background when tests for statistical significance of

variation were applied. (See Section 4.2.6.) The range of exposures measured, varying with altitude and soil constituents, is similar to the range of such exposures found in other areas of the U.S.

Section 2.1.6. Pressurized Ion Chamber (PIC) Network

The PIC network measures ambient gamma radiation exposure rates. The 27 PICs deployed around the Nevada Test Site showed no unexplained deviations from background levels during 1989. The maximum annual average exposure rate of 165 mR/yr was at Austin, NV, the minimum of 52 mR/yr was at Las Vegas, NV. These values were within the United States background maximum and minimum values. The 1989 data was consistent with previous years' trends.

Section 2.1.7. Internal Exposure Monitoring

Internal exposure is assessed by whole-body counting, using a single intrinsic coaxial germanium detector, lung counting using six intrinsic germanium semiplanar detectors and bioassay using radiochemical procedures. In 1989, counts were made on 221 individuals from the following: offsite areas around the NTS, EMSL-LV Laboratory, EG&G facilities throughout the United States, two DOE contractors, and members of the general public concerned about possible radiation exposure. No nuclear test related radioactivity was detected. In addition, physical examinations of the offsite residents revealed a normally healthy population consistent with the age and sex distribution of that population.

Section 2.1.8. Long-Term Hydrological Monitoring Program (LTHMP)

The Long-Term Hydrological Monitoring of wells and surface waters near sites of nuclear tests showed only background radionuclide concentrations except for those wells that showed detectable activity in previous years or those that had been spiked with radionuclides for hydrological tests.

Section 2.1.9. Quality Assurance (QA) and Procedures

The Quality Assurance program conducted by EMSL-LV includes: use of standard operating procedures, data quality objectives, data validation, quality control, health physics oversight, precision and accuracy of analysis. The aim of the QA program is to ensure that all EPA decisions which are dependent on environmental monitoring data are supported by data of known quality. All EPA laboratories participate in a centrally managed and locally implemented QA program.

Section 2.1.10. Community Monitoring Stations (CMS)

The Community Monitoring Stations are operated for the Environmental Protection Agency, Department of Energy and the Desert Research Institute (DRI) by local residents. Fifteen of the CMS became operational in 1982, the sixteenth, seventeenth, and eighteenth in 1988. Each station is an integral part of the Air Surveillance Network, Noble Gas and Tritium Surveillance Network, and the Thermoluminescent Dosimetry Network; in addition, they are equipped with a pressurized ion chamber connected to a gamma rate recorder and a barograph. Samples and data from these stations are analyzed and reported by the EPA at EMSL-LV. Data is also interpreted and reported directly by the DRI. Data from these stations are reported herein as a part of the networks in which they participate. All radiation measurements for 1989 were within the normal background range for the United States.

Section 2.1.11. Dose Assessment

Based on the radionuclides measured in samples collected by the monitoring networks, the maximum dose above background calulated for an adult living in Nevada would have been about 37 μrem (0.37 μSv) for 1989. No radioactivity originating on the NTS was detectable by the monitoring networks; therefore, no dose assessment could be made. Based on the NTS releases reported atmospheric dispersion calculations (AIRDOS/EPA) indicate that the highest individual dose would have been 0.15 μrem (1.5×10^{-3} μSv), and the collective dose to the population within 80 km of Control Point One (CP-1) would have been 1.1×10^{-3} person-rem (1.1×10^{-5} person-Sv). The person receiving the highest dose would also have been exposed to 67 mrem from natural background radiation.

One mule deer was sampled by EPA personnel. In the unlikely event that this deer was consumed by one person, a dose equivalent of 0.06 mrem (0.6 μSv) would have resulted.

Chapter 3. Description of the Nevada Test Site

C. A. Fontana

The principal activity at the Nevada Test Site is the testing of nuclear devices to aid in the development of nuclear weapons, proof testing of weapons, and weapons safety and effects studies. The major activity of the EPA's Offsite Radiological Safety Program is radiation monitoring around the NTS. This section is included to provide readers with an overview of the climate, geology and hydrology, as well as with land uses, in this generally arid and sparsely populated area of the southwest. The information included should provide an understanding of the environment in which nuclear testing and monitoring activities take place, the reasons for the location of instrumentation, the weather extremes to which both people and equipment are subjected, and the distances traveled by field monitoring technicians in collecting samples and maintaining equipment.

SECTION 3.1. LOCATION

The NTS is located in Nye County, Nevada, with its southeast corner about 90 km northwest of Las Vegas (Figure 2). It occupies an area of about 3,500 square km, varies from 40 to 56 km in width (east-west) and from 64 to 88 km in length (north-south). This area consists of large basins or flats about 900 to 1,200 m above mean sea level (MSL) surrounded by mountain ranges rising from 1,800 to 2,300 m above MSL.

Figure 1. Typical Mid-Latitude Steppe Climatological Zone in Nevada.

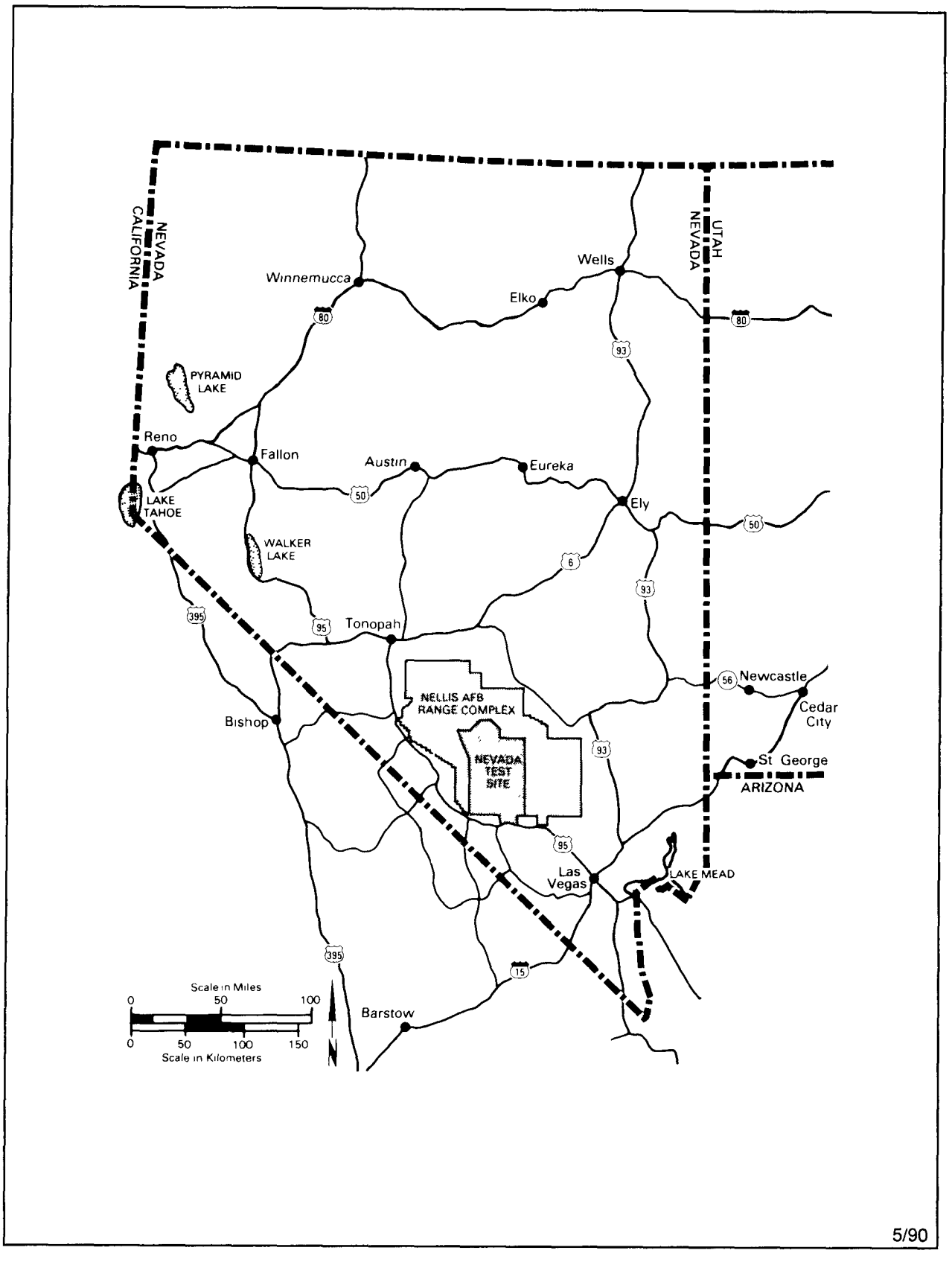

Figure 2. Location of the Nevada Test Site (NTS).

The NTS is surrounded on three sides by exclusion areas, collectively named the Nellis Air Force Base Range Complex, which provides a buffer zone between the test areas and public lands. This buffer zone varies from 24 to 104 km between the test area and land that is open to the public. In the unlikely event of a venting and depending upon wind speed and direction, from 2 to more than 6 hours would elapse before any release of airborne radioactivity would reach over public lands.

SECTION 3.2. CLIMATE

The climate of the NTS and surrounding area is variable, due to its wide range in altitude and its rugged terrain. Most of Nevada has a semi-arid climate characterized as mid-latitude steppe. Throughout the year, there is insufficient water to support the growth of common food crops without irrigation.

Climate may be classified by the types of vegetation indigenous to an area. According to Houghton et al. (HO75), this method of classification developed by Köppen, is further subdivided on the basis of "...seasonal distribution of rainfall and the degree of summer heat or winter cold." Table 1 summarizes the characteristics of climatic types for Nevada.

According to Quiring (QU68), the NTS average annual precipitation ranges from about 10 cm at the lower elevations to around 25 cm on the higher elevations. During the winter months, the plateaus may be snow-covered for a period of several days or weeks. Snow is uncommon on the flats. Temperatures vary considerably with elevation, slope, and local air currents. The average daily temperature ranges at the lower altitudes are around (50° to 25°F) (10° to -4°C) in January and (95° to 55°F) (35° to 13°C) in July, with extremes of 120°F(49°C) and -15°F(-26°C).

TABLE 1. CHARACTERISTICS OF CLIMATIC TYPES IN NEVADA
(from Houghton et al. 1975)

CLIMATE TYPE	MEAN TEMPERATURE °C (°F) WINTER	SUMMER	ANNUAL PRECIPITATION cm (inches) TOTAL*	SNOWFALL	DOMINANT VEGETATION	% OF AREA
Alpine tundra	-18° to -9° (0° to 15°)	4° to 10° (40° to 50°)	38 to 114 (15 to 45)	Medium to heavy	Alpine meadows	—
Humid continental	-12° to -1° (10° to 30°)	10° to 21° (50° to 70°)	64 to 114 (25 to 45)	Heavy	Pine-fir forest	1
Subhumid continental	-12° to -1° (10° to 30°)	10° to 21° (50° to 70°)	30 to 64 (12 to 25)	Moderate	Pine or scrub woodland	15
Mid-latitude steppe	-7° to 4° (20° to 40°)	18° to 27° (65° to 80°)	15 to 38 (6 to 15)	Light to moderate	Sagebrush, grass, scrub	57
Mid-latitude desert	-7° to 4° (20° to 40°)	18° to 27° (65° to 80°)	8 to 20 (3 to 8)	Light	Greasewood, shadscale	20
Low-latitude desert	-4° to 10° (40° to 50°)	27° to 32° (80° to 90°)	5 to 25 (2 to 10)	Negligible	Creosote bush	7

* *Limits of annual precipitation overlap because of variations in temperature which affect the water balance.*

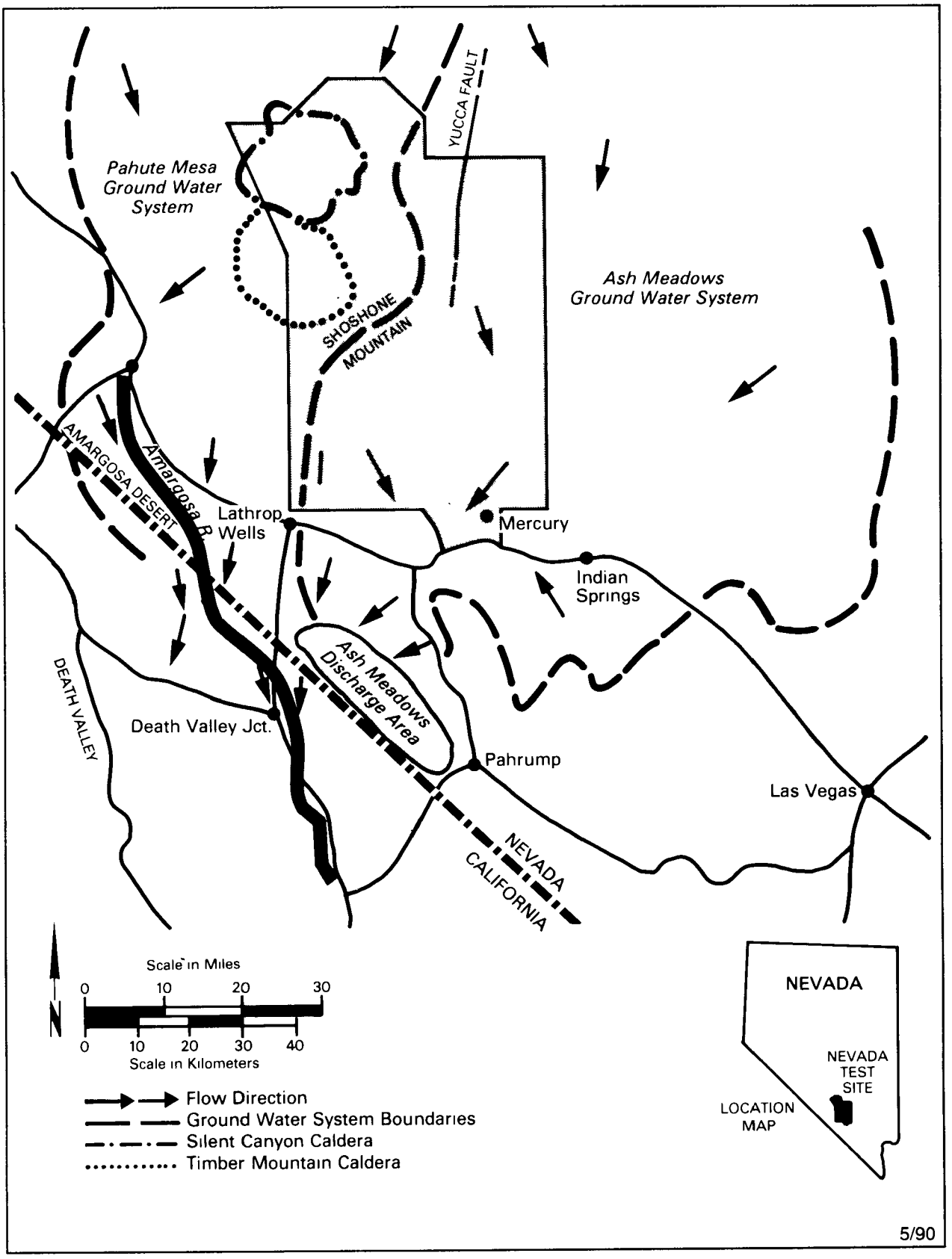

Figure 3. Ground Water Flow Systems Around the Nevada Test Site.

Corresponding temperatures on the plateaus are (35° to 25°F) (2°to -4°C) in January and 80° to 65°F) (27° to 18°C) in July with extremes of 115°F (46°C) and -30°F(-34°C).

The wind direction, as measured on a 30 m tower at an observation station about 9 km NNW of Yucca Lake, is predominantly northerly except during the months of May through August when winds from the south-southwest predominate (QU68). Because of the prevalent mountain/valley winds in the basins, south to southwest winds predominate during daylight hours of most months. During the winter months southerly winds have only a slight edge over northerly winds for a few hours during the warmest part of the day. These wind patterns may be quite different at other locations on the NTS because of local terrain effects and differences in elevation.

SECTION 3.3. GEOLOGY AND HYDROLOGY

Two major hydrologic systems shown in Figure 3 exist on the NTS (ERDA77). Ground water in the northwestern part of the NTS or in the Pahute Mesa area flows at a rate of 2 m to 180 m per year to the south and southwest toward the Ash Meadows Discharge Area in the Amargosa Desert. Ground water to the east of the NTS moves from north to south at a rate of not less than 2 m nor greater than 220 m per year. Carbon-14 analyses of this eastern ground water indicate that the lower velocity is nearer the true value. At Mercury Valley in the extreme southern part of the NTS, the eastern ground water flow shifts south-westward toward the Ash Meadows Discharge Area.

SECTION 3.4. LAND USE OF NTS REGION

Figure 4 is a map of the off-NTS area showing a wide variety of land uses, such as farming, mining, grazing, camping, fishing, and hunting within a 300-km radius of the NTS Control Point-1 (CP-1). West of the NTS, elevations range from 85 m below MSL in Death Valley to 4,420 m above MSL in the Sierra Nevada Range. Parts of two major agricultural valleys (the Owens and San Joaquin) are included. The areas south of the NTS are more uniform since the Mojave Desert ecosystem (mid-latitude desert) comprises most of this portion of Nevada, California, and Arizona. The areas east of the NTS are primarily mid-latitude steppe with some of the older river valleys, such as the Virgin River Valley and Moapa Valley, supporting irrigation for small-scale but intensive farming of a variety of crops. Grazing is also common in this area, particularly to the northeast. The area north of the NTS is also mid-latitude steppe, where the major agricultural activity is grazing of cattle and sheep. Minor agriculture, primarily the growing of alfalfa hay, is found in this portion of the State within 300 km of the CP-1. Many of the residents have access to locally grown fruits and vegetables.

Recreational areas lie in all directions around the NTS (Figure 4), and are used for such activities as hunting, fishing, and camping. In general, the camping and fishing sites to the northwest, north, and northeast of the NTS are closed during winter months. Camping and fishing locations to the southeast, south, and southwest are utilized throughout the year. The peak of the hunting season is from September through January.

SECTION 3.5. POPULATION DISTRIBUTION

Figure 5 shows the current population of counties surrounding the NTS based on 1988 Bureau of Census estimates (DOC88). Excluding Clark County, the major population center (approximately 631,300 in 1988), the population density within a 150 km radius of the NTS is about 0.5 persons per square kilometer. For comparison, the population density of the 48 contiguous states was 29 persons per square kilometer (1980 census). The estimated average population density for Nevada in 1980 was 2.8 persons per square kilometer (DOC86). Knowledge of population densities and spatial distribution of farm animals is necessary to assess protective measures required in the event of an accidental release of radioactivity at the NTS.

The offsite area within 80 km of CP-1 (the primary area in which the dose commitment must be determined for the purpose of this report) is predominantly rural. Several small communities are located in the area, the largest being in the Pahrump Valley. This growing rural community, with an estimated population of approximately 6,000, is located 80 km south of the NTS CP-1. The Amargosa farm area, which has a population of about 950, is located 50 km southwest of CP-1. The largest town in the near offsite area is Beatty, which has a population of about 1,500 and is located approximately 65 km to the west of CP-1.

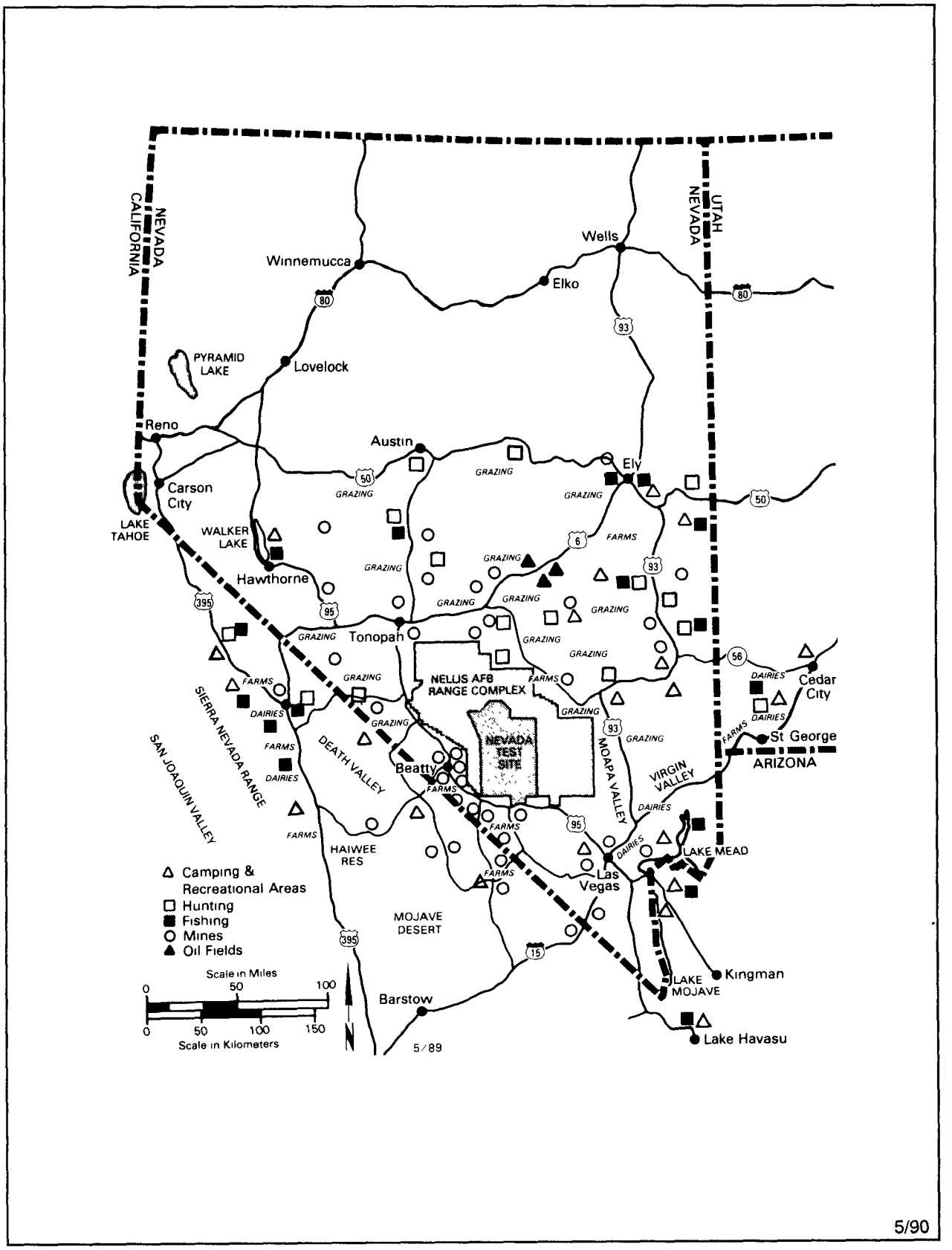

Figure 4. General Land Use Within 300 km of the Nevada Test Site.

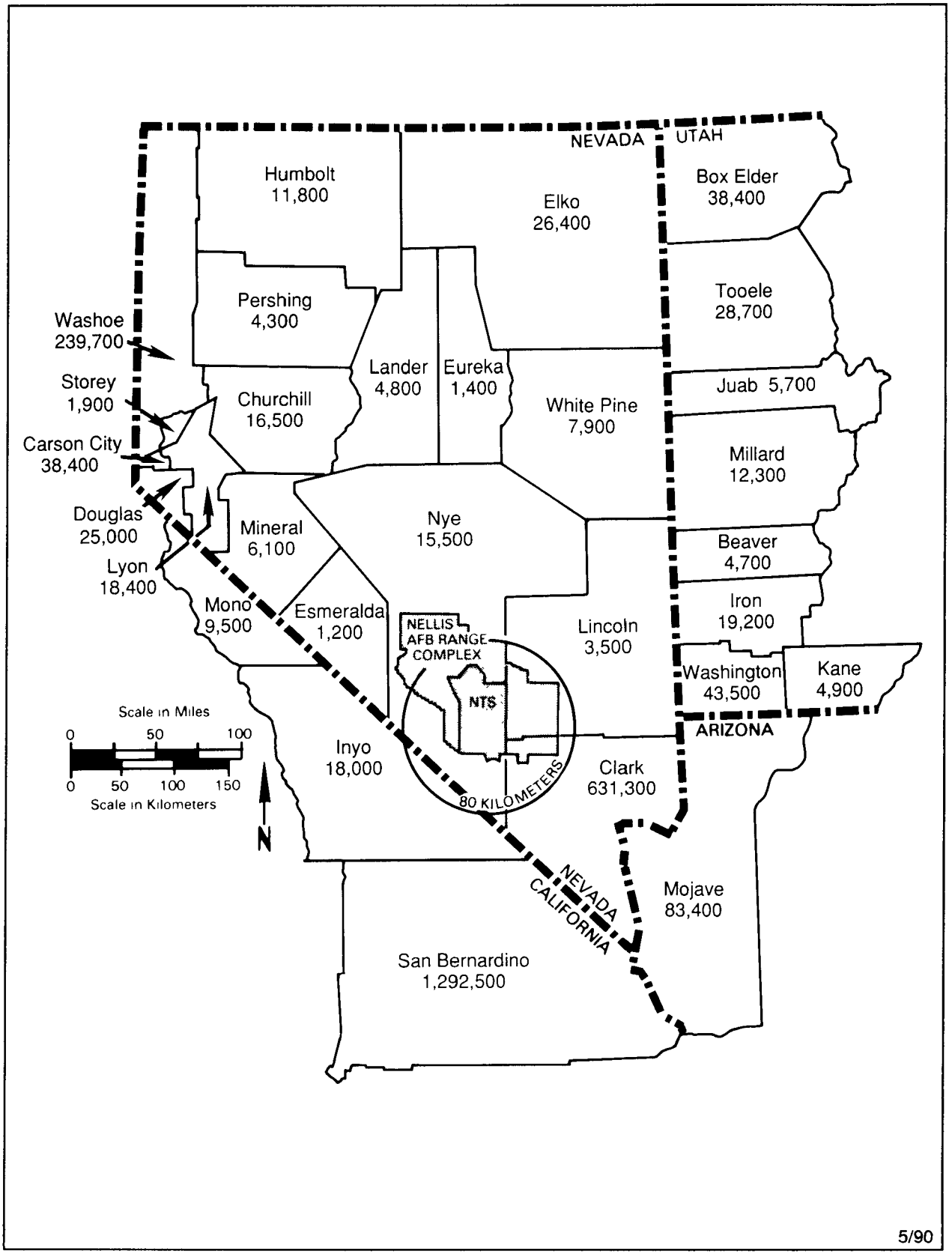

Figure 5. Population of Arizona, California, Nevada, and Utah Counties Near the Nevada Test Site (Based on 1988 Census Estimates).

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The National Park Service (NPS90) estimated that the population within the Monument boundaries ranges from a minimum of 200 permanent residents during the summer months to as many as 5,000 tourists and campers on any particular day during the major holiday periods in the winter months, and as many as 30,000 during "Death Valley Days" in the month of November. The next largest town and contiguous populated area (about 40 square miles) in the Mojave Desert is Barstow, California, located 265 km south-southwest of the NTS, with a 1988 population of about 20,990. The largest populated area is the Ridgecrest-China Lake area, which has a current population of 27,460 and is located 190 km southwest of the NTS. The Owens Valley, where numerous small towns are located, lies 50 km west of Death Valley. The largest town in the Owens Valley is Bishop, located 225 km west-northwest of the NTS, with a population of 3,570.

The extreme southwestern region of Utah is more developed than the adjacent part of Nevada. The largest community is St. George, located 220 km east of the NTS, with a 1988 population of 22,970. The next largest town, Cedar City, with a population of 12,020, is located 280 km east-northeast of the NTS.

The extreme northwestern region of Arizona is mostly range land except for that portion in the Lake Mead Recreation Area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 165 km south-southeast of the NTS, with a 1988 population estimate of 20,160 and Kingman, located 280 km southeast of the NTS, with a population of 11,510. Figures 6 through 9 show the domestic animal populations in the counties near the NTS.

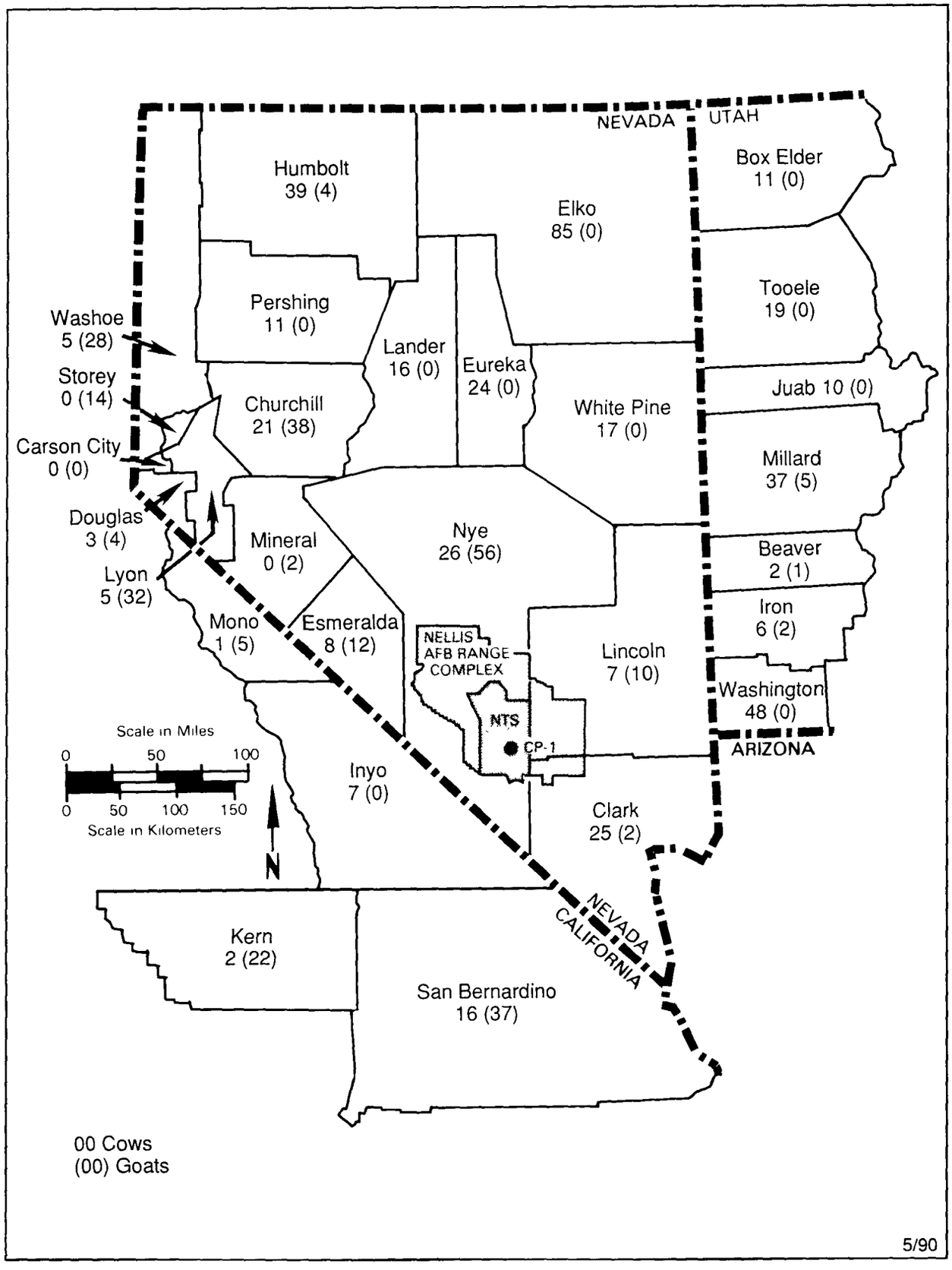

Figure 6. Distribution of Family Milk Cows and Goats, by County (1989).

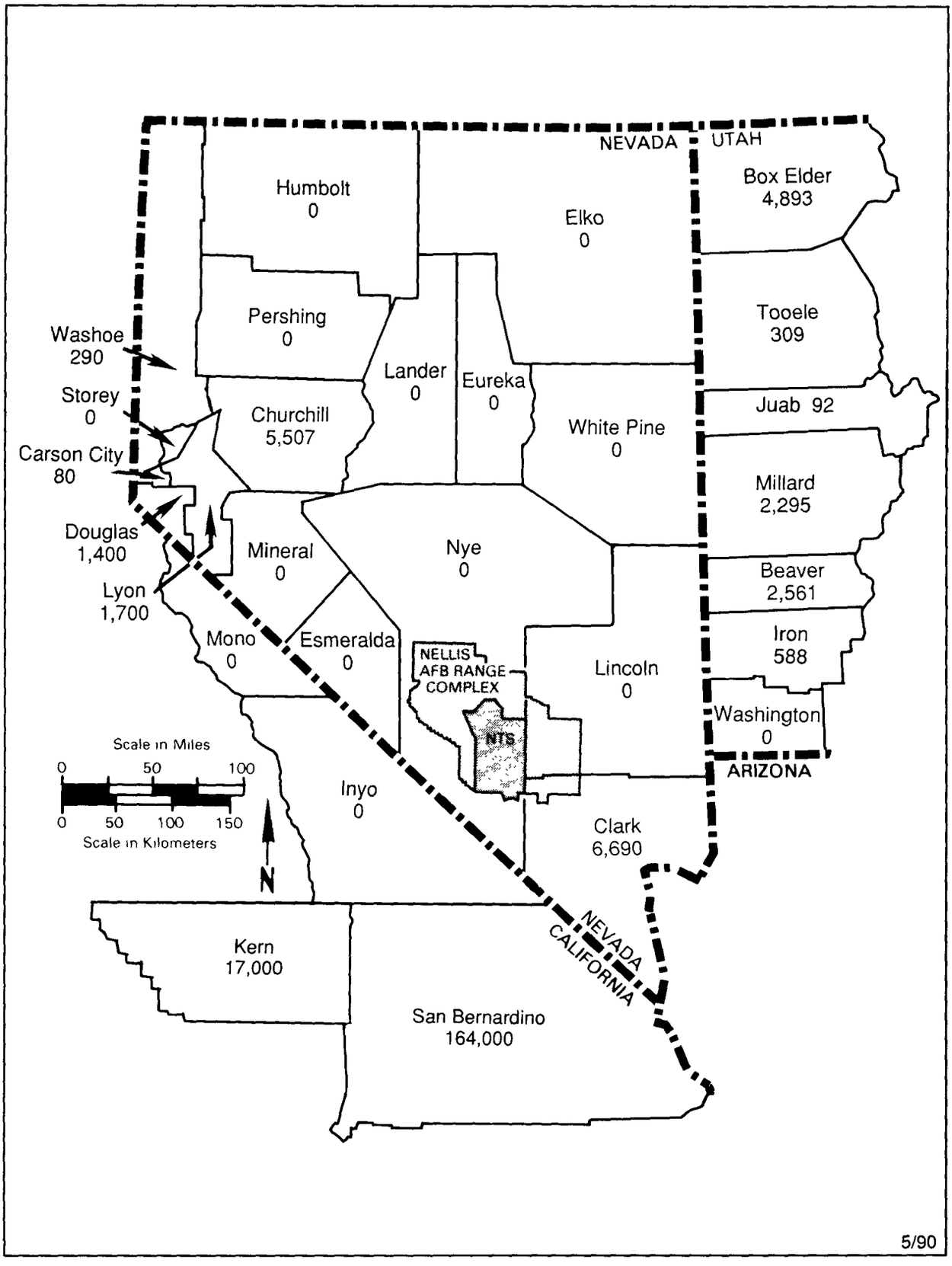

Figure 7. Distribution of Dairy Cows, by County (1989).

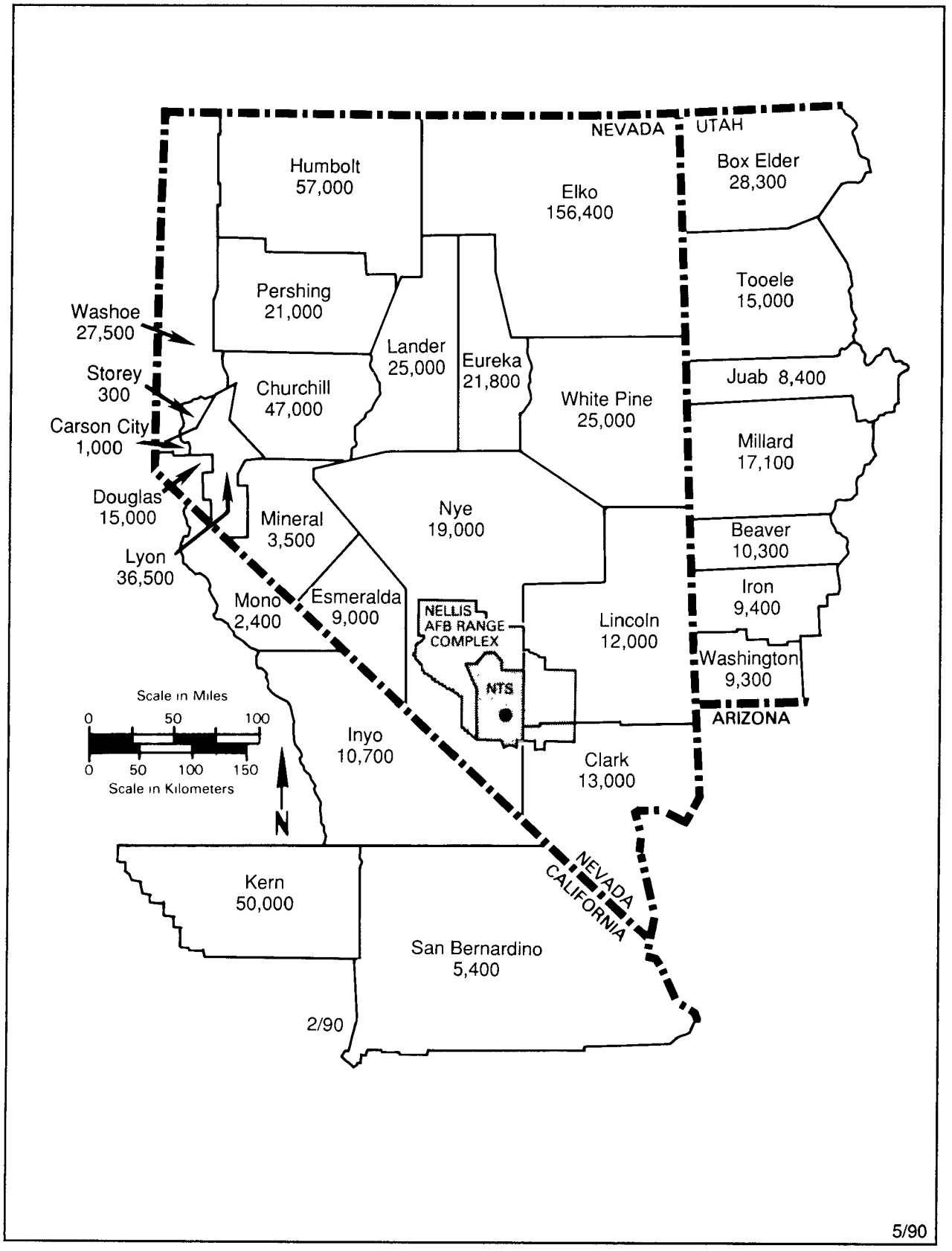

Figure 8. Distribution of Beef Cattle, by County (1989).

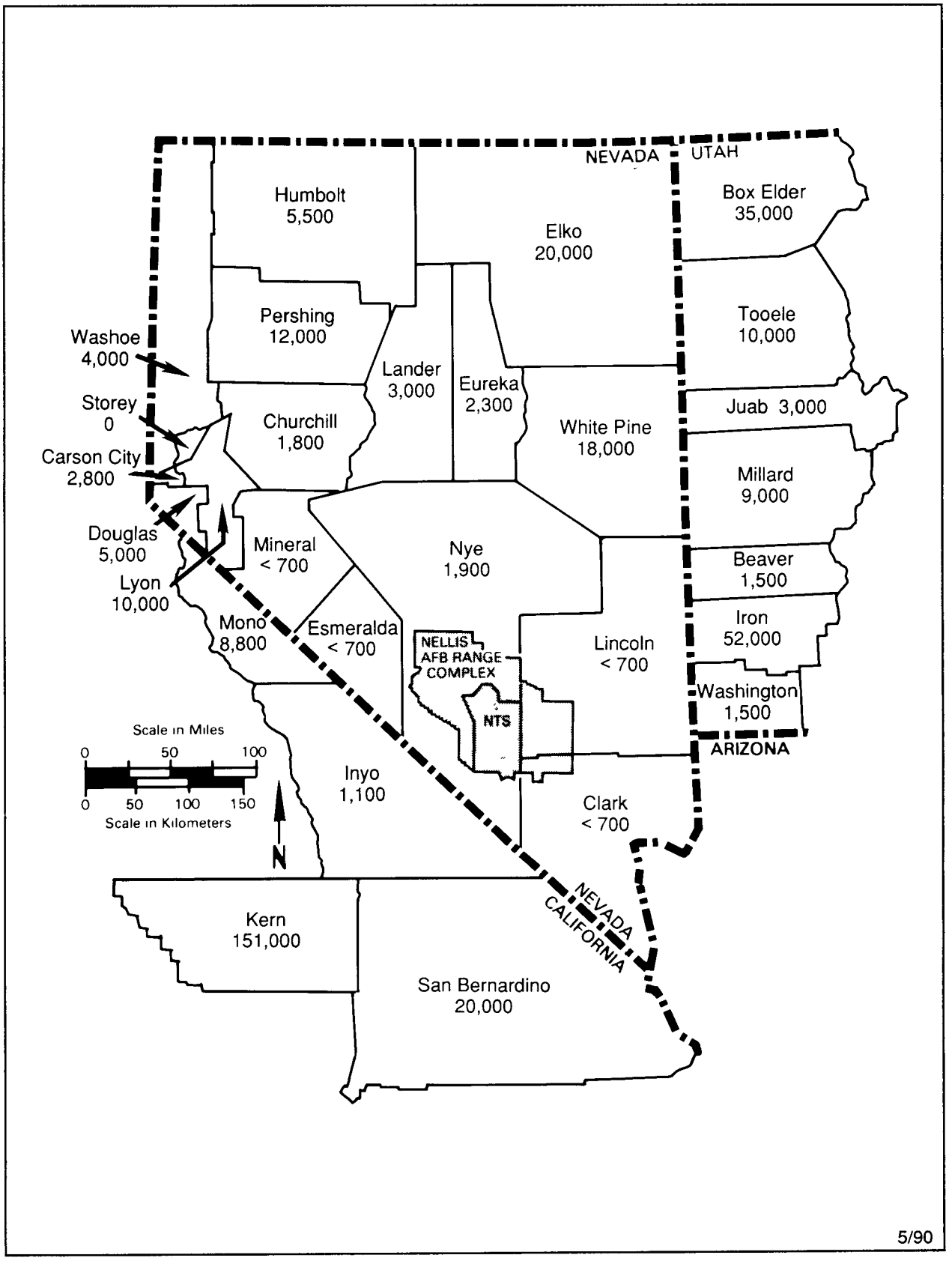

Figure 9. Distribution of Sheep, by County (1989).

Chapter 4. Radiological Safety Activities

C. A. Fontana

The radiological safety activities of the EMSL-LV are divided into two areas, both designed to detect environmental radiation: special test support, and routine environmental surveillance. Routine environmental surveillance includes pathways monitoring and internal and external exposure monitoring. Data acquired from this surveillance provide a basis for assessing possible exposures to individuals or population groups. If an increase in environmental radiation occurs for which protective actions are necessary, specific remedial actions would be provided to keep these exposures to a minimum. These activities are described in the following portions of this report.

SECTION 4.1. SPECIAL TEST SUPPORT

Prior to all nuclear tests, mobile monitoring teams are deployed around the NTS. They are prepared to assist in directing protective actions for offsite residents should that become necessary. Prior to each test, the teams determine the locations of residents, work crews and domestic animal herds, and obtain information relative to residents in communities and remote areas. Monitoring technicians, equipped with a variety of radiation survey instruments, dosimeters, portable air samplers, and supplies for collecting environmental samples, are prepared to conduct a monitoring program as directed via two-way radio communications from CP-1 at the NTS (Figure 10). The radiological safety criteria, or protective action guides, used by the EMSL-LV are based on those specified in NVO-176 (EPA88B).

Senior EPA personnel serve as members of the Test Controller's Advisory Panel to provide advice on possible public and environmental impact of each test and on feasible protective actions in the event that an accidental release of radioactivity should occur.

Figure 10. EPA Monitoring Technician Surveys Ambient Environmental Radiation Using a Handheld Survey Instrument. Foreground from left to right: constant flow air sampler, gamma exposure-rate recorder, and compressed noble gas sampler.

Section 4.1.1. Remedial Actions

"Remedial actions that EPA could implement to reduce whole-body exposures and the thyroid dose resulting from uptake of radionuclides in the food chain, particularly radioiodine in milk are:

- evacuation
- shelter
- access control
- control of livestock feeding practices
- milk control
- food and water control (to a lesser degree)

Which action, if any, is feasible depends largely upon the type of accident and the magnitude of the projected exposures and doses, the response time available for carrying out the action, and local constraints associated with a specific site. Constraints vary, but include such things as:

- the number of people and their distribution in the impacted area
- the availability of transportation and condition of transportation routes
- the season of the year
- the existence of schools and hospitals
- the presence of bedridden people or those unwilling to cooperate

Any of these factors, either alone or collectively, could impair the effectiveness of remedial action.

Another important factor affecting the efficacy of the remedial actions is the degree of credibility EPA personnel maintain with offsite residents and the extent to which they are trusted by those residents. Credibility and trust are created and maintained by routine personal contacts made with local officials and law enforcement personnel as well as the ranchers, miners, and others living in the offsite areas close to the NTS.

Section 4.1.2. Remedial Actions to Minimize Whole-Body Exposure

To determine the feasible remedial actions for an area, EPA uses its best judgment based on experience gained during atmospheric tests and from those tests conducted in the 1960's that contained offsite areas. No remedial actions have been necessary since 1970, so there is no recent experience by which to test this judgment. However, through routine contact with offsite residents, and through continuing population and road surveys, EPA maintains a sense of the degree to which it could implement remedial actions and the kind of cooperation that would be provided by officials and residents of the area" (EPA88B).

If an underground nuclear test is expected to cause ground motion detectable offsite, EPA monitoring technicians are stationed at locations where hazardous situations might occur, such as underground mines. At these locations, occupants are notified of potential hazards so they can take precautionary measures.

EG&G cloud sampling and tracking aircraft are flown over the NTS to gather meteorological data and obtain samples, assess total cloud volume and content and provide long range tracking in the event of a release of airborne radioactivity. A second aircraft is also flown to gather meteorological data and to perform cloud tracking. Information from these aircraft can be used in positioning the mobile radiation monitors.

During calendar year 1989, EMSL personnel were deployed for all underground nuclear tests conducted at the NTS, none of which released radioactivity that could be detected offsite.

SECTION 4.2. ROUTINE ENVIRONMENTAL SURVEILLANCE

Section 4.2.1. Airborne Releases of Radioactivity at the NTS During 1989

S. C. Black

All nuclear detonations during 1989 were conducted underground and were contained. Releases of low-level radioactivity occurred during re-entry drilling, seepage through fissures in the soil or purging of tunnel areas. Table 2 shows the quantities of radionuclides released to the environment, as reported by the DOE Nevada Operations Office (DOE90). Because these releases occurred throughout the year and because of the distance from the points of releases to the nearest offsite sampling station, none of the radioactive material listed in this table was detected offsite. Also listed are radionuclides found in drainage ponds onsite that remain in situ. Evapo-

ration could contribute ^{3}H to the atmosphere but the amounts were too small to be detected by the tritium monitors offsite.

To detect any radioactivity that might escape from the NTS, a routine surveillance program is conducted. This program includes pathway monitoring that consists of air, water, and milk surveillance networks surrounding the NTS and a limited animal sampling program. In addition, external and internal exposures of offsite populations are assessed using state-of-the-art dosimetry equipment. The following portions of this report detail the results of these surveillance programs.

TABLE 2. RADIONUCLIDE EMISSIONS ON THE NTS DURING 1989

RADIONUCLIDE	HALF-LIFE (years)	QUANTITY RELEASED (Ci)
	AIRBORNE RELEASES	
^{3}H	12.35	73
^{37}Ar	0.096	15.1
^{39}Ar	269	0.0042
^{85}Kr	10.72	0.21
^{127}Xe	0.10	3.8×10^{-5}
^{129m}Xe	0.022	0.0022
^{131m}Xe	0.0326	0.34
^{133}Xe	0.0144	63
^{135}Xe	0.001	3.9
^{137}Cs	30.17	7.3×10^{-6}
	TUNNEL & RNM PONDS*	
^{3}H	12.35	2069
^{238}Pu	87.743	1.7×10^{-5}
$^{239+240}Pu$	24065	3.4×10^{-4}
Gross Beta	—	0.20

* *Tunnel drainage and Radionuclide Migration (RNM) study ponds.*

Section 4.2.2. Air Surveillance Network (ASN)

V. E. Niemann

The ASN monitors an important pathway for human exposure to radionuclides, the inhalation of airborne materials. This network consists of 31 continuously operating air samplers (Figure 11) in areas surrounding the NTS and 78 standby air samplers, operated routinely on a quarterly schedule or more often as

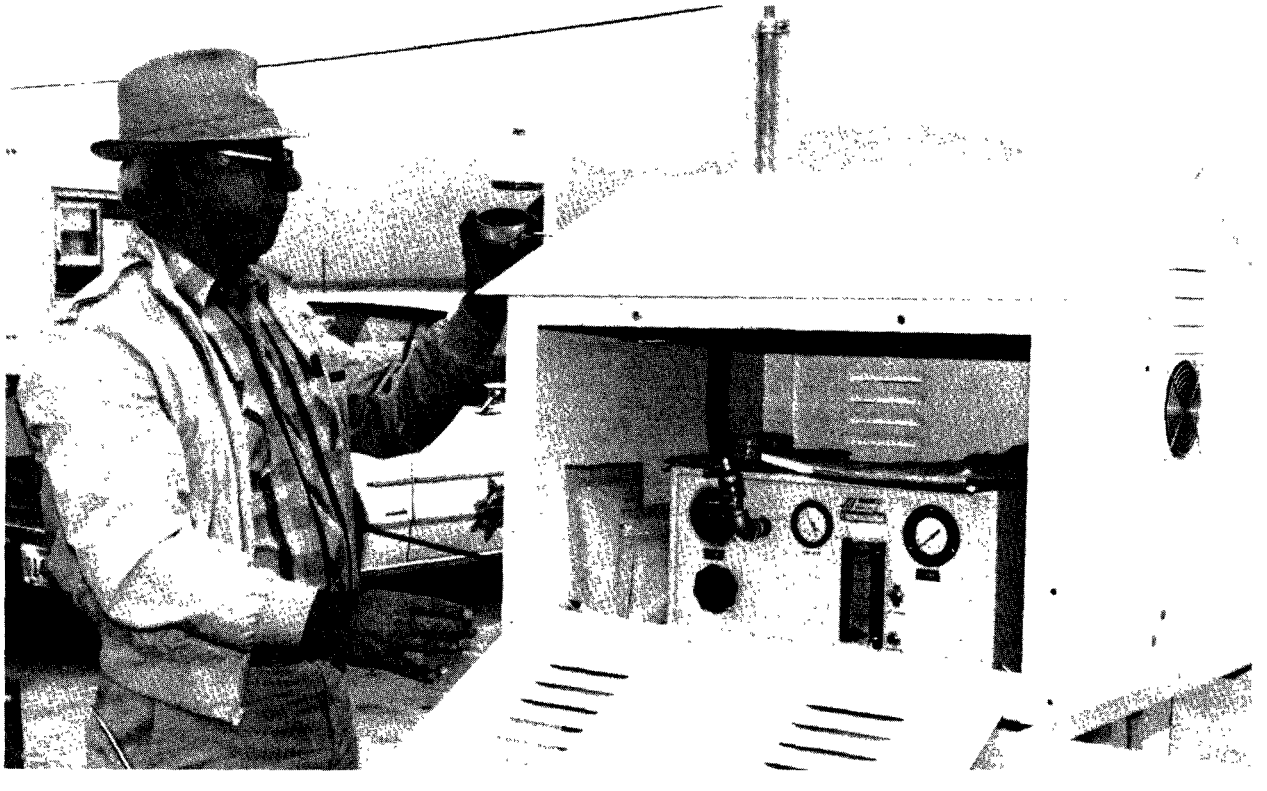

Figure 11. EPA Monitoring Technician Servicing Air Sampler at Pahrump Community Monitoring Station.

needed. Each sampler draws air through a glass-fiber filter (for particulates) and a charcoal cartridge (for gaseous radioiodines) for one week; the filters are then removed for analysis. Both the filters and the charcoal cartridges are analyzed by gamma spectroscopy. The particulate filters are analyzed for gross beta activity, then composited (combined and dissolved) for plutonium analysis. Only naturally occurring ^{7}Be was detected by gamma spectroscopy; the gross beta results were consistent with previous data; and one composited filter sample contained a detectable amount of ^{238}Pu.

SECTION 4.2.2.1. NETWORK DESIGN

Both the concentration and the source of airborne radioactivity must be determined if appropriate cor-

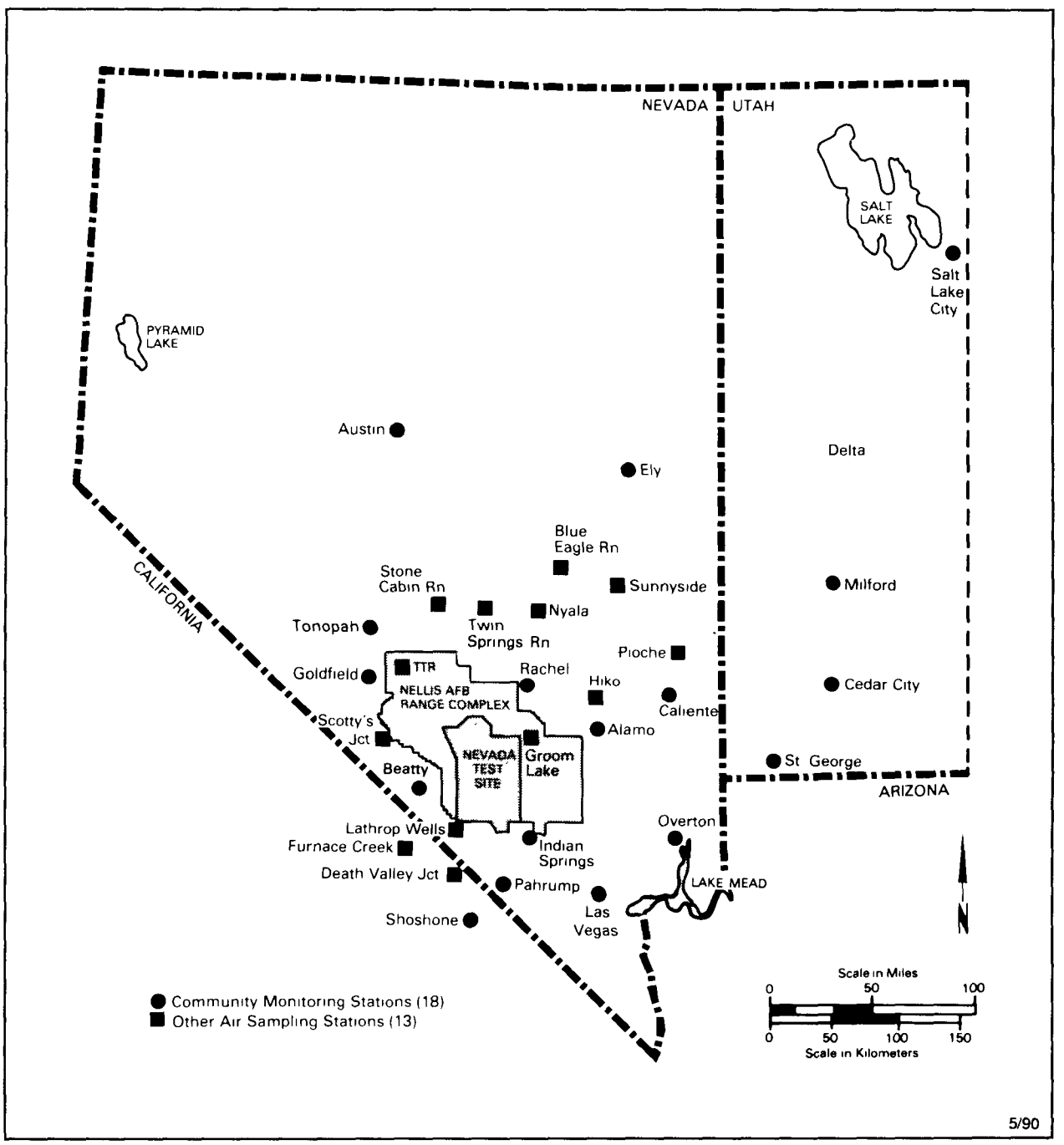

Figure 12. Air Surveillance Network Stations (1989).

rective actions are to be taken. The ASN is designed to monitor the areas within 350 km of the NTS (Figure 12). Station location is dependent upon the availability of electrical power and, at stations distant from the NTS, of a resident willing to operate the equipment. This continuously operating network is supplemented by a standby network which covers the contiguous states west of the Mississippi River (Figure 13).

SECTION 4.2.2.2. METHODS

During 1989, the ASN consisted of 31 continuously operating sampling stations and 78 standby stations. The air sampler at each station was equipped to collect both particulate radionuclides on filters and gaseous radioiodines on charcoal. The filters and charcoal cartridges from all active stations and the filters from the standby stations were routinely analyzed.

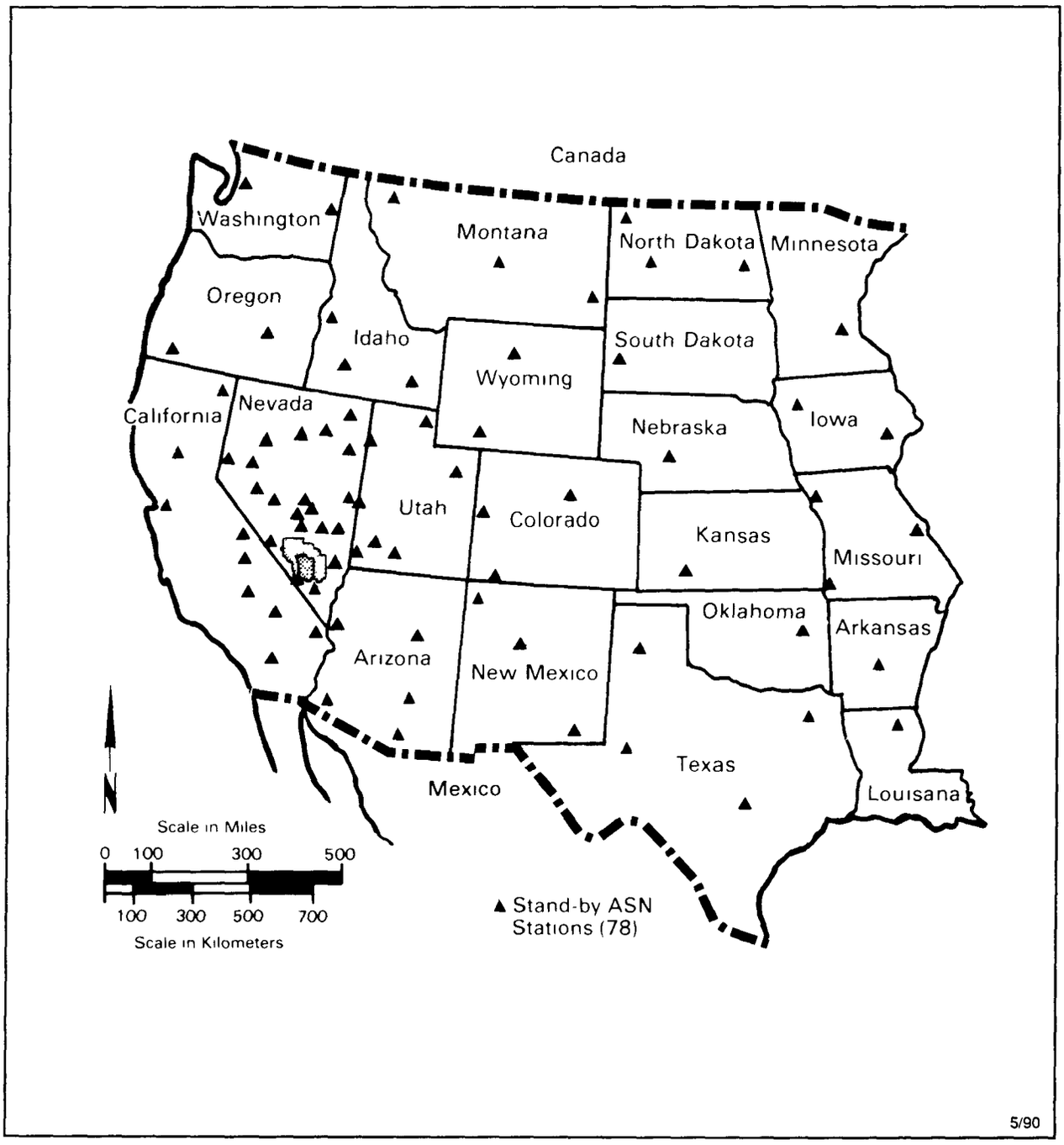

Figure 13. Standby Air Surveillance Network Stations (1989).

Samples of airborne particulates were collected at each active station on 5-cm diameter glass-fiber filters at a flow rate of about 80 m^3 per day. Filters were changed after sampler operation periods of one week (approximately 570 m^3 of sample volume). Activated charcoal cartridges placed directly behind the filters to collect gaseous radioiodines were changed at the same time as the filters. The standby network was activated for approximately one week per quarter. The standby samplers are identical to those used at the active stations and are operated by state and municipal health department personnel or by other local residents. All analytical work was performed at the EMSL-LV.

Gross beta analysis is used to detect trends in atmospheric radioactivity, since it is more sensitive than gamma spectrometry for this purpose. Starting in the first quarter of 1989, filters from all active and standby stations were analyzed for gross beta activity. This analysis was previously performed on only five continuously operating stations.

All air samples are initially analyzed by gamma spectrometry; each of the glass-fiber filters is then analyzed for gross beta activity after a seven-to-fourteen day delay to decrease the contribution from naturally occurring radon-thoron daughter activity. Some filters are then composited (combined) and are analyzed for plutonium. The analytical procedures used are described briefly in Chapter 8 and the quality assurance in Chapter 6.

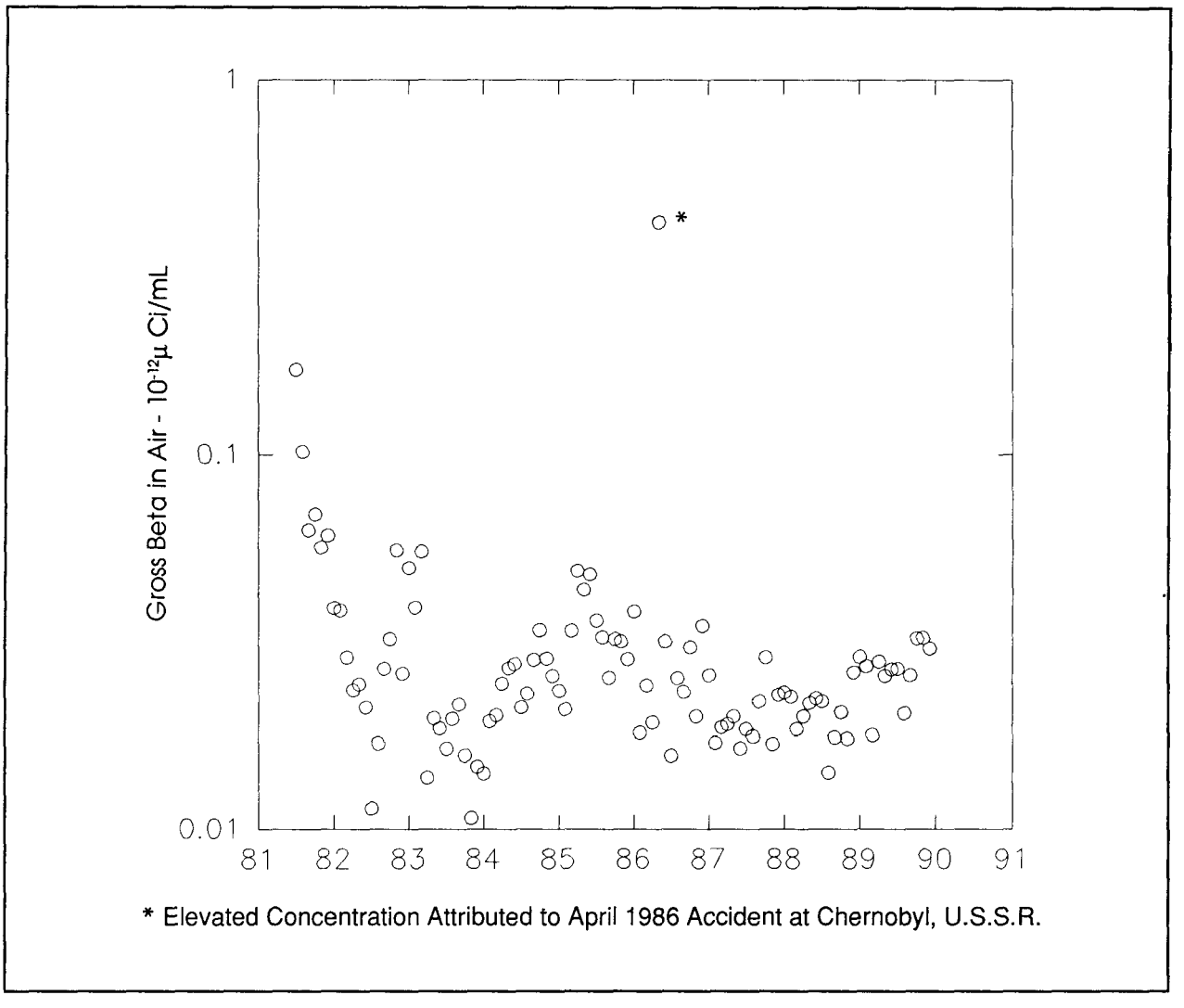

Figure 14. Monthly Average Gross Beta in Air Samples, Las Vegas, NV, 1981 - 1989.

SECTION 4.2.2.3. RESULTS

During 1989, no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from the ASN. Throughout the network, naturally occurring ^{7}Be was the only nuclide detected by gamma spectroscopy. The minimum and maximum concentrations were similar to previous results (.02 to 1.9 x 10^{-12} µCi/mL). The principal means of ^{7}Be production is from spallation (splitting) of ^{16}O and ^{14}N by cosmic rays in the atmosphere.

The monthly average gross beta in air samples from the Las Vegas, Nevada, station since 1981 is plotted in Figure 14. The data from the other stations are similar and suggest little significant difference among stations. A summary of the 1989 ASN data is shown in Table 3 and for 73 of the SASN stations in Table 4.

The filters from the stations at Las Vegas, Lathrop Wells, and Rachel, Nevada, and Salt Lake City, Utah, are composited as monthly samples and submitted quarterly for plutonium analysis. The other samples for plutonium analysis consist of composited filters from two stations in each state in which standby stations are located. The results of the ^{238}Pu and $^{239+240}Pu$ analyses from 14 states are shown in Table 5. The only sample which showed a detectable amount of ^{238}Pu was the January composite from Rachel, Nevada. It is borderline detectable and could be a statistical anomaly. Statistically, about five percent of the time, a sample which does not contain plutonium will yield a false positive result. No $^{239+240}Pu$ was detected. The plutonium results from the last two quarters of 1989 were not available for inclusion in this report and will be reported in the 1990 report.

TABLE 3. SUMMARY OF RESULTS FOR AIR SURVEILLANCE NETWORK STATIONS – 1989

SAMPLING LOCATION	NO. DAYS SAMPLED*	GROSS BETA CONC. (10^{-12} µCi/mL) MAX	MIN	AVG	SAMPLING LOCATION	NO. DAYS SAMPLED*	GROSS BETA CONC. (10^{-12} µCi/mL) MAX	MIN	AVG
DEATH VALLEY JCT CA	326	0.054	-0.004	0.030	PIOCHE NV	313	0.150	0.003	0.025
FURNACE CREEK CA	326	0.160	0.000	0.033	RACHEL NV	322	0.086	0.009	0.022
SHOSHONE CA	357	0.051	-0.006	0.027	SCOTTY'S JCT NV	354	0.051	0.006	0.027
ALAMO NV	334	0.059	0.010	0.026	STONE CABIN RANCH NV	324	0.220	0.000	0.025
AUSTIN NV	330	0.056	-0.004	0.024	SUNNYSIDE NV	317	0.036	0.010	0.022
BEATTY NV	324	0.049	0.010	0.024	TONOPAH NV	319	0.056	0.009	0.024
BLUE EAGLE RANCH NV	318	0.210	0.008	0.026	TONOPAH TEST RANGE NV	332	0.037	0.000	0.021
CALIENTE NV	319	0.240	0.002	0.035	CEDAR CITY UT	332	0.044	0.011	0.025
ELY NV	322	0.420	0.006	0.036	DELTA UT	353	0.180	0.009	0.033
FALLINI'S TWIN SPGS RANCH NV	325	0.040	0.010	0.022	MILFORD UT	351	0.098	0.006	0.028
GOLDFIELD NV	328	0.036	0.009	0.023	SALT LAKE CITY UT	315	0.160	0.000	0.026
GROOM LAKE NV	329	0.043	0.002	0.025	ST GEORGE UT	360	0.260	0.003	0.033
HIKO NV	326	0.047	0.009	0.025					
INDIAN SPRINGS NV	330	0.050	0.002	0.025					
LAS VEGAS NV	359	0.080	0.003	0.027					
LATHROP WELLS NV	334	0.048	0.004	0.023					
NYALA NV	326	0.044	0.000	0.010					
OVERTON NV	329	0.046	0.012	0.027					
PAHRUMP NV	329	0.038	-0.005	0.023					

* *Analysis for gross beta on air filters from all continuously operating stations was initiated (at different times for different stations) during the first quarter of 1989. This analysis previously was done on filters from five continuously operating stations.*

TABLE 4. SUMMARY OF RESULTS FOR STANDBY AIR SURVEILLANCE NETWORK STATIONS – 1989

SAMPLING LOCATION	NO. DAYS SAMPLED*	GROSS BETA CONC. (10^{-12} µCi/mL) MAX	MIN	AVG
GLOBE AZ	14	0.048	0.038	0.043
KINGMAN AZ	23	0.054	0.005	0.027
TUCSON AZ	21	0.041	0.024	0.033
WINSLOW AZ	24	0.088	0.017	0.036
YUMA AZ	28	0.047	0.030	0.038
LITTLE ROCK AR	21	0.041	0.023	0.033
ALTURAS CA	28	0.021	0.011	0.014
BAKER CA	35	0.048	0.025	0.040
BISHOP CA	22	0.048	0.027	0.039
CHICO CA	32	0.025	0.015	0.019
INDIO CA	25	0.057	0.018	0.034
LONE PINE CA	24	0.037	0.004	0.021
NEEDLES CA	21	0.020	0.014	0.017
RIDGECREST CA	20	0.029	0.003	0.014
SANTA ROSA CA	28	0.032	0.009	0.019
CORTEZ CO	14	0.019	0.011	0.016
DENVER CO	37	0.044	0.013	0.024
GRAND JCT CO	29	0.098	0.030	0.059
MOUNTAIN HOME ID	23	0.029	0.003	0.018
NAMPA ID	21	0.032	0.017	0.023
POCATELLO ID	22	0.024	0.017	0.021
FORT DODGE IA	29	0.040	0.028	0.033
IOWA CITY IA	22	0.033	0.025	0.030
DODGE CITY KS	35	0.032	0.014	0.025
MONROE LA	28	0.035	0.018	0.027
MINNEAPOLIS MN	30	0.024	0.012	0.018
CLAYTON MO	14	0.029	0.022	0.025
JOPLIN MO	21	0.043	0.016	0.027
ST JOSEPH MO	22	0.038	0.024	0.030
GREAT FALLS MT	21	0.032	0.018	0.025
KALISPELL MT	28	0.040	0.018	0.025
MILES CITY MT	21	0.029	0.023	0.025
NORTH PLATTE NE	25	0.048	0.024	0.036
ADAVEN NV	45	0.031	0.006	0.019
BATTLE MOUNTAIN NV	28	0.023	0.019	0.020
CURRANT NV - ANGLE WORM RANCH	21	0.042	0.022	0.031
CURRIE NV - CURRIE MAINTENANCE STATION	13	0.036	0.025	0.028
DUCKWATER NV	7	0.029	0.013	0.018
ELKO NV - PHILLIPS 66 TRUCK STOP	14	0.011	0.005	0.008
EUREKA NV	24	0.031	0.019	0.026
FALLON NV	21	0.060	0.022	0.035
LOVELOCK NV	30	0.065	0.015	0.031
LUND NV	36	0.023	0.010	0.017
MESQUITE NV	21	0.042	0.007	0.016
RENO NV	23	0.032	0.013	0.022
ROUND MOUNTAIN NV	21	0.028	0.018	0.022
WELLS NV	28	0.023	0.009	0.017
WINNEMUCCA NV	36	0.049	0.006	0.028
ALBUQUERQUE NM	24	0.052	0.023	0.035
CARLSBAD NM	24	0.051	0.031	0.043
SHIPROCK NM	38	0.049	0.029	0.039
BISMARK ND	24	0.028	0.021	0.026
FARGO ND	21	0.056	0.019	0.036
WILLISTON ND	28	0.056	0.028	0.040
MUSKOGEE OK	21	0.048	0.005	0.030
BURNS OR	21	0.017	0.010	0.013
MEDFORD OR	22	0.023	0.003	0.012
RAPID CITY SD	21	0.029	0.020	0.023
AMARILLO TX	35	0.040	0.031	0.035
AUSTIN TX	34	0.035	0.004	0.014
MIDLAND TX	14	0.021	0.013	0.017
TYLER TX	26	0.038	0.008	0.022
BRYCE CANYON UT	35	0.033	0.011	0.023
ENTERPRISE UT	42	0.055	0.017	0.027
GARRISON UT	16	0.042	0.002	0.007
LOGAN UT	24	0.071	0.022	0.032
PAROWAN UT	44	0.042	0.006	0.021
VERNAL UT	20	0.039	0.016	0.031
WENDOVER UT	23	0.026	0.007	0.020
SEATTLE WA	18	0.016	0.004	0.013
SPOKANE WA	21	0.039	0.021	0.029
ROCK SPRINGS WY	21	0.035	0.013	0.024
WORLAND WY	21	0.044	0.026	0.035

* *Analysis for gross beta on air filters from all standby stations was initiated during the first quarter of 1989. This analysis was not performed on filters from standby stations prior to that time.*

TABLE 5. CONCENTRATIONS OF ^{238}PU AND $^{239+240}PU$ (COMPOSITED AIR SAMPLES – 1989)

SAMPLING LOCATION	COLLECTION DATE 1989	CONCENTRATION ±2 S.D. (MDC) ^{238}Pu (10^{-18} µCi/mL)		$^{239+240}Pu$ (10^{-18} µCi/mL)	
AZ COMPOSITE (WINSLOW & TUCSON)	01/25	-7 ± 27	(48)	0 ± 18	(30)
	04/17	9 ± 13	(16)	0 ± 9	(16)
CA COMPOSITE (BISHOP & RIDGECREST)	02/14	7 ± 18	(24)	-4 ± 12	(24)
	04/24	0 ± 34	(55)	-5 ± 10	(23)
CO COMPOSITE (DENVER & CORTEZ)	02/22	2 ± 8	(12)	0 ± 5	(8)
	04/19	0 ± 31	(50)	5 ± 19	(25)
ID COMPOSITE (BOISE & MOUNTAIN HOME)	01/25	-17 ± 50	(85)	-27 ± 24	(50)
	04/22	11 ± 17	(21)	-3 ± 5	(12)
MO COMPOSITE (CLAYTON & JOPLIN)	01/25	-15 ± 57	(101)	-8 ± 34	(62)
	04/19	13 ± 13	(12)	-4 ± 5	(12)
MT COMPOSITE (GREAT FALLS & MILES CITY)	01/25	54 ± 139	(204)	18 ± 62	(83)
	04/19	0 ± 13	(22)	6 ± 9	(9)
NV COMPOSITE (LAS VEGAS)	01/30	0 ± 50	(82)	-13 ± 25	(51)
	02/27	-29 ± 22	(44)	2 ± 6	(8)
	03/27	8 ± 19	(27)	3 ± 13	(19)
	04/24	3 ± 5	(6)	-2 ± 2	(6)
	05/29	0 ± 6	(10)	1 ± 3	(4)
	06/26	1 ± 8	(12)	0 ± 4	(6)
NV COMPOSITE (LATHROP WELLS)	01/31	-137 ± 65	(133)	-26 ± 41	(78)
	02/28	2 ± 18	(29)	-4 ± 9	(18)
	03/27	-46 ± 29	(58)	12 ± 13	(11)
	04/30	1 ± 8	(12)	3 ± 6	(7)
	05/28	1 ± 5	(8)	-2 ± 3	(8)
	06/26	0 ± 6	(10)	-1 ± 2	(4)
NV COMPOSITE (RACHEL)	01/30	15 ± 11	(11)**	5 ± 7	(8)
	02/27	-9 ± 19	(33)	-9 ± 9	(19)
	03/27	-6 ± 11	(20)	3 ± 9	(13)
	04/24	4 ± 7	(9)	5 ± 5	(5)
	05/29	9 ± 17	(23)	3 ± 10	(13)
	06/26	2 ± 4	(6)	-1 ± 3	(6)
NM COMPOSITE (ALBUQUERQUE & CARLSBAD)	01/27	0 ± 36	(59)	-6 ± 22	(41)
	04/23	0 ± 7	(12)	0 ± 4	(6)
ND COMPOSITE (BISMARCK & FARGO)	01/30	-95 ± 119	(217)	-35 ± 69	(13)
	04/19	7 ± 11	(12)	2 ± 8	(12)
OR COMPOSITE (BURNS & MEDFORD)	01/27	-16 ± 24	(50)	5 ± 19	(25)
	05/02	10 ± 14	(16)	-5 ± 7	(16)
TX COMPOSITE (AUSTIN & AMARILLO)	01/30	-117 ± 107	(203)	8 ± 29	(39)
	05/22	-1 ± 5	(8)	-1 ± 1	(3)
UT COMPOSITE (LOGAN & VERNAL)	02/09	73 ± 126	(169)	-18 ± 63	(120)
	04/24	8 ± 14	(19)	6 ± 9	(9)
UT COMPOSITE (SALT LAKE CITY)	01/30	-17 ± 25	(45)	4 ± 7	(9)
	02/27	1 ± 7	(11)	0 ± 5	(8)
	03/27	-4 ± 62	(103)	-25 ± 31	(60)
	04/25	-2 ± 5	(10)	-1 ± 2	(4)
	05/29	5 ± 6	(8)	1 ± 3	(4)
	06/26	4 ± 6	(7)	1 ± 3	(4)
WA COMPOSITE (SEATTLE & SPOKANE)	01/25	26 ± 392	(641)	-153 ± 193	(376)
	04/19	8 ± 12	(16)	0 ± 5	(9)
WY COMPOSITE (WORLAND & ROCK SPRINGS)	01/25	Sample lost		Sample lost	
	04/19	-2 ± 6	(11)	3 ± 8	(11)

*All concentrations below the minimum detectable concentration (MDC) unless denoted by ***

Section 4.2.3. Noble Gas and Tritium Surveillance Network (NGTSN)

M. W. Chilton and E. A. Thompson

This network was designed to detect noble gas and tritium emissions from the NTS. Samples were routinely collected at 16 noble gas stations and 18 tritium stations during 1989 and no activity attributable to the NTS was identified.

SECTION 4.2.3.1. NETWORK DESIGN

The sources for the radionuclides monitored by this network include noble gases emitted from nuclear reactors, reprocessing facilities, and nuclear testing. Tritium is emitted from the same sources and is also produced naturally. The monitoring network may be impacted by these "background" sources, but it is designed to detect an increase in these levels due to possible NTS emissions. Network samplers are typically located in populated areas surrounding the NTS with emphasis on drainage wind channels leading from the test areas. To provide complete and in-depth coverage in the downwind sector, other samplers are located in communities at some distance from the NTS.

As indicated in Figure 16, in 1989 this network consisted of 20 sampling stations located in the states of Nevada, Utah, and California. In addition to the 18 community monitoring stations, there are also stations in Lathrop Wells and Pioche, Nevada. At Milford and Delta, Utah, there are tritium samplers installed, but they are only used on a standby basis. Noble gas samplers will be installed at these stations when they are available, then these will also be run on a standby basis. The station at Salt Lake City, Utah, has both tritium and noble gas samplers; the tritium sampler is run on a routine basis, but the noble gas sampler is run on a standby basis. Only tritium samples are collected at Pioche, Nevada. Therefore, there were 16 noble gas and 18 tritium sampling stations routinely operating in 1989.

SECTION 4.2.3.2. METHODS

Noble gas samples are collected by compressing air into storage tanks. The equipment continuously samples air over a 7-day period and stores approxi-

Figure 15. EPA Monitoring Technician Changes Noble Gas Tanks and Checks Gauges at Community Monitoring Station.

mately 0.6 m^3 of air in the tanks. The tanks are exchanged weekly and returned to the EMSL-LV where their contents are analyzed. Analysis starts by condensing the samples at liquid nitrogen temperature and using gas chromatography to separate the various radionuclides. The separate fractions of radioxenon and radiokrypton are dissolved in scintillation cocktails and counted in a liquid scintillation counter (see Chapter 8).

For tritium sampling, a molecular sieve column is used to collect water from the sampled air. Up to 10 m^3 of air is passed through the column over a 7-day sampling period. Water adsorbed on the molecular

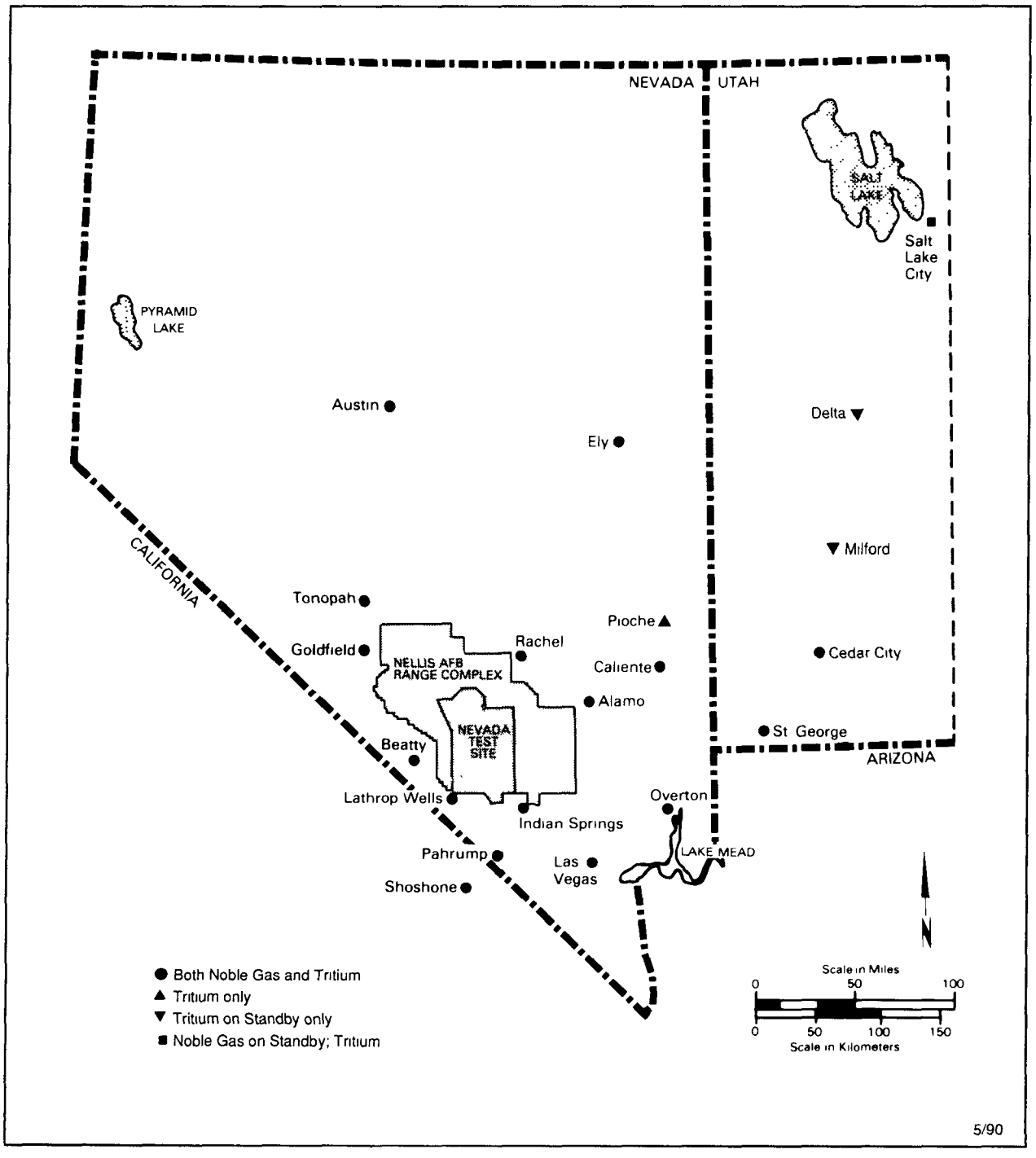

Figure 16. Noble Gas and Tritium Surveillance Network Sampling Locations.

Figure 17. EPA Monitoring Technician Changes Molecular Sieve on Tritium Air Sampler at Community Monitoring Station.

sieve is recovered, and the concentration of tritium in the water is determined by liquid scintillation counting (see Chapter 8). This result can then be combined with the amount of water in the air sampled to calculate the concentration of tritium in air.

SECTION 4.2.3.3. RESULTS

Figure 18 contains individual plots, listed by sampling location, showing the ^{85}Kr results for all samples analyzed in 1989, with the error bars representing

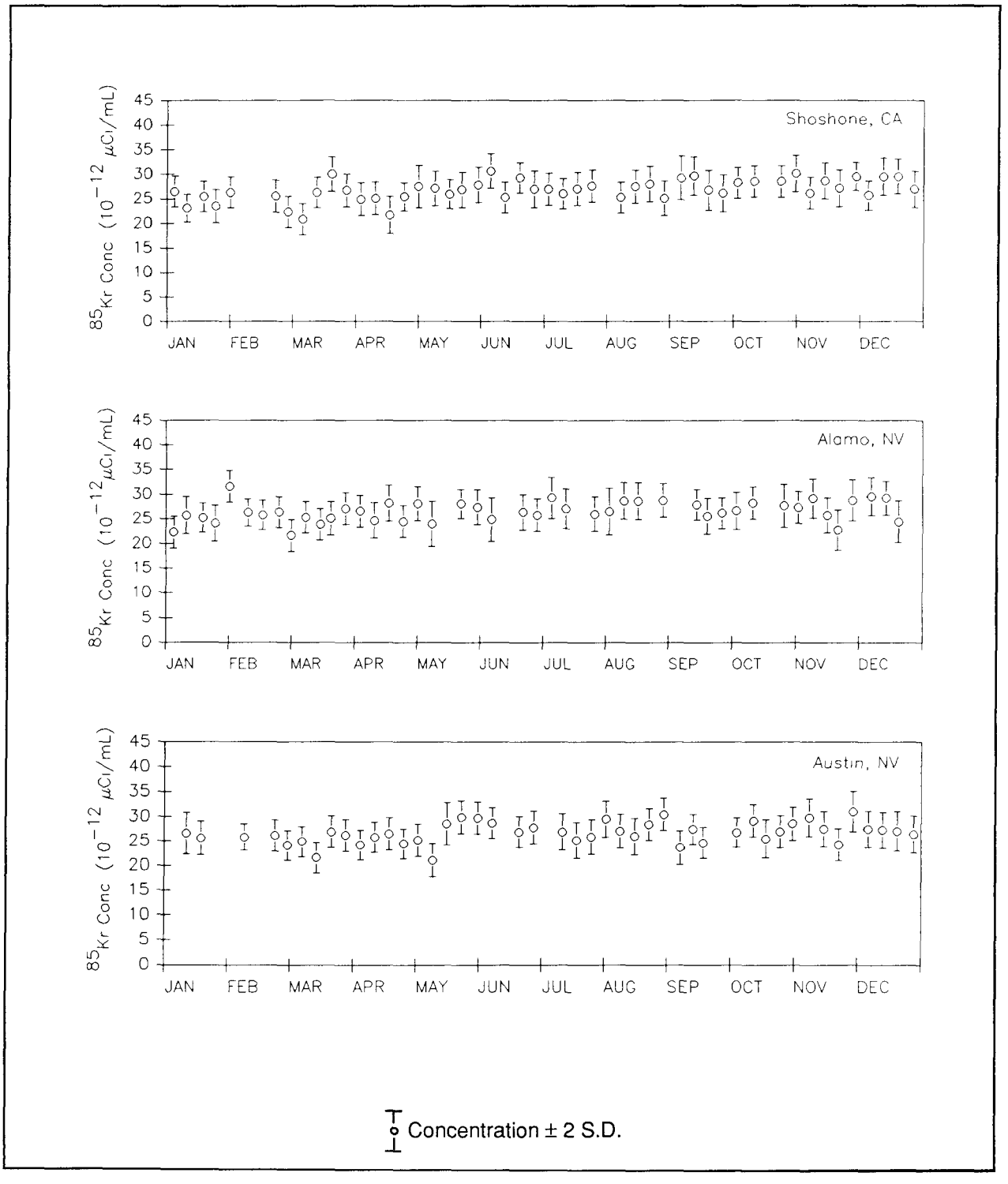

Figure 18. Weekly ^{85}Kr Concentrations in Air by Station, 1989 Data.

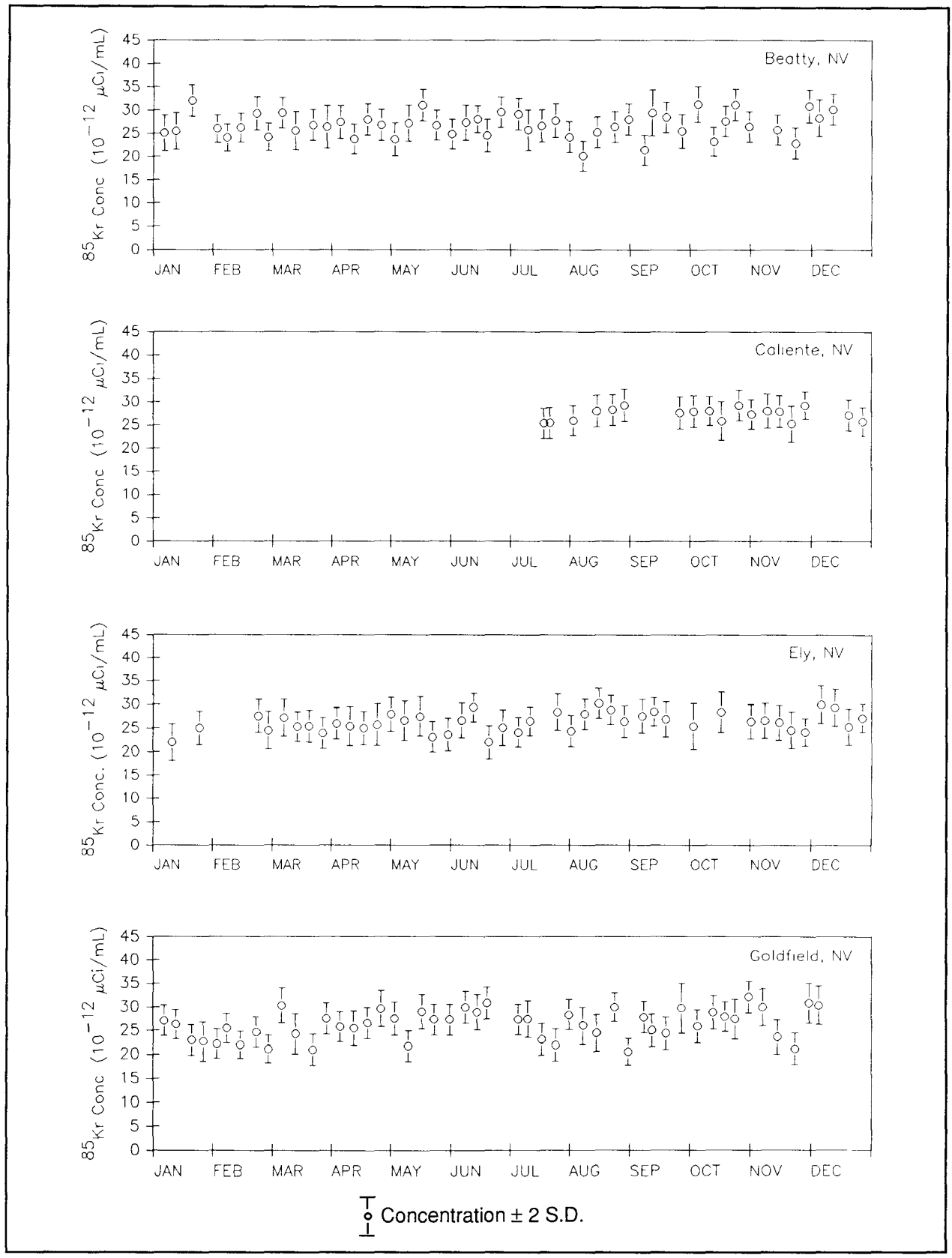

Figure 18. Continued.

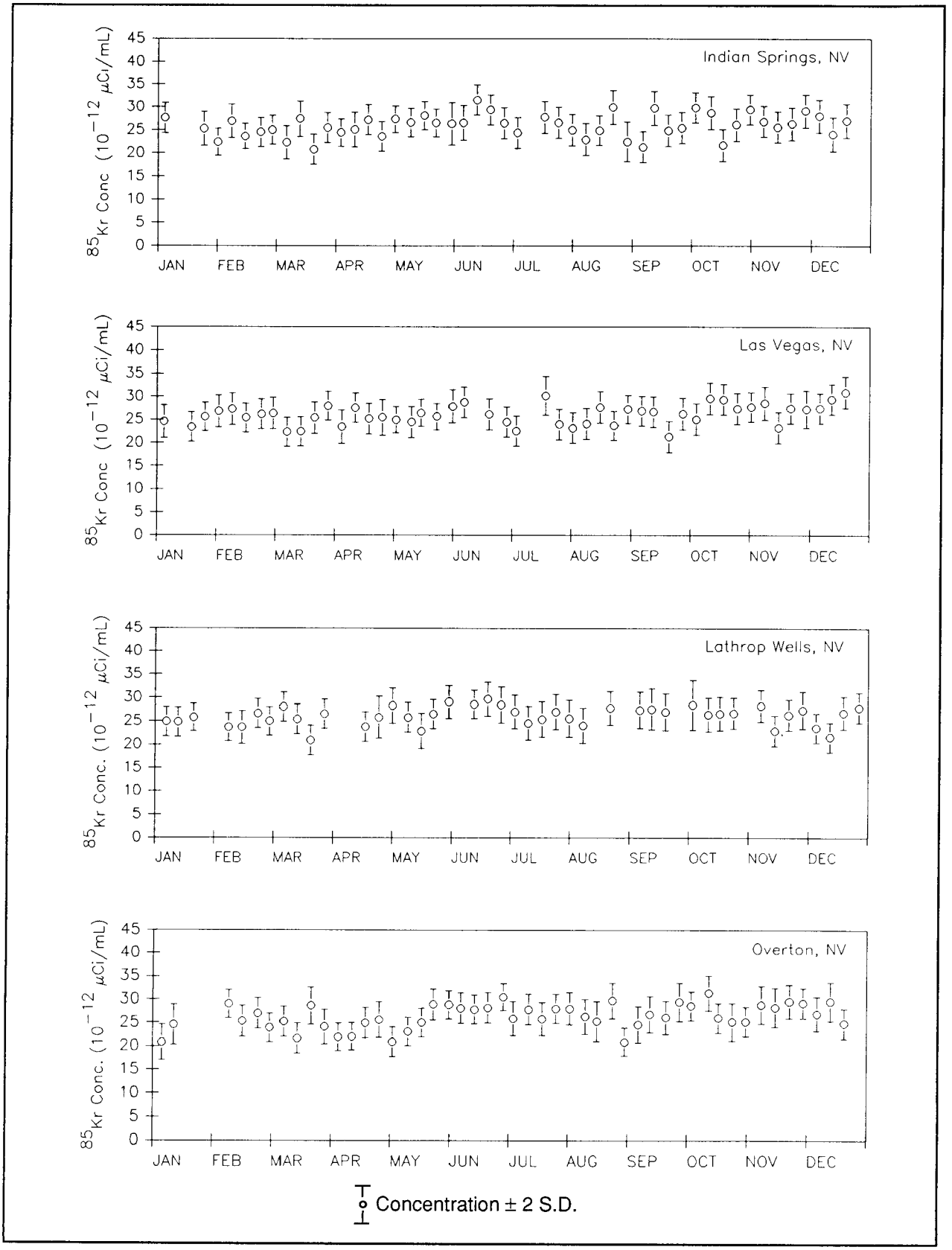

Figure 18. Continued.

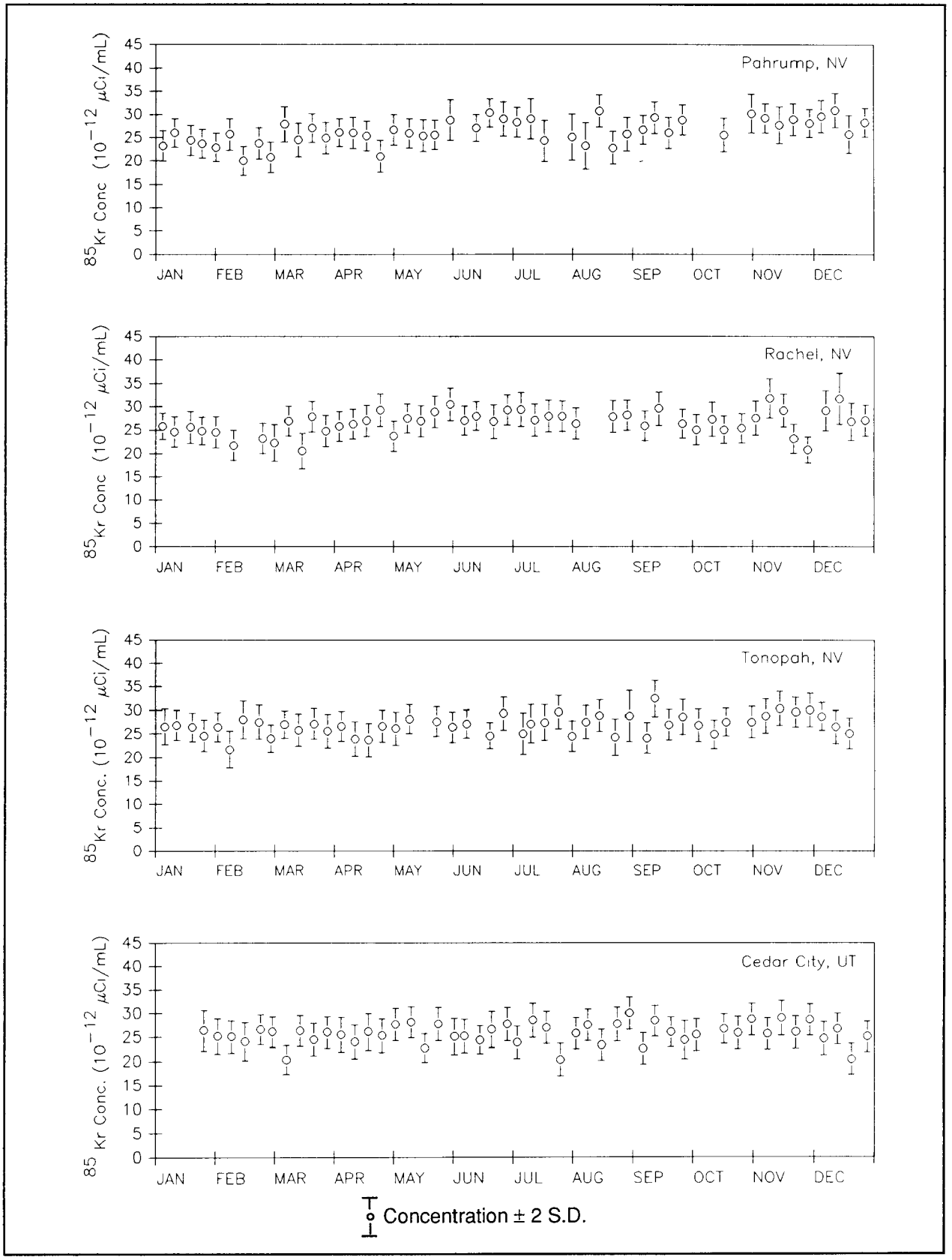

Figure 18. Continued.

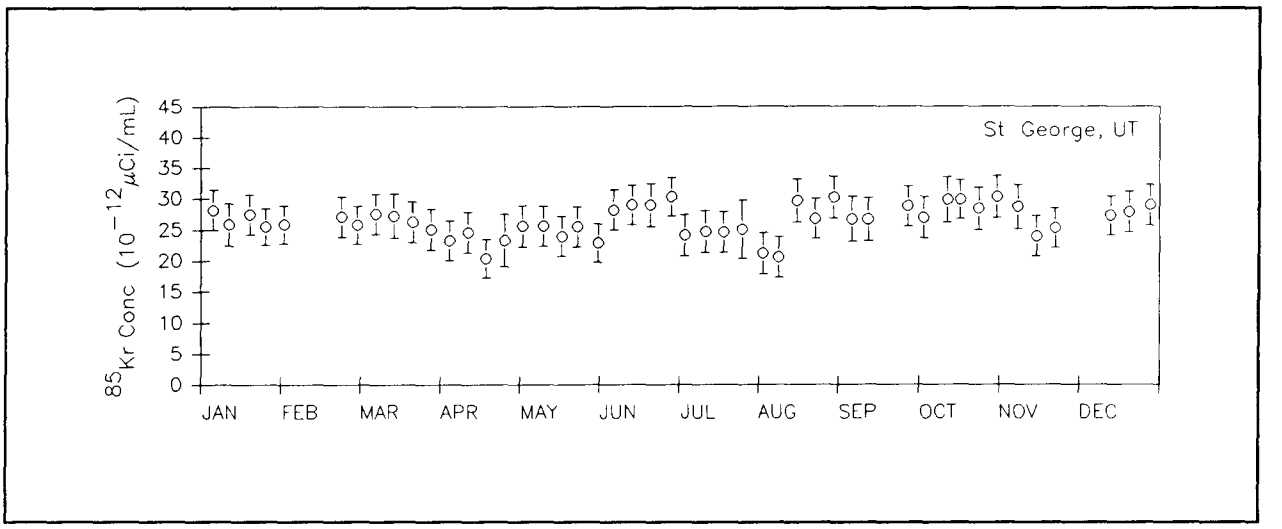

Figure 18. Continued.

the two-standard deviation counting error. While none of the ^{133}Xe results exceeded the Minimum Detectable Concentration (MDC), the ^{85}Kr results routinely exceeded the MDC due to the presence of an enhanced background. The results are, however, within the range expected due to statistical variations in the analytical results obtained from background sampling.

NGTSN sample results are summarized in Tables 6 and 7 for all sampling locations. This summary consists of the maximum, minimum and average concentration for each station. The number of samples analyzed is typically less than the expected number (fifty-two) since samples are occasionally lost in the analysis process, an insufficient sample volume is collected for analysis, or are not collected due to equipment failure. Caliente has a smaller number of samples processed than the other sites because the noble gas sampler was not operational until mid-July. Weekly network averages for ^{85}Kr concentrations (with two-standard deviation error bars) measured in 1989 are shown in Figure 19. The measured ^{85}Kr concentrations ranged from 2.0 to 3.3 x 10^{-11} µCi/mL (0.74 to 1.2 Bq/m^3).

A paper presented in 1973 by Bernhardt et al. (BE73), contained a curve predicting the ^{85}Kr concentration for the future. In recent years, measured levels have not reached those predicted, but have increased less rapidly than expected. One reason for this may be the decision by the United States to defer fuel reprocessing, which is the step in the fuel cycle where the majority of the krypton is actually released.

A historical summary of data for this network shows its trends over time. Network average krypton results for the past ten years are shown in Table 8, while results for the period 1972-1989 have been plotted in Figure 20.

The average concentration for the network, in 1989, was 2.65 x 10^{-11}µCi/mL (0.98 Bq/m^3). This network average concentration, as shown in Figure 20, has gradually increased from the time sampling began in 1972 to the present. This increase, observed at all stations, reflects the worldwide increase in ambient concentrations resulting from the increased use of nuclear technology. There is no evidence in the ^{85}Kr results to indicate that the radioactivity detected resulted from activities conducted at the NTS.

The analysis results for the 737 xenon samples counted were all below the minimum detectable concentration (MDC), which varied but was generally about 1.0 x 10^{-11} µCi/mL (0.37 Bq/m^3).

As in the past, tritium concentrations in atmospheric moisture samples from the sampling stations were generally below the MDC of about 7.0 x 10^{-7} µCi/mL (0.026 Bq/mL) of water (Table 7). Of the 924 network samples analyzed in 1989 only three slightly exceeded the MDC. Due to the statistical variations associated with counting radioactive samples, some samples may yield negative results, results between

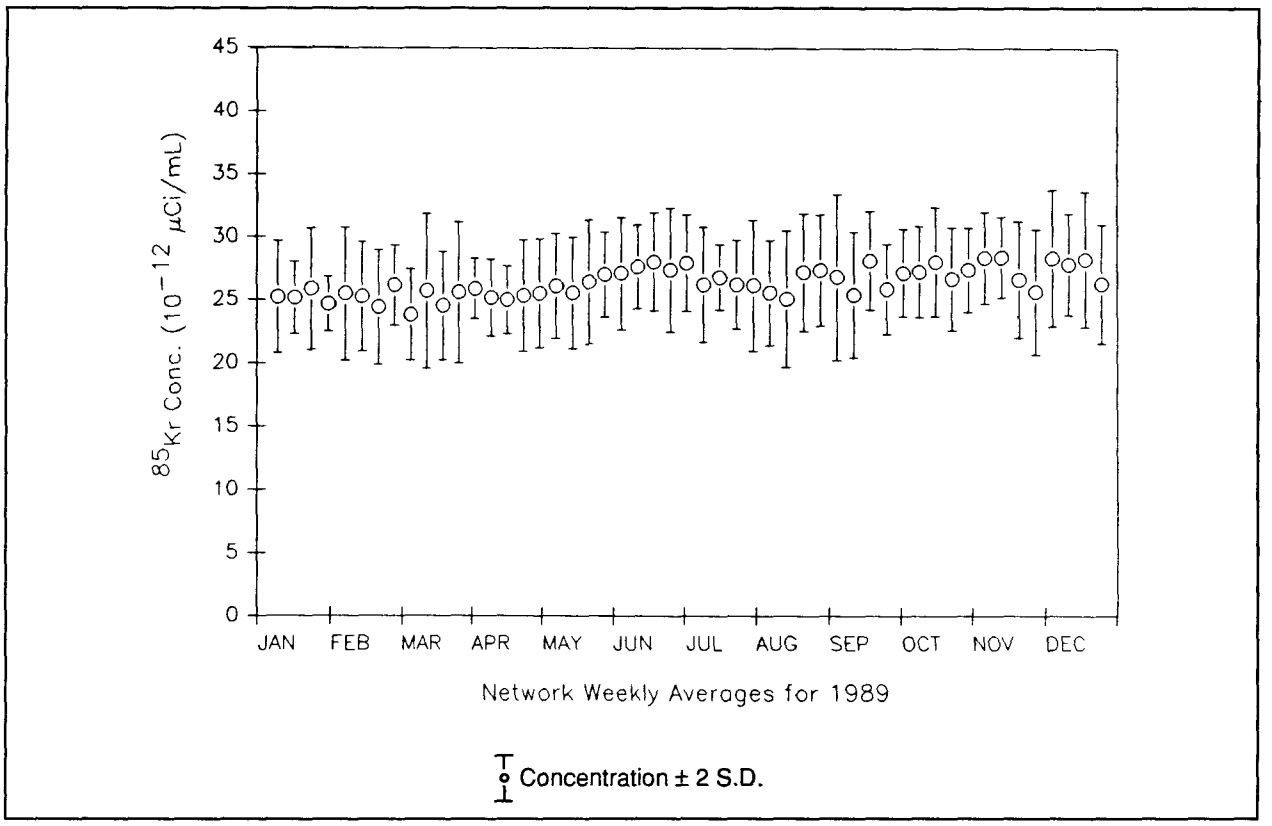

Figure 19. Network Weekly Average ^{85}Kr Concentrations in Air, 1989 Data.

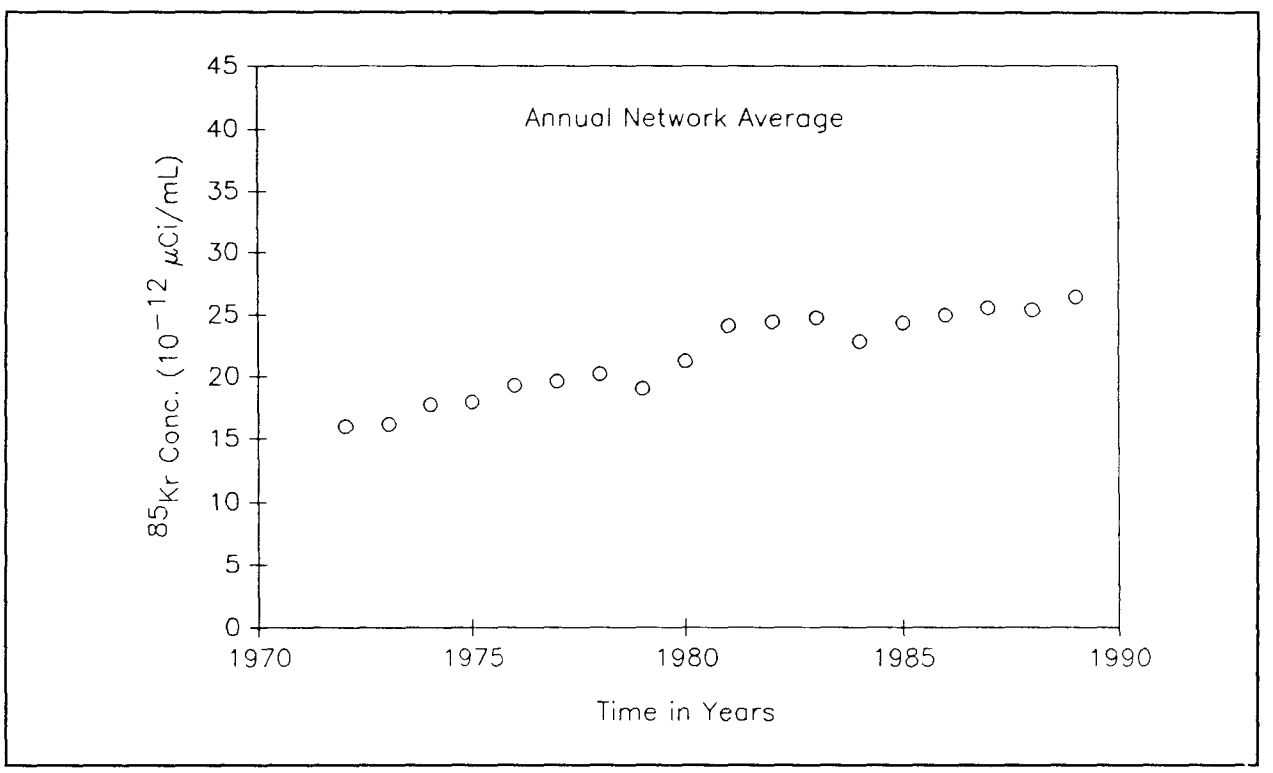

Figure 20. Annual Network Average ^{85}Kr Concentration.

TABLE 6. SUMMARY OF ANALYTICAL RESULTS FOR THE NOBLE GAS SURVEILLANCE NETWORK – 1989

SAMPLING LOCATION	NUMBER SAMPLES ANALYZED	RADIONUCLIDE	RADIOACTIVITY CONC. (10^{-12} µCi/mL)* MAX	MIN	AVG	PERCENT CONC. GUIDE**
SHOSHONE,	48	^{85}Kr	31	21	27	0.02
CA	48	^{133}Xe	7.7	-6.7	1.1	<0.01
ALAMO,	45	^{85}Kr	32	22	27	0.02
NV	47	^{133}Xe	8.1	-16	-0.018	<0.01
AUSTIN,	45	^{85}Kr	31	21	27	0.02
NV	45	^{133}Xe	11	-18	-0.55	<0.01
BEATTY,	50	^{85}Kr	32	20	27	0.02
NV	51	^{133}Xe	11	-10	1.8	<0.01
CALIENTE,	18	^{85}Kr	29	25	27	0.02
NV	18	^{133}Xe	5.7	-17	-1.4	<0.01
ELY,	43	^{85}Kr	30	22	26	0.02
NV	43	^{133}Xe	10	-16	0.42	<0.01
GOLDFIELD,	51	^{85}Kr	32	21	26	0.02
NV	51	^{133}Xe	12	-14	0.82	<0.01
INDIAN SPRINGS,	49	^{85}Kr	32	21	26	0.02
NV	49	^{133}Xe	13	-5.5	0.75	<0.01
LAS VEGAS,	49	^{85}Kr	31	21	26	0.02
NV	49	^{133}Xe	12	-12	1.1	<0.01
LATHROP WELLS,	43	^{85}Kr	30	21	26	0.02
NV	44	^{133}Xe	9.4	-7.5	0.16	<0.01
OVERTON,	49	^{85}Kr	31	21	26	0.02
NV	49	^{133}Xe	10	-13	0.41	<0.01
PAHRUMP,	47	^{85}Kr	31	20	26	0.02
NV	48	^{133}Xe	4.5	-8.0	0.23	<0.01
RACHEL,	48	^{85}Kr	32	21	27	0.02
NV	48	^{133}Xe	9.0	-10	0.47	<0.01
TONOPAH,	49	^{85}Kr	33	22	27	0.02
NV	51	^{133}Xe	11	-13	-0.15	<0.01
CEDAR CITY,	48	^{85}Kr	30	20	26	0.02
UT	48	^{133}Xe	11	-8.8	0.52	<0.01
ST GEORGE,	47	^{85}Kr	30	20	26	0.02
UT	48	^{133}Xe	8.3	-14	0.085	<0.01

* *The units used in this table (10^{-12} µCi/mL) are equal to, and the values in the table may be read as, pCi/m^3.*

** *The concentration guides referenced are calculated from the Annual Limit on Intake (ALI), listed in ICRP-30 and (where applicable) are based on the respiration rate of standard man, with the resulting exposure being equal to the non-occupational exposure guide of 25 mrem for exposure from radionuclides in air.*

TABLE 7. SUMMARY OF ANALYTICAL RESULTS FOR THE TRITIUM IN AIR SURVEILLANCE NETWORK — 1989

SAMPLING LOCATION	NUMBER SAMPLES ANALYZED	RADIONUCLIDE	RADIOACTIVITY CONC. (10^{-6} µCi/mL)* MAX	MIN.	AVG	PERCENT CONC. GUIDE**
SHOSHONE,	52	^{3}H in atm. m.*	0.81	-0.53	0.079	—
CA	52	^{3}H as HTO in air	3.6	-2.1	0.44	<0.01
ALAMO,	51	^{3}H in atm. m.*	0.42	-1.3	0.0061	—
NV	51	^{3}H as HTO in air	6.6	-24	-0.087	<0.01
AUSTIN,	52	^{3}H in atm. m.*	0.59	-1.4	-0.039	—
NV	52	^{3}H as HTO in air	3.2	-9.3	-0.16	<0.01
BEATTY,	51	^{3}H in atm. m.*	0.74	-1.1	0.064	—
NV	51	^{3}H as HTO in air	11	-11	0.52	<0.01
CALIENTE,	52	^{3}H in atm. m.*	0.74	-0.50	0.061	—
NV	52	^{3}H as HTO in air	4.1	-2.9	0.30	<0.01
ELY,	52	^{3}H in atm. m.*	0.68	-1.3	0.00098	—
NV	52	^{3}H as HTO in air	3.9	-11	0.045	<0.01
GOLDFIELD,	52	^{3}H in atm. m.*	0.58	-1.2	0.047	—
NV	52	^{3}H as HTO in air	4.3	-11	0.23	<0.01
INDIAN SPRINGS,	50	^{3}H in atm. m.*	0.87	-0.67	0.066	—
NV	50	^{3}H as HTO in air	4.9	-1.8	0.37	<0.01
LAS VEGAS,	52	^{3}H in atm. m.*	0.71	-0.29	0.076	—
NV	52	^{3}H as HTO in air	2.6	-1.7	0.40	<0.01
LATHROP WELLS,	50	^{3}H in atm. m.*	0.79	-0.41	0.056	—
NV	50	^{3}H as HTO in air	4.7	-2.4	0.28	<0.01
OVERTON,	52	^{3}H in atm. m.*	0.63	-0.52	0.036	—
NV	52	^{3}H as HTO in air	4.5	-3.1	0.17	<0.01
PAHRUMP,	51	^{3}H in atm. m.*	0.57	-0.33	0.068	—
NV	51	^{3}H as HTO in air	4.3	-2.0	0.29	<0.01
PIOCHE,	52	^{3}H in atm. m.*	0.39	-0.45	0.033	—
NV	52	^{3}H as HTO in air	3.5	-2.6	0.22	<0.01
RACHEL,	52	^{3}H in atm. m.*	0.62	-1.3	0.019	—
NV	52	^{3}H as HTO in air	4.2	-15	0.016	<0.01
TONOPAH,	51	^{3}H in atm. m.*	0.59	-1.0	-0.017	—
NV	48	^{3}H as HTO in air	3.9	-7.1	-0.14	<0.01
CEDAR CITY,	52	^{3}H in atm. m.*	0.60	-0.30	0.081	—
UT	52	^{3}H as HTO in air	4.9	-1.8	0.44	<0.01
ST GEORGE,	52	^{3}H in atm. m.*	0.50	-0.66	0.036	—
UT	52	^{3}H as HTO in air	7.8	-3.5	0.51	<0.01
SALT LAKE CITY,	51	^{3}H in atm. m.*	0.72	-0.66	0.063	—
UT	51	^{3}H as HTO in air	4.2	-3.5	0.40	<0.01

** Concentrations of tritiated water vapor in air are given in units of 10^{-6} pCi/mL (pCi/m^3) of air while the activity of tritium in atmospheric moisture is given in units of 10^{-6} µCi/mL (pCi/mL) of water.*

*** The concentration guides referenced are calculated from the Annual Limit on Intake (ALI), listed in ICRP-30 and (where applicable) are based on the respiration rate of standard man, with the resulting exposure being equal to the non-occupational exposure guide of 25 mrem for exposure from radionuclides in air.*

zero and the MDC, or some small percentage of the time even exceed the MDC yielding a false positive indication. Results between zero and the MDC are not necessarily real but are below the sensitivity of the method. Results that slightly exceed the MDC may be true indicators of some slight elevation in activity levels or, as previously indicated, could be a result of statistical counting variations only. The range of tritium concentrations observed at the sampling stations was considered to be representative of statistical variations in counting background samples and not indicative of the presence of increased ^{3}H levels in the environment.

In conclusion, the sampling network found no detectable increase in noble gas or tritium levels which could be attributed to activities at the NTS.

TABLE 8. ANNUAL AVERAGE ^{85}Kr CONCENTRATIONS IN AIR, 1980-1989

SAMPLING LOCATIONS	^{85}Kr CONCENTRATIONS (10^{-12} μCi/mL)									
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Mammoth Lakes, CA*	—	—	—	—	—	—	—	26	25	—
Shoshone, CA	—	—	25	25	23	24	25	26	25	27
Alamo, NV	—	27	24	25	24	24	24	26	25	27
Austin, NV	—	—	24	25	23	25	25	25	25	27
Beatty, NV	21	24	25	24	23	25	26	26	26	27
Caliente, NV	—	—	—	—	—	—	—	—	24	27
Ely, NV	—	—	24	25	22	24	26	25	25	26
Goldfield, NV	—	—	25	24	24	24	25	25	25	26
Groom Lake, NV*	21	24	—	—	—	—	—	—	—	—
Hiko, NV*	21	24	26	—	—	—	—	—	—	—
Indian Springs, NV	21	24	24	25	22	24	26	26	25	26
Las Vegas, NV	—	24	24	24	23	25	25	25	26	26
Lathrop Wells, NV	22	24	24	26	22	24	25	25	26	26
NTS, Mercury, NV*	21	23	—	—	—	—	—	—	—	—
NTS, BJY, NV*	23	26	—	—	—	—	—	—	—	—
NTS, Area 12, NV*	21	24	—	—	—	—	—	—	—	—
NTS, Area 15, NV*	21	25	—	—	—	—	—	—	—	—
NTS, Area 400, NV*	21	23	—	—	—	—	—	—	—	—
Overton, NV	—	26	24	25	23	24	25	25	26	26
Pahrump, NV	—	23	24	24	23	25	25	26	25	26
Rachel, NV	21	24	26	24	22	24	25	25	26	27
Tonopah, NV	21	25	24	25	23	25	25	26	25	27
Cedar City, UT	—	—	25	24	22	24	24	26	25	26
St. George, UT	—	—	24	25	23	24	24	25	26	26
Salt Lake City, UT*	—	—	25	25	25	25	—	—	—	—
NETWORK AVERAGE	21	24	24	25	23	24	25	26	25	26

* *Stations discontinued.*
— *No station was operational at that location during that year.*

Section 4.2.4. Milk Surveillance Network (MSN)

C. J. Rizzardi

Because it is one of the most universally consumed foodstuffs, and because certain radionuclides from any source are readily traceable through the food chain from feed/forage to consumer, milk is particularly important in assessing levels of radioactivity in a given area and, especially, the exposure of the population as a result of ingesting milk or milk products. Accordingly, milk is closely monitored by the EMSL-LV through two intensive and interrelated networks: the Milk Surveillance Network (MSN) and the Standby Milk Surveillance Network (SMSN).

SECTION 4.2.4.1. DESIGN

The MSN consists of 27 locations at which samples of raw milk are collected from either privately owned or dairy milk cows and goats. These locations are within a 300-kilometer radius of the Nevada Test Site to maintain timely surveillance for radioactivity that may result from the NTS nuclear testing program.

The SMSN consists of 106 sampling locations within the major milksheds west of the Mississippi River, except Texas where the State Health Department operates its own milk surveillance network. In the SMSN, samples are collected by State Food and Drug Administration personnel on request through EPA Regional Offices and analyzed at the EMSL-LV to determine radioactivity from any source.

SECTION 4.2.4.2. METHODS

In either network, raw milk is collected in four-liter collapsible cubitainers and preserved with formaldehyde. Routinely in the MSN, samples are collected monthly, and in the SMSN annually on a routine basis, or whenever local or worldwide radiation events suggest possible radiation concerns, such as the Chernobyl incident or nuclear testing by foreign nations. All samples are analyzed by high resolution gamma spectroscopy to detect gamma-emitting radionuclides. One sample per quarter from each MSN location and from two locations in each western state in the SMSN are evaluated by radiochemical analysis. These samples are analyzed for tritium by liquid scintillation counting and for ^{89}Sr and ^{90}Sr by an ion exchange method, as outlined in Chapter 8, Sample Analysis Procedures. Figures 22 and 23 show the locations of the collection sites.

Figure 21. EPA Monitoring Technician Collects Milk Sample From Commercial Dairy.

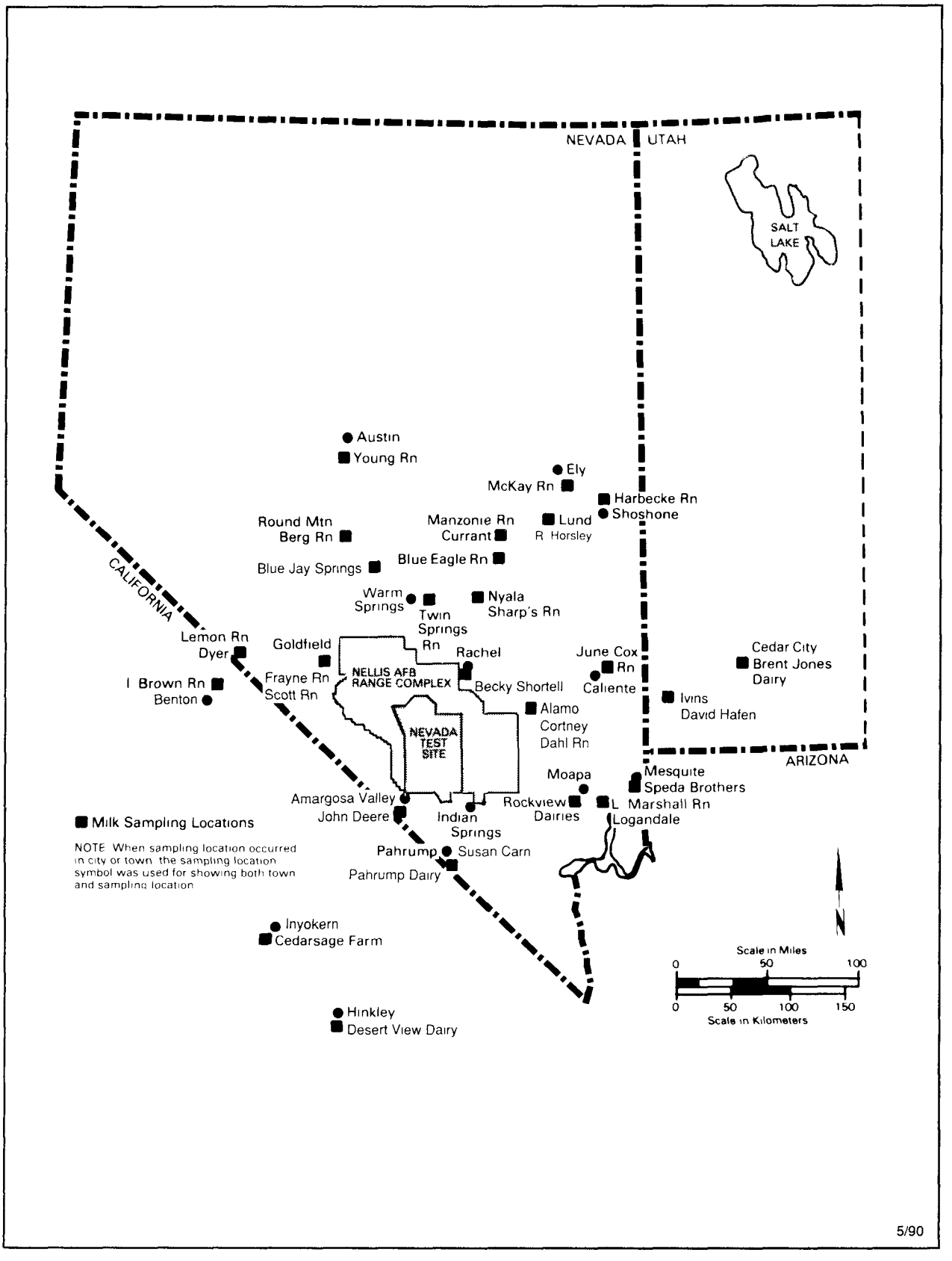

Figure 22. Milk Sampling Locations Within 300 km of the NTS CP-1.

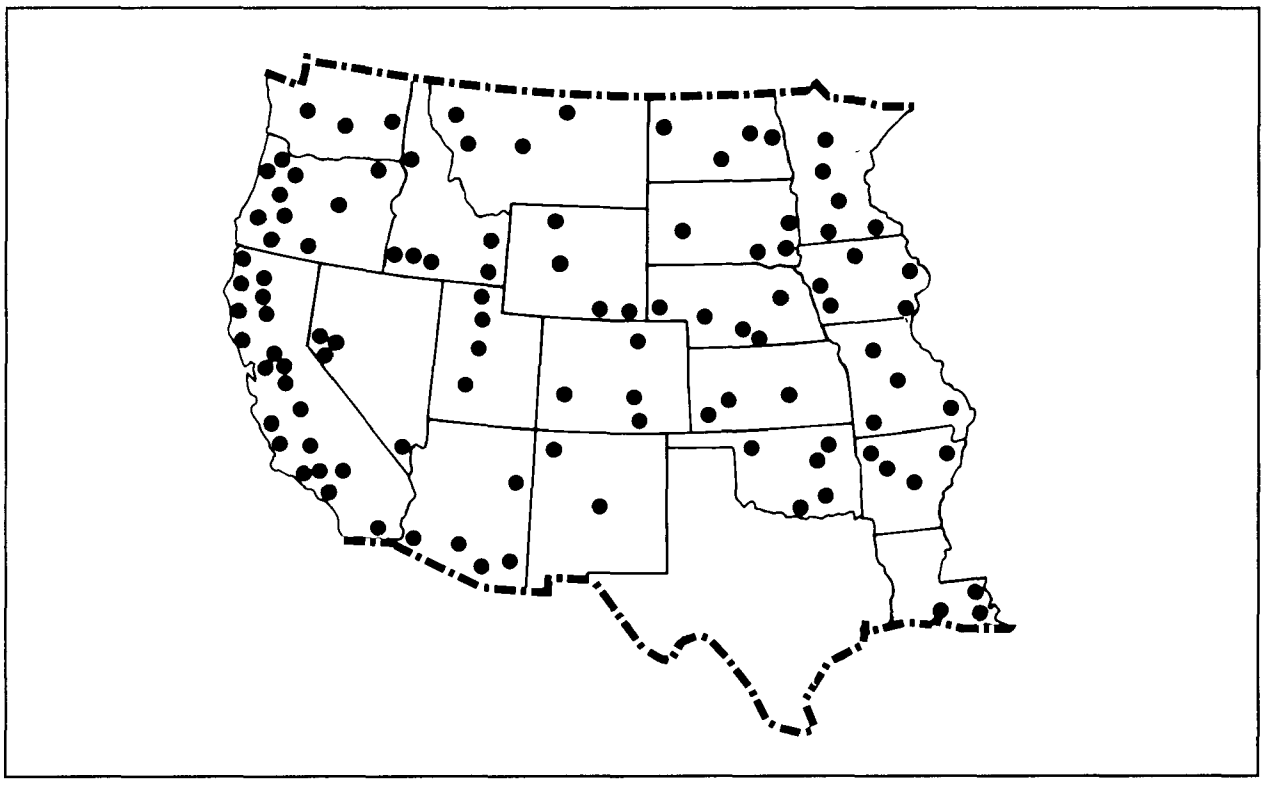

Figure 23. Standby Milk Surveillance Network Stations.

SECTION 4.2.4.3. RESULTS

The analytical results for MSN are in Table 9 and for the SMSN in Table 10. In analysis for gamma emitters, only naturally occurring ^{40}K was detected in samples from either network. Concentrations of radioactivity above minimum detectable levels were measured in several samples: tritium in two MSN locations (Inyokern, CA, and Currant, NV) and two SMSN locations (Delta, CO, and Fosston, MN); and radiostrontiums in seven samples from six different locations in the MSN, and eleven in the SMSN as shown in the accompanying tables. The results were just slightly above the minimum detectable amount for the samples and could represent the 5 percent false positive results that could be expected.

Figure 24 shows how levels of ^{90}Sr in Las Vegas, New Orleans and Salt Lake City milk samples have decreased continuously since the 1960s when atmospheric nuclear tests were conducted worldwide. Results from the New Orleans samples, as shown in the figure, have been consistently higher because of greater soil inventory of radiostrontiums from atmospheric testing as a result of weather patterns and precipitation. Although these figures were compiled through the Pasteurized Milk Network operated by the EPA's Eastern Environmental Radiation Facility, Montgomery, Alabama, data from samples collected in the MSN and SMSN over the years indicate a comparable downward trend in levels of radioactivity.

To facilitate surveillance activities, a comprehensive census of milk cows/goats is compiled. Updated through interim survey as part of routine monitoring and by general resurvey every two years, this information is computerized and a Milk Cow Directory is published containing the number of cows/goats, the type of feed, use of the milk (marketed or consumed by the family), and the precise location of the collection source by both latitude and longitude and road/mileage directions. This survey covers all of Nevada and the counties in California, Idaho, and Utah that border Nevada. The comprehensive resurvey was conducted in 1989 and the Milk Cow Directory will be published and distributed in early 1990.

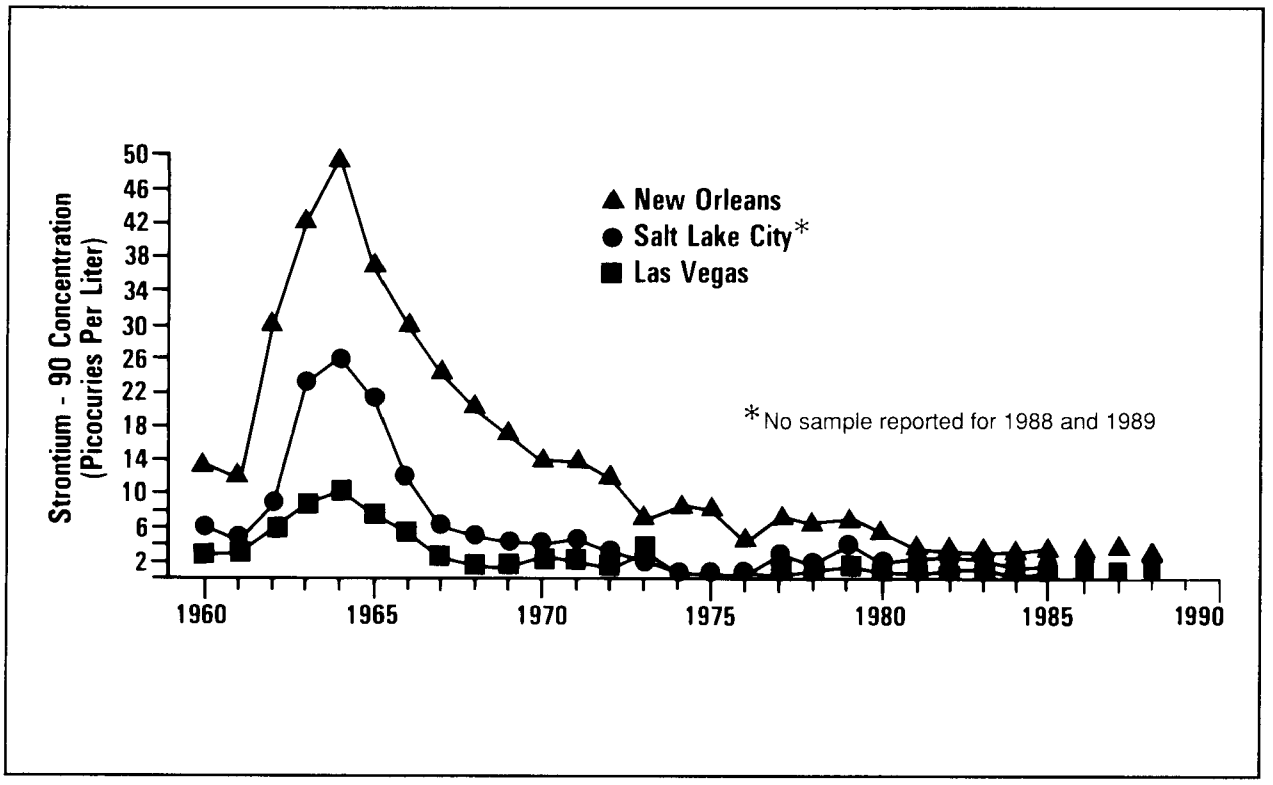

Figure 24. Strontium-90 Concentration in Pasteurized Milk Network Samples.

TABLE 9. SUMMARY OF ANALYTICAL RESULTS FOR THE MILK SURVEILLANCE NETWORK – 1989

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. (MDC) ^{3}H (10^{-9} µCi/mL)	^{89}Sr (10^{-9} µCi/mL)	^{90}Sr (10^{-9} µCi/mL)
BENTON CA				
I. BROWN RANCH	01/04	233 ± 369 (602)	0.7 ± 10.4 (5.3)	0.4 ± 1.4 (2)
	04/04	233 ± 342 (558)	0.2 ± 2.7 (2.2)	1.7 ± 0.6 (1.4)
	07/12	-170 ± 259 (431)	-1.2 ± 3.9 (3.3)	0.5 ± 0.8 (1.8)
	09/02	154 ± 231 (376)	2.3 ± 6.2 (4.1)	0.3 ± 1.0 (1.8)
HINKLEY CA				
DESERT VIEW DAIRY	01/03	43 ± 370 (609)	-9.1 ± 12.7 (7.2)	1.2 ± 1.7 (2.6)
	04/03	197 ± 315 (515)	0.02 ± 2.3 (2)	0.6 ± 0.5 (1.3)
	07/12	146 ± 266 (435)	-1.4 ± 5 (3.9)	0.9 ± 1.0 (2.1)
	10/03	201 ± 246 (401)	0.6 ± 3.2 (2.8)	-0.02 ± 0.6 (1.4)
INYOKERN CA				
CEDARSAGE FARM	01/03	650 ± 377 (608)**	-1.0 ± 8.0 (4.2)	0.8 ± 1.1 (1.6)
	04/04	141 ± 328 (537)	1.3 ± 5.7 (3.6)	0.9 ± 1.2 (1.9)
	07/12	128 ± 261 (427)	-1.6 ± 4.3 (3.4)	0.8 ± 0.9 (1.9)
	10/03	282 ± 259 (420)	1.9 ± 3 (2.5)	0.04 ± 0.5 (1.3)
ALAMO NV				
C. DAHL RANCH	02/02	36 ± 368 (606)	-1.9 ± 6.2 (4.3)	0.7 ± 0.9 (1.4)
	05/02	19 ± 322 (531)	-0.6 ± 3.4 (2.5)	0.6 ± 0.9 (1.8)
	08/08	-9 ± 263 (434)	0.8 ± 3.5 (2.9)	0.2 ± 0.6 (1.3)
	11/01	-35 ± 249 (412)	*	*

(Continued)

TABLE 9. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. (MDC) ^{3}H (10^{-9} µCi/mL)	^{89}Sr (10^{-9} µCi/mL)	^{90}Sr (10^{-9} µCi/mL)
AUSTIN NV				
YOUNG'S RANCH	03/16	289 ± 337 (549)	1.4 ± 4.4 (2.4)	1.0 ± 1.0 (1.4)
	06/14	374 ± 313 (508)	1.8 ± 4.6 (3.3)	1.1 ± 1 (1.7)
	09/12	203 ± 272 (444)	0.6 ± 4.3 (2.8)	1.2 ± 0.9 (1.5)
	12/01	7 ± 245 (404)	*	*
BLUE JAY NV				
BLUE JAY SPRGS RANCH	03/02	245 ± 326 (533)	2.1 ± 4.4 (3.2)	0.05 ± 0.9 (1.6)
	06/07	322 ± 308 (401)	0.7 ± 1.6 (1.1)	-0.004 ± 0.7 (1.5)
	09/11	-54 ± 262 (433)	1.6 ± 4.2 (3.1)	0.21 ± 0.84 (1.6)
	12/04	-5 ± 240 (396)	*	*
CURRANT NV				
BLUE EAGLE RANCH	01/05		NO SAMPLE - COW DRY	
	03/10		NO SAMPLE - COW DRY	
	09/11	87 ± 236 (387)	-0.8 ± 3.7 (2.2)	1.6 ± 0.8 (1.4)**
	12/05	11 ± 245 (404)	*	*
CURRANT NV				
MANZONIE RANCH	03/01	327 ± 326 (531)	0.4 ± 5.5 (3.3)	0.1 ± 1.0 (1.5)
	06/17	524 ± 318 (514)**	-0.06 ± 2.1 (1.6)	0.3 ± 0.8 (1.5)
	10/03	277 ± 250 (405)	2.5 ± 4 (3.2)	-0.02 ± 0.7 (1.5)
	12/05	175 ± 253 (413)	*	*
DYER NV				
LEMON RANCH	03/15	74 ± 327 (537)	2.4 ± 5 (2.8)	0.5 ± 1.1 (1.5)
	06/21	309 ± 306 (498)	0.9 ± 2.0 (1.7)	0.5 ± 0.5 (1.3)
	09/12	86 ± 268 (440)	0.01 ± 4.4 (3)	1.0 ± 0.9 (1.6)
	12/07	284 ± 247 (400)	*	*
ELY NV				
MCKAY RANCH	02/01	54 ± 372 (611)	3.3 ± 15.2 (7.1)	1.4 ± 1.7 (2.2)
	05/02	264 ± 323 (527)	-1.2 ± 2 (1.5)	1 ± 0.6 (1.4)
	08/08	205 ± 279 (455)	-0.08 ± 2.8 (2.2)	0.5 ± 0.8 (1.7)
	11/08		NO SAMPLE - COW DRY	
GOLDFIELD NV				
FRAYNE RANCH	01/11		NO SAMPLE - GOAT DRY	
	03/17	-6 ± 304 (502)	1.8 ± 5 (3)	0.7 ± 1.2 (1.6)
	05/12	490 ± 337 (545)	-1.6 ± 5.6 (4.2)	1.3 ± 1.2 (2.2)
	12/01		NO SAMPLE - GOATS DRY	
GOLDFIELD NV				
S. SCOTT RANCH	01/11		NO SAMPLE - GOAT DRY	
	03/10		NO SAMPLE - GOAT DRY	
	12/07		NO SAMPLE - GOAT DRY	

(Continued)

TABLE 9. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ± 2 S.D. (MDC) ^{3}H (10^{-9} µCi/mL)	^{89}Sr (10^{-9} µCi/mL)	^{90}Sr (10^{-9} µCi/mL)
INDIAN SPRINGS NV				
S. CARR RANCH	05/01	235 ± 313 (511)	0.9 ± 5.4 (3.1)	0.8 ± 1.2 (1.8)
	09/05	55 ± 232 (381)	2.7 ± 5.7 (3.6)	0.5 ± 1.0 (1.7)
	11/06	-28 ± 238 (393)	*	*
LAS VEGAS NV				
D. ANDERSON (LDS FARMS)	01/02	214 ± 366 (598)	1.1 ± 10.1 (5.3)	0.3 ± 1.3 (2)
	04/06	55 ± 326 (537)	*	0.5 ± 0.6 (1.3)
	05/08	363 ± 304 (494)	0.09 ± 1.7 (1.5)	0.3 ± 0.6 (1.3)
	07/14	312 ± 281 (456)	-4.4 ± 5.9 (4.7)	1.2 ± 1.1 (2.5)
	10/02	269 ± 252 (409)	2.3 ± 3.7 (3)	-0.1 ± 0.7 (1.4)
	(Out of Business, November 1989)			
AMARGOSA VALLEY				
J. DEERE RANCH	01/10		NO SAMPLE - GOATS DRY	
	03/10	-62 ± 316 (523)	-0.1 ± 4.0 (2.6)	-0.01 ± 0.8 (1.4)
	06/08	264 ± 314 (512)	-0.4 ± 2.1 (1.9)	0.3 ± 0.5 (1.2)
	07/11	*	*	*
	08/02	-2.6 ± 233 (384)	-0.8 ± 4.7 (3.6)	0.7 ± 0.7 (1.4)
	09/07	206 ± 269 (438)	0.3 ± 6.7 (4.4)	0.7 ± 1.2 (2)
	12/01		NO SAMPLE - COW DRY	
LOGANDALE NV				
L. MARSHALL	02/01	190 ± 366 (599)	-0.7 ± 5.4 (3.8)	0.3 ± 0.7 (1.2)
	05/01	-178 ± 321 (533)	0.3 ± 2.2 (1.7)	-0.2 ± 0.6 (1.5)
	08/07	-52 ± 231 (381)	6.9 ± 7.7 (5.7)	-0.3 ± 1.1 (1.9)
	11/02	204 ± 250 (406)	*	*
LUND NV				
R. PEACOCK	02/01	490 ± 376 (609)	1.7 ± 6.5 (4)	0.6 ± 0.9 (1.3)
LUND NV				
HORSLEY RANCH †	03/02	60 ± 319 (525)	0.3 ± 11.6 (7.5)	0.1 ± 2.1 (3.3)
	05/02	60 ± 320 (527)	1.5 ± 2.5 (1.9)	-0.1 ± 0.7 (1.4)
	08/08	3 ± 232 (381)	1.4 ± 2.9 (2.3)	-0.3 ± 0.8 (1.8)
	11/09	68 ± 253 (416)	1.8 ± 2.5 (1.8)	-0.2 ± 0.7 (1.4)
MESQUITE NV				
SPEDA BROTHERS DAIRY	01/03	100 ± 369 (606)	*	-0.1 ± 1.4 (2.1)
	04/02	-108 ± 322 (533)	-0.7 ± 3.0 (2.2)	1.4 ± 0.7 (1.3)**
	07/03	157 ± 266 (435)	1 ± 2.8 (2.1)	1 ± 0.6 (1.3)
	10/02	100 ± 235 (385)	-0.4 ± 3.1 (2)	1 ± 0.8 (1.5)
MOAPA NV				
ROCKVIEW DAIRIES, INC.	01/03	68 ± 370 (608)	-4.3 ± 9.4 (4.8)	1.1 ± 1.2 (1.8)
	04/03	142 ± 323 (528)	-0.2 ± 3.2 (2.4)	0.7 ± 0.7 (1.4)
	07/03	81 ± 270 (442)	0.2 ± 2.6 (2.3)	0.2 ± 0.5 (1.4)
	10/02	52 ± 232 (381)	1.0 ± 3.0 (2)	0.2 ± 0.8 (1.5)
NYALA NV				
SHARP'S RANCH	03/10	230 ± 319 (521)	0.2 ± 6.1 (4.3)	0.4 ± 1.3 (2.2)
	06/06	252 ± 310 (506)	-0.9 ± 2.6 (1.9)	0.7 ± 0.8 (1.6)
	09/06	128 ± 269 (441)	1.7 ± 4.1 (2.9)	0.8 ± 0.8 (1.5)
	12/04	59 ± 239 (393)	*	*

(Continued)

TABLE 9. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. (MDC) ^{3}H (10^{-9} µCi/mL)	^{89}Sr (10^{-9} µCi/mL)	^{90}Sr (10^{-9} µCi/mL)
PAHRUMP NV				
PAHRUMP DAIRY H. HETTINGA	11/07	-154 ± 241 (401)	*	*
CALIENTE NV				
J. COX RANCH	01/03		NO SAMPLE - COW DRY	
	03/04		NO SAMPLE - GOATS DRY	
	05/01	35 ± 326 (537)	-0.3 ± 1.8 (1.4)	0.4 ± 0.6 (1.3)
	08/07	249 ± 275 (447)	1.8 ± 4.9 (3.9)	0.1 ± 0.7 (1.5)
	11/08	302 ± 267 (434)	3.3 ± 2.8 (1.9)**	-0.8 ± 0.8 (1.5)
ROUND MT NV				
BERG'S RANCH	01/11		NO SAMPLE - COW DRY	
	06/14	433 ± 315 (512)	1.6 ± 4.1 (3.1)	0.7 ± 0.8 (1.7)
	08/09	-121 ± 231 (384)	2.4 ± 5.3 (3.8)	0.6 ± 0.8 (1.5)
	12/01		NO SAMPLE - COW DRY	
SHOSHONE NV				
HARBECKE RANCH	02/01	129 ± 372 (610)	4.5 ± 13.9 (8.3)	1.5 ± 1.1 (1.7)
	05/01	240 ± 328 (534)	-0.5 ± 2.6 (1.7)	2.1 ± 0.8 (1.4)**
	08/07	192 ± 274 (447)	2.7 ± 6.8 (4.2)	2.3 ± 1 (1.6)**
	11/08	206 ± 249 (405)	3 ± 3.6 (1.9)	1.9 ± 1 (1.5)**
RACHEL NV				
B. SHORTELL	06/07	254 ± 316 (516)	-0.8 ± 2.8 (1.9)	1.2 ± 1.2 (2.1)
WARM SPRINGS NV				
TWIN SPRINGS RANCH	03/01	98 ± 323 (531)	0.9 ± 7.7 (4.8)	1 ± 1.4 (2.2)
	06/14	247 ± 301 (490)	2 ± 3 (2.4)	0.7 ± 0.7 (1.4)
	09/11		NO SAMPLE	
	12/05		NO SAMPLE	
CEDAR CITY UT				
B. JONES DAIRY	01/03	135 ± 370 (607)	*	-0.8 ± 1.9 (2.8)
	04/03	198 ± 338 (553)	-1.4 ± 2.7 (2)	1.6 ± 0.6 (1.3)**
	07/03	151 ± 274 (448)	0.8 ± 2.7 (2.2)	0.8 ± 0.6 (1.3)
	10/02	43 ± 227 (373)	0.3 ± 3.2 (2.1)	0.7 ± 0.8 (1.5)
IVINS UT	07/03	-301 ± 261 (437)	0.2 ± 2.8 (2.2)	1.0 ± 0.6 (1.3)
D. HAFEN RANCH ††	10/06	-10 ± 231 (380)	0.3 ± 3.2 (1.9)	1.1 ± 0.9 (1.5)
	01/06	198 ± 369 (603)	3.2 ± 9.3 (5)	-0.4 ± 1.3 (2)
ST GEORGE UT				
T. CANNON	04/03	174 ± 329 (539)	0.9 ± 2.2 (2)	-0.1 ± 0.5 (1.3)

* *Sample not analyzed for this radionuclide.*
** *Concentration is greater than the Minimum Detectable Concentration (MDC).*
† *Replacement for R. Peacock.*
†† *Replacement for T. Cannon.*

TABLE 10. ANALYTICAL RESULTS FOR THE STANDBY MILK SURVEILLANCE NETWORK - 1989

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. (MDC) ^{3}H (10^{-9} µCi/mL)	^{89}Sr (10^{-9} µCi/mL)	^{90}Sr (10^{-9} µCi/mL)
TAYLOR AZ SUNRISE DAIRY	08/10	247 ± 276 (450)	-0.3 ± 2.1 (1.9)	0.5 ± 0.7 (1.6)
TUCSON AZ SHAMROCK DAIRY (PIMA CO)	08/11	49 ± 263 (433)	2.7 ± 5.7 (4)	0.1 ± 0.8 (1.6)
LITTLE ROCK AR BORDENS	11/20	29 ± 250 (412)	0.7 ± 2.9 (1.6)	2.4 ± 1 (1.5)**
RUSSELLVILLE AR ARKANSAS TECH UNIV	08/30	217 ± 265 (431)	0.8 ± 6.1 (3.4)	2 ± 1.1 (1.6)**
BAKERSFIELD CA FAVORITE FOODS, INC	07/20	44 ± 267 (439)	1.2 ± 4.7 (3.2)	0.2 ± 1.4 (2.5)
WEED CA CRANDALL'S CREAMERY	08/16	-66 ± 232 (384)	0.1 ± 3.1 (2.8)	-0.02 ± 1.0 (2.2)
WILLOWS CA GLENN MILK PRODUCERS ASSOCIATION	08/14	173 ± 272 (445)	-0.9 ± 1.6 (1.3)	1 ± 0.6 (1.3)
CANON CITY CO JUNIPER VALLEY FARMS DRY	07/17	270 ± 268 (437)	-0.2 ± 2.3 (2.1)	0.5 ± 0.6 (1.4)
DELTA CO MEADOW GOLD DAIRY	07/29	458 ± 278 (448)**	0.2 ± 3.20 (2.8)	0.6 ± 0.8 (1.9)
QUINCY IL PRAIRIE FARMS DAIRY	06/13	375 ± 319 (517)	-0.6 ± 2.7 (1.9)	1.7 ± 1 (1.7)
BOISE ID MEADOW GOLD DAIRIES	08/17	217 ± 269 (438)	-1.5 ± 3.4 (2.6)	1.2 ± 1.1 (2.1)
IDAHO FALLS ID REEDS DAIRY	08/21	335 ± 260 (421)	-0.4 ± 2.5 (2)	0.4 ± 0.8 (1.8)
DUBUQUE IA SWISS VALLEY FARMS, INC	06/12	404 ± 307 (498)	1.5 ± 2.9 (2)	1.2 ± 1 (1.7)
ELLIS KS MID-AMERICA DAIRY	06/07	444 ± 338 (547)	0.4 ± 1.4 (0.96)	0.9 ± 0.7 (1.3)
SABETHA KS MID-AMERICA DAIRYMEN	06/19	289 ± 307	-0.6 ± 2.6	1.5 ± 1
MONROE LA BORDEN'S DAIRY	09/06	29 ± 236 (388)	3.4 ± 4.2 (2.5)	1.1 ± 0.9 (1.5)
NEW ORLEANS LA BROWN'S VELVET DRY PRO	08/16	119 ± 262 (429)	*	*

(Continued)

TABLE 10. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. (MDC) ^{3}H (10^{-9} µCi/mL)	^{89}Sr (10^{-9} µCi/mL)	^{90}Sr (10^{-9} µCi/mL)
FOSSTON MN LAND O' LAKES INC	06/26	494 ± 305 (492)**	1.9 ± 3 (1.9)	1.6 ± 0.8 (1.3)**
ROCHESTER MN ASSOC.MILK PROD.INC(AMPI)	06/22	435 ± 305 (494)	-1.3 ± 3.1 (2.1)	1.7 ± 1.1 (2)
AURORA MO MID-AMERICA DAIRY INC	06/14	377 ± 297 (482)	0.5 ± 3.0 (1.8)	2.5 ± 1.1 (1.6)**
CHILLICOTHE MO MID-AMERICA DAIRYMEN	06/28	236 ± 305 (498)	-0.3 ± 2.4 (1.5)	2.3 ± 0.7 (1.2)**
BILLINGS MT MEADOW GOLD DAIRY	11/14	121 ± 225	-0.02 ± 2.9	1.9 ± 0.9**
KALISPELL MT EQUITY SUPPLY CO.	12/06	-44 ± 240 (397)	*	*
NORFOLK NE GILLETTE DAIRY	06/26	369 ± 311 (505)	0.3 ± 3.3 (2)	2 ± 0.8 (1.4)**
NORTH PLATTE NE MID AMERICA DAIRYMEN	06/27	309 ± 318 (517)	1.1 ± 2.9 (1.7)	1.6 ± 0.7 (1.3)**
ALBUQUERQUE NM BORDEN'S VALLEY GOLD	12/30	211 ± 255 (415)	SAMPLE RECEIVED 1/25/90	
LA PLATA NM RIVER EDGE DAIRY	12/30	232 ± 247 (401)	SAMPLE RECEIVED 1/25/90	
BISMARCK ND BRIDGEMAN CREAMERY, INC	09/10	-16 ± 266	0.6 ± 4.0	2.3 ± 0.9**
GRAND FORKS ND MINNESOTA DAIRY	09/11	-101 ± 264 (437)	1.6 ± 4.8 (2.8)	1.8 ± 1.1 (1.6)**.
ENID OK AMPI GOLDSPOT DIVISION	06/29	265 ± 296 (482)	2.2 ± 2.9 (1.9)	0.9 ± 0.8 (1.4)
MCALESTER OK JACKIE BRANNON CORR CTR	07/02	366 ± 316 (514)	0.4 ± 2.1 (1.4)	1.0 ± 0.6 (1.2)
CORVALLIS OR SUNNY BROOK DAIRY	08/16	363 ± 259 (419)	-0.4 ± 3.3 (2.7)	0.7 ± 1.0 (2.1)
MEDFORD OR DAIRYGOLD FARMS	08/16	157 ± 262 (428)	-0.3 ± 2.1 (1.8)	0.7 ± 0.7 (1.6)
TILLAMOOK OR TILLAMOOK CO CRMY	08/22	207 ± 266 (434)	0.6 ± 2.1 (1.6)	1.4 ± 0.8 (1.6)

(Continued)

TABLE 10. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. (MDC) ^{3}H (10^{-9} µCi/mL)	^{89}Sr (10^{-9} µCi/mL)	^{90}Sr (10^{-9} µCi/mL)
RAPID CITY SD				
GILLETTE DRY-BLACK HILLS	08/09	215 ± 257 (419)	*	*
SIOUX FALLS SD				
LAND O'LAKES INC	08/11	263 ± 276 (450)	-0.3 ± 3.0 (2)	1.5 ±0.9 (1.7)
BEAVER UT				
CACHE VALLEY DAIRY	08/13	-52 ± 269 (444)	0.8 ± 1.7 (1.3)	0.6 ± 0.6 (1.3)
PROVO UT				
BYU DAIRY PRODUCTS LAB	08/17	53 ± 260 (427)	*	*
SEATTLE WA				
DARIGOLD,INC	08/17	111 ± 256 (419)	-2.9 ± 7.7 (6)	0.8 ± 2.0 (4)
SPOKANE WAS				
DARIGOLD INC	08/21	403 ± 267 (432)	-1.2 ± 3.2 (2.3)	2 ± 1.1 (2)
CHEYENNE WY				
DAIRY GOLD FOODS	08/15	127 ± 253	*	*
SHERIDAN WY				
MYLAND DAIRY	11/14	15 ± 229 (378)	-0.4 ± 2.7 (1.7)	1.7 ± 0.9 (1.4)**

Samples not analyzed.
***Concentration is greater than the Minimum Detectable Concentration (MDC).*

SAMPLING LOCATION	COLLECTION DATE 1989
SAMPLES FROM THE FOLLOWING LOCATIONS WERE ANALYZED BY GAMMA SPECTROSCOPY ONLY: (IN ALL CASES ONLY NATURALLY OCCURRING RADIONUCLIDES WERE DETECTED)	
PIMA AZ	
PIMA DAIRY	08/10
TEMPE AZ	
UNITED DAIRYMEN OF AZ	08/09
YUMA AZ	
COMBS DAIRY	08/10
BATESVILLE AR	
HILLS VALLEY FOODS	08/28
FAYETTEVILLE AR	
UNIVERSITY OF ARKANSAS	08/29
HELENDALE CA	
OSTERKAMP DAIRY NO 2	11/21
CHINO CA	
CA INST FOR MEN	08/22
FERNBRIDGE CA	
HUMBOLDT CREAMERY	08/15
FRESNO CA	
CA STATE UNIV CREAMERY	08/16
HOLTVILLE CA	
SCHAFFNER & SON DAIRY	08/20
MANTECA CA	
LEGEND DAIRY	08/15
MODESTO CA	
FOSTER FARMS DAIRY	08/17
OXNARD CA	
CHASE BROS DAIRY	08/22
PETALUMA CA	
CA CO-OP CREAMERY	08/15
REDDING CA	
MCCOLL'S DAIRY PROD	08/17

(Continued)

TABLE 10. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989
SAN JOSE CA	
MARQUEZ BROS MEXICAN CHEE	08/15
SAN LUIS OBISPO CA	
CAL POLY UNIV DAIRY	08/14
SAUGUS CA	
WAYSIDE HONOR RANCH	08/22
CRESENT CITY CA	
RUMIANO CHEESE CO	08/15
MANCHESTER CA	
CA CO-OP CREAMERY	08/15
FT COLLINS CO	
POUDRE VALLEY CREAMERY	07/26
GRAND JCT CO	
GRAFF DAIRY	08/19
CALDWELL ID	
DAIRYMENS CREAMERY ASSN	08/18
LEWISTON ID	
GOLDEN GRAIN DAIRY PROD	08/22
POCATELLO ID	
ROWLAND'S MEADOWGOLD DRY	08/28
TWIN FALLS ID	
TRIANGLE YOUNG'S DAIRY	08/25
KIMBALLTON IA	
ASSOC. MILK PRO.INC (AMPI)	06/13
LAKE MILLS IA	
LAKE MILLS COOP CRMY	06/19
LEMARS IA	
WELLS DAIRY	06/15
MANHATTAN KS	
KANSAS STATE UNIVERSITY	06/13
SHREVEPORT LA	
FOREMOST DAIRY	09/05
FERGUS FALLS MN	
MID-AMERICA DAIRYMEN	06/23
BROWERVILLE MN	
LAND O' LAKES, INC.	07/10
NICOLLET MN	
DOUG SCHULTZ FARM	06/21
JACKSON MO	
MID-AMERICA DAIRYMEN INC	06/13
JEFFERSON CITY MO	
CENTRAL DAIRY CO	06/09
BOZEMAN MT	
COUNTRY CLASSIC-DAIRYGOLD	06/06
GREAT FALLS MT	
MEADOW GOLD DAIRY	11/15
SOLEDAD CA	
CORR TRAINING FAC DAIRY	08/17
TRACY CA	
DEUEL VOC INST	08/15
SUPERIOR NE	
MID-AMERICA DAIRYMEN	07/01
FALLON NV	
CREAMLAND DAIRY	07/11
LOGANDALE NV	
NEVADA DAIRY	07/11
RENO NV	
MODEL DAIRY	07/11
YERINGTON NV	
VALLEY DAIRY	07/11
DEVILS LAKE ND	
LAKE VIEW DAIRY	08/30
FARGO ND	
CASS CLAY CREAMERY	09/18
ATOKA OK	
MUNGLE DAIRY	10/09
CLAREMORE OK	
SWAN BROS DAIRY	06/22
EUGENE OR	
LOCHMEAD FARMS INC.	08/17
GRANTS PASS OR	
VALLEY OF ROGUE DAIRY	08/16
OMAHA NE	
ROBERTS DAIRY-MARSHALL GR	06/27
CHAPPELL NE	
LEPRINO FOODS	06/29
KLAMATH FALLS, OR	
KLAMATH DAIRY PRODUCTS	07/30
COVE OR	
WILHARRY DAIRY	08/15
MYRTLE POINT OR	
SAFEWAY STORES INC	08/18
PORTLAND OR	
DARIGOLD FARMS	08/28
REDMOND OR	
EBERHARD'S CREAMERY INC	08/17
MITCHELL SD	
CULHANE DAIRY	08/08
VOLGA SD	
LAND O'LAKES INC	08/10
OGDEN UT	
WESTERN DAIRYMEN CO-OP	08/14
RICHFIELD UT	
IDEAL DAIRY	08/14
MOSES LAKE WA	
SAFEWAY STORES INC	08/21
RIVERTON WY	
WESTERN DAIRYMAN CO-OP	08/13

Section 4.2.5. Biomonitoring Program

D. D. Smith

The pathways for transport of radionuclides to humans include air, water and food. Monitoring of air, water, and milk are discussed elsewhere in this report. Meat from grazing animals and locally grown fruit and vegetables are food components that may be potential routes of exposure to offsite residents. Grazing animals ingest forage from large areas of ground surface and so represent a concentrating mechanism. Home garden vegetables may be a direct route of exposure for humans. Analysis of animal and vegetable samples is discussed in this section. Strontium-90 in bone samples was about the same as last year while plutonium was infrequently detected and only near the MDC level.

SECTION 4.2.5.1. METHODS

In the spring and fall of each year, four cattle are purchased from commercial beef herds that graze on areas adjacent to the NTS. The animals are sacrificed and necropsied. Bone and liver samples are analyzed for ^{90}Sr and for $^{238,239+240}Pu$. Muscle, kidney, lung, and thyroid are analyzed for gamma emitters and blood samples are analyzed for ^{3}H.

Once each quarter during the calendar year, a mule deer is collected from the NTS. These may be road kills or collected by hunting. Samples of muscle, liver, lung, thyroid, rumen contents, and bone are collected for analysis of $^{238,239+240}Pu$, the bone is also analyzed for ^{90}Sr and blood is analyzed for ^{3}H.

Also, for the last 32 years, during the desert bighorn sheep hunt each November and December in southern Nevada, licensed hunters donated bone and kidney samples to this Laboratory for analysis. The bone samples are analyzed for ^{90}Sr and $^{238,239+240}Pu$ while the kidney samples are analyzed for ^{3}H. The areas from which the bighorn sheep were collected are shown in Figure 26. Analytical data from bones and kidneys from desert bighorn sheep collected during the late fall of 1988 are presented in Table 11.

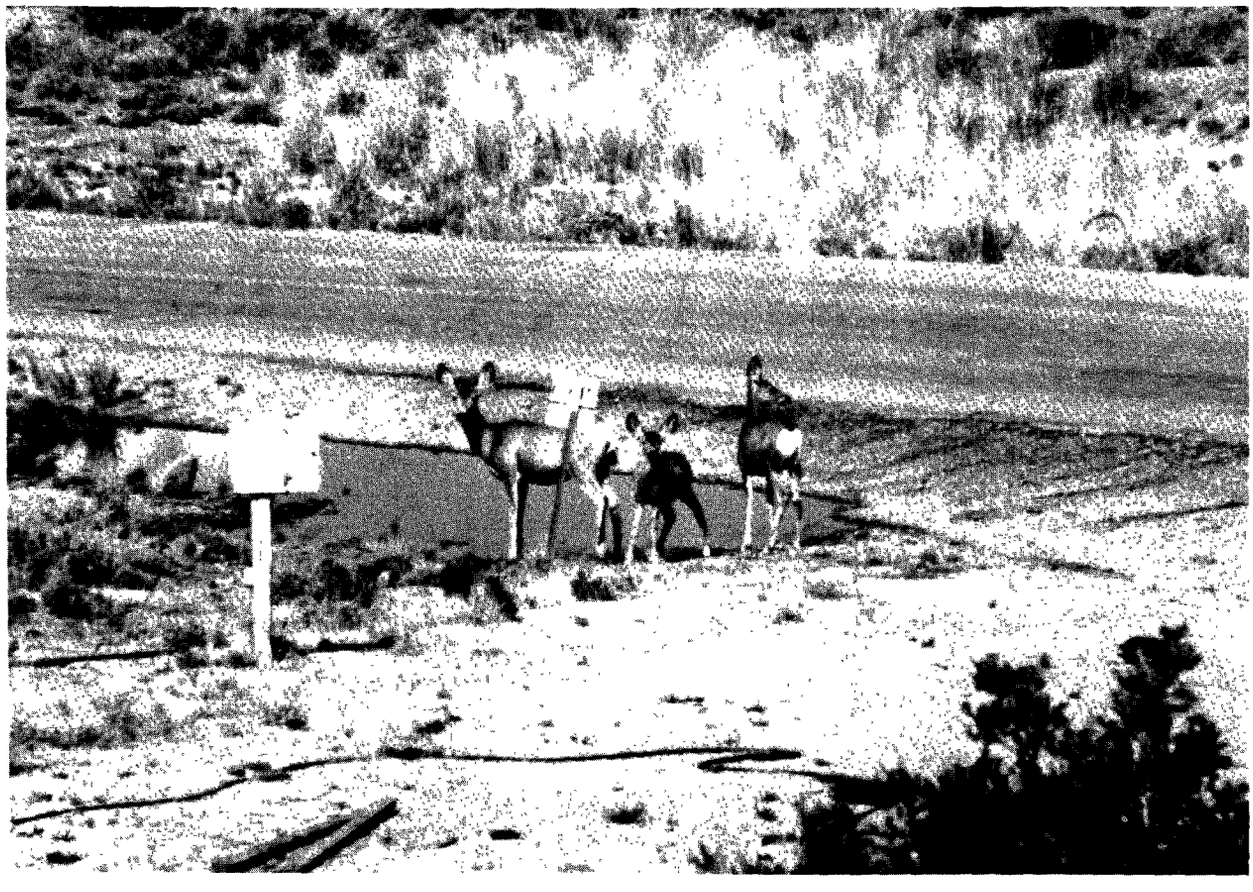

Figure 25. Mule Deer at the Nevada Test Site.

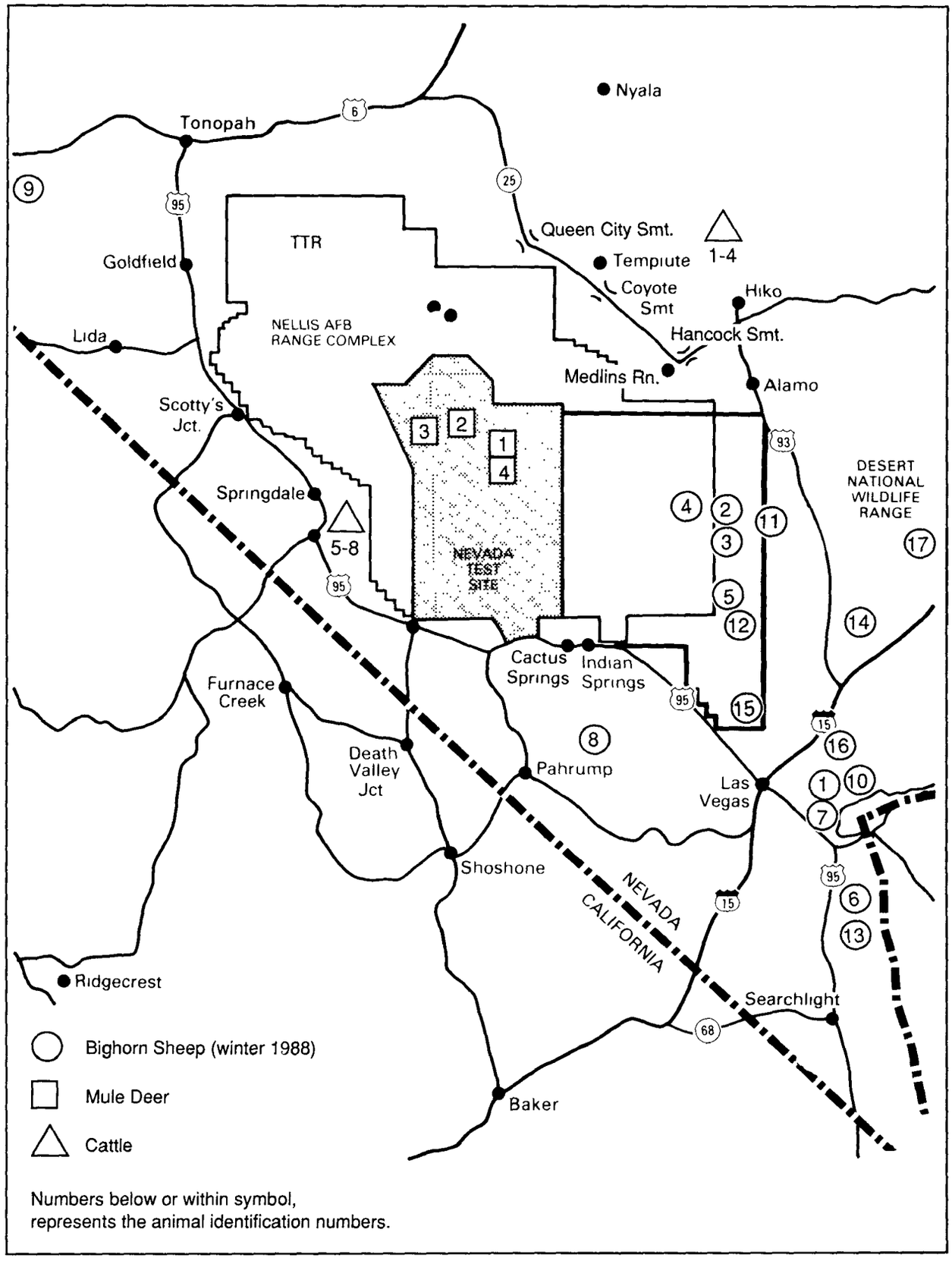

Figure 26. Collection Sites for Animals Sampled.

TABLE 11. RADIONUCLIDE CONCENTRATIONS IN DESERT BIGHORN SHEEP SAMPLES – 1988

BIGHORN SHEEP (COLLECTED WINTER 1988)	% ASH	BONE ^{90}Sr CONC. ±2 S.D. (pCi/g ASH)	BONE ^{238}Pu CONC. ±2 S.D. 10^{-3} pCi/g ASH)	BONE $^{239+240}Pu$ CONC. ±2 S.D. (10^{-3} pCi/g ASH)	KIDNEY ^{3}H CONC. ±2 S.D. (10^{-9} µCi/mL) †
1	21	0.06 ± 0.02	2.4 ± 5.5††	0.6 ± 1.3††	160 ± 350††
2	32	0.1 ± 0.03	7.9 ± 9.8††	1.1 ± 1.5††	-240 ± 350††
3	25	1.8 ± 0.09	4.8 ± 6.1††	0.4 ± 1.3††	1 ± 340††
4	28	1.3 ± 0.08	1.8 ± 5.7††	5.3 ± 3.1	150 ± 340††
5	33	1.4 ± 0.08	0.6 ± 5.7††	0.8 ± 1.6††	NC
6	29	0.1 ± 0.04	5.0 ± 6.0††	0.7 ± 1.4††	180 ± 340††
7	28	0.3 ± 0.02	5.0 ± 6.1††	0.7 ± 1.4††	520 ± 350
8	NC	NC	NC	NC	540 ± 350
9	39	1.4 ± 0.1	5.6 ± 6.0††	3.1 ± 2.3	NC
10	NC	NC	NC	NC	1 ± 300††
11	37	1.8 ± 0.1	1.7 ± 5.4††	1.3 ± 1.7††	-380 ± 340††
12	37	1.4 ± 0.08	2.4 ± 5.2††	2.4 ± 2.0	400 ± 350
13	26	0.2 ± 0.08	5.1 ± 6.5††	2.1 ± 2.2††	1 ± 300††
14	21	1.2 ± 0.08	3.6 ± 6.9††	7.6 ± 4.2††	330 ± 350††
15	26	0.1 ± 0.1	-0.5 ± 5.1††	2.8 ± 2.2	590 ± 350
16	35	0.6 ± 0.1	3.1 ± 5.5††	0.9 ± 1.5††	580 ± 350
17	NC	NC	NC	NC	400 ± 350
Median	28.5	0.9	3.35	1.2	180
Range	21 - 39	0.06 - 1.8	0.5 - 7.9	0.4 - 7.6	-380 - 590

† Aqueous portion of kidney tissue.
†† Counting error exceeds reported activity.
NC = Not collected.

In alternate years, an attempt is made to collect vegetables from home gardens in the near offsite areas or in the prevailing downwind direction. Samples of each type of vegetable, i.e., tubers (such as potatoes), fruits (such as tomatoes, squash) and leafy vegetables (such as chard) are collected if possible. These samples were analyzed by gamma spectrometry and for ^{3}H, ^{90}Sr, and $^{238,239+240}Pu$.

Water was extracted from the blood, kidney and vegetable samples for tritium analyses. Samples for ^{90}Sr and $^{238,239+240}Pu$ analyses were ashed prior to analysis. The analytical methods are summarized in Chapter 8 and the QA procedures in Chapter 6.

SECTION 4.2.5.2. RESULTS

The results obtained from analysis of all the animal tissues are shown in Table 12. Other than naturally occurring ^{40}K, only one of the 107 samples had a detectable gamma emitter, the concentration of ^{137}Cs in a cow liver sample was 0.028 ± 0.016 pCi/g. The sensitivity of the gamma analysis method is stated in Table 31.

The results of radiochemical analyses are shown as the median and range of concentrations detected in ashed samples. All of the ^{90}Sr levels in the 24 bone samples were above the MDC, but only one of the ^{238}Pu results was above the MDC. There were 10 detectable $^{239+240}Pu$ results; one in a cow bone sample and five in cow liver samples although the maximum concentration was only 0.025 pCi/g ash. There were also two detectable concentrations in deer lung samples and three in deer rumen content samples as might be expected for animals that graze on the NTS. The precision and bias of these radiochemical analyses, performed by a contract laboratory, are indicated by the results shown in Table 27 in the Quality Assurance Section of this report. A graph of the

average ^{90}Sr in bone from 1955 to date is shown in Figure 27. The 1989 data fit the pattern.

The ^{3}H analysis of cow blood samples and bighorn sheep kidney samples showed only background levels, median values <400 pCi/L, as is found in surface waters in this area. The blood samples from two deer, however, contained elevated levels of ^{3}H with a maximum of 580,000 pCi/L, due to the deer having access to the tunnel drainage ponds on the NTS. The unfenced tunnel drainage ponds of area 12, NTS continue to be a potential source of exposure to the offsite population which may consume meat from mule deer or migratory fowl that may have drank from those ponds.

The vegetable samples collected were as follows:

City & State	Type of sample
Virgin, Utah	Carrots and tomatoes
St. George, Utah	Beets and grapes
Castleton Farms, Nevada	Potatoes and zucchini squash
Rachel, Nevada	Turnips and Swiss chard
Hiko, Nevada	Potatoes and squash

Other than naturally occurring ^{40}K, there were no detectable gamma emitters, none of the samples had a ^{3}H, or a ^{90}Sr, or a ^{238}Pu concentration that exceeded the MDC. There was only one sample, the Swiss chard from Rachel, Nevada, that had a detectable $^{239+240}Pu$ concentration (0.017 ± 0.013 pCi/g ash). This may have been due to incomplete washing of the soil from the sample.

TABLE 12. RADIOCHEMICAL RESULTS FOR ANIMAL SAMPLES

SAMPLE TYPE (NO.)	ASH/FRESH WT. RATIO	^{90}Sr pCi/L MEDIAN (RANGE)	^{238}Pu pCi/L MEDIAN (RANGE)	$^{239+240}Pu$ pCi/L MEDIAN (RANGE)	^{3}H pCi/L MEDIAN (RANGE)
Cattle Blood (8)					420 (100,600)
Cattle Liver (8)	0.011		0.0023 (-0.0034,0.0096)	0.0081 (-0.046,0.025)	
Deer Muscle (3)	0.010		0.0017 (0.001,0.0042)	0.0024 (0.0001,0.0053)	
Deer Lung (3)	0.012		0.0087 (0.0004,0.016)	0.010 (0.0044,0.012)	
Deer Liver (3)	0.012		0.0018 (0.0001,0.0067)	0.0068 (0.0056,0.018)	
Deer Rumen Cont (3)	0.019		0.010 (0.005,0.013)	0.040 (0.040,0.040)	
Deer Blood (4)					15000 (1,580000)
Deer Bone (3)	0.327	1.2 (1.0,1.4)	0.002 (-0.0001,0.012)	0.0017 (0.0013,0.0020)	
Cattle Bone (7)*	0.195	0.8 (0.4,1.0)	0.0009 (-0.0001,0.0048)	0.0016 (0.0007,0.0033)	
Sheep Bone (14)	0.285	0.9 (0.06,1.8)	0.0034 (-0.0005,0.0079)	0.0012 (0.0004,0.0076)	
Sheep Kidney (15)					180 (-380,590)

* *One Cattle sample was lost.*

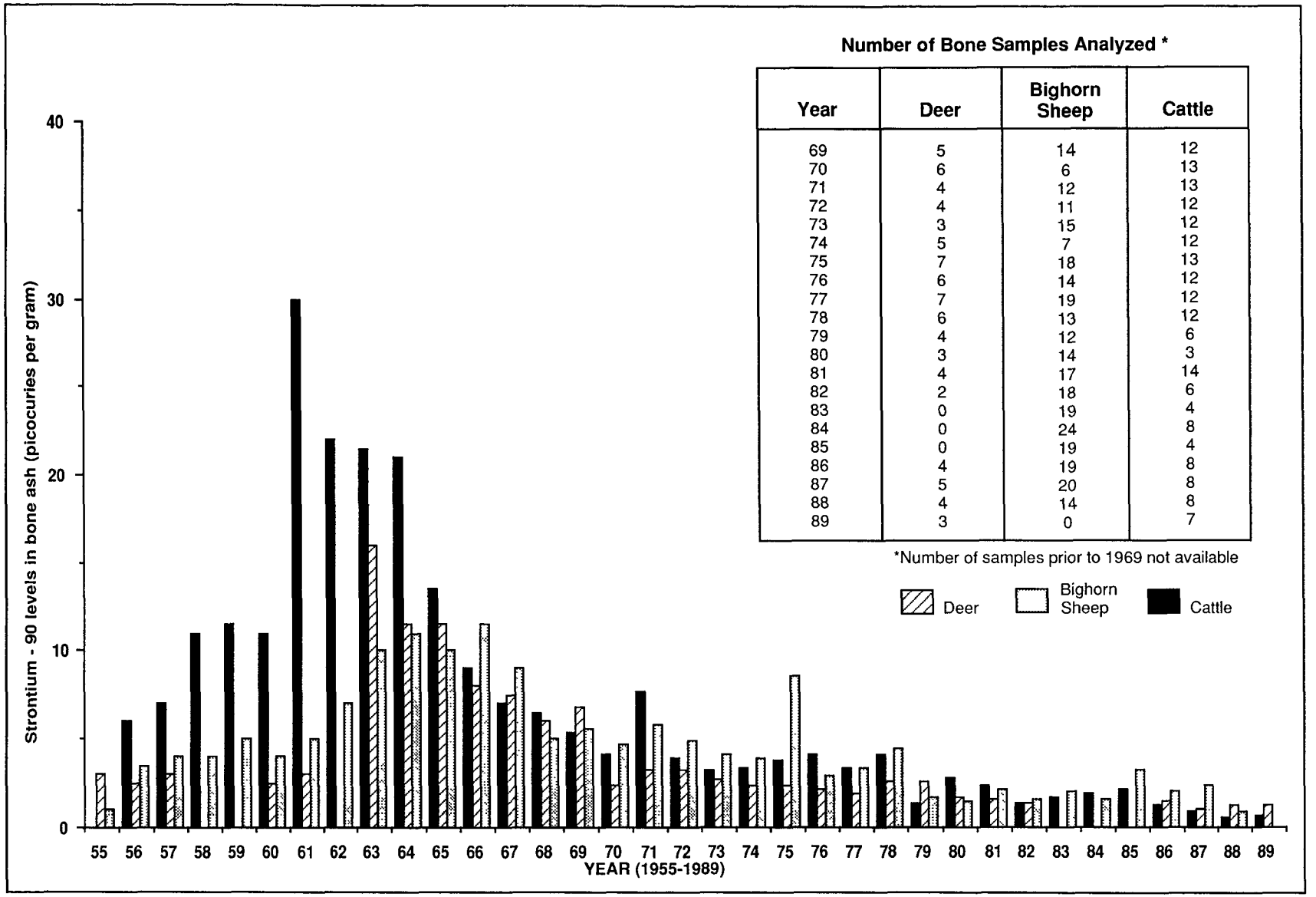

Figure 27. Average ^{90}Sr Concentrations in Animal Bone Ash.

Section 4.2.6. Thermoluminescent Dosimetry (TLD) Network

B. B. Dicey

A total of 65 individuals and 135 fixed environmental stations were monitored with TLDs in 1989. Of the 65 individuals monitored, 60 showed zero detectable exposure above that measured at the associated reference background location. Except for one individual who wore a TLD while undergoing a medical radiographic examination, none of the apparent individual exposures detectable above background represented a statistically significant variation from expected natural background levels at the monitored individual's location. During 1989, the maximum net annual exposure at a fixed environmental station was measured to be 316 mR. This exposure, at Warm Springs #2 (WS-2), NV, was determined to be due to high levels of naturally occurring radioactive material in ground water at that location. A detailed description of the Warm Springs monitoring location is included in this report. All other fixed environmental TLD results were within the range of natural background levels expected for any location in the United States. Statistical analysis of personnel and fixed environmental TLD results indicated no unexplained results outside the range of naturally occurring background radiation and also indicated that the distribution of measured exposures was consistent with natural (i.e., random) occurrences rather than discrete events such as planned or unplanned releases of radioactivity from NTS operations.

SECTION 4.2.6.1. NETWORK DESIGN

The primary method of measuring external ambient gamma radiation exposures is the thermoluminescent dosimeter (TLD). Since 1987, environmental and personnel monitoring for ambient gamma exposures have been accomplished using the Panasonic TLD system. This system provides greater sensitivity, precision, and tissue equivalence (for TLDs used to monitor offsite residents) than was possible using film or earlier TLD systems. This facilitates correlating individual measured exposures with the absorbed biological dose equivalent.

The TLD network is designed primarily to measure total ambient gamma exposures at fixed locations. A secondary function of the network is the measurement of exposures to a smaller number of specific in-

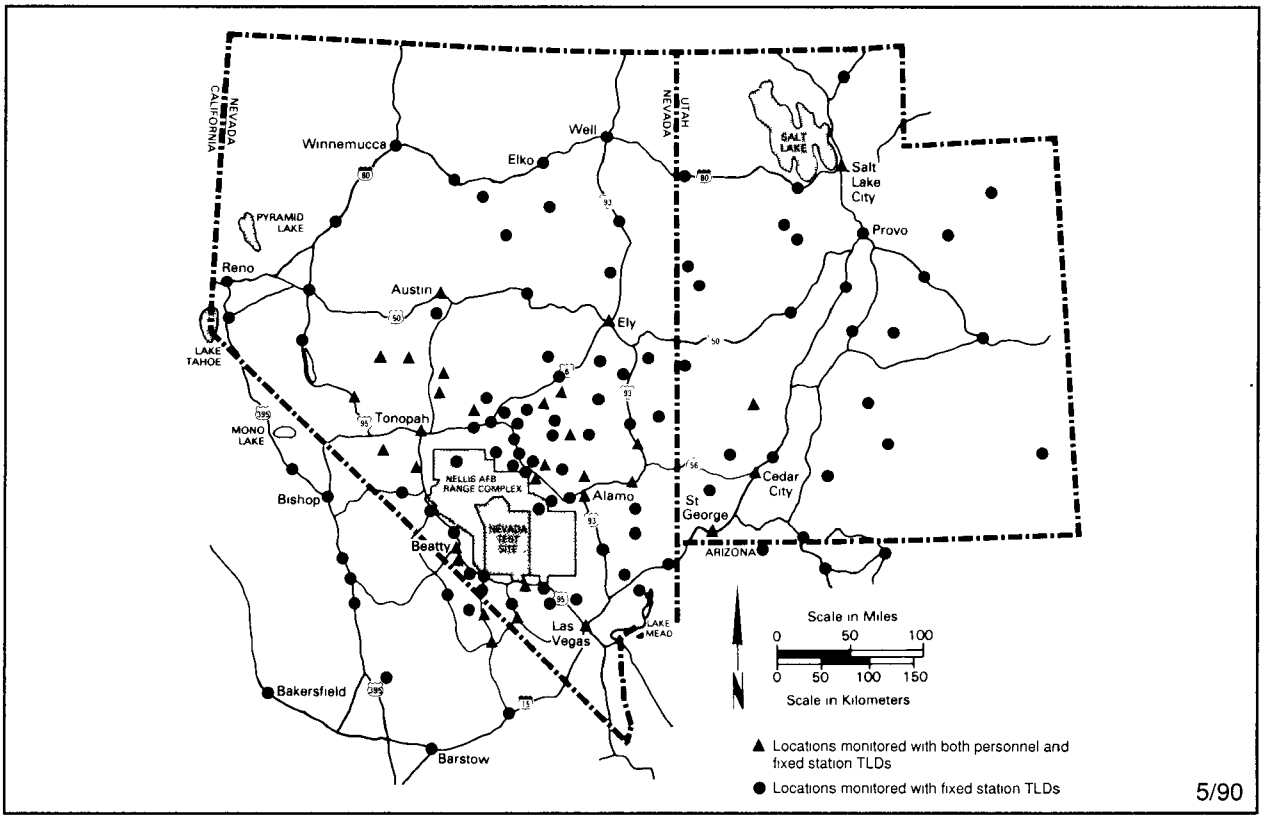

Figure 28. Locations Monitored with TLDs.

dividuals. Individuals monitored as part of this network live both within and outside estimated fallout zones from past nuclear tests at the Nevada Test Site. Measurement of exposures to individuals involves multiple uncontrollable variables associated with any personnel monitoring program. Measuring environmental ambient gamma exposures in fixed locations provides a reproducible index which can then be easily correlated to the maximum exposure an individual would have received were he continuously present at that location. Monitoring of individuals makes possible an estimate of individual exposures and helps to confirm the validity of correlating fixed-site ambient gamma measurements to projected individual exposures.

A network of environmental stations and monitored personnel has been established in locations encircling the NTS. Monitoring locations are shown on Figure 28. This arrangement facilitates estimation of average background exposures and detection of any increase due to NTS activities. TLDs used for routine monitoring of fixed environmental stations are deployed and read on a quarterly cycle. TLDs for monitored personnel are deployed and read on a monthly cycle.

Monitoring of offsite personnel is accomplished with the Panasonic UD-802 dosimeter. This dosimeter contains two elements of $Li_2B_4O_7$:Cu and two of $CaSO_4$:Tm phosphors. The four elements of the UD-802 dosimeter are behind 14, 300, 300, and 1000 mg/cm^2 filtration, respectively. These filtrations closely approximate the attenuation afforded by the dead layer of the skin, the cornea of the eye, and the "deep" tissues of the body.

The lithium borate used in the UD-802 dosimeter is $^{nat}Li_2{}^{nat}B_4O_7$ This compound is nearly as sensitive to neutron irradiations as is enriched $^6Li_2{}^{10}B_4O_7$. The neutron cross section for $^6Li_2{}^{10}B_4O_7$ is so high that its low abundance by weight in the natural compound is of little significance. The major consideration in neutron dosimetry is not so much sensitivity of a phosphor to neutrons as is the ability to determine neutron energy and thus to properly calculate an absorbed dose equivalent.

Monitoring of offsite environmental stations is accomplished with the Panasonic UD-814 dosimeter. This dosimeter contains a single element of $Li_2B_4O_7$:Cu and three replicate $CaSO_4$:Tm elements. The first element is filtered by 14 mg/cm^2 of plastic and the remaining three are filtered by 1000 mg/cm^2 of plastic+lead. The three replicate phosphors are used to provide improved statistics and extended response range. Figure 29 illustrates the construction of a typical Panasonic dosimeter.

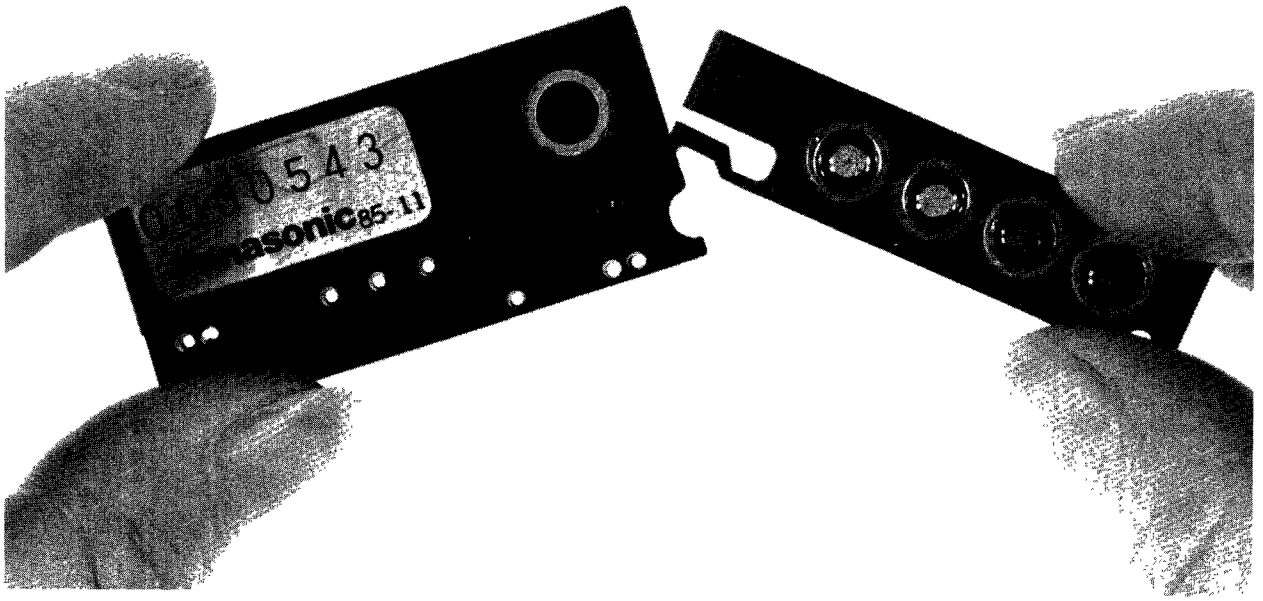

Figure 29. Construction of a Typical Panasonic Dosimeter.

Section 4.2.6.1.1. Results of TLD Monitoring - Offsite Personnel

During 1989, a total of 65 individuals living in areas surrounding the Nevada Test Site were provided with personnel TLD dosimeters. The TLDs used to monitor individuals are sensitive to beta, gamma, neutron, and to low and high energy x-radiations. The TLDs used to monitor fixed reference background locations are designed to be sensitive only to gamma and high-energy x-radiations. Because personnel dosimeters are cross-referenced to associated fixed reference background TLDs, all personnel exposures are presumed to be due to gamma or high energy x-radiations. Exposures of this type are numerically equivalent to absorbed dose. TLDs used to monitor individuals are provided in holders which are designed to be worn on the front of an individual's body, between the neck and the waist. When worn in this manner, the TLD may be used to estimate not only ambient gamma radiation exposure but also to characterize the absorbed radiation dose an individual may have received while wearing the dosimeter. Figure 30 illustrates a typical personnel TLD holder. TLDs issued to individuals are normally deployed and collected on a monthly schedule.

The net exposure to any individual is determined by comparing the results of each dosimeter issued to that individual with the results obtained from the previous four "valid" dosimeters located at the associated reference background location established for that individual. Reference background dosimeters measure ambient gamma radiation exposure. Any associated reference background dosimeter reading that varies by greater than a statistically determined amount (± 2 standard deviations) from the historical average for that location is not used in calculating net exposures to individuals because of the possibility that this variation could represent an anomaly or a contribution due to NTS activities. Also, reference background readings containing less than three useable phosphors are not included in the calculation. This situation could arise in the event one of the two dosimeters included in a fixed environmental station deployment were damaged or otherwise unreadable. In either case, (unacceptable variation from historical average or insufficient number of phosphors) additional historical data points are then selected for calculating the historic average until a total of four is available. By this method, a consistent number of prior data points in the average is selected and also individual TLDs that may have received elevated exposures due to an episodic occurrence are excluded from "natural background."

Of the 65 individuals monitored, 60 showed zero detectable exposure above that measured at the as-

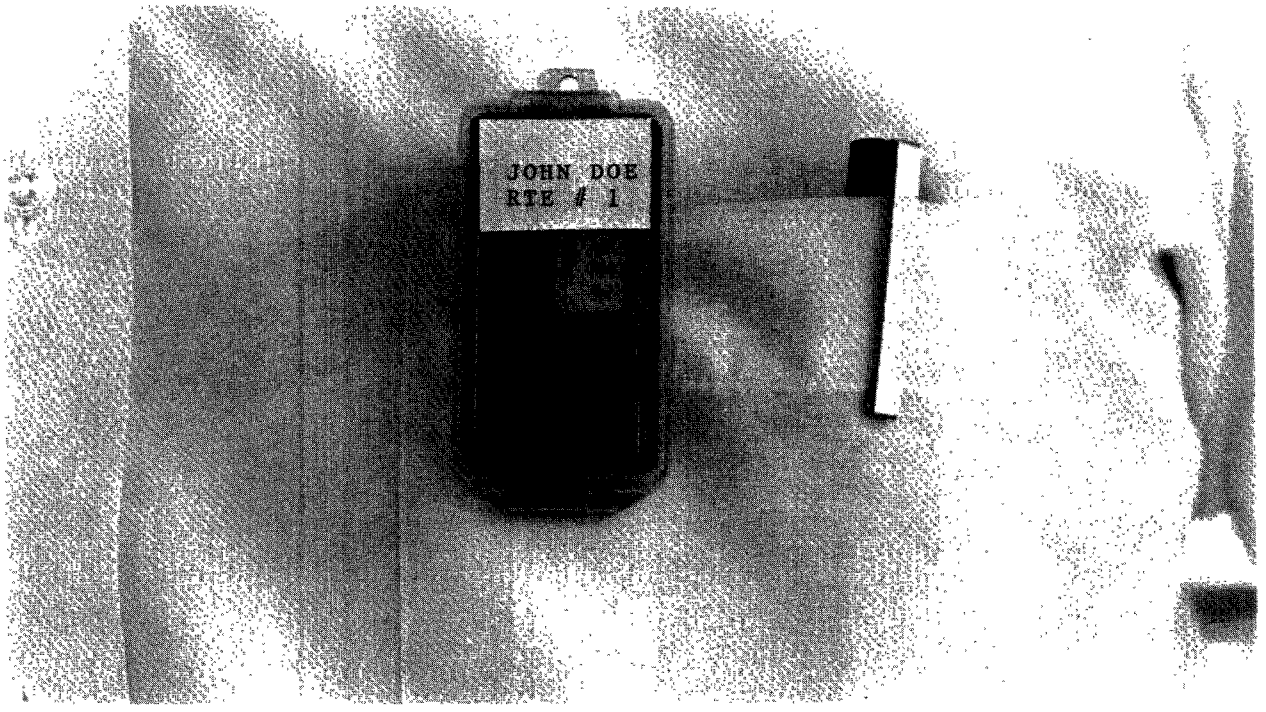

Figure 30. Typical Personnel TLD Holder as Worn by Individual.

sociated reference background location. The apparent individual exposures were slightly greater than the associated reference background. These ranged from 16 to 48 mrem absorbed dose equivalent for the year. Each of these represented total exposures obtained from several dosimeters worn during the year. Apparent exposures to an individual dosimeter of less than three times the associated reference background are considered to be within the range of normal variation for the Panasonic TLD system. Therefore, none of the three apparent net individual exposures are considered to represent an abnormal occurrence. Table 13 lists the results of offsite personnel TLD monitoring for 1989.

TABLE 13. OFFSITE RESIDENT TLD RESULTS — 1989

RESIDENT ID NUMBER	ASSOCIATED REFERENCE BACKGROUND LOCATION	MEASUREMENT PERIOD		ELAPSED TIME (days)	EQUIVALENT DOSE RATE (mrem/day)			ANNUAL MEASURED DOSE (mrem/yr) mrem/yr = AVERAGE mrem/day X # of DAYS	ASSOCIATED REFERENCE BACKGROUND EXPOSURE ±2 S.D. (mR/year)
		ISSUE DATE	COLLECT DATE		MAX	MIN	AVG		
>>> PERSONNEL MONITORED IN ARIZONA <<<									
No individuals residing in Arizona were monitored during the period covered by this report.									
>>> PERSONNEL MONITORED IN CALIFORNIA <<<									
359	Death Valley Jct., CA	04/04/89	01/04/90	275	0.28	0.06	0.21	58	50 ±2
304	Death Valley Jct., CA	01/06/89	01/05/90	364	0.45	0.16	0.32	116	66 ±3
331	Death Valley Jct., CA	01/05/89	04/04/89	89	0.15	0.03	0.10	9	16 ±1
60	Shoshone, CA	01/04/89	01/02/90	363	0.35	0.01	0.15	54	51 ±2
>>> PERSONNEL MONITORED IN NEVADA <<<									
22	Alamo, NV	01/04/89	01/10/90	371	0.22	0.06	0.11	41	67 ±3
329	Austin, NV	01/12/89	01/10/90	363	0.40	0.07	0.20	73	98 ±5
38	Beatty, NV	01/06/89	01/04/90	363	0.52	0.19	0.28	102	87 ±4
21	Beatty, NV	01/06/89	01/04/90	363	0.38	0.07	0.20	73	87 ±4
9	Blue Eagle Ranch, NV	01/04/89	01/03/90	364	0.37	0.03	0.13	47	44 ±2
2	Caliente, NV	01/04/89	01/08/90	369	0.33	0.11	0.22	81	70 ±3
336	Caliente, NV	01/04/89	01/08/90	369	0.27	0.03	0.14	52	70 ±3
11	Complex 1, NV	01/05/89	01/09/90	369	0.34	0.10	0.22	81	85 ±4
10	Complex 1, NV	01/05/89	01/09/90	369	0.34	0.08	0.22	81	85 ±4
56	Corn Creek, NV	01/03/89	01/02/90	364	0.23	0.02	0.09	33	25 ±1
25	Corn Creek, NV	01/03/89	01/02/90	364	0.18	0.03	0.08	29	25 ±1
15	Coyote Summit, NV	01/04/89	01/09/90	370	0.23	0.04	0.15	56	89 ±4
14	Coyote Summit, NV	01/04/89	01/09/90	370	0.21	0.06	0.15	56	89 ±4
233	Ely, NV	01/11/89	01/08/90	362	0.19	0.05	0.11	40	58 ±3
47	Ely, NV	01/11/89	01/08/90	362	0.32	0.05	0.14	51	58 ±3
302	Gabbs, NV	01/10/89	01/09/90	364	0.19	0.07	0.13	47	47 ±2
343	Gabbs, NV	01/10/89	11/07/89	301	0.25	0.04	0.15	45	39 ±2
7	Goldfield, NV	01/11/89	01/16/90	370	0.23	0.08	0.15	56	59 ±3
19	Goldfield, NV	01/11/89	01/17/90	371	0.27	0.03	0.15	56	59 ±3

(Continued)

TABLE 13. (Continued)

RESIDENT ID NUMBER	ASSOCIATED REFERENCE BACKGROUND LOCATION	MEASUREMENT PERIOD		ELAPSED TIME (days)	EQUIVALENT DOSE RATE (mrem/day)			ANNUAL MEASURED DOSE (mrem/yr) mrem/yr = AVERAGE mrem/day X # of DAYS	ASSOCIATED REFERENCE BACKGROUND EXPOSURE ±2 S.D. (mR/year)
		ISSUE DATE	COLLECT DATE		MAX	MIN	AVG		
40	Goldfield, NV	01/11/89	01/12/90	366	0.83	0.09	0.23	84	59 ±3
232	Hiko, NV	01/04/89	01/09/90	370	0.20	0.02	0.12	44	67 ±3
3	Hot Creek Ranch, NV	01/05/89	01/04/90	364	0.44	0.09	0.21	76	66 ±3
37	Indian Springs, NV	01/03/89	01/02/90	364	0.20	0.03	0.10	36	29 ±1
6	Indian Springs, NV	01/03/89	01/02/90	364	0.23	0.03	0.12	44	29 ±1
381	Ione, NV	11/07/89	01/09/90	63	0.27	0.08	0.17	11	13 ±1
300	Koyne's Ranch, NV	01/12/89	01/09/90	362	0.24	0.09	0.15	54	65 ±3
49	Las Vegas (UNLV), NV	01/03/89	01/02/90	364	0.22	0.02	0.09	33	18 ±1
377	Las Vegas (USDI), NV	07/31/89	01/02/90	155	0.27	0.02	0.12	19	16 ±1
349	Las Vegas (USDI), NV	01/03/89	04/03/89	90	0.06	0.04	0.05	5	9 ±0.4
376	Las Vegas (USDI), NV	07/31/89	01/02/90	155	0.20	0.05	0.11	17	16 ±1
297	Las Vegas (USDI), NV	01/03/89	01/02/90	364	0.13	0.01	0.05	18	36 ±2
326	Las Vegas (USDI), NV	01/03/89	01/02/90	364	0.23	0.03	0.09	33	36 ±2
342	Lavada's Market, NV	01/04/89	01/04/90	365	0.36	0.07	0.16	58	66 ±3
380	Lavada's Market, NV	09/05/89	01/04/90	121	0.38	0.15	0.25	30	22 ±1
379	Manhattan, NV	09/13/89	01/10/90	119	0.29	0.17	0.23	27	31 ±1
307	Mina, NV	01/10/89	01/09/90	364	0.25	0.08	0.17	62	69 ±3
18	Nyala, NV	01/04/89	01/03/90	364	0.29	0.03	0.15	55	58 ±3
348	Overton, NV	01/10/89	01/04/90	359	0.21	0.02	0.09	32	43 ±2
372	Pahrump, NV	07/06/89	01/02/90	180	0.14	0.02	0.08	14	14 ±1
354	Pahrump, NV	01/04/89	07/06/89	183	0.22	0.02	0.14	26	15 ±1
36	Pahrump, NV	01/04/89	01/02/90	363	0.16	0.03	0.09	33	29 ±1
248	Penoyer Farms, NV	01/05/89	01/09/90	369	0.29	0.03	0.16	59	92 ±4
293	Pioche, NV	01/04/89	01/08/90	369	0.23	0.06	0.14	52	59 ±3
264	Rachel, NV	01/05/89	01/09/90	369	0.30	0.10	0.20	74	85 ±4
54	Rachel, NV	01/03/89	03/27/89	83	0.12	0.01	0.05	4	19 ±1
334	Rachel, NV	01/05/89	01/09/90	369	0.27	0.04	0.16	59	85 ±4
299	Round Mountain, NV	01/12/89	01/10/90	363	0.33	0.10	0.23	83	80 ±4
341	Silver Peak, NV	01/11/89	01/17/90	371	0.31	0.07	0.18	67	70 ±3
29	Stone Cabin Ranch, NV	01/04/89	01/03/90	364	0.31	0.03	0.21	76	87 ±4
42	Tonopah, NV	01/13/89	01/19/90	371	0.35	0.10	0.20	74	89 ±4
339	Tonopah, NV	01/11/89	01/11/90	365	0.27	0.15	0.21	77	88 ±4
8	Twin Springs Ranch, NV	01/04/89	05/02/89	118	0.29	0.20	0.25	30	28 ±1
370	Twin Springs Ranch, NV	06/06/89	01/03/90	211	0.24	0.03	0.16	34	51 ±2
358	US Ecology, NV	03/09/89	01/04/90	301	0.43	0.15	0.26	78	72 ±3
>>> PERSONNEL MONITORED IN UTAH <<<									
44	Cedar City, UT	01/04/89	01/04/90	365	0.21	0.04	0.14	51	44 ±2
345	Delta, UT	01/06/89	01/08/90	367	0.81	0.05	0.22	81	55 ±3
344	Delta, UT	01/06/89	01/08/90	367	0.22	0.03	0.13	48	55 ±3
347	Milford, UT	01/06/89	01/08/90	367	0.29	0.04	0.17	62	88 ±4
346	Milford, UT	01/06/89	01/08/90	367	0.28	0.07	0.17	62	88 ±4
52	Salt Lake City, UT	01/04/89	01/03/90	364	0.31	0.09	0.17	62	44 ±2
45	St. George, UT	01/06/89	01/04/90	363	0.20	0.03	0.10	36	33 ±2

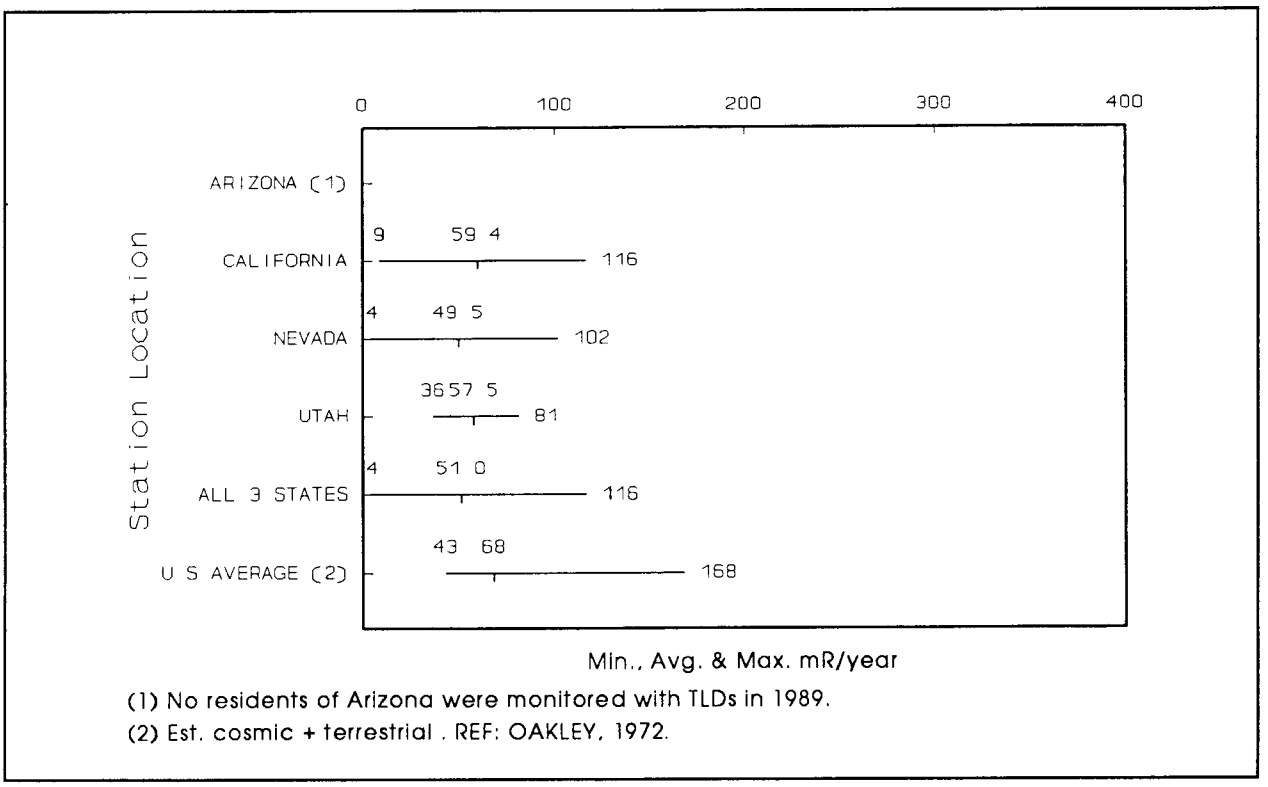

Figure 31. Summary of Ambient Gamma Exposures of Offsite Residents by State — 1989.

Figure 31 summarizes TLD monitoring results for offsite residents living in California, Nevada, and Utah. There was no statistically significant difference among the States in the recorded minima, maxima, or averages.

Section 4.2.6.1.2. Results of TLD Monitoring - Offsite Stations

During 1989 a total of 135 offsite stations were monitored to determine background ambient gamma radiation levels. Each station has a custom designed holder that can hold from one to four Panasonic TLDs. Normal operations involve packaging two TLDs in a heat-sealed bag to provide protection from the elements and placing the dosimeter packet into the fixed station holder. Figure 32 illustrates a typical fixed environmental TLD monitoring station. Fixed environmental monitoring TLDs are normally deployed for a period of approximately three months (one calendar quarter).

The annual adjusted ambient gamma exposure (mR/year) was calculated by multiplying the average daily rate for each station by 365. A review of the measurement periods shows that few stations were monitored for exactly 365 days. However, when the results of a "nominal" 365 day year are compared with the results obtained by multiplying the average mR/day by the actual number of days, calculational differences are less than 1 mR/year. This is considered to be an insignificant discrepancy.

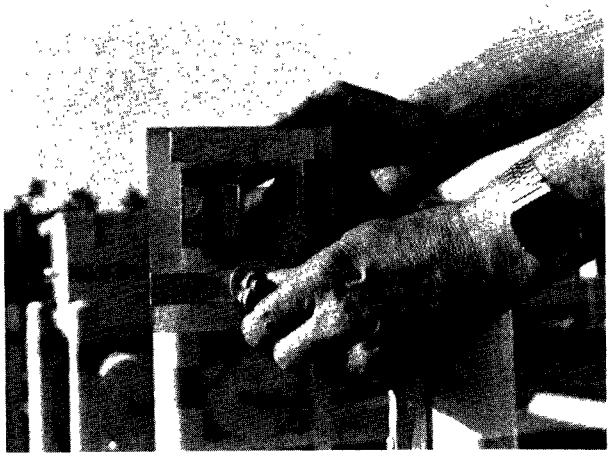

Figure 32. Typical Fixed Environmental TLD Monitoring Station.

TABLE 14. OFFSITE RESIDENT TLD RESULTS — 1989

	OFFSITE RESIDENT TLD STATISTICS — 1989					
	ARIZONA	CALIFORNIA	NEVADA	UTAH	ALL 3 STATES	U.S. AVERAGE
Number of Individuals Monitored:	0	4	54	7	65	
Number of Days Each Station Monitored:						
Minimum		89	63	363	63	
Maximum		364	371	367	371	
Average		272.8	316.4	365.7	319.0	
Standard Deviation		112.1	95.0	1.6	93.0	
Calculated C.V.		41.1%	30.0%	0.4%	29.2%	
Equivalent Daily Ambient Gamma Exposures (mR/day)						
Minimum		0.01	0.01	0.03	0.01	
Maximum		0.45	0.83	0.81	0.83	
Average		0.195	0.156	0.157	0.158	
Standard Deviation		0.082	0.057	0.035	0.057	
Calculated C.V.		42.1%	36.4%	22.5%	36.3%	
Calculated Annual Ambient Gamma Exposures (mR/year) (Reference background NOT subtracted)						
Minimum		9	4	36	4	43
Maximum		116	102	81	116	168
Average		59.4	49.5	57.5	51.0	68
Standard Deviation		38.2	22.9	13.1	23.6	
Calculated C.V.		64.3%	46.3%	22.7%	46.2%	

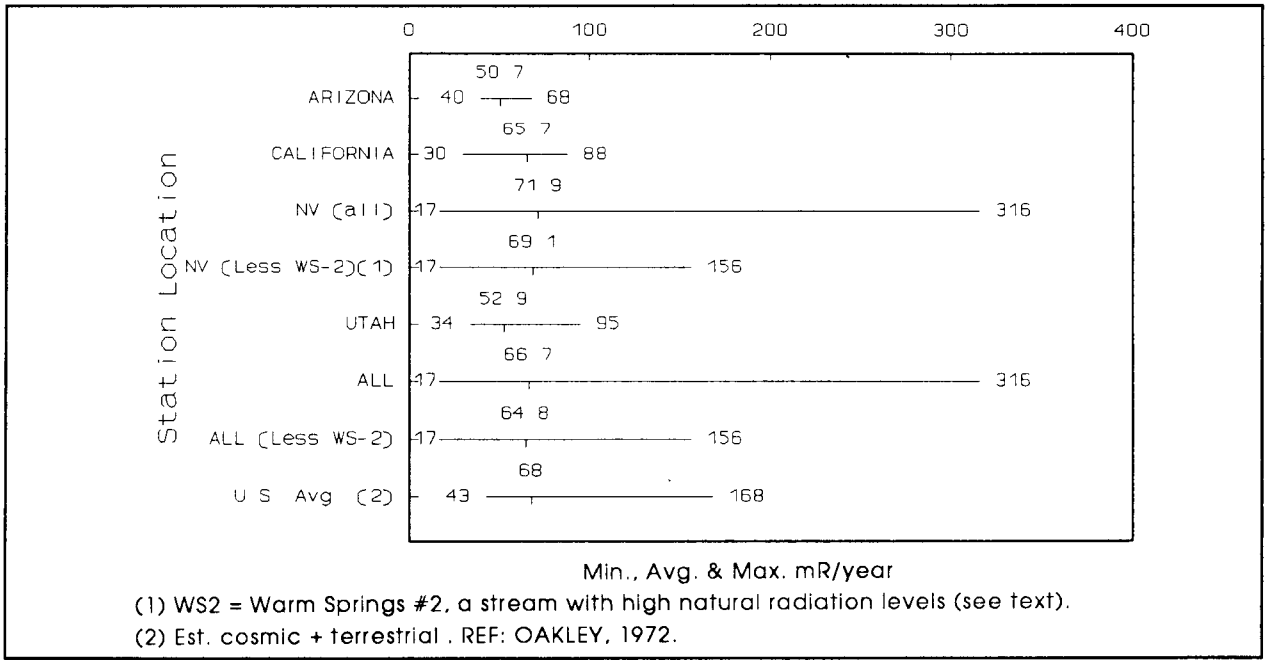

Figure 33. Range of Ambient Gamma Exposures of Fixed Environmental Stations by State — 1989.

Annual exposures measured at fixed environmental stations ranged from 17 to 316 mR, with an average of 66 ± 32 mR. These values represent gross ambient gamma radiation levels measured at the respective locations.

The primary function of fixed environmental station TLDs is to characterize ambient (natural background) gamma radiation fields. The practice of subtracting reference background readings from fixed environmental station results is valid only to evaluate whether a single measurement varies by a significant amount from the historical record for that location.

The extremes occurred at the University of Nevada Las Vegas and Warm Springs #2 fixed monitoring locations, respectively. Tables 15 and 16 detail the results obtained at each of the fixed environmental stations monitored by TLDs during 1989. Figure 33 summarizes the results obtained from measurements of natural background ambient gamma radiation levels at fixed environmental station locations. This figure also illustrates that, when data from Warm Springs #2 is excluded, the averages and ranges of measured ambient gamma exposures is very similar throughout the geographic area covered by this network.

The exposure at Warm Springs #2, NV, was determined to be due to high levels of naturally occurring radioactive material in ground water at that location. A second TLD, Warm Springs #1, NV, is located in a parking lot approximately 100 feet from the spring. Details of a special evaluation conducted of the Warm Springs site are included below.

TABLE 15. OFFSITE STATION TLD RESULTS — 1989

STATION LOCATION	MEASUREMENT PERIOD ISSUE DATE	MEASUREMENT PERIOD COLLECT DATE	ELAPSED TIME (days)	MEASURED DAILY EXP. EQUIVALENT (mR/day) MAX	MIN	AVG	GAMMA EXPOSURE (mR/year ± 2 S.D.) [mR/yr = AVG. mR/day X 365]
>>> STATIONS LOCATED IN ARIZONA <<<							
Colorado City, AZ	11/01/88	11/06/89	370	0.16	0.10	0.12	44 ± 18
Jacob's Lake, AZ	11/01/88	11/06/89	370	0.22	0.15	0.19	68 ± 22
Page, AZ	11/01/88	11/07/89	371	0.13	0.09	0.11	40 ± 12
>>> STATIONS LOCATED IN CALIFORNIA <<<							
Baker, CA	11/02/88	11/07/89	370	0.20	0.12	0.17	64 ± 24
Barstow, CA	11/02/88	11/07/89	370	0.29	0.18	0.24	88 ± 34
Bishop, CA	11/02/88	11/14/89	377	0.27	0.18	0.23	83 ± 28
Death Valley Jct., CA	01/06/89	01/05/90	364	0.22	0.16	0.18	65 ± 18
Furnace Creek, CA	01/06/89	01/05/90	364	0.15	0.12	0.13	48 ± 10
Independence, CA	11/02/88	11/08/89	371	0.20	0.17	0.19	69 ± 10
Lone Pine, CA	11/02/88	11/08/89	371	0.21	0.15	0.18	67 ± 18
Mammoth Geothermal, CA	11/02/88	11/14/89	377	0.25	0.18	0.23	83 ± 22
Mammoth Lakes, CA	11/02/88	11/14/89	377	0.25	0.16	0.21	78 ± 28
Olancha, CA	11/02/88	11/08/89	371	0.22	0.15	0.19	68 ± 22
Ridgecrest, CA	11/02/88	11/08/89	371	0.19	0.14	0.17	61 ± 16
Shoshone, CA	11/01/88	11/07/89	371	0.15	0.11	0.14	50 ± 12
Valley Crest, CA	01/06/89	01/05/90	364	0.10	0.08	0.08	30 ± 6
>>> STATIONS LOCATED IN NEVADA <<<							
Alamo, NV	11/03/88	11/01/89	363	0.22	0.14	0.18	66 ± 24
American Borate, NV	01/04/89	01/02/90	363	0.23	0.20	0.22	79 ± 10
Atlanta Mie, NV	12/01/88	12/01/89	365	0.17	0.13	0.15	56 ± 12
Austin, NV	11/22/88	11/08/89	351	0.31	0.21	0.27	100 ± 28
Battle Mountain, NV	11/29/88	12/13/89	379	0.17	0.14	0.16	58 ± 10
Beatty, NV	01/04/89	01/04/90	365	0.29	0.22	0.24	89 ± 22

(Continued)

TABLE 15. (Continued)

STATION LOCATION	MEASUREMENT PERIOD ISSUE DATE	MEASUREMENT PERIOD COLLECT DATE	ELAPSED TIME (days)	MEASURED DAILY EXP. EQUIVALENT (mR/day) MAX	MIN	AVG	GAMMA EXPOSURE (mR/year ± 2 S.D.) [mR/yr= AVG. mR/day X 365]
Blue Eagle Ranch, NV	01/04/89	01/03/90	364	0.14	0.10	0.12	43 ± 12
Blue Jay, NV	01/05/89	01/04/90	364	0.32	0.23	0.26	96 ± 28
Cactus Springs, NV	11/01/88	11/06/89	370	0.11	0.07	0.10	35 ± 12
Caliente, NV	11/01/88	11/01/89	365	0.22	0.15	0.19	68 ± 20
Carp, NV	11/03/88	11/01/89	363	0.19	0.12	0.16	59 ± 20
Cherry Creek, NV	12/01/88	11/29/89	363	0.22	0.19	0.21	77 ± 10
Clark Station, NV	01/04/89	01/03/90	364	0.28	0.21	0.23	86 ± 22
Coaldale, NV	11/08/88	11/07/89	364	0.27	0.21	0.23	83 ± 18
Complex 1, NV	11/02/88	11/01/89	364	0.27	0.17	0.23	83 ± 30
Corn Creek, NV	11/01/88	11/06/89	370	0.07	0.06	0.07	24 ± 4
Cortez Rd/Hwy 278, NV	11/29/88	12/12/89	378	0.26	0.20	0.23	85 ± 18
Coyote Summit, NV	11/03/88	11/01/89	363	0.27	0.20	0.24	87 ± 20
Crescent Valley, NV	11/29/88	12/12/89	378	0.17	0.14	0.16	59 ± 10
Crystal, NV	11/01/88	01/30/89	90	0.09	0.09	0.09	34 ± 0
Currant, NV	01/05/89	01/04/90	364	0.24	0.18	0.21	75 ± 18
Currie, NV	12/01/88	11/29/89	363	0.23	0.20	0.21	77 ± 10
Diablo Maint Sta, NV	01/06/89	01/05/90	364	0.31	0.21	0.26	94 ± 30
Duckwater, NV	01/05/89	01/04/90	364	0.22	0.17	0.19	71 ± 14
Elgin, NV	11/03/88	11/01/89	363	0.71	0.24	0.39	143 ± 142
Elko, NV	11/29/88	12/12/89	378	0.15	0.13	0.14	52 ± 6
Ely, NV	12/01/88	11/29/89	363	0.19	0.15	0.16	58 ± 12
Eureka, NV	01/05/89	01/04/90	364	0.39	0.19	0.25	93 ± 62
Fallon, NV	12/01/88	12/14/89	378	0.16	0.13	0.15	54 ± 10
Flying Diamond Camp, NV	11/02/88	11/01/89	364	0.16	0.13	0.14	52 ± 10
Gabbs, NV	11/16/88	11/07/89	356	0.17	0.11	0.13	49 ± 18
Geyser Ranch, NV	12/01/88	12/01/89	365	0.22	0.17	0.20	73 ± 16
Goldfield, NV	11/07/88	11/09/89	367	0.22	0.07	0.16	60 ± 46
Groom Lake, NV	11/08/88	11/13/89	370	0.18	0.13	0.17	61 ± 16
Halloway Ranch, NV	01/05/89	03/03/89	57	0.08	0.08	0.08	30 ± 0
Hancock Summit, NV	11/03/88	11/01/89	363	0.66	0.31	0.43	156 ± 106
Hiko, NV	11/03/88	11/01/89	363	0.29	0.11	0.18	64 ± 54
Hot Creek Ranch, NV	01/05/89	01/04/90	364	0.20	0.15	0.18	64 ± 14
Indian Springs, NV	11/01/88	11/06/89	370	0.09	0.07	0.08	29 ± 6
Ione, NV	11/16/88	11/07/89	356	0.22	0.19	0.20	74 ± 8
Kirkeby Ranch, NV	12/01/88	12/01/89	365	0.17	0.11	0.14	52 ± 18
Koyne's Ranch, NV	11/03/88	11/01/89	363	0.21	0.15	0.18	66 ± 18
Las Vegas Airport, NV	01/03/89	01/02/90	364	0.09	0.03	0.07	24 ± 12
Las Vegas (UNLV), NV	01/03/89	01/02/90	364	0.06	0.01	0.05	17 ± 16
Las Vegas (USDI), NV	01/03/89	01/02/90	364	0.12	0.07	0.10	37 ± 14
Lathrop Wells, NV	01/04/89	01/02/90	363	0.21	0.17	0.19	69 ± 12
Lavada's Market, NV	01/04/89	01/04/90	365	0.21	0.16	0.18	66 ± 16
Lida, NV	11/08/88	11/01/89	358	0.21	0.17	0.19	71 ± 12
Lovelock, NV	11/30/88	12/13/89	378	0.15	0.13	0.14	52 ± 6
Lund, NV	12/01/88	11/30/89	364	0.17	0.15	0.16	60 ± 6
Manhattan, NV	11/17/88	11/08/89	356	0.29	0.24	0.26	95 ± 14
Medlin's Ranch, NV	11/01/88	11/01/89	365	0.26	0.17	0.22	82 ± 26
Mesquite, NV	11/01/88	11/02/89	366	0.12	0.08	0.10	37 ± 12

(Continued)

TABLE 15. (Continued)

STATION LOCATION	MEASUREMENT PERIOD ISSUE DATE	MEASUREMENT PERIOD COLLECT DATE	ELAPSED TIME (days)	MEASURED DAILY EXP. EQUIVALENT (mR/day) MAX	MIN	AVG	GAMMA EXPOSURE (mR/year ± 2 S.D.) [mR/yr = AVG. mR/day X 365]
Mina, NV	11/16/88	11/07/89	356	0.22	0.17	0.19	69 ± 14
Moapa, NV	11/01/88	11/02/89	366	0.20	0.08	0.15	54 ± 36
Mtn Meadows Ranch, NV	01/04/89	01/03/90	364	0.15	0.11	0.12	45 ± 12
Nash Ranch, NV	11/03/88	11/01/89	363	0.18	0.09	0.14	52 ± 26
Nevada LLW Site, NV	03/22/89	01/04/90	288	0.60	0.23	0.34	123 ± 90
Nyala, NV	01/04/89	01/03/90	364	0.18	0.15	0.16	59 ± 10
Overton, NV	11/01/88	11/02/89	366	0.13	0.10	0.12	43 ± 10
Pahrump, NV	11/01/88	11/06/89	370	0.09	0.06	0.08	27 ± 10
Penoyer Farms, NV	11/02/88	11/01/89	364	0.29	0.20	0.25	90 ± 26
Pine Creek Ranch, NV	11/03/88	11/01/89	363	0.30	0.21	0.26	95 ± 26
Pioche, NV	11/01/88	11/01/89	365	0.19	0.14	0.16	60 ± 16
Queen City Summit, NV	01/06/89	01/05/90	364	0.30	0.26	0.28	101 ± 12
Rachel, NV	11/03/88	11/01/89	363	0.27	0.19	0.23	85 ± 24
Reed Ranch, NV	01/06/89	01/05/90	364	0.29	0.22	0.24	89 ± 22
Reno, NV	11/30/88	12/14/89	379	0.15	0.13	0.14	52 ± 6
Round Mountain, NV	11/14/88	11/08/89	359	0.25	0.14	0.22	79 ± 34
Ruby Valley, NV	11/29/88	12/12/89	378	0.25	0.18	0.22	81 ± 22
S Desert Corr Ctr, NV	11/01/88	11/06/89	370	0.09	0.05	0.07	25 ± 12
Shurz, NV	12/01/88	12/14/89	378	0.24	0.19	0.22	79 ± 16
Silver Peak, NV	11/16/88	11/07/89	356	0.22	0.15	0.19	69 ± 20
Springdale, NV	01/05/89	01/04/90	364	0.27	0.21	0.24	87 ± 18
Steward Ranch, NV	12/01/88	12/01/89	365	0.26	0.21	0.23	85 ± 16
Stone Cabin Ranch, NV	01/04/89	01/03/90	364	0.29	0.20	0.24	87 ± 26
Sunnyside, NV	12/01/88	11/30/89	364	0.11	0.07	0.09	34 ± 12
Tempiute, NV	11/02/88	11/01/89	364	0.30	0.21	0.25	90 ± 26
Tonopah Test Range, NV	11/15/88	01/04/90	415	0.28	0.21	0.25	93 ± 24
Tonopah, NV	11/08/88	11/08/89	365	0.25	0.21	0.24	86 ± 12
Twin Springs Ranch, NV	01/04/89	01/03/90	364	0.27	0.21	0.24	86 ± 18
Uhalde's Ranch, NV	11/02/88	11/01/89	364	0.27	0.19	0.24	86 ± 24
US Ecology, NV	01/04/89	01/04/90	365	0.28	0.22	0.24	89 ± 18
Warm Springs #1, NV	01/04/89	01/03/90	364	0.29	0.24	0.26	96 ± 14
Warm Springs #2, NV	04/05/89	01/03/90	273	0.93	0.80	0.86	316 ± 30
Wells, NV	11/29/88	12/12/89	378	0.18	0.15	0.17	61 ± 10
Winnemucca, NV	11/29/88	12/13/89	379	0.18	0.15	0.17	62 ± 10
Young's Ranch, NV	11/17/88	11/08/89	356	0.20	0.16	0.19	68 ± 12
>>> STATIONS LOCATED IN UTAH <<<							
Boulder, UT	12/01/88	12/01/89	365	0.17	0.14	0.16	57 ± 10
Bryce Canyon, UT	12/01/88	12/01/89	365	0.16	0.13	0.14	52 ± 10
Cedar City, UT	12/01/88	12/04/89	368	0.13	0.11	0.12	43 ± 6
Delta, UT	01/06/89	01/08/90	367	0.16	0.12	0.15	53 ± 12
Duchesne, UT	01/04/89	01/10/90	371	0.13	0.11	0.12	43 ± 6
Enterprise, UT	12/01/88	12/01/89	365	0.27	0.24	0.25	91 ± 10
Ferron, UT	01/04/89	01/10/90	371	0.12	0.11	0.12	42 ± 4
Garrison, UT	12/01/88	11/29/89	363	0.13	0.10	0.12	45 ± 10
Grantsville, UT	01/05/89	01/09/90	369	0.13	0.11	0.12	45 ± 6
Green River, UT	11/02/88	11/07/89	370	0.17	0.10	0.13	49 ± 22
Gunnison, UT	12/01/88	12/01/89	365	0.12	0.09	0.11	40 ± 10

(Continued)

TABLE 15. (Continued)

STATION LOCATION	MEASUREMENT PERIOD ISSUE DATE	MEASUREMENT PERIOD COLLECT DATE	ELAPSED TIME (days)	MEASURED DAILY EXP. EQUIVALENT (mR/day) MAX	MIN	AVG	GAMMA EXPOSURE (mR/year ± 2 S.D.) [mR/yr = AVG. mR/day X 365]
Ibapah, UT	12/01/88	11/29/89	363	0.24	0.21	0.23	83 ± 10
Kanab, UT	11/01/88	11/06/89	370	0.14	0.08	0.11	40 ± 18
Loa, UT	12/01/88	12/01/89	365	0.27	0.24	0.26	95 ± 10
Logan, UT	01/03/89	01/03/90	365	0.12	0.10	0.11	41 ± 6
Lund, UT	12/01/88	12/01/89	365	0.23	0.20	0.22	79 ± 10
Milford, UT	12/01/88	12/01/89	365	0.25	0.23	0.24	89 ± 6
Monticello, UT	11/02/88	11/07/89	370	0.20	0.14	0.17	63 ± 18
Nephi, UT	01/06/89	01/09/90	368	0.12	0.08	0.11	39 ± 12
Parowan, UT	12/01/88	12/01/89	365	0.14	0.13	0.14	50 ± 4
Price, UT	01/04/89	01/10/90	371	0.13	0.11	0.12	44 ± 6
Provo, UT	01/05/89	01/09/90	369	0.10	0.08	0.09	34 ± 6
Salt Lake City, UT	01/04/89	01/03/90	364	0.15	0.10	0.12	45 ± 14
St. George, UT	12/01/88	12/04/89	368	0.12	0.08	0.09	34 ± 12
Trout Creek, UT	12/01/88	11/29/89	363	0.17	0.13	0.15	54 ± 12
Vernal, UT	01/04/89	01/10/90	371	0.14	0.11	0.13	48 ± 10
Vernon, UT	01/05/89	01/08/90	368	0.15	0.13	0.14	51 ± 6
Wendover, UT	11/28/88	12/11/89	378	0.15	0.13	0.13	49 ± 8
Willow Sprgs Ldge, UT	01/05/89	01/09/90	369	0.11	0.08	0.10	36 ± 10

Additional data was collected in 1989 to study the possibility that some TLD readings may be slightly lowered due to self-annealing of the phosphors during the hottest portion of the year. As part of this study, a six-month test of TLD fade characteristics is currently underway. In addition, "test" TLDs have been deployed at indoor locations at the Las Vegas Airport and the Las Vegas U.S. Department of the Interior (USDI) office. When one year's data has been collected, the results obtained from the indoor and outdoor TLDs at these two locations will be compared to determine the extent to which ambient temperature may affect readings. Preliminary analysis of historical data from TLDs deployed at Death Valley, CA, failed to confirm a statistically significant seasonal variation in ambient gamma readings at this location. This phenomenon will be studied in greater detail during the coming year.

Because of the great range in the results, an average for all offsite station TLDs is not an appropriate tool for estimating individual exposures. Environmental ambient radiation levels vary markedly with natural radioactivity in the soil, with altitude, and other factors. If environmental TLD data is to be used in estimating the background radiation exposure of an individual, results obtained at the fixed environmental station closest to that individual would be the most appropriate reference point.

Section 4.2.6.1.3. Special Evaluation of Elevated Radiation Levels at Warm Springs Monitoring Location

A special evaluation was conducted to verify that the elevated results observed at Warm Springs #2 were due to naturally occurring radioactive material in the water. Radiochemical analyses of special samples taken from this site were found to contain elevated amounts of naturally occurring ^{222}Rn, as summarized as follows:

ISOTOPE	CONCENTRATION ±2 S.D.
^{230}Th	9.5 ± 1.5 fCi/L
^{232}Th	4.3 ± 1.0 fCi/L
^{234}U	185 ± 27 fCi/L
^{238}U	90 ± 17 fCi/L
^{222}Rn	2942 ± 48 pCi/L (±1 S.D.)
^{3}H	1.5 ± 7 pCi/L (±1 S.D.)

TABLE 16. OFFSITE STATION TLD RESULTS — 1989

ANNUAL SUMMARY REPORT — OFFSITE STATION TLDs
FIXED ENVIRONMENTAL STATION TLD STATISTICS — 1989

	ARIZONA	CALIFORNIA	NEVADA STATIONS		UTAH	ENTIRE TLD NETWORK		
			INCLUDING WS - 2	EXCLUDING WS - 2		INCLUDING WS - 2	EXCLUDING WS - 2	U.S. AVERAGE
Number of Fixed Stations Monitored:								
	3	13	88	87	29	133	132	
Number of Days Each Station Monitored:								
Minimum	370	364	57	57	363	57	57	
Maximum	371	8	415	415	378	415	415	
Average	370.3	370.6	357.5	358.5	367.4	361.2	361.9	
Standard Deviation	0.5	4.4	45.9	45.3	3.3	37.8	37.1	
Calculated C.V.	0.1%	1.2%	12.8%	12.6%	0.9%	11.9%	10.3%	
Equivalent Daily Exposures (mR/day)								
Minimum	0.09	0.08	0.01	0.01	0.08	0.01	0.01	
Maximum	0.22	0.29	0.93	0.71	0.27	0.93	0.71	
Average	0.140	0.180	0.197	0.189	0.145	0.177	0.177	
Standard Deviation	0.036	0.043	0.098	0.068	0.047	0.087	0.064	
Calculated C.V.	25.4%	0.4%	49.8%	35.9%	32.7%	1.0%	36.1%	
Calculated Gross Annual Exposures (mR/year)								
Minimum	40	30	17	17	34	17	17	43
Maximum	68	88	316	156	95	316	156	168
Average	50.7	65.7	71.9	69.1	52.9	66.7	64.8	68
Standard Deviation	12.4	15.5	36.0	24.8	17.2	31.8	23.4	8
Calculated C.V.	24.4%	23.6%	50.0%	36.0%	32.5%	47.7%	36.1%	

Except for the ^{222}Rn, isotopic analysis of water from Warm Springs was very similar to that obtained from analyzing other springs and from analyzing rain water. Radon-222 concentrations in other sources were measured to be in the range of 138-367 pCi/L except for another hot spring not a part of the EPA's routine environmental monitoring network (Bailey's Hot Spring), which showed ^{222}Rn concentration of 3560 ± 30 pCi/L. For further details regarding the radiochemical analyses, please see "Thorium-230 Dating of Thermal Waters in the Vicinity of the Nevada Test Site" (HOL89)

A special instrument survey of the Warm Springs area was conducted June 27, 1989. The purpose of this survey was to confirm differences in ambient gamma radiation levels noted by TLDs located in this area. The following results were obtained:

Instrument Used: Ludlum Model 19 micro-R meter, SN 7952
Date Calibrated: 8 June, 1989

Location Surveyed	Latitude[1]	Longitude[1]	Survey Results (μR/hr)
A. Edge of Stream	38°11'13"	116°22'56"	115
B. TLD# 004STA977 ("Warm Springs TLD #2") (6-10' from stream)	38°11'12"	116°22'56"	80
C. TLD# 004STA975 ("Warm Springs TLD #1") (Picnic ground west of cafe)	38°11'11"	116°22'55"	26
D. Inside bath house (1" above water)	38°11'12"	116°22'60"	120

[1] *Latitude and longitude measured using a vehicle-mounted Loran-C set to a reference base location of 36°06'70" Latitude and 115°88'10" Longitude. Loran-C units set to different reference base locations may give different results, but the relative differences between locations surveyed should be similar.*

From these survey meter readings, integrated exposures of approximately 2.8, 1.9, 0.6, and 2.9 mR/day could be anticipated at locations A, B, C, and D, respectively. These compare well with TLD monitoring results at locations B and C, as summarized in Table 17.

Section 4.2.6.1.4. Comparing Routine TLD Results with Direct Exposure Measurements

When calculated TLD exposures are compared with results obtained from collocated Pressurized Ionization Chambers a uniform under-response of TLD vs PIC was noted.

TABLE 17. TLD RESULTS — WARM SPRINGS, NV VICINITY

MEASUREMENT PERIOD		ELAPSED TIME (days)	GROSS EXPOSURE (mR)	HISTORICAL REFERENCE BACKGROUND (mR)	NET mR ABOVE REF. BACKGROUND
ISSUE DATE	COLLECT DATE				
WARM SPRINGS, NV					
1/14/87	3/30/87	75	TLDs LOST — NO DATA THIS PERIOD		
10/7/87	1/4/88	89	30.1	42.9	0.0
7/7/88	10/4/88	89	36.1	40.6	0.0
10/4/88	1/4/89	92	32.0	40.4	0.0
1/4/89	4/5/89	91	21.8	36.7	0.0
4/5/89	7/11/89	97	26.1	32.1	0.0
7/11/89	10/3/89	84	TLDs LOST — NO DATA THIS PERIOD		
WARM SPRINGS #2, NV					
3/30/87	4/6/87	98	92.7	47.3	45.4
7/6/87	10/7/87	93	102.9	44.9	58.0
1/4/88	4/5/88	92	81.3	42.0	39.3
4/5/88	7/7/88	93	76.8	42.4	34.4
4/5/89	7/11/89	97	77.5		
7/11/89	10/3/89	84	78.6		

SUMMARY RESULTS:	WARM SPRINGS	WARM SPRINGS #2
Avg. mR/day ±2 S.D.:	0.32 ±0.11	0.83 ±0.20
mR/meas. pd. ±2 S.D.:	29.2 ±9.9	85.0 ±19.3
Min. mR/meas. pd.:	21.8	76.8
Max. mR/meas. pd.:	36.1	102.9
Calculated C.V.:	16.9%	11.7%

A detailed description of the PIC monitoring system is included in Section 4.2.7. of this report.

This difference may be attributed to several factors:

(1) The PIC measures ionization in air (the Roentgen) while the TLD measures energy deposited in matter (the rad). Results of the two methods are not adjusted to account for this difference.

(2) The PIC is an exposure rate measuring device, sampling every five seconds, while the TLD as an integrating dosimeter is analyzed approximately once each quarter. Some reduction in TLD results may be due to a small loss due to normal fading (studies by Panasonic have shown this loss to be minimal over the sampling period used). As noted above, a six-month fade study is currently being completed to confirm that fading is negligible.

(3) PICs are more sensitive to lower energy gamma radiation than are the TLDs. A review of manufacturer's specifications for the PIC and TLD systems shows their responses to be almost linear above approximately 80 keV and above approximately 150 keV, respectively;

(4) The PIC units are calibrated by the manufacturer against ^{60}Co, while the TLDs are calibrated using ^{137}Cs. No adjustment is made to account for the differing energies at which the two systems are calibrated. Studies are planned for 1990 to determine the extent to which this factor influences PIC response; and

(5) The use of TLDs for environmental monitoring requires several approximations, each of which contributes to the noted difference between the two systems:

   (a) Environmental TLDs do not have a "flat" response at the low (<100 keV) energies characteristic of many noble gases and of beta radiations. The $CaSO_4$ used in environmental TLDs is known to overrespond at low energies.

   (b) Environmental TLDs, while calibrated in a fixed geometry with a parallel beam incident upon the dosimeter, are deployed in an immersion cloud geometry. This results in a portion of the exposure occurring behind the filter. Because of this, development of an appropriate algorithm to correct environmental TLDs for differences in radiation type and energy is normally not attempted.

   (c) By their design, environmental TLDs are effectively incapable of discerning beta radiations.

For these reasons, it is important that neither the TLD nor the PIC be considered as "definitive" devices, but as two complementary components of a comprehensive environmental monitoring system.

Figure 34 compares PIC and TLD results for 1989.

Section 4.2.6.1.5. Historical Trends in TLD Network

Annual exposures at fixed environmental stations were evaluated to determine historical trends. Data for past years was taken from previous annual reports of the offsite monitoring program. Data for 1989 showed no statistically significant variation in annual ambient gamma exposure levels from those reported in previous years dating back to 1973. No statistically significant variation based on State or other location criterion was noted in the historic data. Figure 35 illustrates the average ±2 S.D. annual exposures obtained at all fixed monitoring stations in each year since 1971.

A noticeable decrease in annual exposure levels occurred in 1974. Based on the best available information, this apparent decrease is most likely due primarily to a combination of switching from bulb-type dosimeters to the Harshaw TLD system in 1974 and to a general decline in global fallout as also noted by other monitoring networks. Overlaid upon the data in Figure 35 is a shaded box illustrating the range of natural background exposures in the United States due to cosmic and terrestrial radiations (OAK, 1972). This overlay illustrates that the ambient gamma exposures measured by TLDs at fixed environmental stations as part of this network were within the range of exposures anticipated throughout the United States due to "natural background."

Section 4.2.6.1.6. Statistical Evaluation of TLD Results

Reviews of station and personnel TLD results were completed using the statistical "z-score" test. This test evaluates the distribution of measured values as

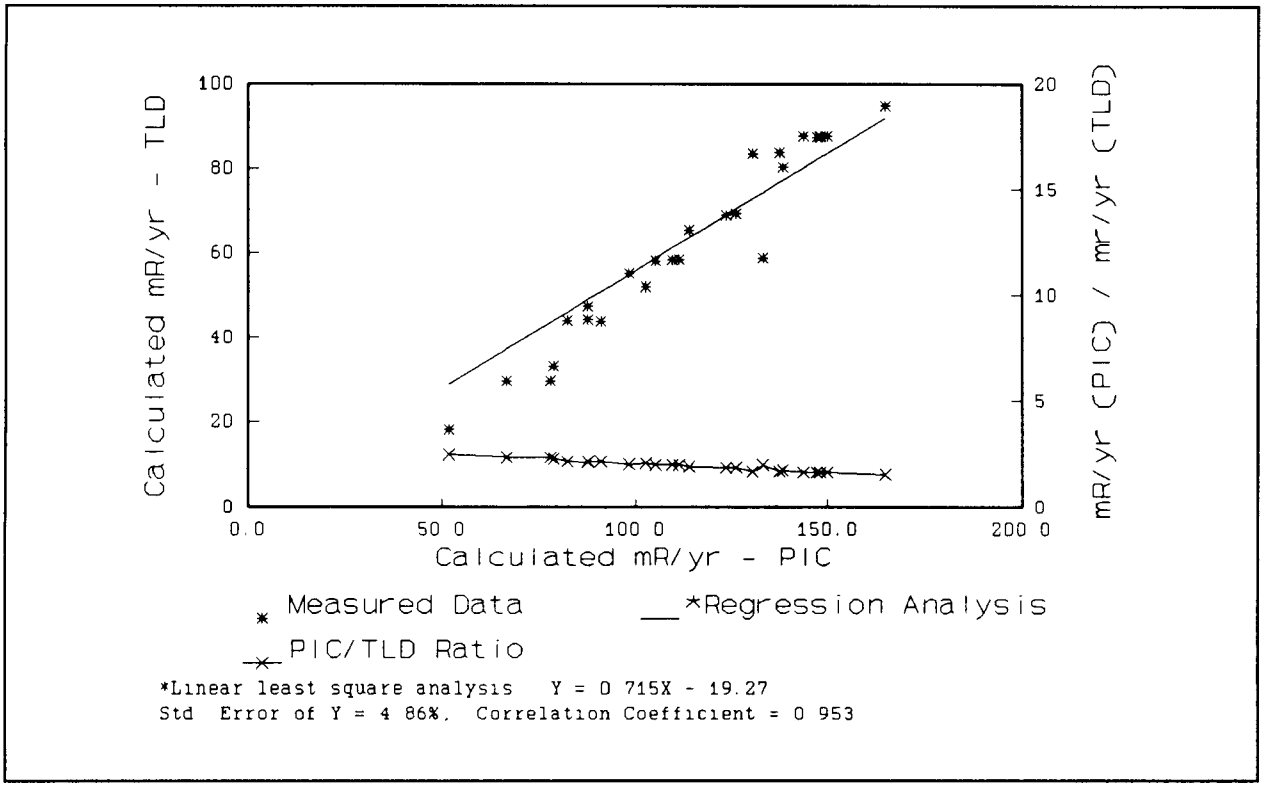

Figure 34. Correlating TLD and PIC Results — 1989.

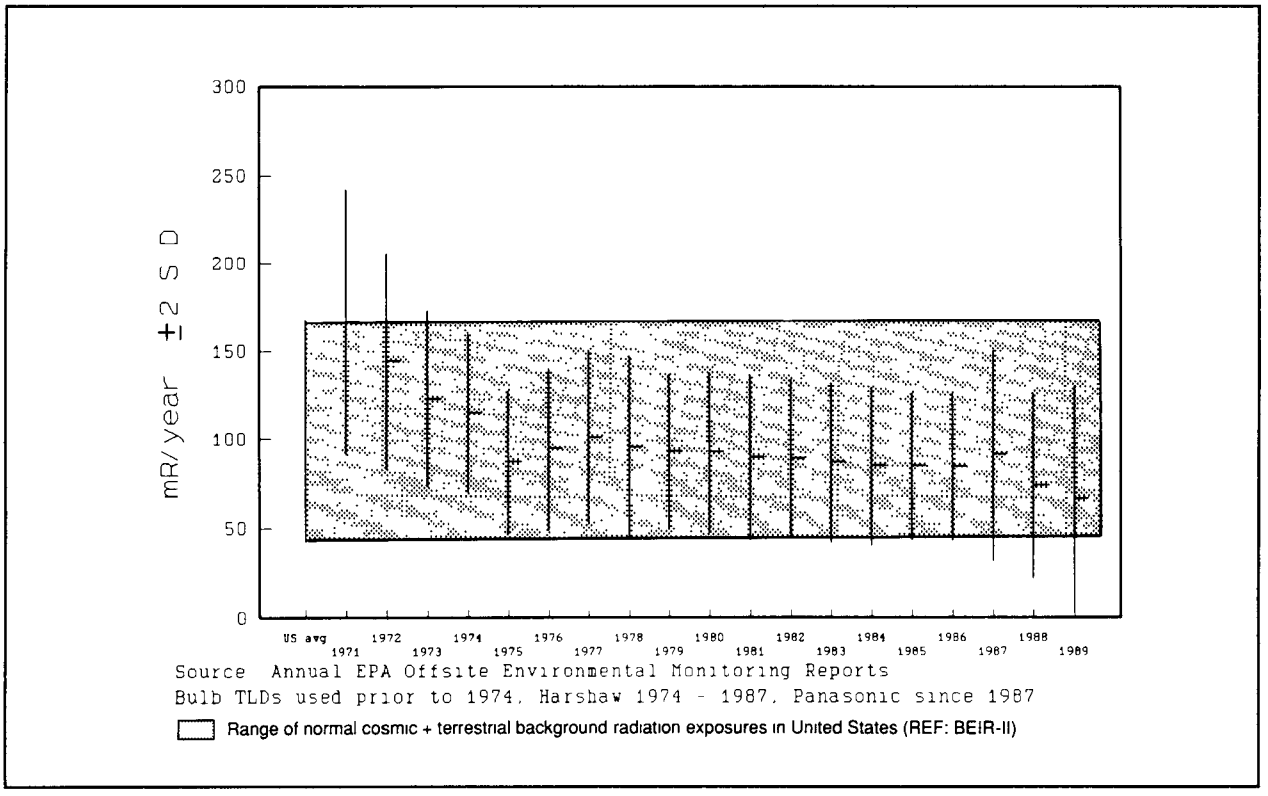

Figure 35. Historical Trends — TLD Exposures at Fixed Environmental Stations — 1971-1989.

a function of their variation from the average of all results. When plotted, 99% of data that is normally distributed will fall on a straight line with a range of ± 3 S.D.

The z-score measures how many standard deviations an individual data point is away from the mean. It is formally defined as follows:

"The z-score of any number x in a distribution whose mean is μ and whose standard deviation is σ, is given by:

$$z = \frac{x - \mu}{\sigma}$$

where: x = value of number in original units
μ = population mean
σ = population standard deviation

The z-score of a number in a population is sometimes called the z-value or measurement in standard units. Since σ is always a positive number, z will be a negative number whenever $x < \mu$. A z-score of 0 implies that the term has the same value as the mean" (STA75).

Figures 36 and 37 confirm that personnel and station TLD results fall within the range anticipated by randomly distributed data. Figure 43 (Section 4.2.7.) illustrates that PIC results for 1989 are also randomly distributed. No personnel TLD result fell outside the range of ±3 S.D.. Two fixed background station TLD results fell within the range of >+3 but <+5 S.D. Analysis of these two stations, Elgin and Hancock Summit, NV, showed the anticipated range of exposures to be 76 - 218 mR/yr (Elgin) and 103 - 209 mR/yr (Hancock Summit). Results obtained during 1989 for these two stations were statistically indistinguishable from results obtained at these same locations in 1988 and 1987.

To determine if exposures being measured represent "natural background" or increases due to identifiable events (i.e., NTS activities), it is helpful to compare the distribution of measured results against the distribution of a large number of known random events. If exposures were due to identifiable (i.e., non-random, not naturally occurring events), one would expect their frequency distribution to be non-random. Figure 38 superimposes the frequency distribution of 1,000 known random events (numbers obtained by using a

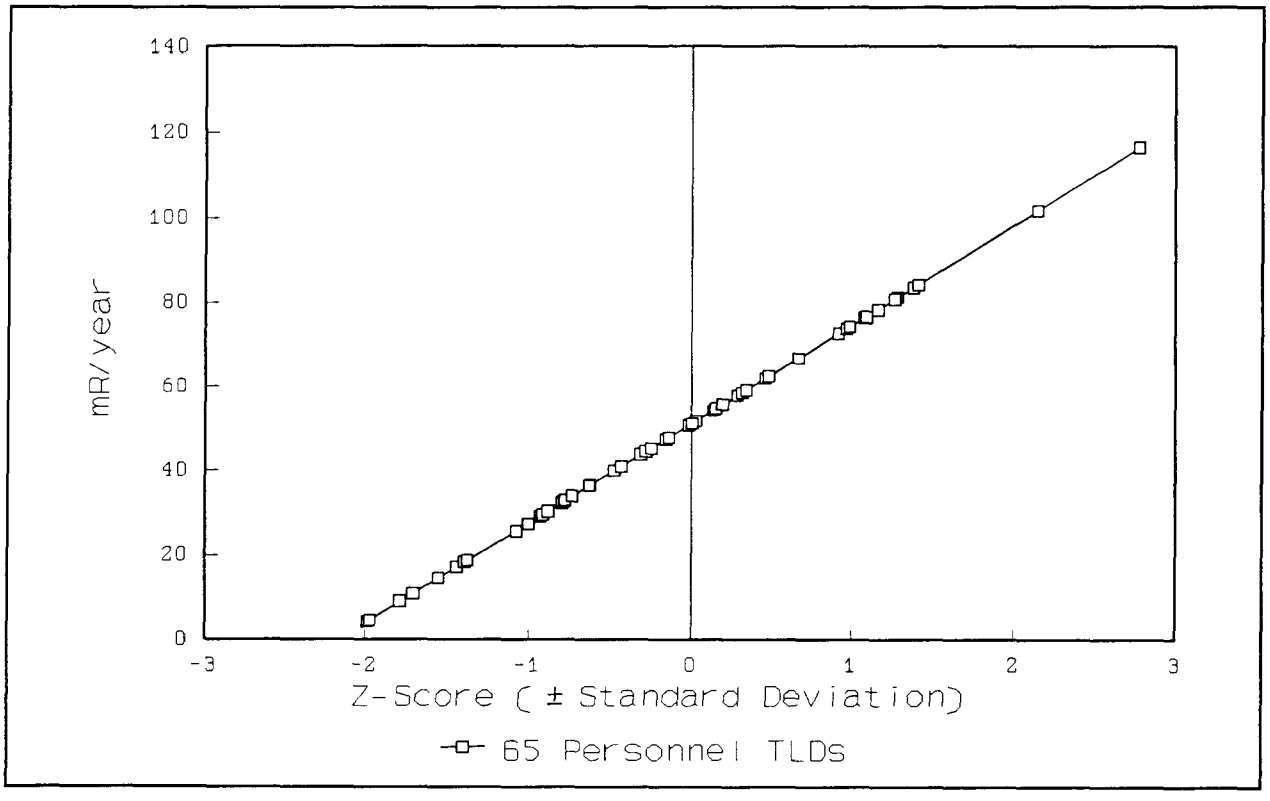

Figure 36. Distribution of Personnel TLD Results — 1989.

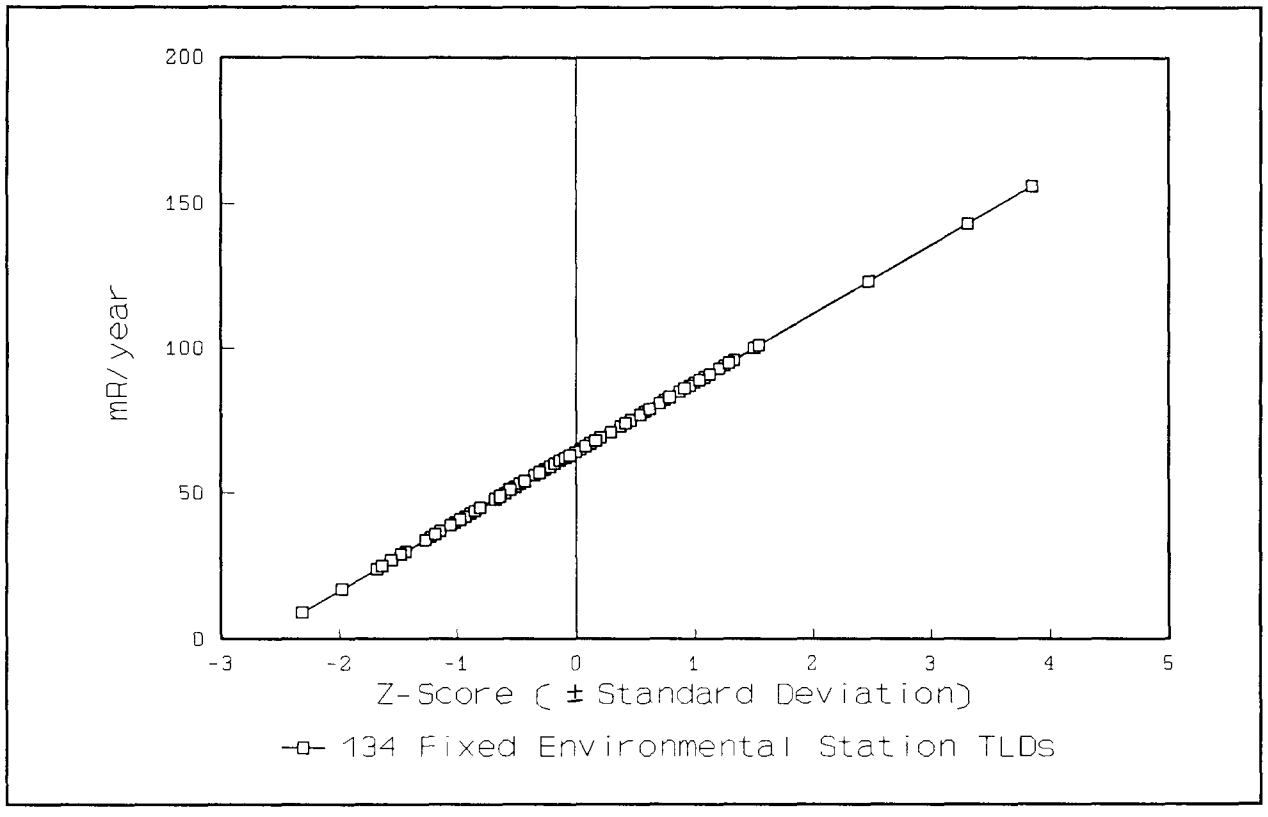

Figure 37. Distribution of Fixed Station TLD Results — 1989.

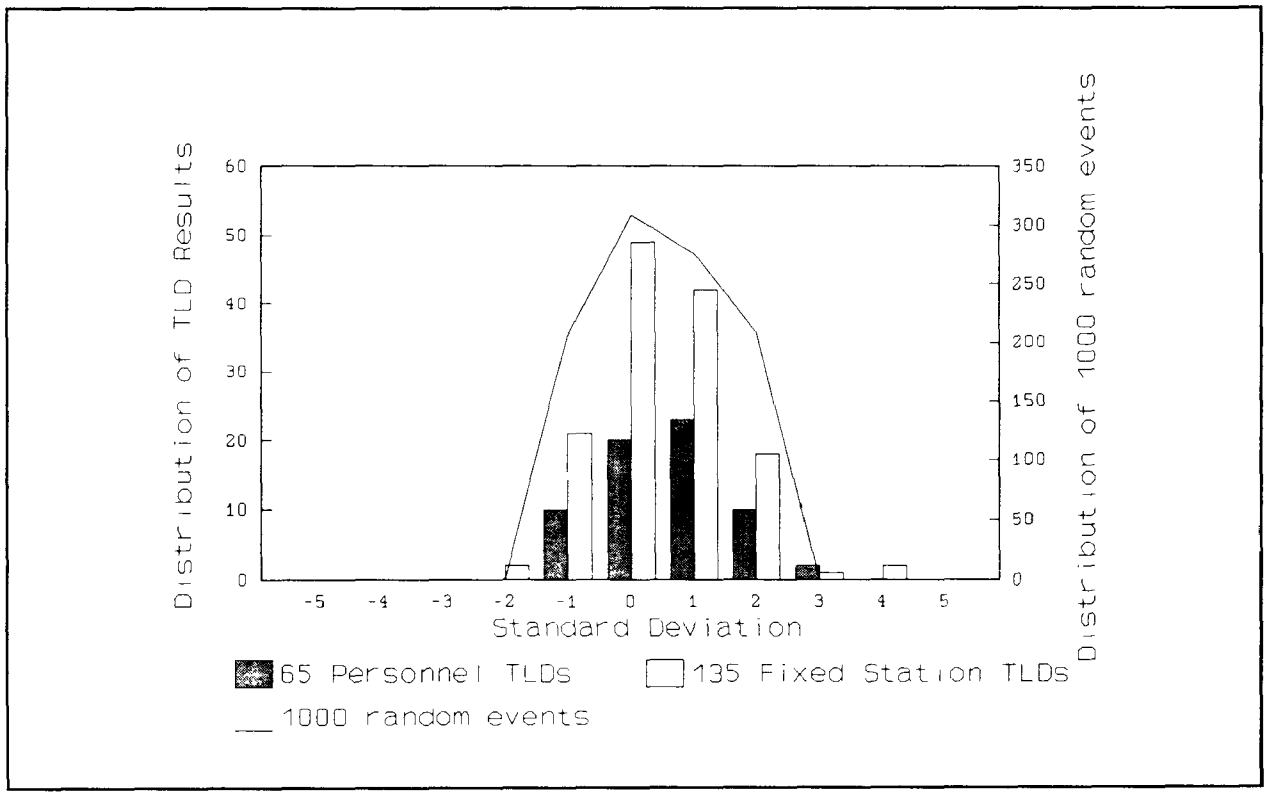

Figure 38. Frequency Distribution Analysis Fixed Station and Personnel TLDs — 1989.

random number generator) with the frequency distribution of fixed station and personnel TLD results. This figure illustrates that both fixed station and personnel TLD results in fact are distributed in a random manner, further confirming that they represent natural background as opposed to exposures due to discrete, identifiable events.

Section 4.2.6.1.7. Conclusion

During the calendar year 1989, a total of 65 individuals and 135 fixed environmental stations were monitored with TLDs. One individual showed a single exposure that was apparently significantly above levels expected from natural background at that location. Upon further investigation it was learned that the individual had worn the TLD while undergoing a medical radiographic procedure. No other exposures to monitored individuals were statistically detectable above associated natural background levels. Exposures to TLDs issued to individuals ranged from 4 to 116 mR for the entire year.

The range of exposures to individuals compared favorably to the range of 17 to 156 mR noted for the 135 fixed environmental station TLDs. Exposures to the fixed environmental station TLDs averaged 66.7 ± 31.8 mR for the year. A detailed evaluation was conducted to determine the cause of elevated radiation levels at the Warm Springs #2 monitoring location. These were found to be due to high levels of naturally occurring radioactive material in the stream.

Statistical evaluation of the distribution of personnel and fixed station exposures confirmed that the exposures occurred in a pattern consistent with random (i.e., naturally occurring) events. Except as noted above no apparent exposures were caused by a discrete event or events. There was no evidence that any exposure measured by the TLDs was caused by planned or unplanned releases of radioactivity from NTS operations.

Published estimates of natural background (terrestrial + cosmic) radiation exposure for the United States indicate an expected range of annual exposures of 43 - 168 mR, with an anticipated average of 68 mR (OAK72). The range and average of exposures noted for both individuals and fixed environmental stations participating in this network is therefore within the range of anticipated exposures for inhabitants of the United States.

Section 4.2.7. Pressurized Ion Chamber Network (PIC)

C. A. Fontana

The PIC network measures ambient gamma radiation exposure rates. The 27 PICs deployed around the NTS showed no unexplained deviations from background levels during 1989. The maximum annual average exposure rate of 165 mR/yr was at Austin, NV, the minimum of 52 mR/yr was at Las Vegas, NV. These values were within the United States background maximum and minimum values (BEIR80). The 1989 data was consistent with previous years trends, and no prolonged unexplained deviations from background occurred during the year.

SECTION 4.2.7.1. NETWORK DESIGN

The purpose of the PIC network is to measure ambient gamma radiation exposure rates. These rates will vary with altitude (cosmic radiation) and natural radioactivity in the soil (terrestrial radiation). The Pressurized Ion Chamber is a spherical shell filled with argon gas to a pressure 25 times that of the atmospheric. In the center of the chamber is a spherical electrode with a charge opposite to the outer shell. When gamma radiation penetrates the sphere, ionization of the gas occurs and the ions are collected by the center electrode. A current generated is measured and the intensity of the radiation field is determined from the magnitude of this current.

There are 27 PICs deployed around the Nevada Test Site in nearby communities. Of these, 18 are at Community Monitoring Stations described in Section 5.4., and nine are at other locations. Figure 39 shows PIC locations in California, Nevada, and Utah.

SECTION 4.2.7.2. METHODS

Data are collected via satellite transmissions. In addition to telemetry retrieval, the data are also recorded on magnetic tapes and strip charts for hardcopy backup. In the unlikely event of an accidental release of radioactivity from the NTS, signals via the satellite telemetry system could provide instantaneous data from all affected PIC locations.

Data is displayed in μR/hr (microroentgens per hour) on a digital readout display at each location for easy access by the public. The roentgen is a measure of

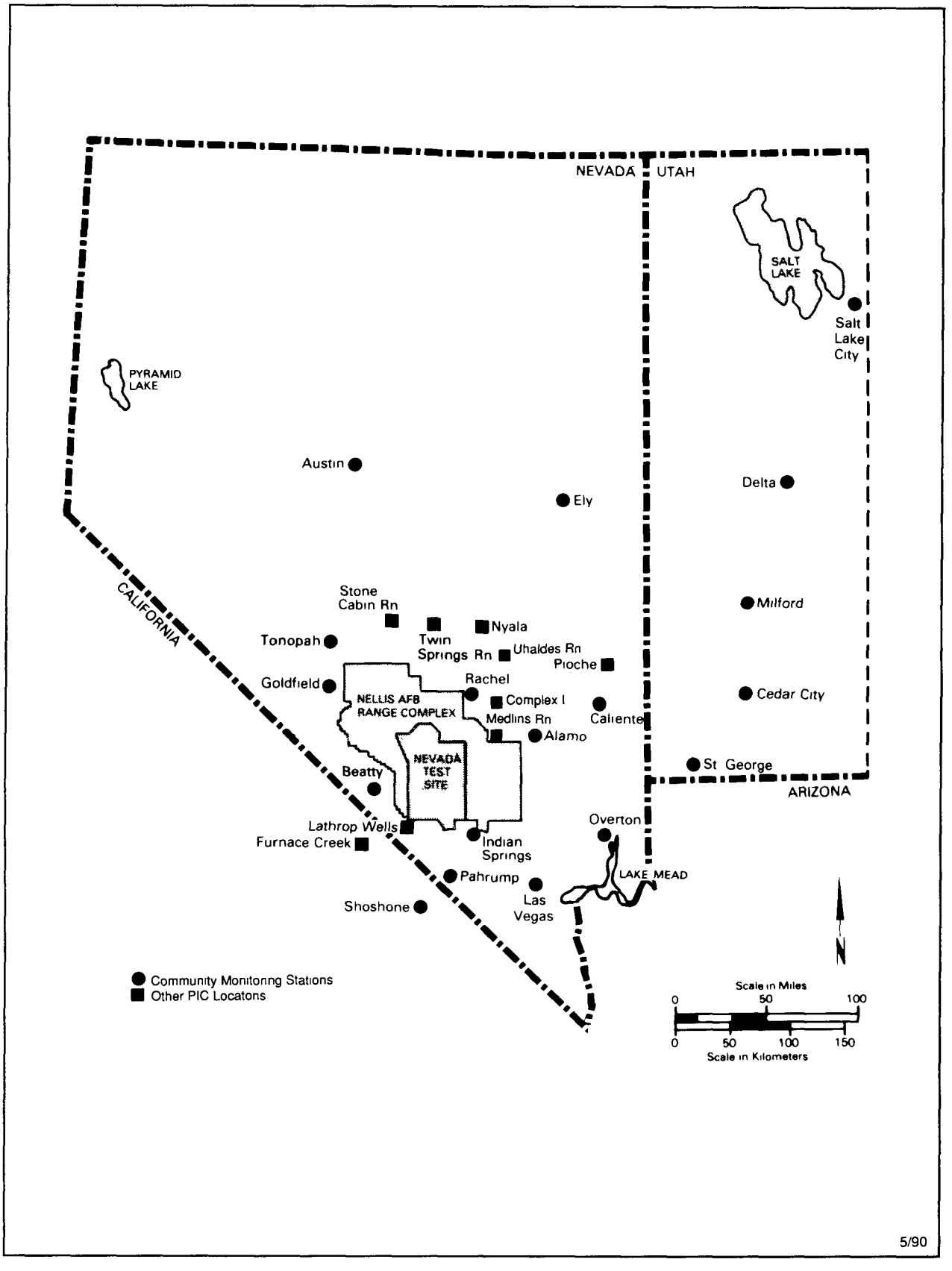

Figure 39. Community Monitoring PIC Stations and Other PIC Station Locations — 1989.

exposure to X or gamma radiation. For example, one chest x-ray results in an exposure of 20,000 to 40,000 microroentgens. Computer analysis of the data is evaluated weekly at EMSL-LV. As part of routine quality assurance procedures, trends are noted. Source checks are conducted weekly and data are plotted by the EMSL-LV specialist for comparison to previous weeks. Figure 40 shows PIC equipment setup in the field.

SECTION 4.2.7.3. RESULTS

Data for 1989 are displayed in Table 18 as the average μR/h and annual mR/yr from each station. Figure 41 shows annual averages for each location in mR/yr as compared to the maximum and minimum United States background (BEIR80). Figure 42 shows annual averages for each location in microroentgens per hour with error bars representing two standard deviations about the mean of the weekly averages. Figure 43 illustrates a z-score plot of the PIC data for 1989. See Section 4.2.6.1.6. for a definition of z-score. This demonstrates that there is good correspondence to the mean of all results. The averages of the 27 PICs varied from 51.7 milliroentgens per year at Las Vegas, NV, to 164.7 milliroentgens per year at Austin, NV. The U.S. background maximum and minimum values of the combined terrestrial and cosmic components of environmental gamma radiation exposure rates represent the highest and lowest values respectively. Figure 44 shows historical annual mR/yr PIC exposure rates from representative stations. The 1989 PIC data is consistent with previous years trends, and within U.S. background maximum and minimum values. No prolonged unexplained deviations from these background levels occurred.

(Text continued on page 80)

TABLE 18. PRESSURIZED ION CHAMBER READINGS — 1989

STATION LOCATION	NO. OF WEEKLY VALUES	EXPOSURE RATE (μR/hr)* MAX	MIN	AVG ± 2 S.D.	mR/yr ± 2 S.D.
Alamo, NV	52	13.6	12.7	13.0 ± 0.3	113.9 ± 2.9
Austin, NV	47	20.0	15.4	18.8 ± 2.1	164.7 ± 18.6
Beatty, NV	52	17.7	16.4	16.9 ± 0.6	147.8 ± 5.3
Caliente, NV	52	15.0	13.6	14.4 ± 0.6	126.1 ± 4.9
Cedar City, UT	50	10.4	9.6	10.0 ± 0.3	87.2 ± 2.8
Complex I, NV	50	16.7	14.3	15.7 ± 0.9	137.8 ± 7.8
Delta, UT	52	12.1	10.2	11.2 ± 0.7	98.2 ± 6.4
Ely, NV	52	12.4	11.8	12.0 ± 0.3	105.4 ± 2.6
Furnace Creek, CA	42	10.7	9.6	10.0 ± 0.6	88.0 ± 4.9
Goldfield, NV	51	16.0	14.7	15.2 ± 0.5	133.4 ± 4.3
Indian Springs, NV	52	9.3	8.5	8.9 ± 0.4	78.1 ± 3.4
Las Vegas, NV	51	6.3	5.6	5.9 ± 0.4	51.7 ± 3.2
Lathrop Wells, NV	50	14.6	13.9	14.1 ± 0.3	123.4 ± 2.9
Medlin's Ranch, NV	51	16.5	14.7	15.8 ± 0.6	138.4 ± 5.3
Milford, UT	49	18.4	15.4	17.1 ± 1.3	149.4 ± 11.6
Nyala, NV	37	14.0	11.3	12.5 ± 0.9	109.3 ± 7.5
Overton, NV	52	10.0	9.0	9.4 ± 0.5	82.4 ± 4.3
Pahrump, NV	51	8.0	7.2	7.6 ± 0.3	66.6 ± 2.8
Pioche, NV	52	13.1	12.2	12.7 ± 0.4	111.1 ± 3.4
Rachel, NV	52	16.3	11.8	14.9 ± 1.9	130.8 ± 16.9
St. George, UT	52	9.8	8.5	9.0 ± 0.7	79.0 ± 5.7
Salt Lake City, UT	51	12.7	8.8	10.4 ± 1.4	91.0 ± 12.0
Shoshone, CA	51	12.8	11.0	11.7 ± 0.6	102.8 ± 5.6
Stone Cabin Ranch, NV	44	18.2	16.0	16.9 ± 1.1	148.2 ± 9.7
Tonopah, NV	51	17.1	15.1	16.4 ± 0.7	143.3 ± 6.4
Twin Springs Ranch, NV	40	18.3	15.5	16.9 ± 1.2	148.3 ± 10.8
Uhalde's Ranch, NV	49	17.7	14.7	16.8 ± 1.5	147.0 ± 13.5

** Weekly averages.*

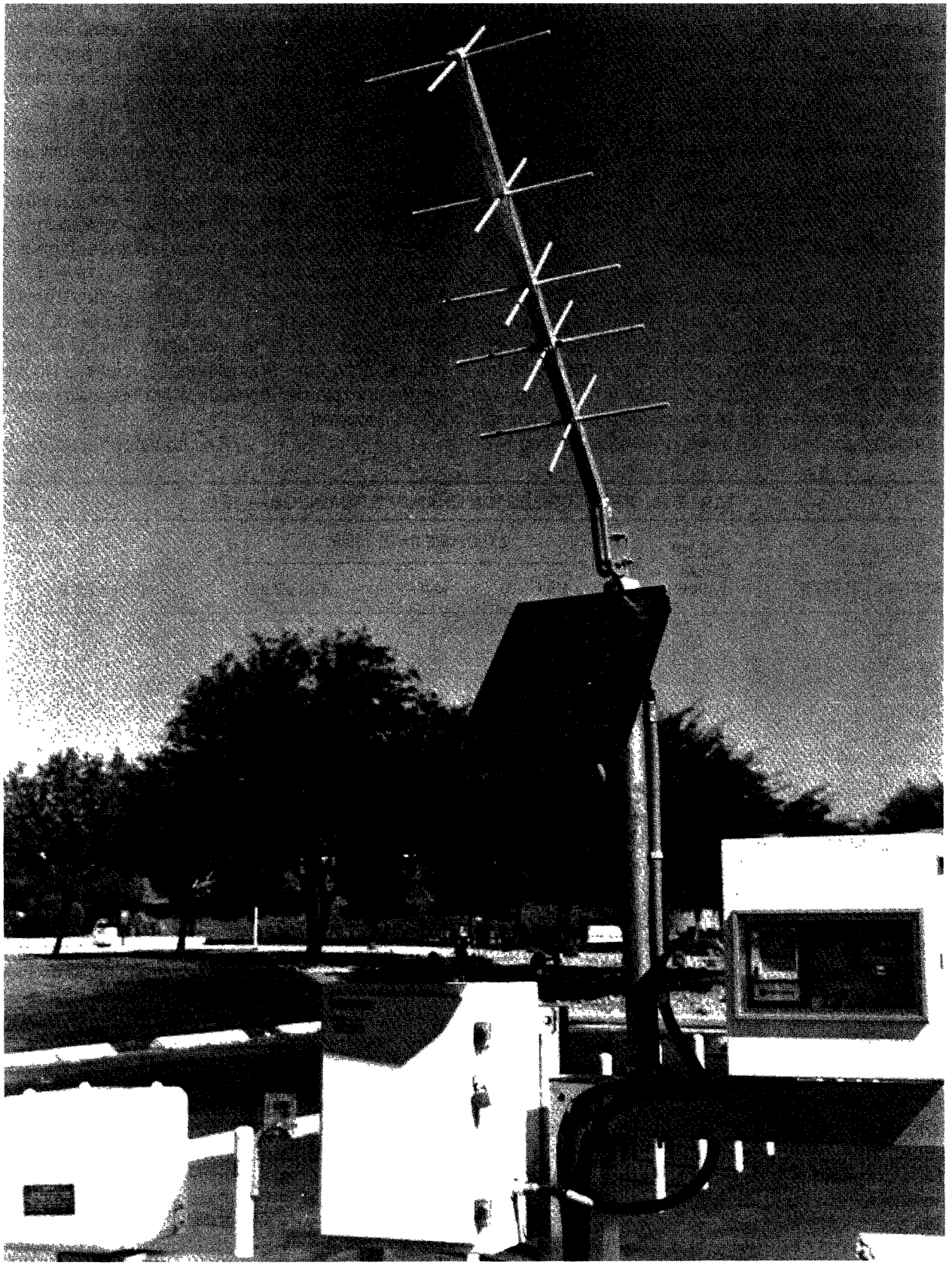

Figure 40. Pressurized Ion Chamber (left) Gamma-Rate Recorder Remote Processor Unit (right) with Chart Recorder, Digital Readout, and Telemetry Antenna with Solar Panel (top center).

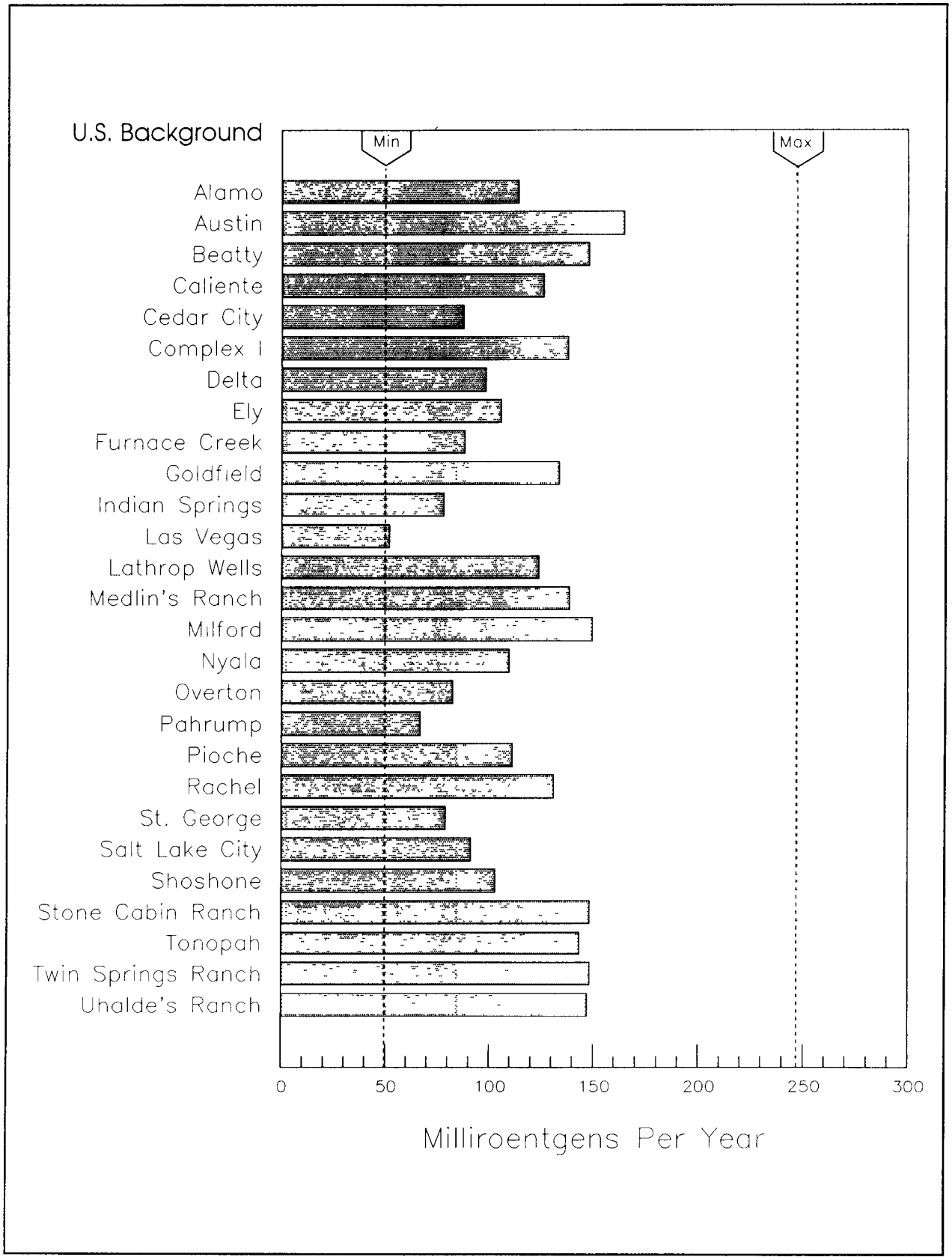

Figure 41. Annual PIC Averages by Station in Milliroentgens per Year — 1989.

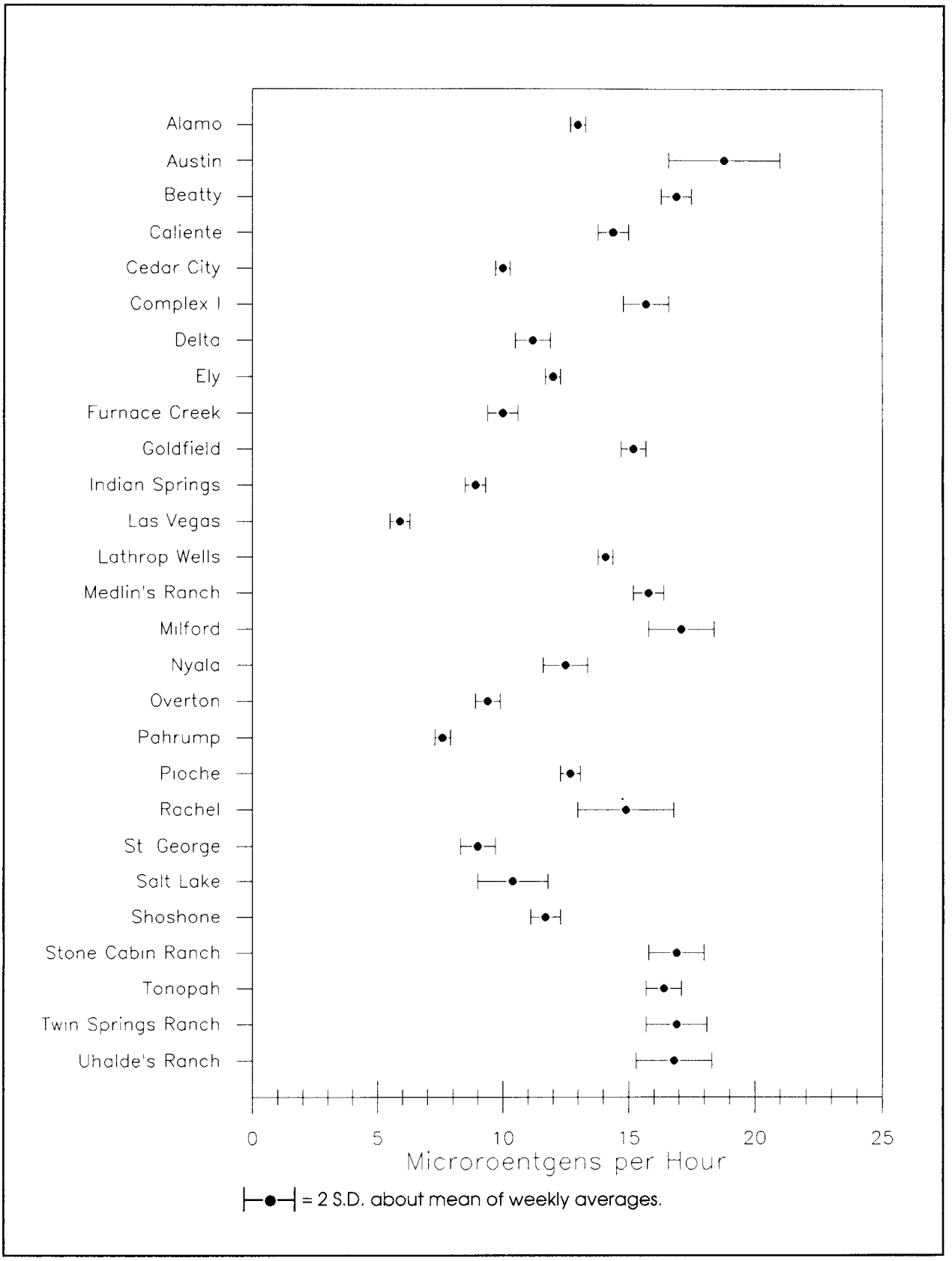

Figure 42. Annual PIC Averages by Station in Microroentgens per Hour — 1989.

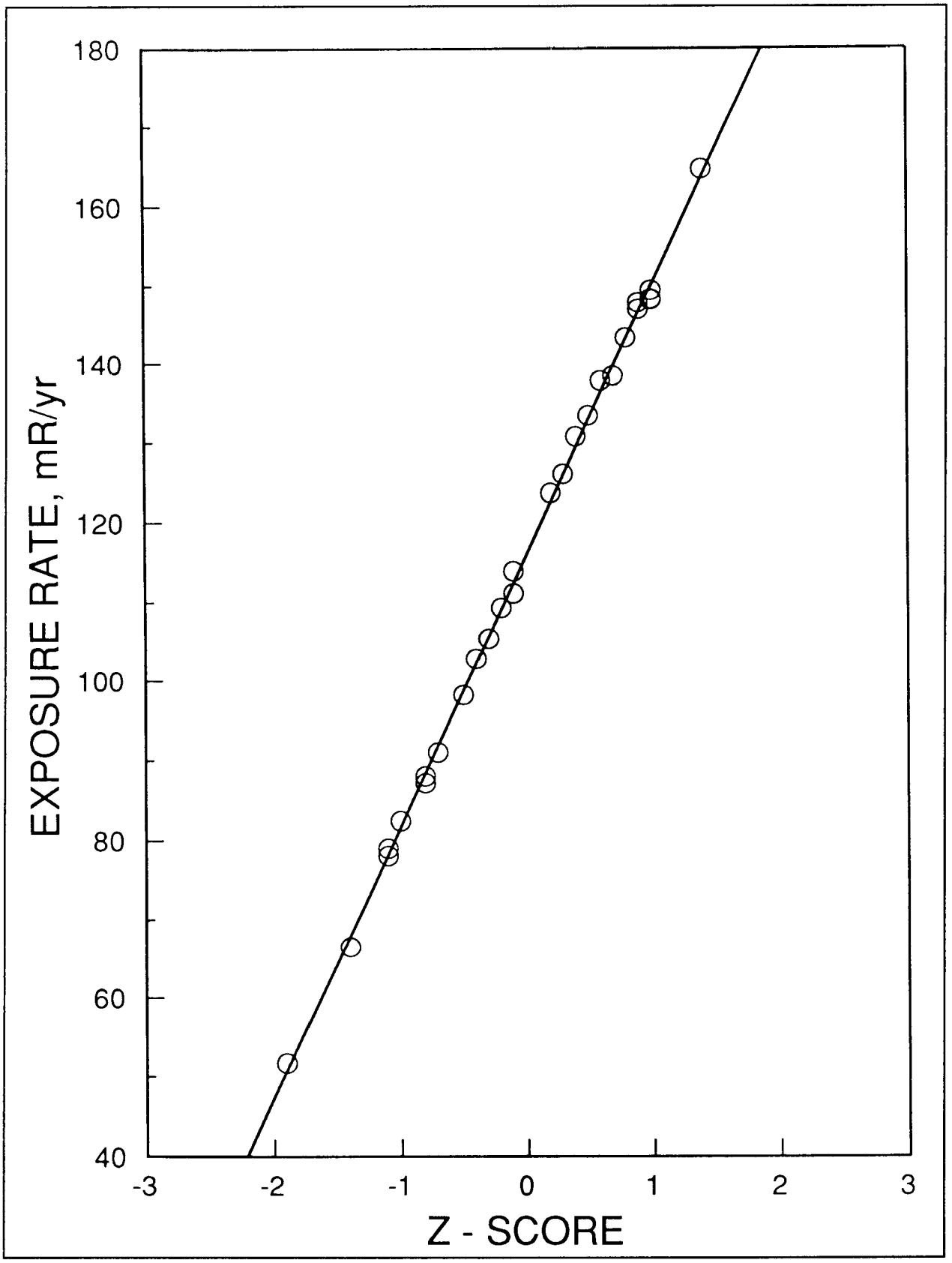

Figure 43. Z-Score Plot of PIC Data — 1989.

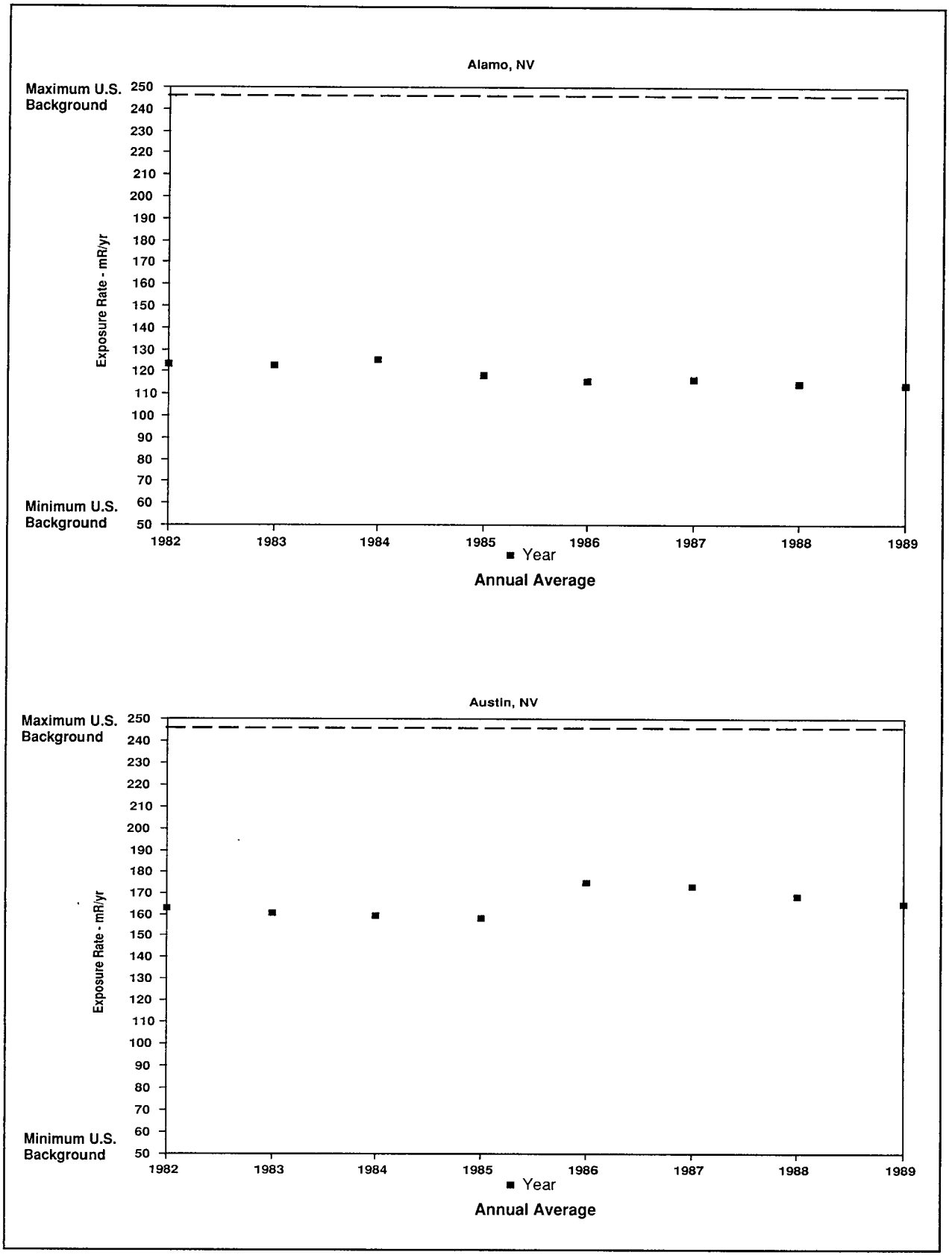

Figure 44. Representative Trends in Annual Average PIC Data.

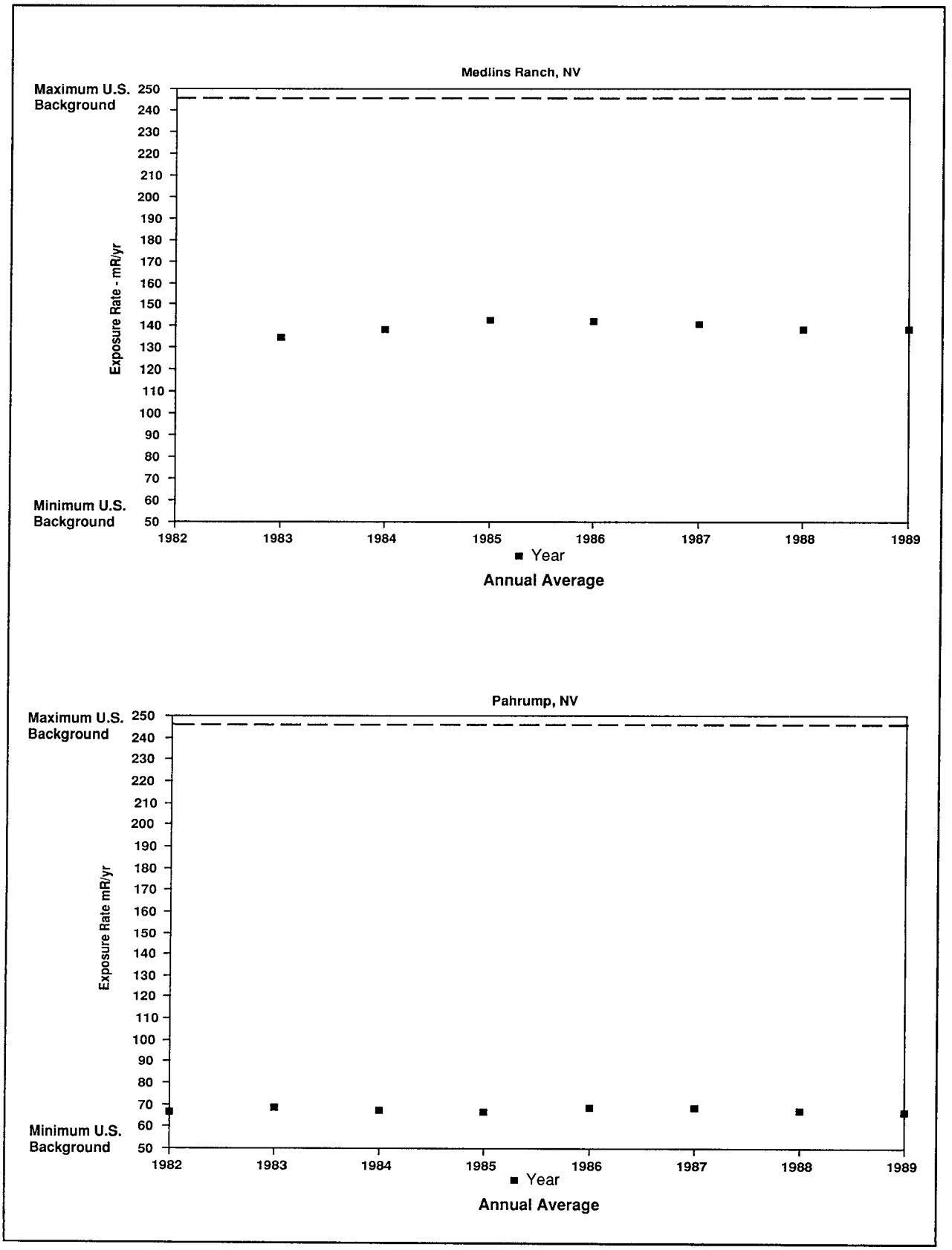

Figure 44. Continued.

Section 4.2.8. Internal Exposure Monitoring

A. A. Mullen

No internal exposure above applicable regulatory limits was detected in either occupationally exposed individuals or members of the general public who participated in the Offsite Human Surveillance Program at EMSL-LV. Several individuals either returning from European visits or visiting the laboratory from European countries were found to have very small internal concentrations from ^{137}Cs released during the Chernobyl accident and still present in the food chain.

Internal exposure is caused by ingested or inhaled radionuclides that remain in the body either temporarily or for longer times because of storage in tissues. At EMSL-LV two methods are used to detect body burdens: whole-body counting and urinalysis.

SECTION 4.2.8.1. SYSTEM DESIGN

The whole-body counting facility has been maintained at EMSL-LV since 1966 and is equipped to determine the identity and quantity of gamma-emitting radionuclides which may have been inhaled or ingested. Routine examination consists of a 2000 second count in each of the two shielded examination vaults. In one vault a single intrinsic germanium coaxial detector positioned over an adjustable chair allows detection of gamma radiation with energies ranging from 60 keV to 2.0 meV in the whole body. The other vault contains an adjustable chair with six intrinsic germanium semi-planar detectors mounted above the chest area. The semi-planar array is designed for detection of gamma, and x-ray emitting radionuclides with energy ranges from 10 to 300 keV. Specially designed software allows individual detector spectra to be analyzed to obtain a summation of left- or right-lung arrays and the total lung area. This provides much greater sensitivity for the transuranic radionuclides but maintains the ability to pinpoint "hot spots." Custom designed detector mounts allow maximum flexibility for the placement of detectors in various configurations for skull, knee, ankle, or other geometries.

SECTION 4.2.8.2. NETWORK DESIGN

This activity consists of two portions, an Offsite Human Surveillance Program and a Radiological Safety Program. The Offsite Human Surveillance Program is designed (1) to measure radionuclide body burdens in a representative number of families who reside in areas that were subjected to fallout during the early years of nuclear weapons tests, and (2) to act as a biological monitoring system for present nuclear testing activities. A few families who reside in areas not affected by such fallout were also selected for comparative study. Members of the general public concerned about possible exposure to radionuclides are also counted periodically as a public service.

The Radiological Safety Program is designed to assess internal exposure for EPA employees, DOE contractor employees, and by special request, for employees of companies who may have had an accidental exposure to radioactive material.

SECTION 4.2.8.3. METHODS

The Offsite Human Surveillance Program was initiated in December 1970, to determine levels of radionuclides in some of the families residing in communities and ranches surrounding the NTS. Biannual counting is performed in the spring and fall. This program started with 34 families (142 individuals). In 1989, 15 of these families (36 individuals) were still active in the program together with six families added in recent years. When the Community Monitoring Station Network was started in 1981, the families of the station managers interested in participating were added to the program. These 24 families are counted in the winter and summer of each year. The geographical locations of the families which participated in 1989 are shown in Figure 45.

These persons travel to the EMSL-LV where a whole-body count and a lung count of each person is made to determine the body burden of gamma-emitting radionuclides. A urine sample is collected for tritium analysis. Results of the whole-body count are available before the families leave the facility and are discussed with the subjects. At 18-month intervals a physical exam, health history and the following are performed: a urinalysis, complete blood count, serology, chest x-ray (three-year intervals), sight screening, audiogram, vital capacity, EKG (over 40 years old), and thyroid panel. The individual is then examined by a physician. The results of the examination can be requested for use by their family physician.

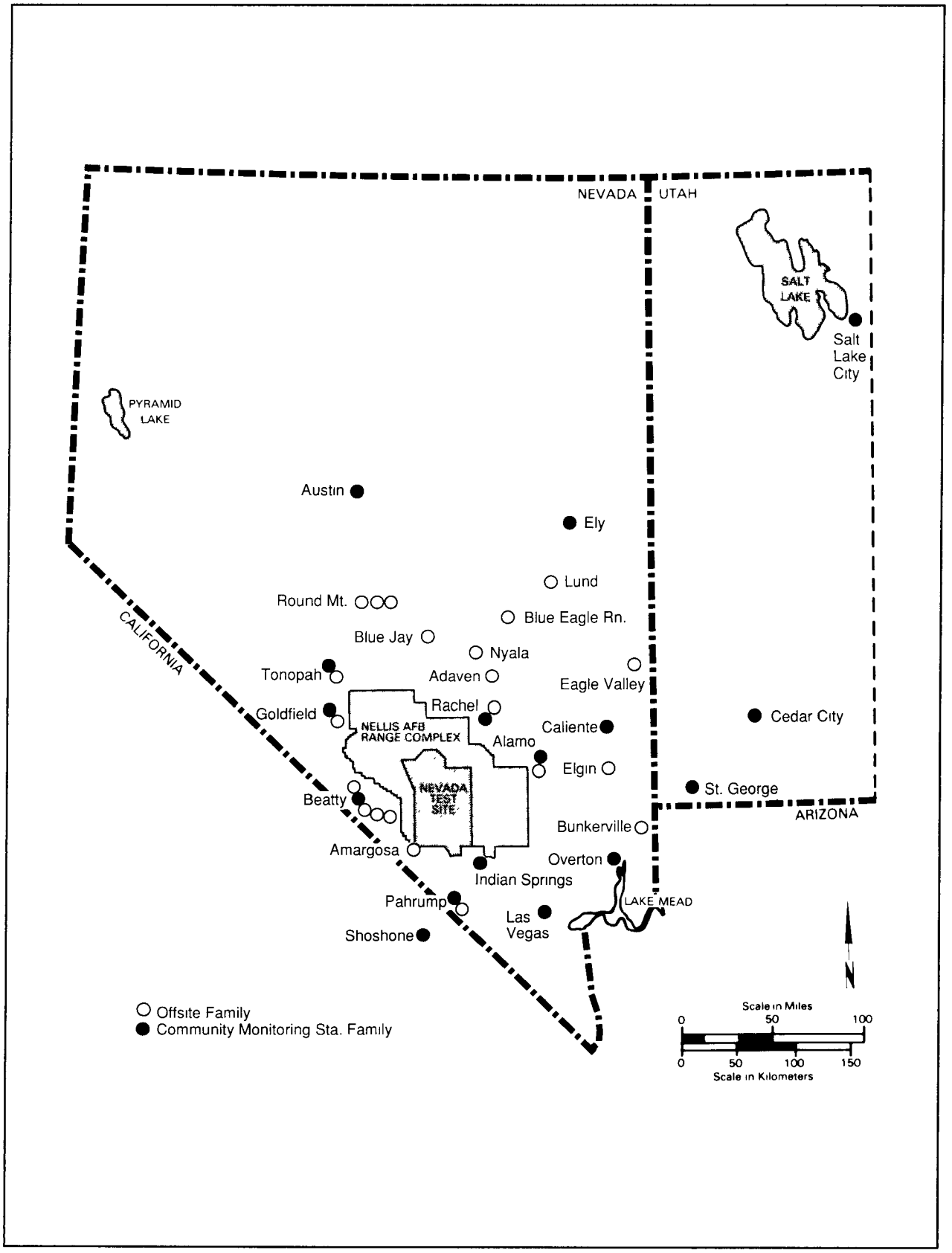

Figure 45. Location of Families in the Offsite Human Surveillance Program.

Figure 46. Calibration of the Semi-Planar Detectors for Transuranic Radionuclides Using the LLNL Realistic Lung Phantom. (The thyroid and coaxial detectors are calibrated for the radioiodines with the thyroid neck phantom.)

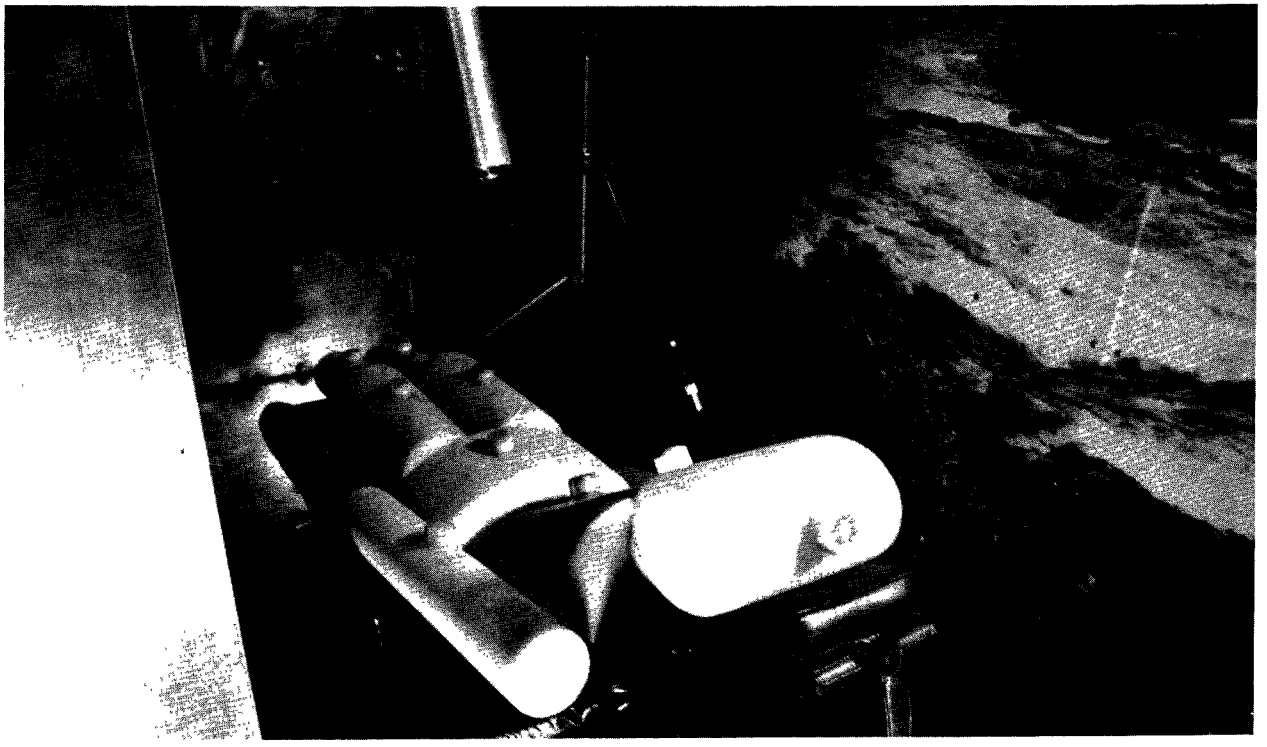

Figure 47. The BOMAB Phantom is Shown During Calibration of the Coaxial Whole-Body Counting Detector.

The Quality Control Program utilizes daily equipment checks analyzed with the help of specially designed software. Calibrations with National Institute of Standards and Technology traceable radionuclides are done yearly using standard phantoms (see Figures 46 and 47). Calibration phantoms are exchanged among this facility and other whole-body counting facilities across the nation for intercomparison studies.

SECTION 4.2.8.4. RESULTS

During 1989, a total of 904 gamma spectra were obtained from 221 individuals, of whom 101 were participants in the Offsite Human Surveillance Program. Also, 1440 spectra for calibrations and background were generated. Cesium-137 is generally the only fission product detected in the body. As a result of worldwide fallout following the Chernobyl accident, a trace amount of ^{137}Cs was detected in a limited number of individuals who had been visiting or residing in Europe. In general, the spectra were representative of normal background for people and showed only naturally occurring ^{40}K, and radon and thoron daughter products. No transuranic radionuclides were detected in any lung counting data.

The tritium concentrations in urine samples from EPA, DRI and SAIC employees had a range from below the (MDC) (average value 3.45 x 10^{-7} μCi/mL 12.8 Bq/L) to 1.25 x 10^{-6} μCi/mL (46.2 Bq/L). This value was 0.05 percent of the annual limit on intake for occupationally exposed employees (see Table 19).

TABLE 19. TRITIUM IN URINE RADIOLOGICAL SAFETY PROGRAM

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. (MDC) (10^{-9} μCi/mL)		ORGANIZATION
LAS VEGAS NV	02/06	349±251	(406)	SAIC
	02/06	289±251	(408)	SAIC
	02/06	304±252	(409)	SAIC
	02/06	488±254	(409)**	SAIC
	02/07	-277±201	(337)	SAIC
	02/09	-329±242	(405)	SAIC
	02/13	95±243	(398)	SAIC
	02/17	-237±241	(401)	EPA
	02/17	74±207	(339)	EPA
	02/22	237±212	(344)	EPA
	03/06	-95±209	(347)	EPA
	03/06	-115±211	(350)	EPA
	03/07	-134±207	(345)	EPA
	03/07	-131±202	(336)	EPA
	03/08	50±209	(343)	EPA
	03/10	-220±204	(341)	EPA
	03/15	126±218	(357)	EPA
	03/16	298±188	(303)	EPA
	03/16	190±194	(316)	EPA
	03/17	8.6±217	(358)	EPA
	03/31	90±218	(357)	EPA
	03/31	-190±213	(355)	EPA
	04/07	309±224	(362)	EPA
	04/21	175±218	(356)	EPA
	04/21	221±216	(351)	EPA
	04/21	272±222	(360)	EPA
	04/26	193±215	(350)	EPA
	04/27	283±216	(349)	EPA
	04/27	101±213	(349)	EPA
	05/03	0±212	(349)	EPA
	05/03	851±224	(351)**	EPA
	05/04	400±216	(347)**	EPA
	05/04	122±214	(350)	EPA
	05/04	27±213	(350)	EPA
	05/04	130±217	(355)	EPA
	05/05	494±222	(355)**	EPA
	05/05	265±215	(348)	EPA
	05/09	50±213	(350)	EPA
	05/09	181±213	(347)	EPA
	05/11	220±219	(356)	EPA
	05/11	247±222	(361)	EPA
	05/11	397±196	(315)**	EPA
	05/12	117±213	(348)	EPA
	05/15	158±196	(319)	EPA
	05/18	419±196	(314)**	SAIC
	06/08	60±194	(319)	EPA
	06/28	-304±187	(315)	EPA
	07/12	-19±189	(311)	EPA
	07/27	40±190	(312)	EPA
	12/12	1247±213	(326)**	EPA
	12/13	236±186	(301)	SAIC
	12/13	210±188	(305)	SAIC
	12/13	249±195	(316)	SAIC
RENO NV	07/11	171±191	(311)	DRI
	11/21	158±186	(302)	DRI
	11/21	67±185	(304)	DRI
	11/21	194±188	(305)	DRI

***Concentration is greater than the Minimum Detectable Concentration (MDC).*

Bioassay results for the Offsite Human Surveillance Program showed that the concentration of tritium in single urine samples collected at random periods of time varied from below the minimum detectable concentration (MDC) (average 3.65 x 10^{-7} μCi/mL, 13.5 Bq/L) to 4.66 x 10^{-6} μCi/mL (172 Bq/L)(see Table 20). The average value for tritium in urine was 3.9 x 10^{-7} μCi/mL (14.5 Bq/L). Nearly half of the concentrations were below the MDC. None of the values above the MDC were over applicable limits. The highest value 4.66 x 10^{-6} μCi/mL was 2.5 percent of the annual limit on intake for the general public. The higher than MDC tritium values seen in the offsite population occur routinely. There appears to be no correlation with tritium found in air samples at a statistically acceptable confidence level.

TABLE 20. TRITIUM IN URINE OFFSITE HUMAN SURVEILLANCE PROGRAM

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. (MDC) (10^{-9} μCi/mL)
SHOSHONE CA	05/12	44 ± 212 (348)
	05/12	156 ± 218 (356)
ALAMO NV	03/17	138 ± 220 (360)
	03/17	-58 ± 218 (360)
BEATTY NV	03/13	-26 ± 216 (356)
	03/13	81 ± 216 (354)
	03/13	146 ± 182 (297)
	03/23	136 ± 221 (361)
	03/23	403 ± 233 (375)**
	04/25	110 ± 216 (354)
	04/25	244 ± 216 (351)
	04/25	354 ± 226 (364)
	04/25	-119 ± 214 (355)
	07/01	319 ± 194 (313)**
	07/12	373 ± 191 (306)**
	07/12	460 ± 192 (307)**
	12/13	107 ± 184 (300)
	12/13	135 ± 187 (305)
	12/13	99 ± 185 (303)
CALIENTE NV	07/14	473 ± 195 (311)**
	07/14	269 ± 194 (314)
	07/14	930 ± 205 (319)**
	07/14	397 ± 195 (312)**
	07/14	425 ± 195 (312)**
CURRANT NV		
BLUE EAGLE RANCH	08/04	515 ± 199 (316)**
	08/04	755 ± 203 (318)**
ELY NV	03/20	125 ± 228 (373)
	03/20	17 ± 215 (354)
	04/07	38 ± 214 (351)
	04/07	730 ± 232 (366)**
	10/11	144 ± 204 (334)
	10/11	62 ± 203 (334)
GOLDFIELD NV	08/17	423 ± 193 (309)**
	08/17	445 ± 192 (307)**
	08/17	798 ± 214 (336)**
	08/17	346 ± 194 (312)**
INDIAN SPRINGS NV	08/11	136 ± 203 (331)
	08/11	691 ± 198 (311)**
	09/06	268 ± 202 (327)
	09/06	207 ± 204 (331)
	09/06	218 ± 206 (335)
LAS VEGAS NV	07/14	937 ± 196 (303)**
STATELINE NV	03/15	50 ± 195 (321)
	03/15	167 ± 219 (357)
AMARGOSA FARM AREA NV	07/13	523 ± 195 (310)**
	07/13	445 ± 192 (306)**
	07/19	768 ± 200 (313)**
	07/21	361 ± 193 (310)**
NYALA NV	03/14	-68 ± 153 (253)
	03/14	271 ± 158 (254)**
	03/14	104 ± 221 (361)
	03/24	208 ± 219 (357)
	11/02	225 ± 194 (315)
	11/02	101 ± 185 (302)
	11/16	191 ± 187 (304)
	11/16	100 ± 186 (305)
OVERTON NV	06/27	1192 ± 219 (336)**
	06/27	521 ± 195 (310)**
	06/27	397 ± 194 (310)**
	06/27	377 ± 195 (313)**
	06/27	270 ± 192 (310)
	08/16	268 ± 191 (308)
	08/16	389 ± 198 (318)**
	08/16	290 ± 193 (312)

TABLE 20. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. (MDC) (10^{-9} µCi/mL)
OVERTON NV	08/16	377 ± 194 (311)**
	08/16	538 ± 196 (312)**
PAHRUMP NV	05/12	40 ± 212 (349)
	06/16	-123 ± 192 (319)
	06/16	69 ± 194 (318)
	06/16	77 ± 194 (318)
	08/11	291 ± 192 (310)
	08/11	INSUFFICIENT SAMPLE
RACHEL NV	03/31	604 ± 225 (357)**
	03/31	423 ± 220 (354)**
	08/08	480 ± 196 (314)**
	08/08	656 ± 198 (313)**
	08/21	331 ± 194 (312)**
TONOPAH NV	03/24	-195 ± 212 (354)
	06/23	7.5 ± 188 (309)
	06/23	96 ± 187 (306)
TONOPAH NV	06/23	471 ± 194 (310)**
	06/23	487 ± 194 (310)**
	08/18	3743 ± 232 (309)**
	08/18	483 ± 195 (310)**
	08/18	376 ± 192 (309)**
	08/18	4662 ± 240 (307)**
	11/16	123 ± 185 (301)
CEDAR CITY UT	02/03	417 ± 255 (412)**
	02/03	652 ± 264 (421)**
	02/03	157 ± 249 (406)
	02/03	315 ± 254 (412)
	07/24	386 ± 194 (312)**
	07/24	607 ± 204 (323)**
	07/24	387 ± 193 (309)**
	07/24	258 ± 192 (310)
	07/24	537 ± 195 (309)**
ST GEORGE UT	05/12	238 ± 220 (357)

*** Concentration is greater than the Minimum Detectable Concentration (MDC).*

As reported in previous years, medical examinations of the offsite families revealed a generally healthy population. The blood examinations and thyroid profiles showed no abnormal results which could be attributed to past or present NTS testing operations.

The plot of the average tritium in urine from the Offsite Human Surveillance Program (Figure 48) shows the values vary over the years. Additional sampling, during planned releases (if any) from NTS, will be performed in 1990.

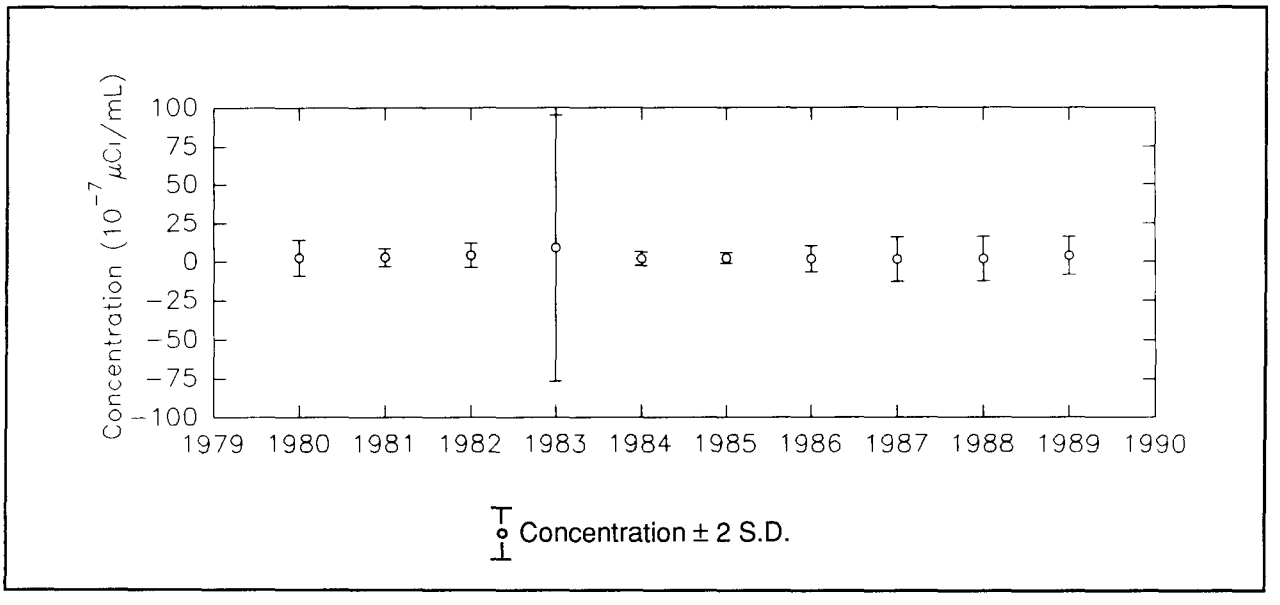

Figure 48. Mean and Standard Deviation for the Concentration of Tritium in Urine of Offsite Residents.

Section 4.2.9. Long-Term Hydrological Monitoring Program (LTHMP)

S. C. Black

Tritium and gamma-spectral analyses were performed on samples taken from 217 wells, springs, and other sources at locations near sites where underground nuclear explosives tests have been conducted. Gamma radioactivity was found in only three sampled locations, as would be expected from previous results. Tritium concentrations found during this sampling year were consistent with the levels found in previous years. In only three samples were the tritium concentrations greater than the Drinking Water Standards, and those samples were from wells not accessible to the general public.

SECTION 4.2.9.1. BACKGROUND

Surface- and ground-water sampling and analysis have been performed for many years on water sources around the NTS. Also, when underground nuclear tests occurred in other states, water sampling programs were instituted. Finally, in 1972, all of the water sampling programs were combined to constitute the Long-Term Hydrological Monitoring Program (LTHMP). At each of the sites of underground nuclear tests, water sampling points were established by the U.S. Geological Survey so that any migration of radioactivity from the test cavities to potable water sources could be detected by radioanalysis.

The 37 wells on the NTS and a like number of wells in areas near the NTS that are part of this program are shown in Figures 50 and 51, respectively. The locations of sampling points at sites in Nevada outside the NTS and at sites in Alaska, Colorado, Mississippi, and New Mexico are shown in Figures 52 through 63.

Because of news reports of leakage from the Project Dribble test cavity, several residents requested that their water be analyzed (10 extra water samples were collected) and venison from deer collected at the Tatum Dome site was also received for analysis.

SECTION 4.2.9.2. METHODS

At nearly all locations, the standard operating procedure is to collect four samples. Two samples are collected in 500 mL glass bottles to be analyzed for tritium. The results from analysis of one of these is reported while the other sample serves as a backup in case of loss. If the tritium is found at a detectable concentration, the second sample serves as a duplicate sample. The remaining two samples are collected in 3.8-liter plastic containers (cubitainers). One of these is analyzed by gamma spectrometry and the other is stored as a backup or for duplicate analysis. For wells with operating pumps, the samples are collected at the nearest convenient outlet. If the well has no pump, a truck-mounted sampling rig is used. With this rig, it is possible to collect 3-liter samples from wells as deep as 1800 meters. At a few locations, because of limited supply, only 500 mL samples are collected for ^{3}H analysis. At the normal sample collection sites, the pH, conductivity, and water temperature are measured when the sample is collected. This estimates the stability of the water supply. Also, the first time samples are collected from a well, $^{89,90}Sr$, ^{226}Ra, $^{238,239+240}Pu$ and uranium isotopes are determined by radiochemistry as time permits.

The ^{3}H and gamma spectrometric analyses are described in Chapter 8, Sample Analysis Procedures. For those samples in which the ^{3}H concentration is less than 7×10^{-7} μCi/mL (26 Bq/L), an enrichment procedure is performed to reduce the MDC from about 5×10^{-7} to about 1×10^{-8} μCi/mL (from 22 to 0.4 Bq/L).

For those operations conducted in other states, samples for the LTHMP are collected annually. For the locations on the NTS listed in Table 22, the samples are collected monthly, when possible, and analyzed by gamma spectrometry as well as for tritium. For a few NTS wells and for all the water sources around the NTS shown in Table 23, a sample is collected twice per year at about a 6-month interval. One of the semi-annual samples is analyzed for ^{3}H by the conventional method, the other by electrolytic enrichment. A 3.8 L cubitainer of water is collected each month from these sites and analyzed by gamma spectrometry.

Because of the variability noted in past years in samples obtained from the shallow monitoring wells at Project Dribble in Mississippi, a second sample is taken after pumping for awhile or after the hole has refilled with water. These second samples are frequently higher in ^{3}H concentration and may be more representative of formation water.

(Text continued on page 103)

Figure 49. EPA Monitoring Technician Collecting City Water Sample from Pahrump, Nevada.

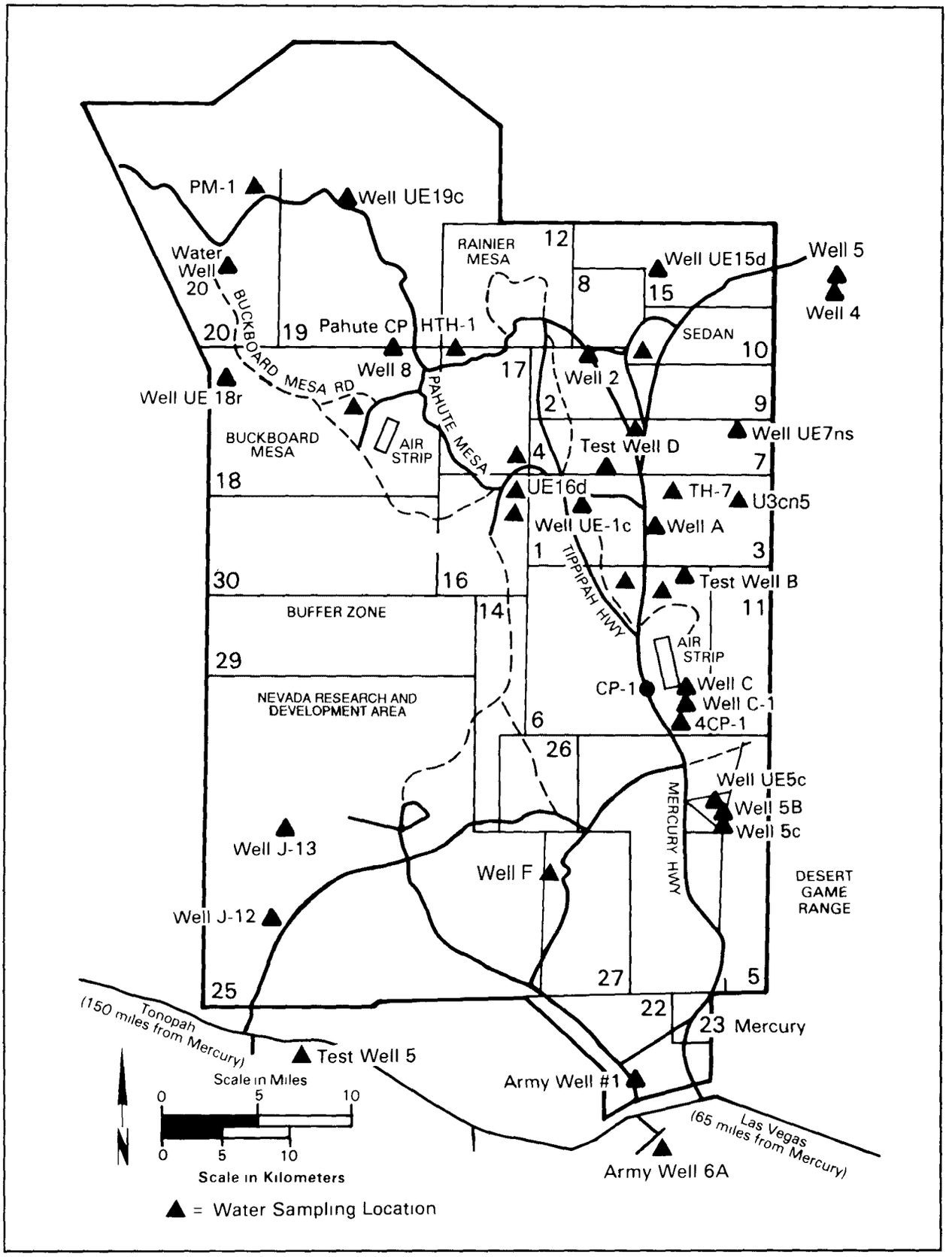

Figure 50. LTHMP Sampling Locations on the NTS.

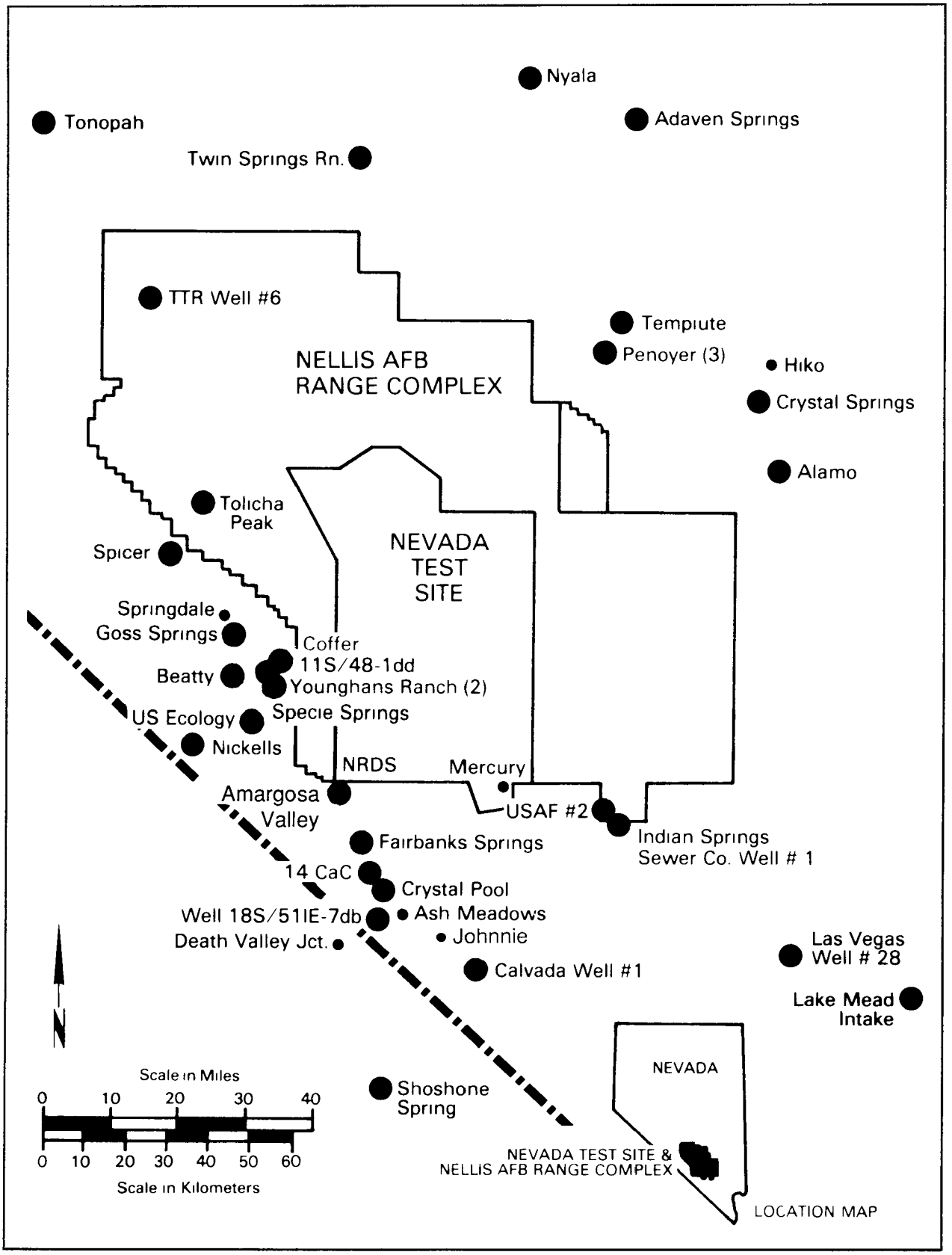

Figure 51. LTHMP Sampling Locations Near the NTS.

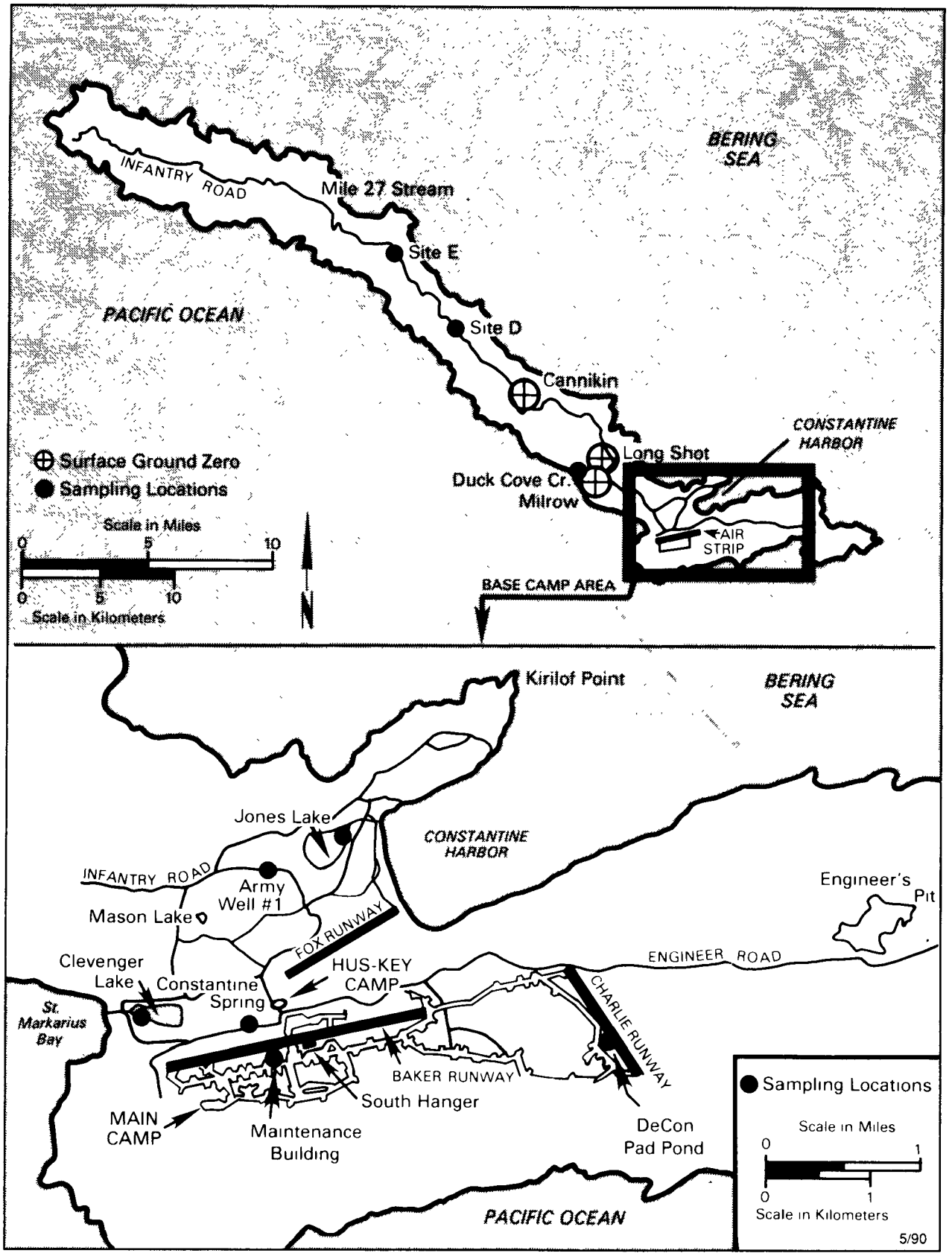

Figure 52. Amchitka Island and Background Sampling Locations for the LTHMP.

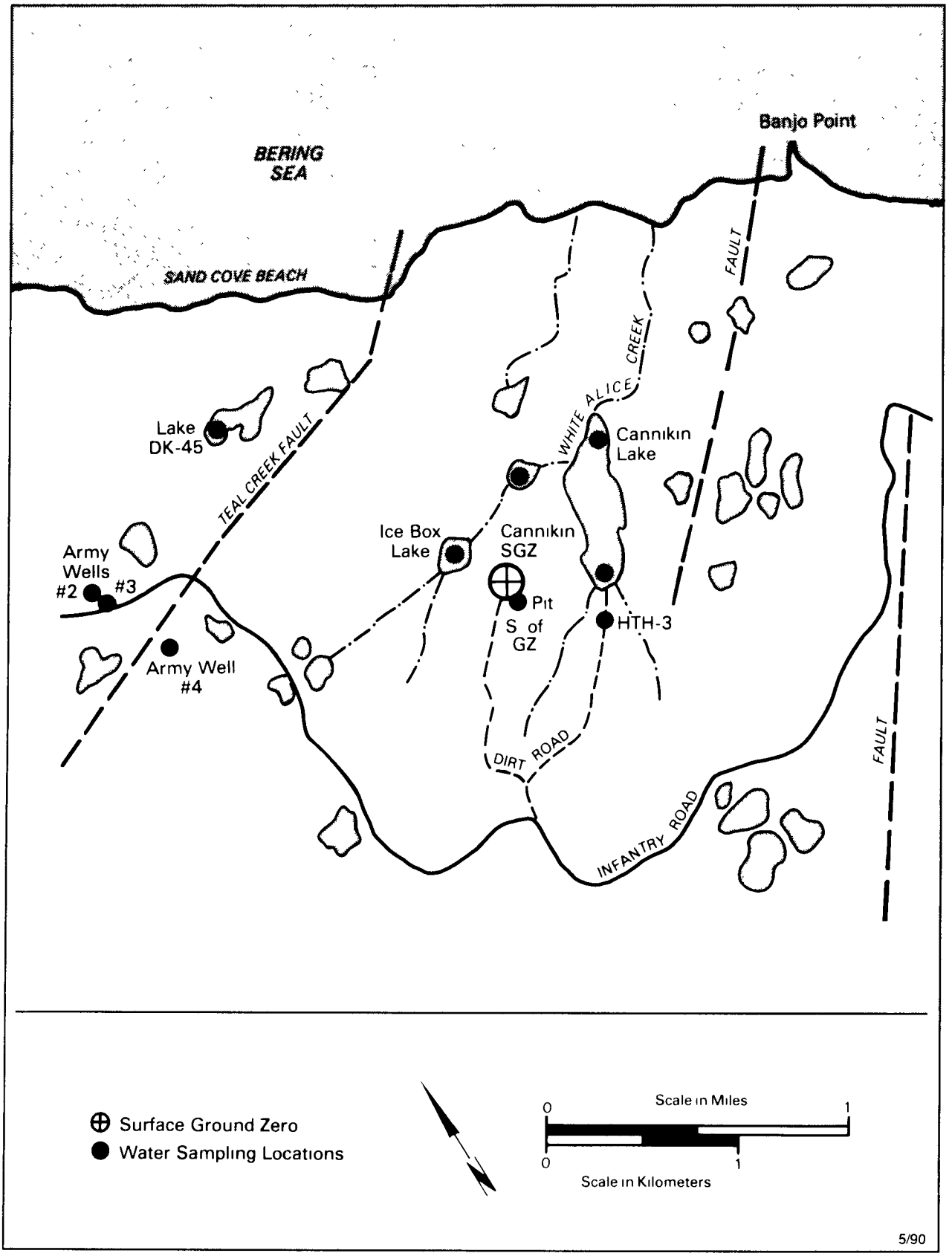

Figure 53. LTHMP Sampling Locations for Project Cannikin.

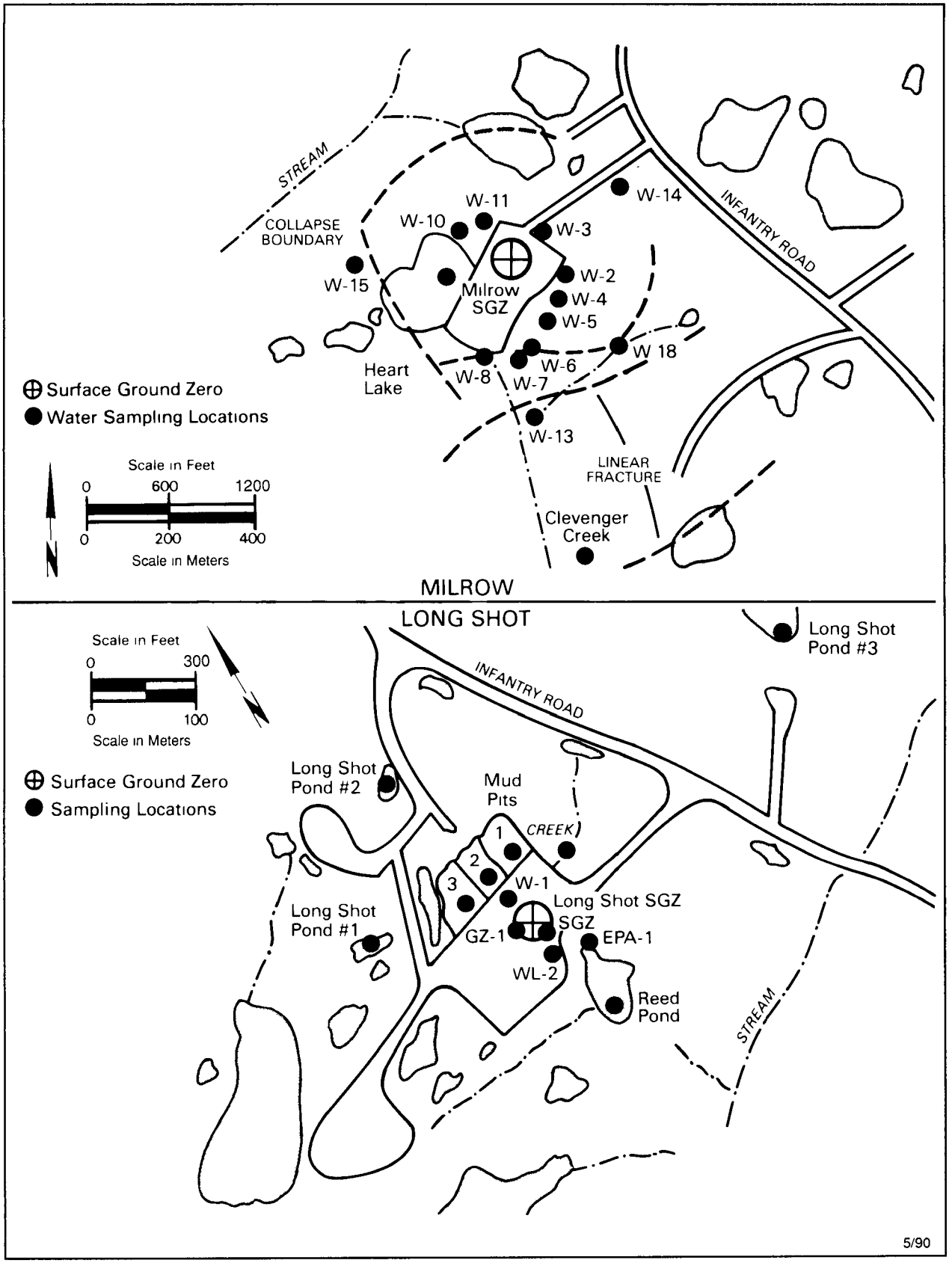

Figure 54. LTHMP Sampling Locations for Projects Milrow and Long Shot.

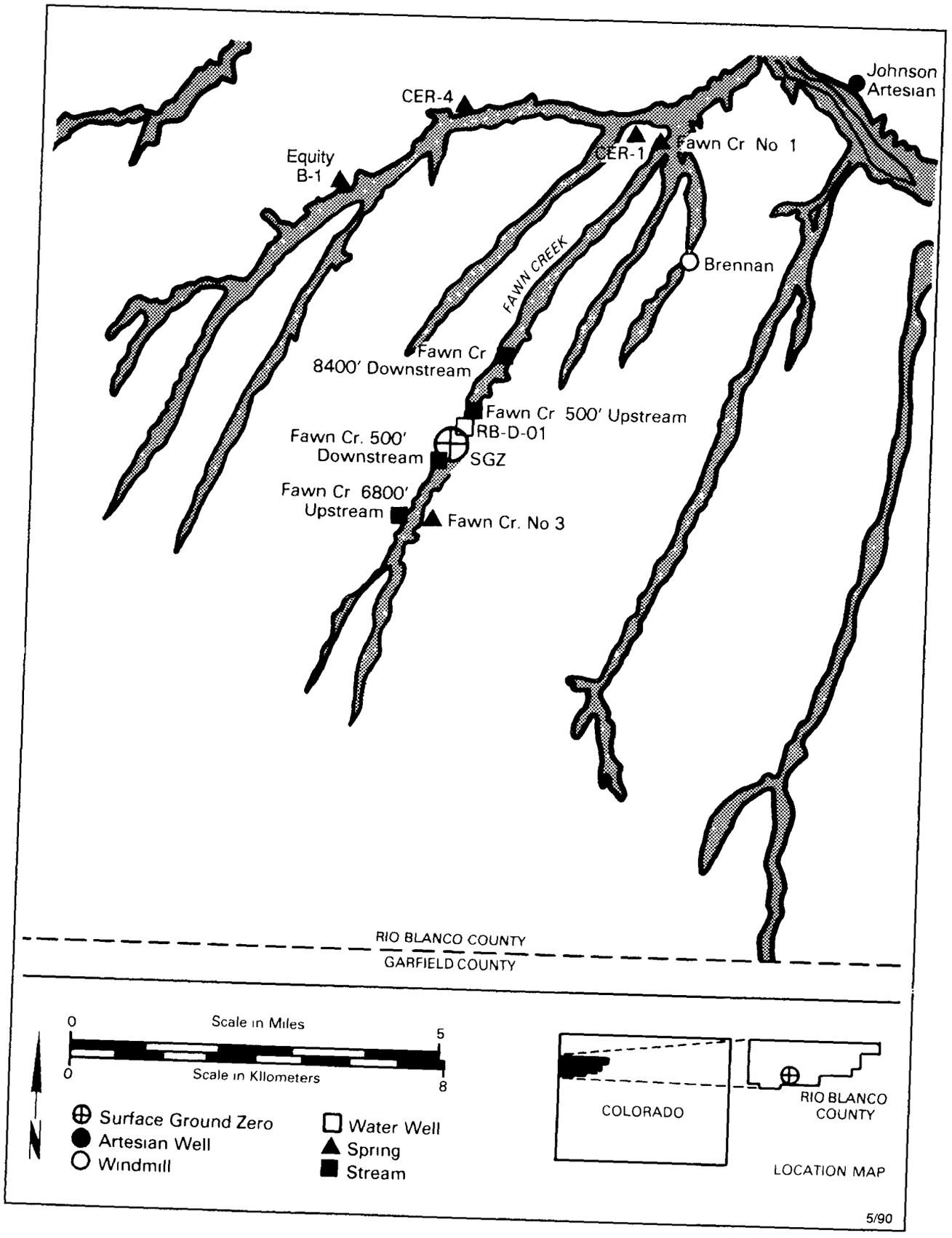

Figure 55. LTHMP Sampling Locations for Project Rio Blanco.

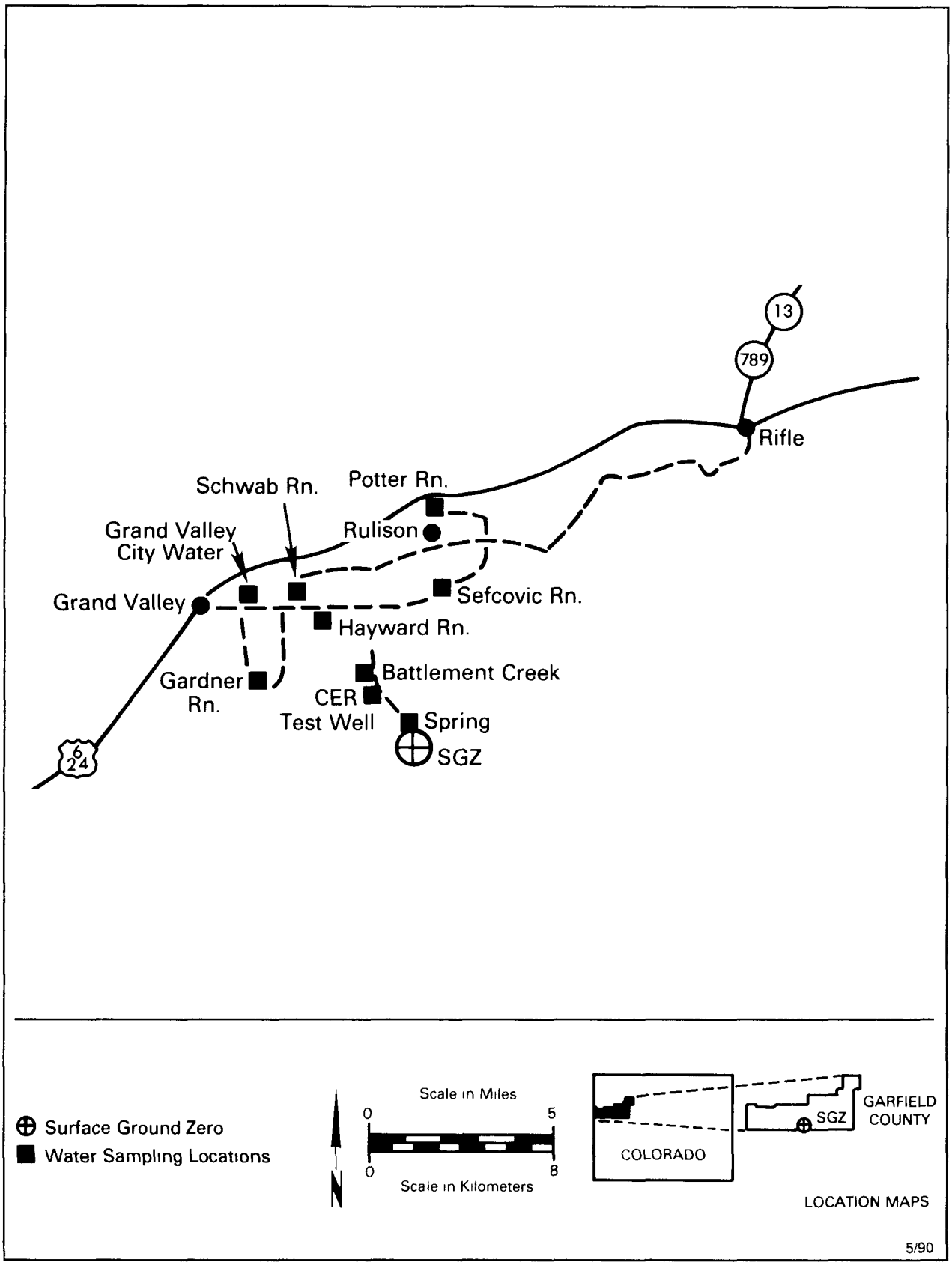

Figure 56. LTHMP Sampling Locations for Project Rulison.

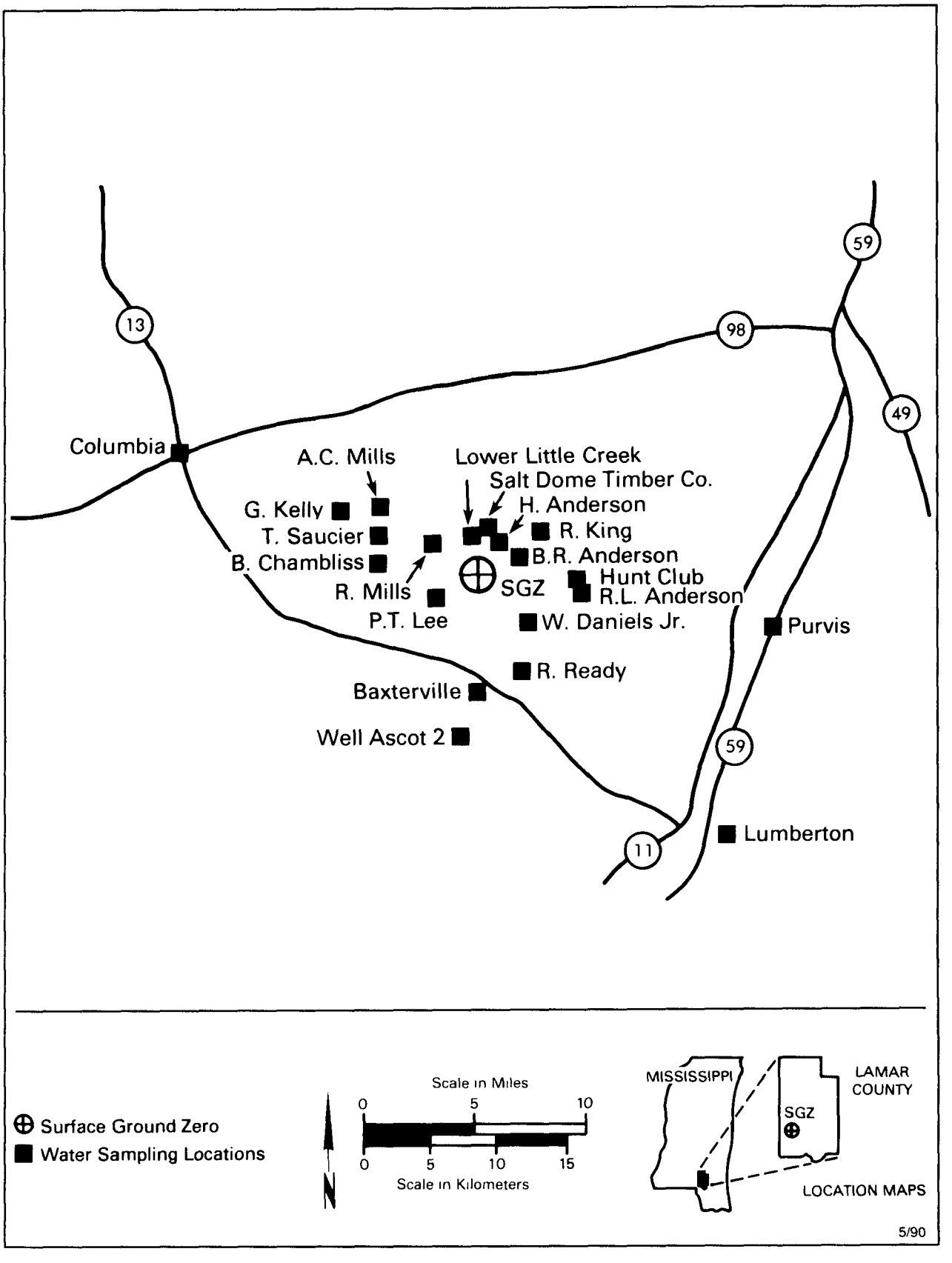

Figure 57. LTHMP Sampling Locations for Project Dribble — Towns and Residences.

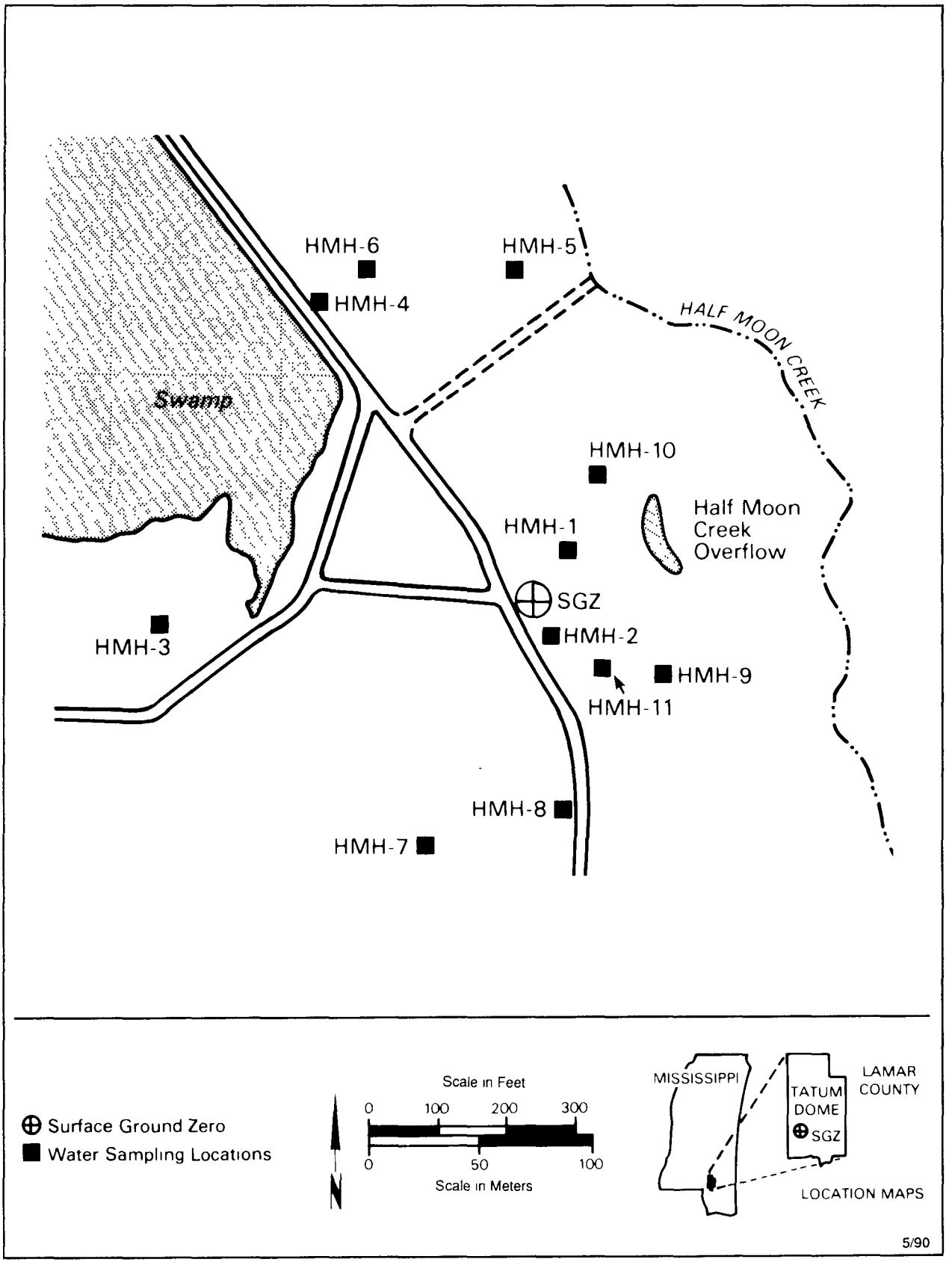

Figure 58. LTHMP Sampling Locations for Project Dribble — Near GZ.

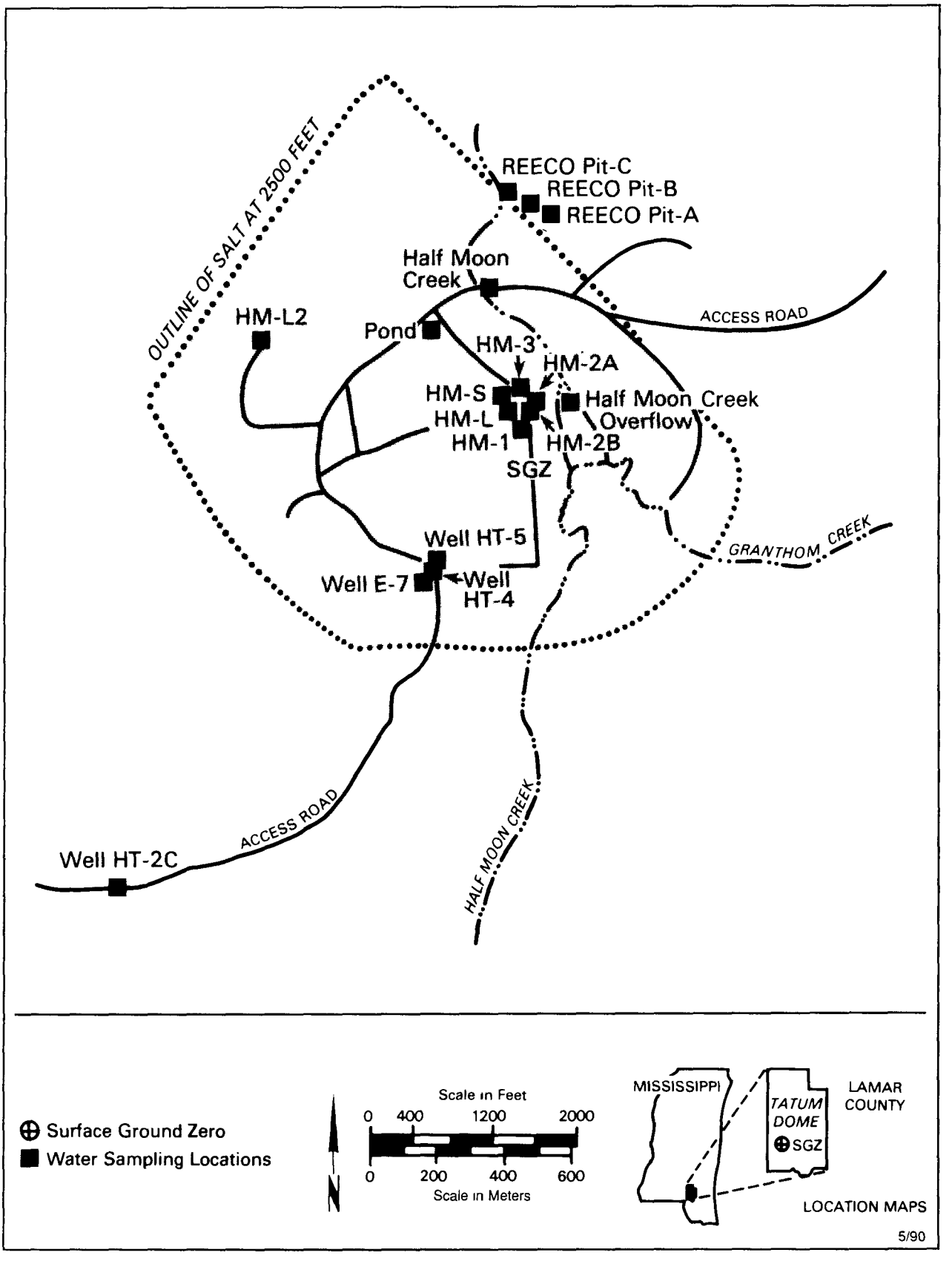

Figure 59. LTHMP Sampling Locations for Project Dribble — Near Salt Dome.

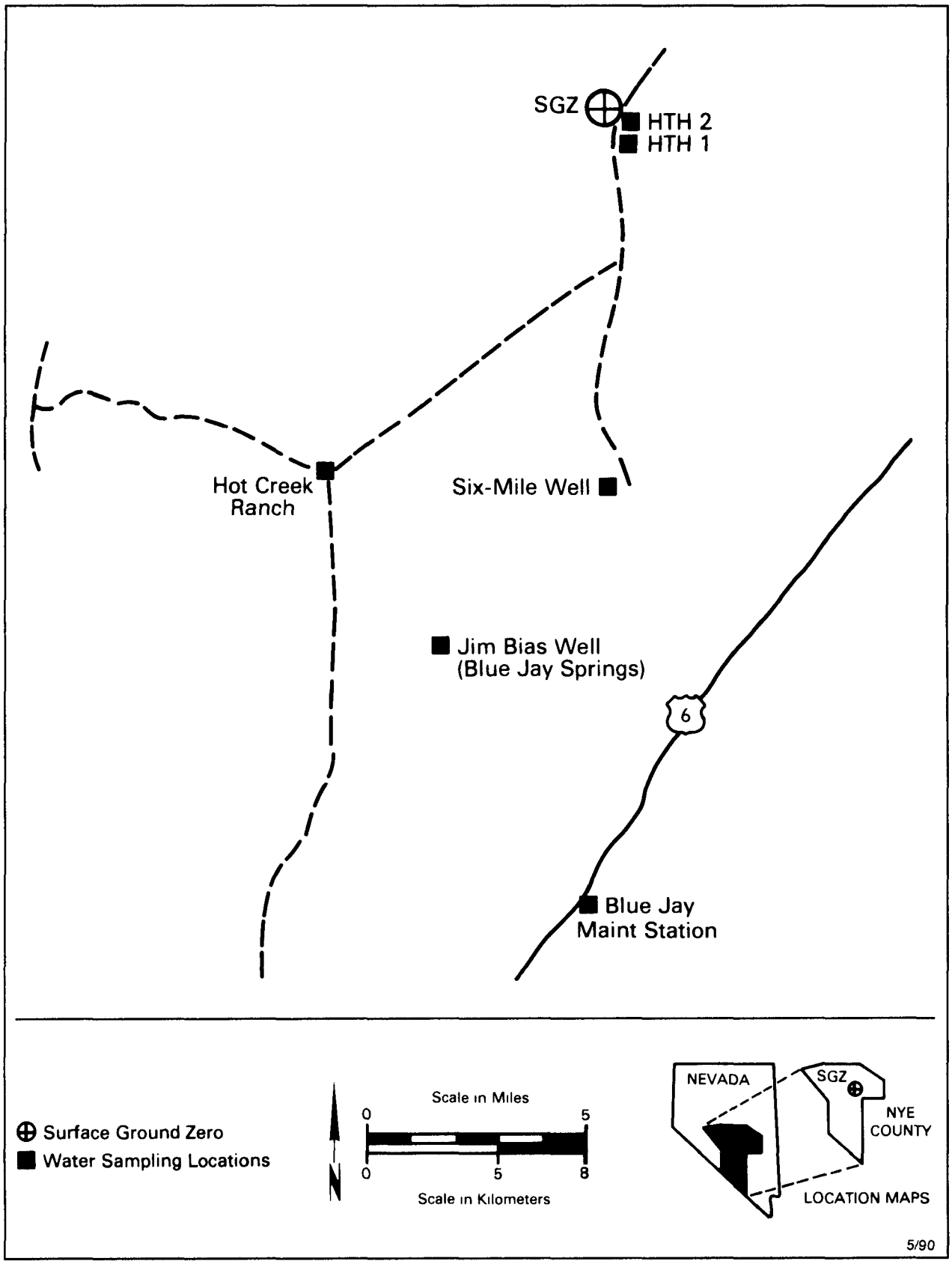

Figure 60. LTHMP Sampling Locations for Project Faultless.

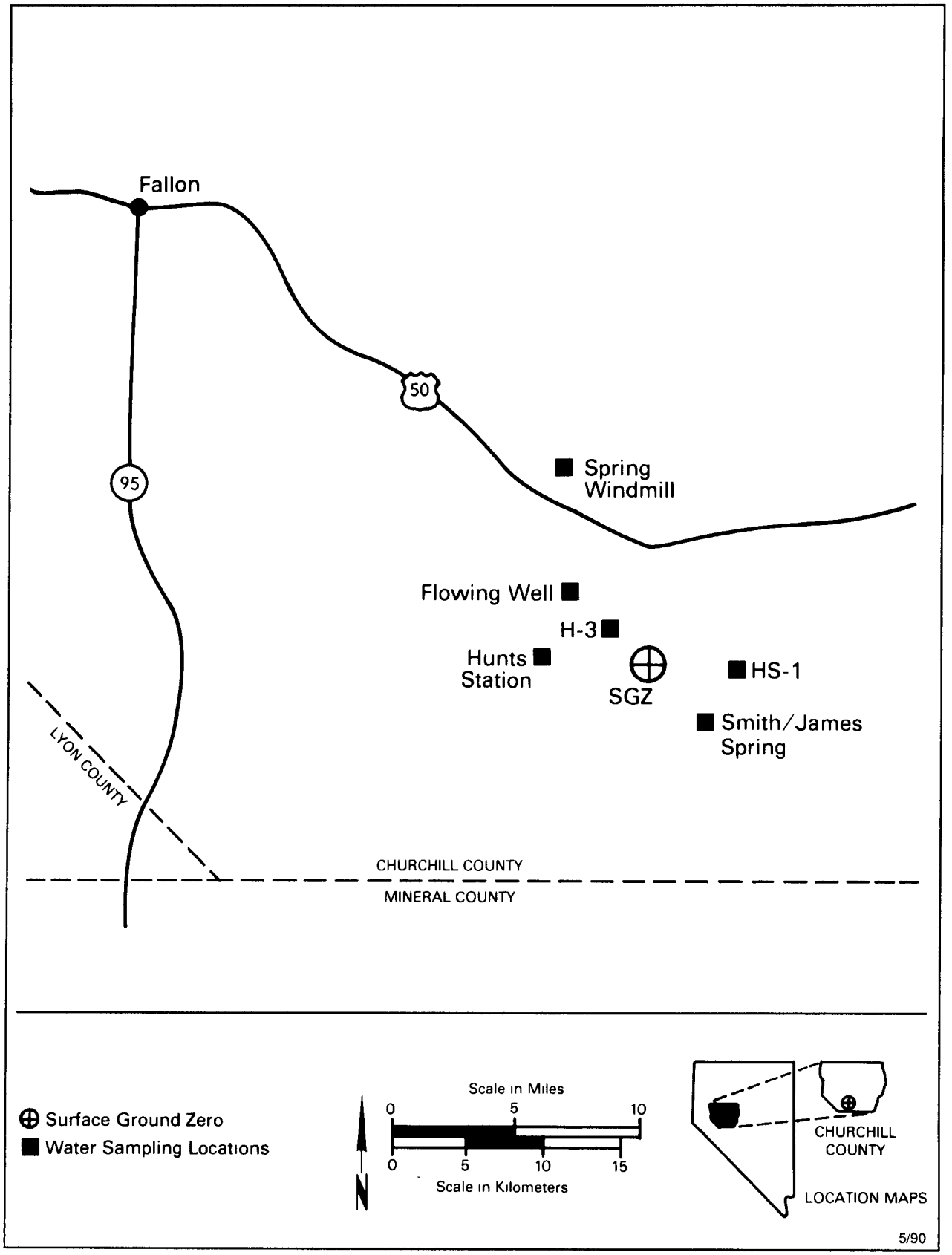

Figure 61. LTHMP Sampling Locations for Project Shoal.

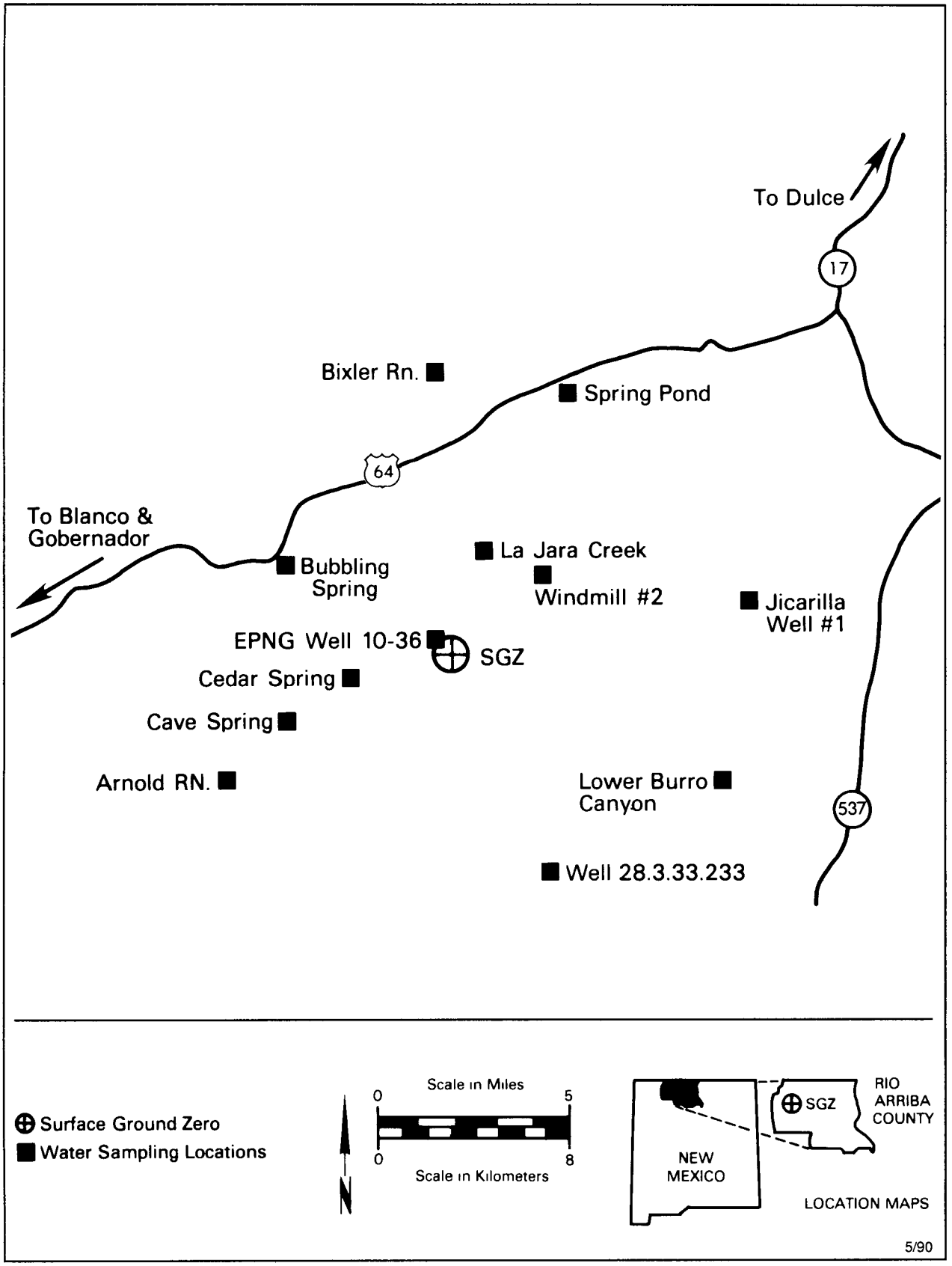

Figure 62. LTHMP Sampling Locations for Project Gasbuggy.

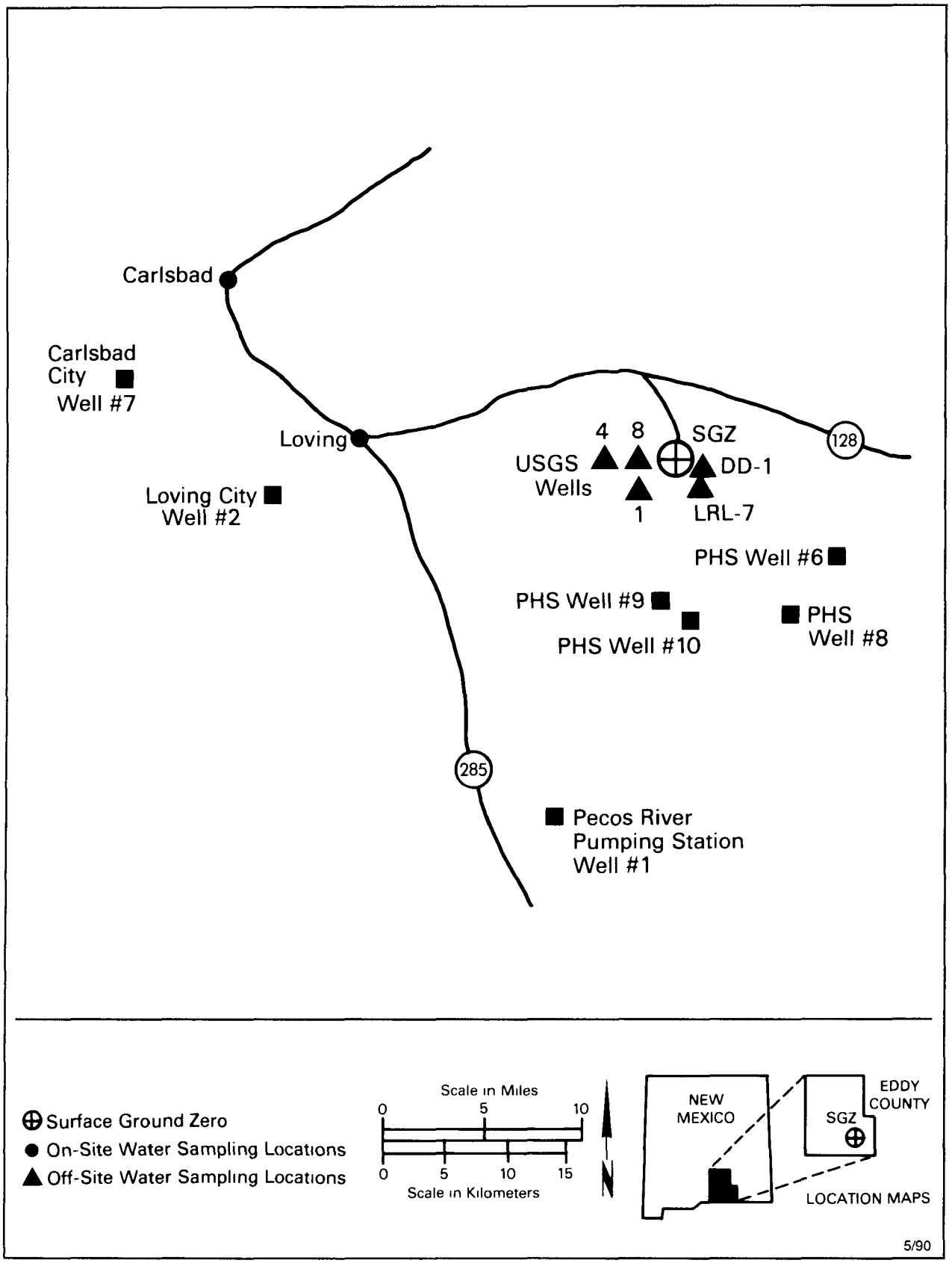

Figure 63. LTHMP Sampling Locations for Project Gnome.

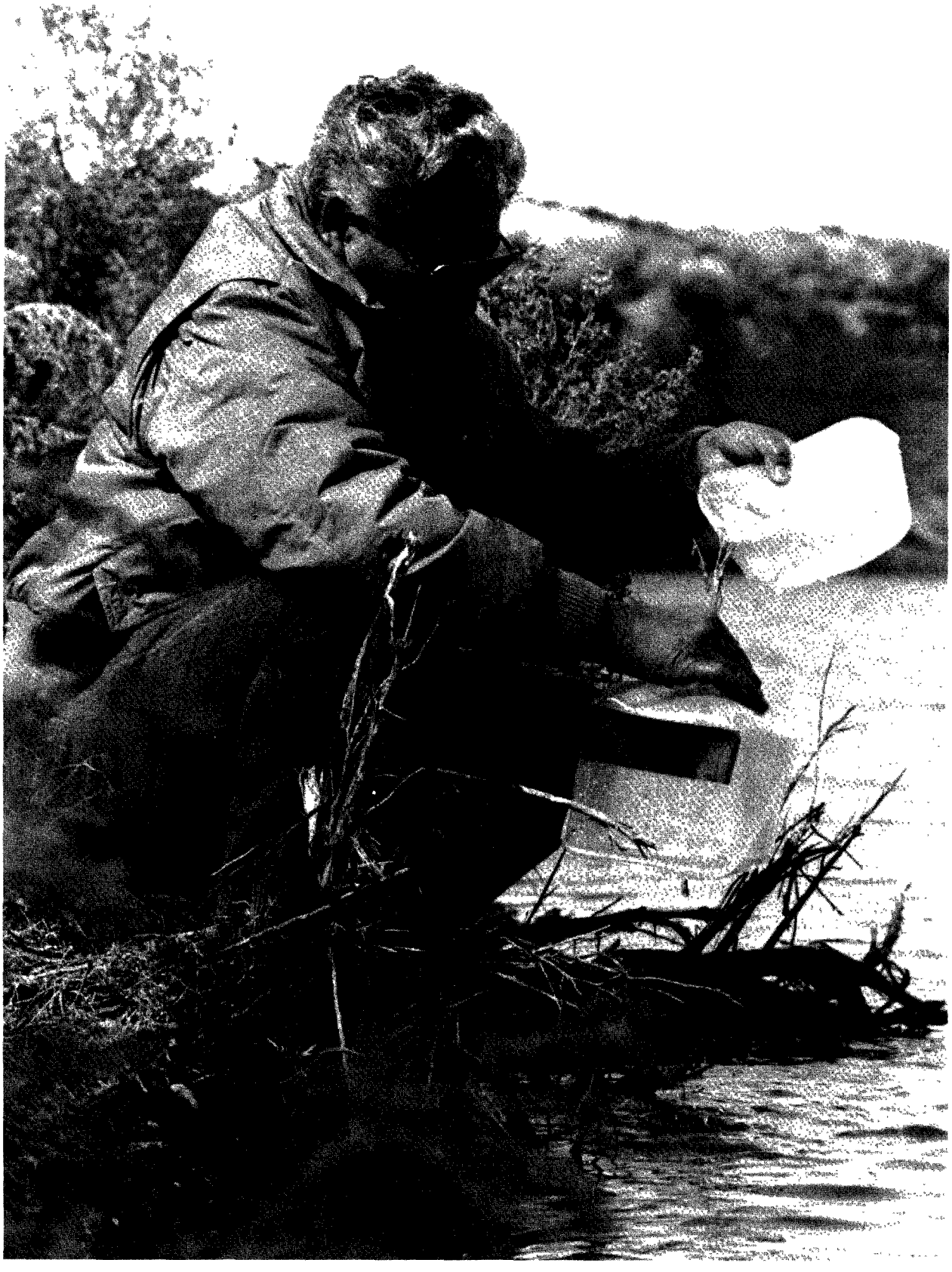

Figure 64. EPA Monitoring Technician Collecting Fresh Water Sample.

SECTION 4.2.9.3. RESULTS

The locations at which the water samples contain man-made radioactivity are shown in Table 21 along with the analytical results. For ^{3}H only those samples having a concentration exceeding one percent of the Drinking Water Regulations, i.e., >2 x 10^{-7} µCi/mL, are shown. Except for Well UE-5n on the NTS, the radioactivity detected in the sampled locations has been reported previously and is decreasing. Well DD-1 is linked to the Gnome cavity, as is LRL-7, so the results are expected. The result for Well USGS-8 is also expected as radioactivity was added to that well for hydrological testing. The ^{3}H in samples from Project Dribble are a result of post-shot drilling operations and disposal of low-level contaminated debris.

Except for the three samples listed in Table 21, all the gamma spectra were negligible (no measurable gamma-emitting fission products over the energy range 60 - 2,000 keV). Therefore, only the ^{3}H results are listed in Tables 22, 23, and 24.

Table 22 shows the maximum, minimum and average ^{3}H concentrations found in the NTS wells that are sampled monthly. Shown in Table 23, are the ^{3}H results for those onsite and offsite water sources that are analyzed semi-annually. Finally, Table 24 contains the ^{3}H concentration in water samples collected around sites used for underground nuclear tests that were performed outside the Nevada Test Site.

SECTION 4.2.9.4. DISCUSSION

The results for the residents' special request samples are shown in Table 24 at the end of the Project Dribble listing. The two venison samples had ^{137}Cs contents of 3.8 and 4.3 x 10^{-7} µCi/g and ^{3}H concentrations near the MDC. The cesium concentrations were similar to those in deer from other locations in the U.S.

TABLE 21. SAMPLING LOCATIONS WHERE WATER SAMPLES CONTAINED MAN-MADE RADIOACTIVITY — 1989

SAMPLING LOCATION	RADIONUCLIDE	CONCENTRATION (10^{-9} µCi/mL)
NTS NETWORK, NV		
Well UE-5n	^{3}H	460
PROJECT GNOME, NM		
USGS Well 8	^{3}H	1.3 x 10^{5}
	^{137}Cs	85
Well LRL-7	^{3}H	1.6 x 10^{4}
	^{137}Cs	200
Well DD-1	^{3}H	1.2 x 10^{8}
	^{137}Cs	7.5 x 10^{5}
PROJECT DRIBBLE, MS		
Half Moon Creek Overflow	^{3}H	1.4 x 10^{3}
Wells HMH-1,2, and 5	^{3}H	1.1 x 10^{3} - 1.2 x 10^{4}
Well HM-S	^{3}H	1 x 10^{4}
Well HM-L	^{3}H	1.8 x 10^{3}
REECo Pit B	^{3}H	740
REECo Pit C	^{3}H	300
PROJECT LONGSHOT, AK		
Well GZ-1	^{3}H	2.3 x 10^{3}

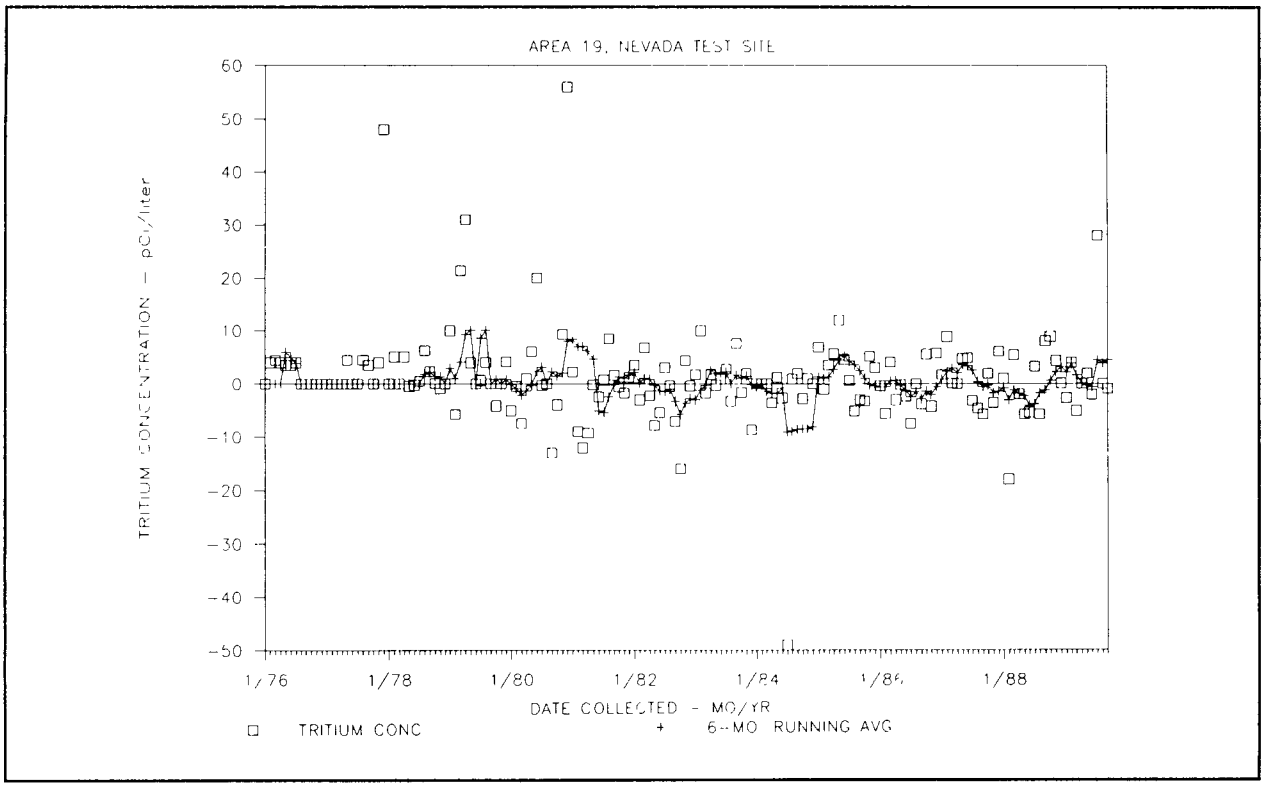

Figure 65. Typical Tritium Concentration in Deep Water Wells — 1989.

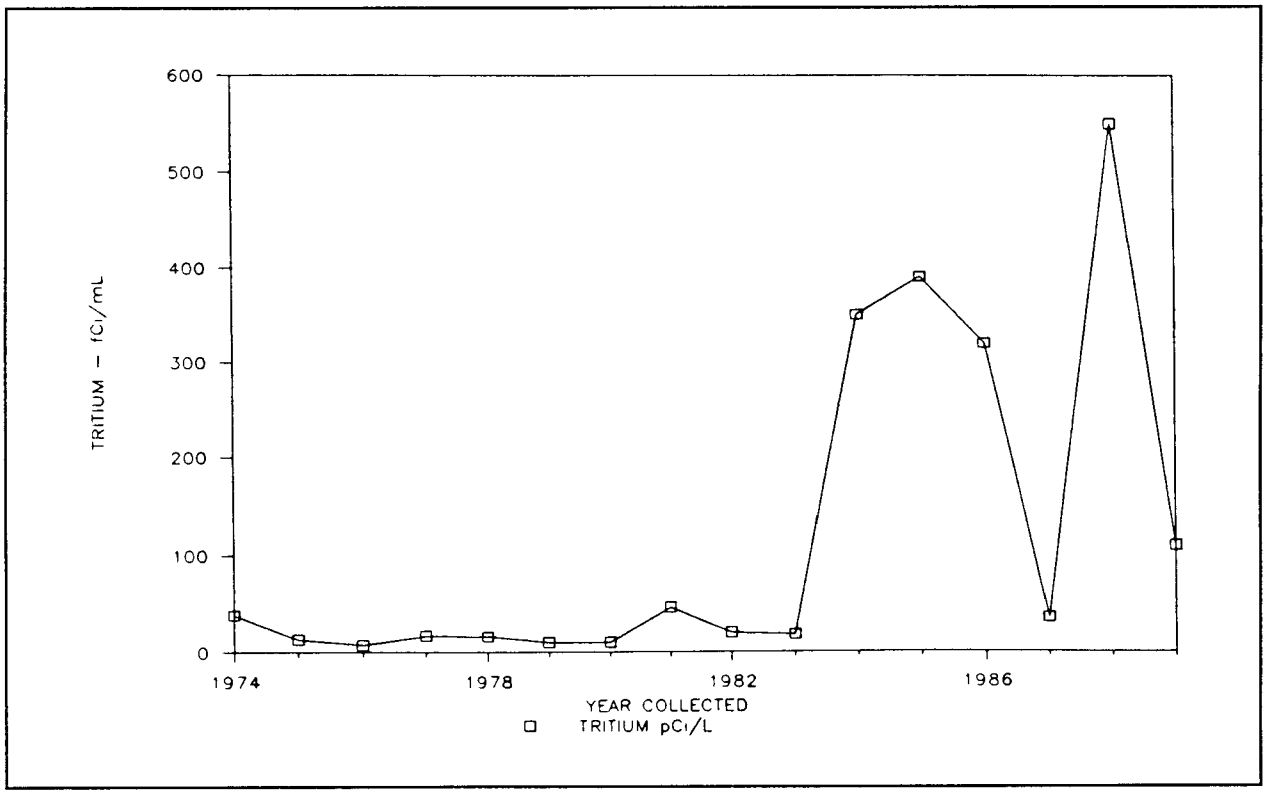

Figure 66. Tritium Concentration Increasing with Time.

The graphs of results for some water samples are shown in Figures 65-67. The results for samples from Well UE-19c are typical of most deep water sources we have sampled, i.e., no trend with time. The running average data show pulses that may represent surface water infiltration on about a 20 month cycle. Data from natural springs are similar but the average concentration will be higher because of relatively rapid surface water recharge. For those water sources that had above background levels of ^{3}H at earlier times, graphs such as those for Test Well B on the NTS and for the HMH holes at Project Dribble in Figure 66 are typical, showing a general downward trend with time. Other locations that follow this trend are wells C and C-1 on the NTS, HM-L and HM-S at Dribble and wells PHS-6, USGS-4 and USGS-8 at Gnome.

The final graph in Figure 67 shows some upward trend. The graph for Well EPNG 10-36 at Gasbuggy indicates low-level pulse of ^{3}H passing through the area. On the Nevada Test Site, an upward trend in ^{3}H concentration may be starting in Well UE-15d similar to that reported for Well A in the 1988 annual report.

Regardless of the finding of detectable amounts of radioactivity in some water samples, the exposure to the public is negligible. The HMH holes at Dribble tap shallow, non-potable water and the HM-S and HM-L wells are locked. The wells at the Gnome site are locked and inaccessible for the general public while the EPNG well at Gasbuggy is a monitoring well with no pump.

TABLE 22. LTHMP TRITIUM RESULTS FOR NTS MONTHLY NETWORK — 1989

SAMPLING LOCATION	NO. SAMPLES	TRITIUM CONCENTRATION (10^{-9} µCi/mL) MAX	MIN	AVG	% CONC. GUIDE
WELL 1 ARMY	13	5.9	-33	-2.7	<0.01
WELL 2	12	5.0	-4.7	0.82	<0.01
WELL 3*	2*	5.1	-4.4	0.36	<0.01
WELL 4	12	4.7	-28	-2.2	<0.01
WELL 4 CP-1	12	1.1	-26	-4.2	<0.01
WELL 5	11	34	-11	2.9	0.01
WELL 5C	12	2.9	-13	-2.3	<0.01
WELL 8	12	3.3	-3.9	-0.33	<0.01
WELL 20†	9 †	3.6	-5.7	-1.3	<0.01
WELL B TEST	12	150	67	120	0.61
WELL C	11	43	0.0	20	0.10
WELL J-12	12	7.8	-25	-2.3	<0.01
WELL J-13	12	27	-29	0.25	<0.01
WELL UE19C	12	28	-5.0	2.8	0.01

**Replaced by Well 5.*

† Samples not collected while pump inoperative.

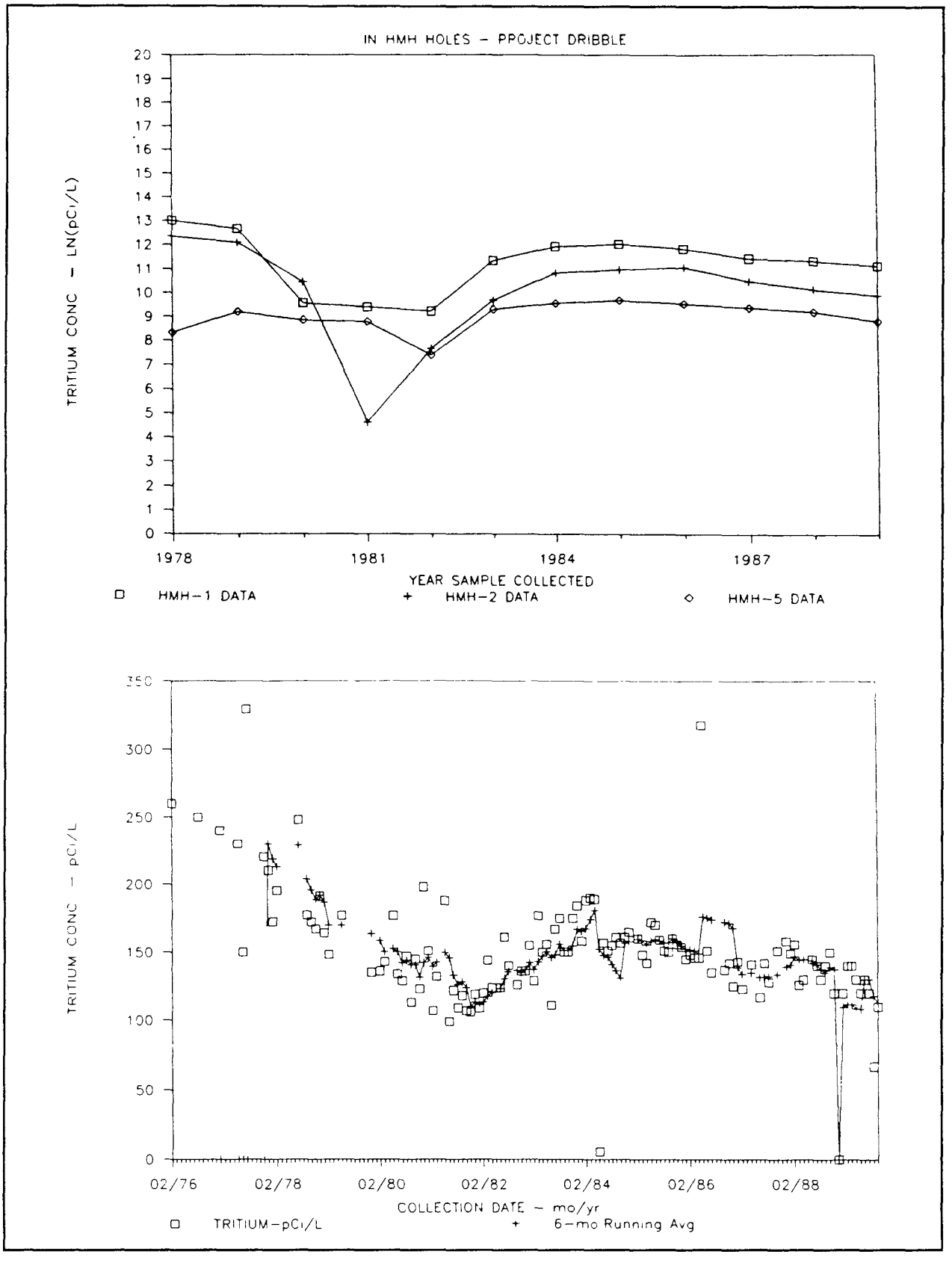

Figure 67. Wells that Had Higher Levels Early.

TABLE 23. TRITIUM RESULTS FOR THE LTHMP — 1989

SAMPLING LOCATION	COLLECT DATE	TRITIUM CONCENTRATION (10^{-9} μCi/mL) ± 2 S.D.	%CONC. GUIDE
NTS SEMI-ANNUAL NETWORK			
SHOSHONE CA			
SHOSHONE SPRING	01/04	17 ± 6	0.08
	07/11	200 ± 280*	---†
ADAVEN NV			
ADAVEN SPRING	07/06	83 ± 270*	---
ALAMO NV			
CITY WELL 4	06/05	2 ± 6*	<0.01
	07/07	26 ± 7	0.13
AMARGOSA VALLEY NV			
CRYSTAL POOL	02/01	3.9 ± 6 .6*	0.02
	09/07	38 ± 290	---
FAIRBANKS SPRING	02/17	-10 ± 6*	<0.01
	03/01	-5 ± 6*	<0.01
	09/07	0 ± 300*	---
M.NICKELL'S WELL	02/01	-1.1 ± 7 .1*	<0.01
	06/08	-4 ± 7*	<0.01
15S-50E-18CDC	01/04	-1.8 ± 6 .8*	<0.01
	06/06	-2.1 ± 6 .8*	<0.01
17S-50E-14CAC	02/01	-1.1 ± 6 .3*	<0.01
	09/07	-75 ± 290*	---
18S-51E-7DB	02/01	0 ± 6 .7*	<0.01
	06/01	22 ± 290	---
BEATTY NV			
LLW SITE	01/04	-0.9 ± 6 .8*	<0.01
	09/07	NA	
SPICERS ROAD D	02/01	-9 ± 6*	<0.01
	09/14	-130 ± 290*	---
SPECIE SPRINGS	03/08	48 ± 7	0.24
	09/07	22 ± 290*	---
BEATTY NV			
TOLICHA PEAK	02/01	7 ± 7*	<0.01
	09/26	140 ± 290*	---
YOUNGHANS RANCH	01/05	-0.9 ± 7 .6*	<0.01
	02/01	-3.9 ± 6 .5*	<0.01
	03/09	-7 ± 7*	<0.01
11S-48-1DD	02/01	-5 ± 6 .4*	<0.01

(Continued)

TABLE 23. (Continued)

SAMPLING LOCATION	COLLECT DATE	TRITIUM CONCENTRATION (10^{-9} µCi/mL) ±2 S.D.	%CONC. GUIDE
COFFERS	08/02	-140 ± 290*	---
12S-47E-7DBD	04/06	-5.9 ± 6.4*	<0.01
	10/04	49 ± 290*	---
BOULDER CITY NV			
LAKE MEAD INTAKE	02/07	75 ± 7	0.38
	03/10	79 ± 7	0.39
	04/07	78 ± 7	0.39
CLARK STA. NV	04/05	-2.1 ± 7.1**	<0.01
TTR WELL 6	10/04	-53 ± 290*	---
HIKO NV			
CRYSTAL SPRINGS	05/02	23 ± 7	0.12
	11/08	240 ± 290*	---
INDIAN SPRINGS NV			
WELL 2 AIR FORCE	01/05	4.4 ± 7.2*	<0.01
	11/06	75 ± 290*	---
SEWER CO WELL 1	01/03	-0.9 ± 6.9*	<0.01
	05/01	2 ± 6*	<0.01
	11/06	58 ± 290*	---
JOHNNIE NV			
JOHNNIE MINE	08/01	2.9 ± 6.3*	<0.01
LAS VEGAS NV			
WATER WELL 28	05/31	3 ± 6.6*	<0.01
	11/07	210 ± 290*	---
NYALA NV			
SHARP'S RANCH	06/06	-2.3 ± 6.8*	<0.01
OASIS VALLEY NV			
GOSS SPRINGS	06/07	-2 ± 7	<0.01
PAHRUMP NV			
CALVADA WELL	06/01	3.6 ± 6.7*	<0.01
	07/11	32 ± 7	0.16
RACHEL NV			
WELLS 7&8 PENOYER	02/01	112 ± 290*	---
	07/06	27 ± 6	0.14
WELL 13 PENOYER	08/16	4.8 ± 6.3*	<0.01
PENOYER CULINARY	07/06	27 ± 7	0.14
TEMPIUTE NV			
UNION CARBIDE WELL	08/09	-2 ± 6*	<0.01
TONOPAH NV			
CITY WELL	08/02	2 ± 6*	<0.01

(Continued)

TABLE 23. (Continued)

SAMPLING LOCATION	COLLECT DATE	TRITIUM CONCENTRATION (10^{-9} μCi/mL) ± 2 S.D.	%CONC. GUIDE
WARM SPRINGS NV			
TWIN SPRINGS RN	08/01	2.2 ± 6.2*	<0.01
NEVADA TEST SITE (AREA)			
WELL UE-1c (1)	02/14	-0.8 ± 6.3*	<0.01
	06/29	8 ± 300*	---
WELL UE-1L (1)	01/19	12 ± 6	0.06
	06/29	CAVED IN	
TEST WELL 7 (3)	08/21	-180 ± 290*	---
TEST WELL D (4)	03/21	8 ± 6.3*	0.04
	09/06	9 ± 6.6*	0.04
WELL UE-5c (5)	02/15	-3 ± 7*	<0.01
WELL UE-5n	03/01	460 ± 9	2.3
WELL UE-6e (6)	04/20	48 ± 7	0.24
WELL C-1 (6)	02/15	2.5 ± 6.5*	0.01
	09/05	8.5 ± 6.3*	0.04
UE-10ITS#3 (10)	03/30	45 ± 230*	---
WELL UE-15d (15)	01/10	100 ± 7	0.50
	02/15	83 ± 7	0.42
	08/09	79 ± 7	0.40
	11/02	58 ± 290*	---
WELL UE-16d (16)	05/16	120 ± 280*	---
	08/09	-90 ± 290*	---
WELL UE-16f (16)	01/25	9.2 ± 6.4*	0.05
	02/22	8.8 ± 6.6*	0.04
	11/08	89 ± 290*	---
WELL UE-17a (17)	01/18	-2.6 ± 6.5*	<0.01
WELL HTH #1 (17)	08/08	140 ± 8	0.70
WELL UE-18r (18)	01/12	-5.9 ± 6.6*	<0.01
	05/17	4 ± 6.5*	0.02
WELL UE-18t (18)	08/10	11 ± 6*	0.06
ARMY 6A (OFFSITE)	07/12	26 ± 6	0.13

* *Indicates results that are less than minimum detectable amt ±2 S.D. (<MDA)*

† *%CG is indeterminate for conventional analysis that is <MDA.*

TABLE 24. RESULTS FOR LTHMP OFF-NTS SITES — 1989

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ± 2 S.D. TRITIUM (10^{-9} µCi/mL)	% CONC. GUIDE
	PROJECT RIO BLANCO		
RIO BLANCO CO			
B-1 EQUITY CAMP	06/14	81 ± 8	0.40
BRENNAN WINDMILL	06/14	2.2 ± 6.9*	0.01
CER NO. 1 BLACK SULPHUR	06/14	73 ± 7	0.36
CER NO. 4 BLACK SULPHUR	06/14	82 ± 8	0.41
FAWN CREEK 1	06/14	34 ± 7	0.17
FAWN CREEK 3	06/14	41 ± 7	0.20
FAWN CREEK 6800 FT UPSTRM	06/14	55 ± 7	0.28
FAWN CREEK 500 FT UPSTRM	06/15	48 ± 7	0.24
FAWN CREEK 500 FT DWNSTRM	06/15	53 ± 7	0.26
FAWN CREEK 8400 FT DWNSTRM	06/14	56 ± 7	0.28
WELL JOHNSON ARTESIAN	06/14	-4 ± 7*	<0.01
WELL RB-D-01	06/15	3 ± 7*	0.02
WELL RB-D-03	06/15	5.6 ± 7.9*	0.03
WELL RB-S-03	06/15	3 ± 7*	0.02
	PROJECT RULISON		
GRAND VALLEY CO			
BATTLEMENT CREEK	06/13	86 ± 8	0.43
CITY SPRINGS	06/13	1.1 ± 6.8*	0.01
ALBERT GARDNER RANCH	06/13	140 ± 8	0.70
SPRING 300 YRD N OF GZ	06/13	73 ± 7	0.36
WELL CER TEST	06/13	140 ± 8	0.70
RULISON CO			
LEE HAYWARD RANCH	06/13	170 ± 8	0.85
POTTER RANCH	06/13	120 ± 8	0.60
R SEARCY RANCH (SCHWAB)	06/13	89 ± 8	0.45
F SEFCOVIC RANCH	06/13	77 ± 8	0.38
	PROJECT DRIBBLE		
BAXTERVILLE MS			
HALF MOON CREEK	04/15	26 ± 7	0.13
	04/17	36 ± 7	0.18

(Continued)

TABLE 24. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ± 2 S.D. TRITIUM (10^{-9} µCi/mL)	% CONC. GUIDE
HALF MOON CREEK OVERFLOW	04/15	1200 ± 290	6
	04/17	1400 ± 190	7
LOWER LITTLE CREEK	04/17	32 ± 7	0.16
POND WEST OF GZ	04/15	17 ± 7	0.08
	04/17	17 ± 7	0.08
REECO PIT DRAINAGE-A	04/17	49 ± 7	0.24
REECO PIT DRAINAGE-B	04/17	740 ± 11	3.7
REECO PIT DRAINAGE-C	04/17	300 ± 9	1.5
SALT DOME HUNTING CLUB	04/18	32 ± 8	0.16
SALT DOME TIMBER CO	04/17	28 ± 7	0.14
ANDERSON, B. R.	04/18	16 ± 7	0.08
ANDERSON, H.	04/18	17 ± 7	0.08
ANDERSON, R. LOWELL	04/17	22 ± 7	0.11
CHAMBLISS, B.	04/17	-7 ± 7*	<0.01
DANIELS, W. JR.	04/18	23 ± 7	0.11
KELLY, G.	04/17	-9 ± 6*	<0.11
KING, RHONDA	04/18	22 ± 8	0.11
LEE, P. T.	04/18	39 ± 8	0.19
MILLS, A. C.	04/17	-11 ± 6*	<0.01
MILLS, R.	04/18	18 ± 7	0.09
READY, R.	04/18	53 ± 7	0.26
SAUCIER, T.S.	04/17	34 ± 7	0.17
SAUCIER, DENNIS	04/17	56 ± 7	0.28
WELL E-7	04/18	-0.5 ± 7*	<0.01
WELL HM-1	04/17	-3.7 ± 6.8*	<0.01
	04/17	-1.7 ± 6.8*	<0.01
WELL HM-2A	04/17	0.6 ± 6.8*	<0.01
	04/17	4.5 ± 7*	0.02
WELL HM-2B	04/17	0.5 ± 6.9*	<0.01
	04/17	1.5 ± 7.1*	<0.01
WELL HM-3	04/17	2.1 ± 7.5*	0.01
	04/17	3 ± 7*	0.02
	04/17	8.1 ± 7.2*	0.04
	04/17	2 ± 7*	0.01
	04/17	1 ± 7*	<0.01

(Continued)

TABLE 24. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. TRITIUM (10^{-9} µCi/mL)	% CONC. GUIDE
WELL HM-L	04/17	1200 ± 290	6.0
	04/17	1800 ± 290	9.0
WELL HM-L2	04/17	0 ± 7*	<0.01
	04/17	2 ± 7*	0.01
WELL HM-S	04/16	10000 ± 360	50.0
	04/17	9700 ± 350	48.0
WELL HMH-1	04/16	7800 ± 340	39.0
	04/17	12000 ± 370	60.0
WELL HMH-2	04/16	3300 ± 300	16.0
	04/17	11000 ± 360	55.0
WELL HMH-3	04/16	24 ± 7	0.12
WELL HMH-4	04/16	25 ± 7	0.13
WELL HMH-5	04/16	1100 ± 280	5.5
	04/17	1100 ± 13	5.5
WELL HMH-6	04/16	150 ± 8	0.75
WELL HMH-8	04/16	17 ± 7	0.08
WELL HMH-9	04/16	45 ± 7	0.22
WELL HMH-10	04/16	22 ± 7	0.11
WELL HMH-11	04/16	41 ± 7	0.21
	04/17	79 ± 8	0.39
WELL HT-2C	04/18	15 ± 7	0.08
WELL HT-4	04/18	4.3 ± 6.6*	0.02
WELL HT-5	04/18	0 ± 7*	<0.01
BAXTERVILLE CITY SUPPLY	04/18	35 ± 7	0.18
COLUMBIA WELL 64B	04/18	7 ± 7*	0.04
LUMBERTON CITY WELL 2	04/18	-30 ± 7*	<0.01
PURVIS CITY SUPPLY	04/18	-4 ± 8*	<0.01
	SPECIAL REQUEST SAMPLES		
BAXTERVILLE MS			
NOBLES POND	04/17	18 ± 8	0.09
JR. GREEN CREEK	04/17	23 ± 7	0.11
LITTLE CREEK #1	04/18	34 ± 7	0.17
BURGE, JOE	04/17	12 ± 8	0.06

(Continued)

TABLE 24. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ± 2 S.D. TRITIUM (10^{-9} µCi/mL)	% CONC. GUIDE
SAUCIER, WILMA & YANCY	04/17	-13 ± 10	<0.01*
NOBLES, W. H.	04/17	56 ± 8	0.28
SMITH, RITA	04/17	31 ± 7	0.15
ANDERSON, ROBERT L.	04/17	32 ± 7	0.16
CLARK, JAMES	04/17	21 ± 8	0.10
DANIELS - WELL #2	04/18	35 ± 7	0.17
NOBLES QUAIL HOUSE	04/18	56 ± 8	0.28
DANIELS, RAY	04/18	24 ± 7	0.12
	PROJECT FAULTLESS		
BLUEJAY NV			
HOT CREEK RANCH SPRING	06/21	7.1 ± 6 .3*	0.04
MAINTENANCE STATION	06/23	5.2 ± 6 .3*	0.03
WELL BIAS	06/23	3 ± 6 .3*	0.02
WELL HTH-1	06/21	4 ± 6 .3*	0.02
WELL HTH-2	06/21	5.2 ± 6 .3*	0.03
	PROJECT SHOAL		
FRENCHMAN STATION NV			
HUNT'S STATION	02/27	-10 ± 6 .6*	<0.01
SMITH/JAMES SPRINGS	02/27	48 ± 7	0.24
SPRING WINDMILL	02/27	1.4 ± 6 .8*	<0.01
WELL FLOWING	02/27	0 ± 6 .6*	<0.01
WELL HS-1	02/27	-1.1 ± 6 .4*	<0.01
	PROJECT GASBUGGY		
GOBERNADOR NM			
ARNOLD RANCH	07/20	5 ± 6*	0.02
BIXLER RANCH	04/26	11 ± 7*	0.06
BUBBLING SPRINGS	04/26	61 ± 7	0.3
CAVE SPRINGS	04/26	140 ± 9	0.7
CEDAR SPRINGS	04/26	79 ± 7	0.4
LA JARA CREEK	07/20	44 ± 7	0.22
LOWER BURROW CANYON	04/26	11 ± 7*	0.06

(Continued)

TABLE 24. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ± 2 S.D. TRITIUM (10^{-9} µCi/mL)	% CONC. GUIDE
POND N WELL 30.3.32.343	04/26	150 ± 8	0.75
WELL EPNG 10-36	07/20	110 ± 7	0.55
WINDMILL2	04/26	5 ± 7*	0.03
	PROJECT GNOME		
CARLSBAD NM			
WELL 7 CITY	04/24	-14 ± 7*	<0.01
LOVING NM			
WELL 2 CITY	04/23	-5 ± 7*	<0.01
MALAGA NM			
WELL 1 PECOS PUMPING STA	04/24	6 ± 6*	0.03
WELL DD-1	04/22	12×10^7 ± 82000	6×10^5 (1)
WELL LRL-7	04/22	16000 ± 400	80 (2)
WELL PHS 6	04/23	51 ± 7	0.25
WELL PHS 8	04/23	15 ± 6	0.08
WELL PHS 10	04/23	10 ± 6*	0.05
WELL USGS 1	04/23	59 ± 7	0.3
WELL USGS 8	04/22	130,000 ± 850	650 (3)
	BACKGROUND SAMPLE		
AMCHITKA AK			
CONSTANTINE SPRING	10/23	19 ± 6	0.09 (4)
DUCK COVE CREEK	10/23	23 ± 6	0.11
JONES LAKE	10/23	23 ± 6	0.11
SITE D HYDRO EXPLORE HOLE	10/22	NOT SAMPLED	
SITE E HYDRO EXPLORE HOLE	10/22	NOT SAMPLED	
WELL ARMY 1	10/23	33 ± 7	0.17
WELL ARMY 2	10/23	16 ± 8	0.08
WELL 4 ARMY	10/23	50 ± 7	0.25
	PROJECT CANNIKIN		
CANNIKIN LAKE (NORTH END)	10/22	24 ± 6	0.12
CANNIKIN LAKE (SOUTH END)	10/22	28 ± 7	0.14
DK-45 LAKE	10/23	28 ± 6	0.14
ICE BOX LAKE	10/22	42 ± 7	0.21

(Continued)

TABLE 24. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. TRITIUM (10^{-9} µCi/mL)	% CONC. GUIDE
PIT SOUTH OF CANNIKIN GZ	10/22	0.6 ± 5.5	<0.01
WELL HTH-3	10/22	26 ± 9	0.13
WHITE ALICE CREEK	10/22	25 ± 6	0.13
	PROJECT LONG SHOT		
LONG SHOT POND 1	10/23	21 ± 5	0.10
LONG SHOT POND 2	10/23	18 ± 6	0.09
LONG SHOT POND 3	10/23	38 ± 6	0.19
MUD PIT NO. 1	10/23	-1.5 ± 5.9*	<0.01
MUD PIT NO. 2	10/23	-3.1 ± 5.6*	<0.01
MUD PIT NO. 3	10/23	40 ± 6	0.20
REED POND	10/23	45 ± 7	0.22
STREAM EAST OF LONGSHOT	10/23	-1.4 ± 5.4*	<0.01
WELL EPA-1	10/24	8.7 ± 9.6*	<0.04
	10/24	34 ± 7	0.17
WELL GZ NO. 1	10/24	2300 ± 310	11.5
WELL GZ NO. 2	10/24	130 ± 8	0.66
WELL WL-2	10/24	49 ± 10	0.24
	PROJECT MILROW		
CLEVENGER CREEK	10/23	31 ± 6	0.15
	10/23	41 ± 6	0.21
HEART LAKE	10/23	54 ± 7	0.27
WELL W-2	10/23	23 ± 7	0.11
WELL W-3	10/23	29 ± 7	0.15
WELL W-4	10/23	NOT SAMPLED	
WELL W-5	10/23	21 ± 6	0.10
WELL W-6	10/23	25 ± 7	0.13
WELL W-7	10/23	NOT SAMPLED	
WELL W-8	10/23	31 ± 7	0.15
WELL W-9	10/23	NOT SAMPLED	
WELL W-10	10/23	27 ± 7	0.13
WELL W-11	10/23	65 ± 7	0.32

(Continued)

TABLE 24. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1989	CONC. ±2 S.D. TRITIUM (10^{-9} µCi/mL)	% CONC. GUIDE
WELL W-12	10/23	NOT SAMPLED	
WELL W-13	10/23	32 ± 7	0.16
WELL W-14	10/23	22 ± 7	0.11
WELL W-15	10/23	27 ± 6	0.13
WELL W-16	10/23	NOT SAMPLED	
WELL W-17	10/23	25 ± 6	0.13
WELL W-18	10/23	48 ± 6	0.24
WELL W-19	10/23	21 ± 6	0.10

** Result is less than minimum detectable concentration.*

FOOTNOTES

	Isotope	Concentration ±2 S.D.	Unit
(1)	^{137}Cs	750,000 ± 58,000	(10^{-9} µCi/mL)
	^{141}Ce	1,800 ± 2,200*	(10^{-9} µCi/mL)
	^{238}Pu	0.17 ± 0.94*	(10^{-9} µCi/mL)
	^{239}Pu	0.41 ± 0.45*	(10^{-9} µCi/mL)
	^{40}K	8,300 ± 3,000	(10^{-9} µCi/mL)
(2)	^{137}Cs	200 ± 17	(10^{-9} µCi/mL)
(3)	^{137}Cs	85 ± 12	(10^{-9} µCi/mL)
(4)	Alpha	24 ± 10	(10^{-9} µCi/mL)
	^{226}Ra	0.11 ± 0.11	(10^{-9} µCi/mL)

Chapter 5. Public Information and Community Assistance Programs

D. J. Thomé

In addition to its many monitoring and data analysis activities, the Nuclear Radiation Assessment Division (NRD) conducts a comprehensive program designed to provide information and assistance to individual citizens, organizations, and local government agencies in communities in the vicinity of the NTS. During 1989, activities included: participation in public hearings; "town hall" meetings; continued support of Community Monitoring Stations; and a variety of tours, lectures, and presentations.

SECTION 5.1. TOWN HALL MEETINGS

Eighty-six town hall meetings have been conducted since 1982. These meetings provide an opportunity for the public to meet directly with EPA, DOE, and DRI personnel, ask questions, and express their concerns regarding nuclear testing. During a typical meeting, the procedures used and the safeguards in place during every nuclear test are described. The EPA's radiological monitoring and surveillance networks are explained. For meetings in Nevada, the proposed High Level Waste Repository at Yucca Mountain is also discussed.

In addition to the regular town hall meetings held in 1989, similar presentations were given to several high schools and a Chamber of Commerce in Utah. The locations of these meetings were as follows:

LOCATION	DATE
Panaca Valley High School	09/22/89
Caliente, NV	09/21/89
Pioche, NV	09/20/89
Leeds, UT	07/20/89
Virgin, UT	07/19/89
Amargosa Valley, NV	05/19/89
Kanab, UT	04/12/89
Kanarraville, UT	04/11/89
Hurricane Valley Chamber of Commerce, UT	02/16/89
Springdale, UT	02/16/89
Toquerville, UT	02/15/89

SECTION 5.2. ANIMAL INVESTIGATIONS

One of the public service functions of the EMSL-LV is to investigate claims of injury allegedly due to radiation originating from NTS activities. A veterinarian, qualified by education and experience in the field of radiobiology, investigates questions about domestic animals and wildlife to determine whether radiation exposure may be involved.

No animal investigations were requested during 1989.

SECTION 5.3. NTS TOURS

To complement the town hall meetings and to familiarize citizens with both the DOE testing program at the NTS and the Environmental Radiological Monitoring Program conducted by the EPA, tours are arranged for business and community leaders and individuals from towns around the NTS, as well as for government employees and the news media. Between January and December 1989, the following tours were sponsored by the EPA:

Residents of Rachel, NV	February 21-22
Public Officials and Residents of Kingman, AZ	March 13-14
EPA Personnel (Washington D.C., Cincinnati and RTP)	March 16
EPA Employees and Dependents	May 8
Residents of Hawaii	August 1
Senior EPA Officials (Washington, D.C., Cincinnati, OH, and Las Vegas, NV)	September 26

SECTION 5.4. COMMUNITY MONITORING STATIONS

Beginning in 1981, DOE and EPA established a network of Community Monitoring Stations in the offsite areas in order to increase public awareness of radiation monitoring activities. The DOE, through an interagency agreement with EPA, sponsors the program and holds contracts with DRI to manage the stations, and with the University of Utah to train station managers. Each station is operated by a local

resident, in most cases a science teacher, who is trained in radiation monitoring methods. These stations continued to be maintained by the NRD personnel during 1989. Samples were collected and analyzed at the EMSL-LV. Both the EPA and the DRI provide data interpretation to the communities involved and the DRI handles personnel, right-of-way and utility meters for the stations.

All of the 18 stations except for Milford and Delta, UT, contain one of the samplers for the Air Surveillance Network (ASN), Noble Gas and Tritium Surveillance Network (NGTSN) and Dosimetry networks discussed earlier. In addition, each station contains a pressurized ion chamber (PIC) with a recorder for immediate readout of external gamma exposure, and a recording barograph. The stations at Milford and Delta are complete except for noble gas samplers. All of the equipment is mounted on a stand at a prominent location in each community so the residents are aware of the surveillance and, if interested, can have ready access to the PIC and barometric data. The data from these stations are included in the tables in Chapter 5 with the other data from the appropriate networks. Table 18 contains a summary of the PIC data.

Computer generated reports for each station are issued weekly. These reports indicate the current weekly PIC average, the average over the previous week and the average for that week in the previous year. These reports additionally show the maximum and minimum backgrounds in the U.S. In addition to being posted at each station, copies are sent to newspapers in Nevada and Utah and provided to appropriate federal and state personnel in California, Nevada and Utah. All of the Community Monitoring Stations are equipped with satellite telemetry transmitting equipment. With this equipment, gamma exposure measurements acquired by the pressurized ion chambers are transmitted, via the Geostationary Operational Environmental Satellite (GOES) directly to the NTS and from there to the EMSL-LV by dedicated telephone line. The transmission of these data occurs automatically every four hours. However, whenever the gamma exposure measurements at any station exceeds 50 μR/hr that station goes into an emergency mode and transmits data every minute. This continues until the measurement is again less than 50 μR/hr. Then the PIC reverts to its routine condition.

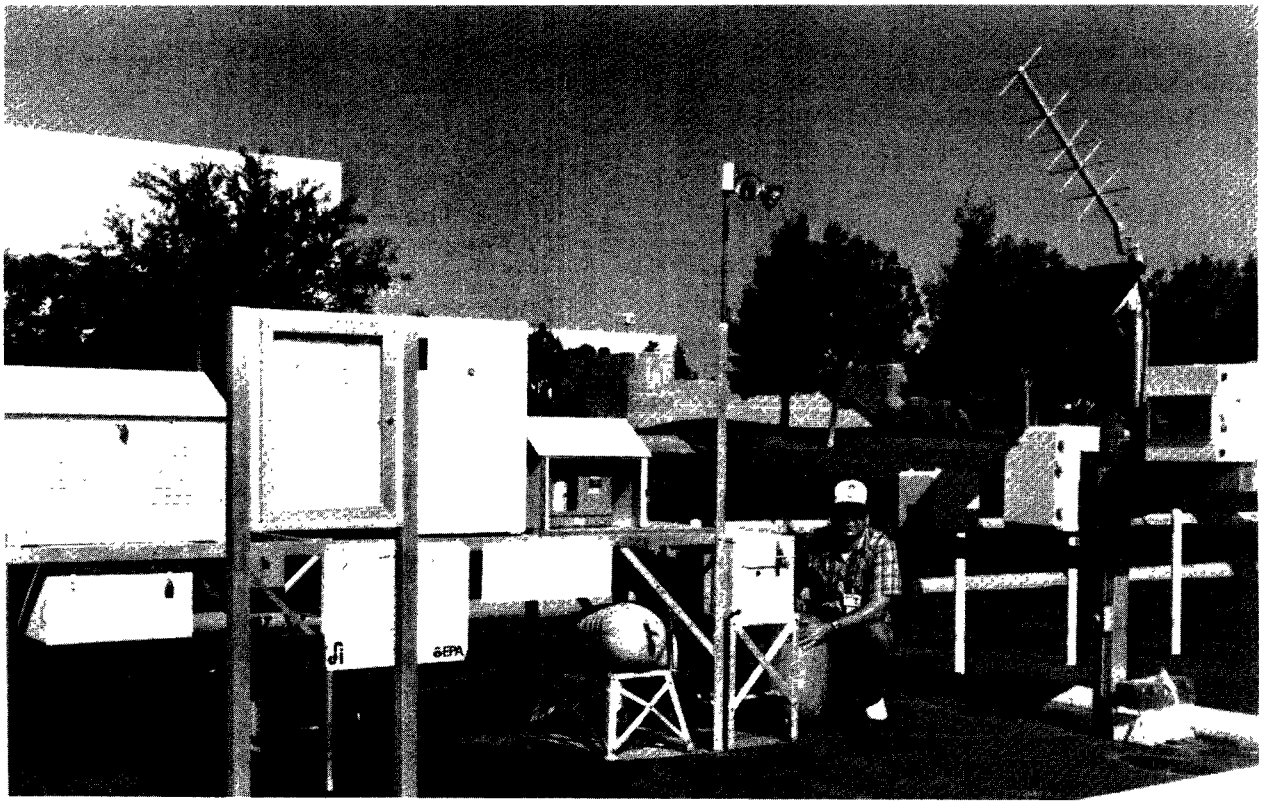

Figure 68. Community Monitoring Station at the University of Nevada - Las Vegas. (From left to right: particulates and reactive gases sampler, tritium sampler, microbarograph, noble gas sampler, gamma radiation exposure rate recorder, and TLD.)

Chapter 6. Quality Assurance and Procedures

C. K. Liu and C. A. Fontana

The quality assurance program conducted by EMSL-LV includes: standard operating procedures, data quality objectives, data validation, quality control, health physics oversight, precision and accuracy of analysis. Duplicate samples were analyzed for the ASN, NGTSN, Dosimetry, MSN, and, LTHMP networks. The coefficient of variation of replicate samples for these networks varied from a median value of 2.1 percent for the LTHMP to 59 percent for the ASN. The EPA/EML ratios from the DOE program for 1989 varied from .76 to 1.40, indicating good correlation between the two laboratories. The results of participation in the EPA QA Intercomparison Study Program indicated that the analytical procedures were in control except for a strontium in water in January and a strontium in milk in April. The reason for the low recovery of strontium has been identified and corrected.

SECTION 6.1. POLICY

One of the major goals of the Agency is to ensure that all EPA decisions which are dependent on environmental data are supported by data of known quality. Consequently, agency policy requires that all EPA laboratories participate in a centrally managed and locally implemented Quality Assurance (QA) Program.

EMSL-LV's QA policies and requirements are summarized in EPA/600/X-87/241, Quality Assurance Program Plan (reference EPA87), and are fully adhered to by the Nuclear Radiation Assessment Division (NRD).

SECTION 6.2. STANDARD OPERATING PROCEDURES

Elements of the QA program include local Standard Operating Procedures (SOPs) which define methods of sample collection, handling, sample control, analysis, data validation, trending and reporting. These SOPs support the goal of the QA program in maintaining the quality of results within established limits of acceptance, with the primary purpose of assessing the effects of human exposures to radiological hazards in the environment.

SECTION 6.3. DATA QUALITY OBJECTIVES

The EPA requires all projects involving environmentally-related measurements to develop data quality objectives (DQOs). DQOs must clearly define the level of uncertainty that a decision maker is willing to accept in results derived from environmental data (SCB89). DQOs contain quantitative statements relating to the decision to be made, how environmental measurements will be used, time and resource constraints on data collection, descriptions of the data or measurements to be made, specifications of which portions of the physical systems from which samples will be collected, and the calculations that will be performed on the data in order to arrive at a result.

SECTION 6.4. DATA VALIDATION

An essential element of QA is the validation of data. Four categories of data validation methods are employed by NRD: procedures which are applied routinely to ensure adherence of acceptable analytical methods, those that ensure that completeness of data is attained, those which are used to test the internal comparability within a given data set, and procedures for comparing data sets with historical data and other data sets.

Completeness is the amount of data successfully collected with respect to that amount intended in the design, and comparability refers to the degree of similarity of data from different sources included in a single data set. All data are reviewed by supervisory personnel to ensure that sufficient data have been collected and the conclusions are based upon valid data. Completeness is an important part of quality, since missing data may reduce the precision of estimates, introduce bias, and thus lower the level of confidence in the conclusions.

SECTION 6.5. QUALITY CONTROL

The quality control (QC) portion of the NRD QA program consists of routine use of methods and

procedures designed to achieve and maintain the specified level of quality for the given measurement system. Accuracy of analysis is achieved through the regular determination of bias and precision of the results.

Bias is defined as the difference between the data set mean value (or sample average for statistical purposes) and the true or reference value (EPA87). The NRD laboratory participates in EPA, DOE/ Environmental Measurements Laboratory (EML), and World Health Organization (WHO) laboratory intercomparison crosscheck studies. The results of the EPA intercomparison study are discussed later in this section. Blank samples and samples "spiked" with known quantities of radionuclides are also routinely analyzed. Internal "blind spiked" samples, (that is, samples spiked with known amounts of radionuclides but unknown to the analyst) are also entered into the normal chain of analysis.

Precision is the degree of mutual agreement among individual measurements made under prescribed conditions (EPA87). As a minimum, 10 percent of all samples are collected and analyzed in duplicate, and results compared.

In addition, instruments are calibrated with standards directly or indirectly traceable to National Institute for Standards and Technology (NIST; formerly National Bureau of Standards) or NIST-approved EPA-generated sources. Performance checks are routinely accomplished, control charts of background and check source data are maintained, and preventive maintenance on equipment is scheduled, and performed.

SECTION 6.6. HEALTH PHYSICS OVERSIGHT

All analytical results receive a final review by the health physics staff of the Dose Assessment Branch for completeness and comparability. Trends of increasing or decreasing amounts of radionuclides in the environment are identified, and potential risks to humans and the environment are determined based on the data.

SECTION 6.7. PRECISION OF ANALYSIS

The duplicate sampling program was initiated for the purpose of routinely assessing the errors due to sampling, analysis, and counting of samples obtained from the surveillance networks maintained by the EMSL-LV.

The program consists of analyzing of duplicate or replicate samples from the ASN, the NGTSN, the MSN, and LTHMP, and the Dosimetry Network. As the radioactivity concentration in samples collected from the LTHMP and the MSN are usually below detection levels, most duplicate samples for these networks are prepared from spiked solutions. The noble gas samples are generally split for analysis, and duplicate samples are collected in the ASN. Since two TLD cards consisting of three TLD phosphors each are used at each station of the Dosimetry Network, no additional samples were necessary.

At least 30 duplicate samples from each network are normally collected and analyzed over the report period. The standard deviation is obtained by taking the square root of the variance. Table 25 summarizes the sampling information for each surveillance network (SNE67).

The variance, s^2, of each set of replicate results was estimated by the standard expression,

$$s^2 = \sum_{i=1}^{n} (x_i - \bar{x})^2 / (n-1) \qquad \text{Eq. 1}$$

where n = number of sets of replicates.

The principal that the variances of random samples collected from a normal population follow a chi-square distribution (X^2) was then used to estimate the expected population standard deviation for each type of sample analysis. The expression used is as follows: (FRE62)

$$s = \sqrt{\sum_{i=1}^{k} (n_i - 1)s_i^2 / \sum_{i=1}^{k} (n_i - 1)} \qquad \text{Eq. 2}$$

where n_i-1 = the degrees of freedom for n_i samples collected for the ith replicate sample

s_i^2 = the expected variance of the ith replicate sample

s = the pooled estimate of sample standard deviation derived from the variance estimates of all replicate samples (the expected value of s^2 of σ^2).

TABLE 25. SAMPLES AND ANALYSES FOR DUPLICATE SAMPLING PROGRAM — 1989

SURVELIIANCE NETWORK	NUMBER OF SAMPLING LOCATIONS	SAMPLES COLLECTED THIS YEAR	SETS OF DUPLICATE SAMPLES COLLECTED	NUMBER PER SET	SAMPLE ANALYSIS
ASN	114	2,288	110	2	Gross beta, γ Spectrometry
NGTSN	18	710(^{85}Kr) 734(^{133}Xe)	53 —	2	^{85}Kr, ^{3}H, H_2O, HTO, ^{133}Xe
Dosimetry	133	531	531	6	Effective dose from gamma
MSN	33	394	129	2	^{40}K, ^{89}Sr, ^{90}Sr, ^{3}H
LTHMP	217	816	416	2	^{3}H

For expressing the precision of measurement in common units, the coefficient of variation ($s/\bar{x}$) was calculated for each sample type. These are displayed in Table 26 for those analyses for which there were adequate data (NEL75).

To estimate the precision of counting, approximately ten percent of all samples are counted twice. These are unknown to the analyst. Since all such replicate counting gave results within the counting error, the precision data in Table 26 represents errors in sampling and analysis.

TABLE 26. SAMPLING AND ANALYTICAL PRECISION — 1989

SURVEILLANCE NETWORK	ANALYSIS	SETS OF REPLICATE SAMPLES EVALUATED	COEFFICIENT OF VARIATION (%)
ASN	^{7}Be	6	59
NGTSN	^{85}Kr	53	6.8
Dosimetry	TLD	531	6.9
MSN	^{90}Sr	24	11.6
LTHMP	^{3}H	44	2.1*
	^{3}H+ (enriched tritium)	68	7.8*

* *Median Value*

SECTION 6.8. ACCURACY OF ANALYSIS

Data from the analysis of intercomparison samples are statistically analyzed and compared to known values and values obtained from other participating laboratories. A summary of the statistical analysis is given in Table 27, which compares the mean of three replicate analyses with the known value. The normalized deviation is a measure of the accuracy of the analysis when compared to the known concentration. The determination of this parameter is explained in detail in the reference (JA81). If the value of this parameter (in multiples of standard normal deviate, unitless) lies between control limits of -3 and +3, the precision or accuracy of the analysis is within normal statistical variation. However, if the parameters exceed these limits, one must suspect that there is some other than normal statistical variation that contributed to the difference between the measured values and the known value. As shown by Table 28, all analyses were within the control limit.

The analytical methods were further validated by laboratory participation in the semiannual Department of Energy Quality Assurance Program conducted by the Environmental Measurements Laboratory (EML), New York, New York. The results from these tests (Table 27) indicate that this laboratory's results were of acceptable quality.

To measure the performance of the contractor laboratory that analyzed the animal tissues, a known amount of activity was added to several sets of bone ash samples. The reported activity is compared to

TABLE 27. QUALITY ASSURANCE RESULTS FROM DOE PROGRAM — 1989

ANALYSIS	MONTH	EPA EMSL-LV RESULTS	EML RESULTS	RATIO EPA/EML	ANALYSIS	MONTH	EPA EMSL-LV RESULTS	EML RESULTS	RATIO EPA/EML
^{7}Be in air	April	2.07×10^{3}	1.95×10^{3}	1.06	$^{239+240}$Pu in vegetation	Sept.	2.44×10^{-2}	2.20×10^{-2}	1.11
	Sept.	1.28×10^{2}	1.2×10^{2}	1.04					
^{54}Mn in air	Sept.	4.77	4.17	1.14	^{3}H in water	April	6.18	6.31	0.98
						Sept.	4.00×10^{2}	3.95×10^{2}	1.01
^{60}Co in air	April	1.35×10^{2}	1.26×10^{2}	1.07	^{54}Mn in water	Sept	66.2	65.0	1.02
	Sept.	9.18	8.17	1.12					
^{134}Cs in air	April	1.55×10^{2}	1.58×10^{2}	0.98	^{57}Co in water	Sept.	1.37×10^{2}	1.35×10^{2}	1.01
	Sept.	9.21	9.33	0.99					
^{137}Cs in air	April	2.13×10^{2}	1.89×10^{2}	1.13	^{60}Co in water	Sept.	1.53×10^{2}	1.55×10^{2}	0.99
	Sept.	4.22	3.58	1.18					
^{144}Ce in air	April	3.90×10^{2}	3.27×10^{2}	1.19	^{90}Sr in water	April	5.37×10^{-1}	5.50×10^{-1}	0.98
	Sept.	9.14	7.08	1.29		Sept.	40.2	31.7	1.27
$^{239+240}$Pu in air	April	2.50	2.70	0.93	^{134}Cs in water	April	2.27	2.73	0.83
	Sept.	1.76×10^{2}	18.0	0.98		Sept.	61.5	68.3	0.90
^{137}Cs in soil	April	29.1	20.8	1.40	^{137}Cs in water	April	2.48	2.55	0.97
	Sept.	7.44×10^{2}	6.42×10^{2}	1.16		Sept.	69.7	68.3	1.02
$^{239+240}$Pu in soil	April	4.26×10^{-1}	4.20×10^{-1}	1.01	$^{239+240}$Pu in water	April	6.08×10^{-3}	5.90×10^{-3}	1.03
	Sept.	15.7	17.1	0.92		Sept.	2.67×10^{-1}	3.50×10^{-1}	0.76
^{137}Cs in vegetation	April	1.77	1.60	1.11					
	Sept.	5.19	47.9	1.08					

the known amount in bone ash (Table 28). The average bias for $^{239+240}$Pu was +16 percent and the average bias for ^{90}Sr was -29 percent. The average precision determined from two sets of duplicate bone samples was 20.2 percent for $^{239+240}$Pu and 5.1 percent for ^{90}Sr. The average precision for two sets of liver samples was 56 percent for $^{239+240}$Pu. The percent bias for the spiked samples was determined by subtracting 100 from the average percent of activity recovered. Precision was determined by calculating the coefficient of variation for each pair of values and then averaging.

TABLE 28. EPA QUALITY ASSURANCE INTERCOMPARISON RESULTS — 1989

ANALYSIS	MONTH	MEAN OF REPLICATE ANALYSES (10^{-9} µCi/mL)	KNOWN VALUE	NORMALIZED DEVIATION FROM KNOWN CONCENTRATION	ANALYSIS	MONTH	MEAN OF REPLICATE ANALYSES (10^{-9} µCi/mL)	KNOWN VALUE	NORMALIZED DEVIATION FROM KNOWN CONCENTRATION
Water Studies:									
^{3}H	June	4874	4503	1.4	^{89}Sr	January	25.7	40.0	-5.0
	October	3835	3496	1.6		April	8.7	8.0	0.2
						May	7.7	6.0	0.6
^{51}Cr	February	235.3	235.0	0.0		September	14.0	14.0	0.0
						October	11.0	15.0	-1.4
^{60}Co	February	10.0	10.0	0.0					
	June	30.7	31.0	-0.1	^{90}Sr	January	25.3	25.0	0.4
	October	30.7	30.0	0.2		April	8.3	8.0	0.4
						May	5.3	6.0	-0.8
^{65}Zn	February	167.7	159.0	0.9		September	8.7	10.0	-1.5
	June	171.7	165.0	0.7		October	7.3	7.0	0.4
	October	134.3	129.0	0.7					

(Continued)

TABLE 28. (Continued)

ANALYSIS	MONTH	MEAN OF REPLICATE ANALYSES (10^{-9} μCi/mL)	KNOWN VALUE	NORMALIZED DEVIATION FROM KNOWN CONCENTRATION
^{106}Ru	February	166.3	178.0	-1.1
	June	112.7	128.0	-2.0
	October	150.3	161.0	-1.2
^{131}I	February	105.3	106.0	-0.1
	August	84.7	83.0	0.4
^{133}Ba	June	48.3	49.0	-0.2
	October	60.7	59.0	0.5
^{134}Cs	February	9.0	10.0	-0.3
	June	35.7	39.0	-1.2
	October	26.3	29.0	-0.9
	October	4.7	5.0	-0.1
^{137}Cs	February	10.3	10.0	0.1
	June	20.3	20.0	0.1
	October	59.7	59.0	0.2
	October	5.9	5.0	0.0
U(Nat.)	March	5.3	5.0	0.1
	April	2.0	3.0	-0.3
$^{239+240}$Pu	January	4.4	4.2	1.0
Milk Studies:				
^{89}Sr	April	47.7	39.0	3.0
^{90}Sr	April	48.7	55.0	-3.7
^{137}Cs	April	49.0	50.0	-0.3
Air Filter Studies:				
Gross Alpha	March	20.0	21.0	-0.3
	August	5.0	6.0	-0.3
Gross Beta	March	64.3	62.0	0.8
^{137}Cs	March	20.3	20.0	0.1
	August	9.7	10.0	-0.1

TABLE 29. QUALITY ASSURANCE RESULTS FOR THE BIOENVIRONMENTAL PROGRAM — 1989

SAMPLE ID AND SHIPMENT NUMBER	NUCLIDE	ACTIVITY ADDED pCi/g BONE ASH	ACTIVITY REPORTED pCi/g BONE ASH
Bone Ash		SPIKED SAMPLES	
Ash 1 78	$^{239+240}$Pu	0	(1.2 ± 0.7) x 10^{-3}
	^{90}Sr	0	2.3 ± 0.64
Ash 2 78	$^{239+240}$Pu	0	(19 ± 2) x 10^{-3}
	^{90}Sr	0	4.6 ± 1.03
Ash 3 78	$^{239+240}$Pu	0.0885	0.13 ± 0.03
	^{90}Sr	22.34	20.1 ± 0.3
Ash 4 78	$^{239+240}$Pu	0.0897	0.11 ± 0.03
	^{90}Sr	22.65	19.9 ± 0.3
Ash 1 80	$^{239+240}$Pu	0.0863	0.085± 0.012
	^{90}Sr	21.8	16.1 ± 2
Ash 2 80	$^{239+240}$Pu	0.0944	0.11 ± 0.015
	^{90}Sr	23.8	20 ± 3
Ash 3 80	$^{239+240}$Pu	0	(1.2 ± 1.9) x 10^{-3}
	^{90}Sr	0	2.3 ± 0.1
Ash 1 81	$^{239+240}$Pu	0.436	0.55 ± 0.08
	^{90}Sr	0	0.5 ± 0.08
Ash 2 81	$^{239+240}$Pu	0.431	0.52 ± 0.06
	^{90}Sr	0	0.5 ± 0.07
Ash 3 81	$^{239+240}$Pu	0	(0.8 ± 1.4) x 10^{-3}
	^{90}Sr	2.633	2.3 ± 0.08
Ash 4 81	$^{239+240}$Pu	0	(7.0 ± 3.0) x 10^{-3}
	^{90}Sr	2.666	2.5 ± 0.1
Ash 5 81	$^{239+240}$Pu	0	(1.0 ± 2.0) x 10^{-3}
	^{90}Sr	0	0.5 ± 0.07
DUPLICATE SAMPLES			
Bone Cow #2 80	$^{239+240}$Pu	0	(1.5 ± 1.7) x 10^{-3}
	^{90}Sr	0	1.0 ± 0.06
Dup-Bone Cow #2 80	$^{239+240}$Pu	0	(1.3 ± 1.5) x 10^{-3}
	^{90}Sr	0	0.97 ± 0.06
Liver-Cow #2 80	$^{239+240}$Pu	0	(5.3 ± 3.7) x 10^{-3}
Dup Liver-Cow #2 80	$^{239+240}$Pu	0	(1.2 ± 0.7) x 10^{-3}
Bone-Cow #5 81	$^{239+240}$Pu	0	(1.7 ± 1.8) x 10^{-3}
	^{90}Sr	0	0.41 ± 0.04
Dup Bone-Cow #5 81	$^{239+240}$Pu	0	(1.1 ± 1.5) x 10^{-3}
	^{90}Sr	0	0.46 ± 0.04
Liver-Cow #5 81	$^{239+240}$Pu	0	0.025± 0.009
Dup Liver Cow #5 81	$^{239+240}$Pu	0	-0.018± 0.008

Chapter 7. Dose Assessment

S. C. Black

SECTION 7.1. ESTIMATED DOSE FROM NTS ACTIVITIES

The estimate of dose equivalent due to NTS activities is based on the total release of radioactivity from the site as listed in Table 2. Since no significant radioactivity of recent NTS origin was detectable off site by the various monitoring networks, no significant exposure to the population living around the NTS would be expected. To confirm this expectation, a calculation of estimated dose was performed using EPA's AIRDOS/RADRISK program. The individuals exposed were considered to be all of those living within a radius of 80 km of CP-1 on the NTS, a total of 8,400 individuals. The hypothetical individual with the maximum calculated exposure from airborne NTS radioactivity would have been continuously present at Pahrump, NV, which is south of the NTS. That maximum dose was 0.15 μrem (1.5 x 10^{-3} μSv). The population dose within 80 km would have been 1.1 x 10^{-3} pers-rem (1.1 x 10^{-5} person-Sv).

During calendar year 1989 there were four sources of possible radiation exposure to the population of Nevada that were measured by our monitoring networks.

- Operational releases of radioactivity from the NTS, including those from drillback and purging activities
- Radioactivity accumulated in migratory animals resident on the NTS
- Worldwide distributions such as ^{90}Sr in milk, ^{85}Kr in air, etc.
- Background radiation due to natural sources such as cosmic radiation, natural radioactivity in soil, and ^{7}Be in air

The estimated dose equivalent exposures from these sources to people living near the NTS are calculated separately in the following subsections.

Table 30 summarizes the annual effective dose equivalents due to operations at the Nevada Test Site during 1989.

SECTION 7.2. ESTIMATED DOSE FROM WORLDWIDE FALLOUT

From the monitoring networks described in previous sections of this report, the following concentrations of radioactivity were found:

^{3}H (0.24 x 10^{-12} μCi/m^3 of air [9 mBq/m^3])
^{85}Kr (26 x 10^{-12} μCi/m^3 of air [0.98 Bq/m^3])
^{90}Sr (0.64 x 10^{-9} μCi/mL in milk [24 mBq/L])
^{137}Cs (28 pCi/kg beef liver [1 Bq/kg])
$^{239+240}$Pu (24 fCi/kg beef liver [0.9 fBq/kg])

The dose is estimated from these findings by using the assumptions and dose conversion factors as follows:

Adult breathing rate is 8400 m^3/yr;
Milk intake (10-yr old) is 160 L/yr;
Liver consumption is 0.5 lb/week = 11.8 kg/yr;
Meat consumption is 248 g/day (when liver consumption is subtracted this is 78.7 kg/yr.)

The following dose conversion factors are based on the occupational ALI in Becquerels divided by 50 to convert to public ALI in Becquerels, then multiplied by 100 and by 0.037 and inverted to convert to mrem/pCi:

^{3}H (6.2 x 10^{-8} mrem/pCi)
^{90}Sr (1.8 x 10^{-4} mrem/pCi)
^{137}Cs (4.5 x 10^{-5} mrem/pCi)
$^{239+240}$Pu (9 x 10^{-4} mrem/pCi)
^{85}Kr (1.6 x 10^{-4} mrem/yr per pCi/m^3)
^{133}Xe (2 x 10^{-4} mrem/yr per pCi/m^3)

As an example calculation, the following is the result for tritium:

0.24 x 10^{-12} μCi/m^3 x 8400 m^3/yr x 6.2 x 10^{-8} mrem/pCi x 10^{3} μrem/mrem = 0.12 μrem

Also:

^{90}Sr (0.64 x 160 L/yr x 1.8 x 10^{-4} x 10^{3} = 18 μrem)
^{137}Cs (28 x 11.8 x 4.5 x 10^{-5} x 10^{3} = 15 μrem)
$^{239+240}$Pu (24 x 10^{-3} pCi/Kg x 11.8 x 9 x 10^{-4} x 10^{3} = 0.26 μrem)
^{85}Kr (26.4 x 1.6 x 10^{-4} x 10^{3} = 4.2 μrem)

Therefore, exposure to worldwide fallout causes a dose equivalent equal to the sum of the above or 37 μrem (0.37 μSv).

Estimated Dose from Radioactivity in NTS Deer

The highest measured concentrations of radionuclides in mule deer tissues occurred in deer collected on the NTS. The maximum values were:

Tissue	^{3}H	$^{239+240}Pu$
Liver (pCi/kg)	87×10^{3}	0.19
Muscle (pCi/kg)	17×10^{3}	0.06

The tritium concentration was calculated by using 5.8×10^{5} pCi/L in blood and assuming liver was 15 percent blood and muscle was 3 percent blood (ICRP-23). In the unlikely event that one such deer was collected by a hunter in offsite areas, his intake could be calculated. Assuming 3 pounds of liver and 100 pounds of meat and the radionuclide concentrations listed above, the dose equivalents could be:

Liver: 1.36 kg $[(87 \times 10^{3} \times 6.2 \times 10^{-8}) + (0.19 \times 9 \times 10^{-4})] = 8$ μrem

Muscle: 45.4 kg $[(17 \times 10^{3} \times 6.2 \times 10^{-8}) + (0.06 \times 9 \times 10^{-4})] = 50$ μrem

Thus, approximately 0.06 mrem would be delivered to one individual consuming the stated quantity of meat and assuming no radioactivity was lost in food preparation. About 97 percent of this dose equivalent is contributed by the tritium content of the meat.

SECTION 7.3. DOSE FROM BACKGROUND RADIATION

In addition to external radiation exposure due to cosmic rays and that due to the gamma radiation from naturally occurring radionuclides in soil (^{40}K, uranium and thorium daughters, etc.), there is a contribution from ^{7}Be that is formed in the atmosphere by cosmic ray interactions with oxygen and nitrogen. The annual average ^{7}Be concentration measured by our air surveillance network was 0.11 pCi/m^{3}. With a dose conversion factor for inhalation of 2.6×10^{-7} mrem/pCi, this equates to 3×10^{-8} mrem, a negligible quantity when compared with the PIC measurements that vary from 52 to 165 mR/yr, depending on location.

SECTION 7.4. SUMMARY

For an individual with the highest exposure to NTS effluent, that is someone living at Pahrump, Nev., the NTS exposure, plus that due to worldwide fallout plus background would add to: (0.0002 + 0.04 + 67)mrem = 67 mrem (0.67 mSv). Both the NTS and worldwide distributions contribute a negligible amount of exposure compared to natural background.

TABLE 30. SUMMARY OF ANNUAL EFFECTIVE DOSE EQUIVALENTS DUE TO OPERATIONS AT THE NTS DURING 1989

	MAXIMUM DOSE AT NTS BOUNDARY[a]	MAXIMUM DOSE TO AN INDIVIDUAL[b]	COLLECTIVE DOSE TO POPULATION WITHIN 80 km OF NTS
Dose	0.22 ± 0.02 μrem (2.2E-3 μSv)	0.15 ± 0.02 μrem (1.5E-3 μSv)	1.1E-3 person-rem (1.1E-5 person-Sv)
Location	Boundary 43 km south of CP-1	Pahrump, Nev. 80 km S of CP-1	8400 people within 80 km of NTS CP-1
NESHAPS Standard	———	25 mrem (0.25 mSv)	———
Percentage of NESHAPS	———	6E-4%	———
Background	80 mrem (0.80 mSv)	67 mrem (0.67 mSv)	784 person-rem (7.84 person-Sv)
Percentage of Background	2.8E-4%	2.2E-4%	1.4E-4%

(a) Maximum boundary dose is the dose to a hypothetical individual at the NTS boundary where the highest dose rate occurs. It assumes that the person remains in the open continuously all year.

(b) Maximum individual dose is to an individual outside the NTS boundary at a residence where the highest dose rate occurs and also assumes that person remains outside at that location continuously all year long. Calculated from the reported effluent (Table 2) using AIRDOS-PC, versions 3 (1989), software.

Chapter 8. Sample Analysis Procedures

R. W. Holloway

The procedures for analyzing samples collected for this report were described by Johns et al. (EMSL79) and are summarized below. These include gamma analysis, gross beta on air filters, strontium, tritium, plutonium and noble gas analysis. These procedures outline standard methods used to perform given analytical procedures.

TABLE 31. SUMMARY OF ANALYTICAL PROCEDURES

TYPE OF ANALYSIS	ANALYTICAL EQUIPMENT	COUNTING PERIOD (min)	ANALYTICAL PROCEDURES	SAMPLE SIZE	APPROXIMATE DETECTION LIMIT*
IG Ge(Li) Gamma Spectrometry**	IG or GE(Li) detector calibrated at 0.5 keV/channel (0.04 to 2 MeV range) individual detector efficiencies ranging from 15% to 35%.	Air charcoal cartridges and individual air filters, 30 min; 100 min for milk, water, suspended solids.	Radionuclide concentration quantified from gamma spectral data by on-line computer program. Radionuclides in air filter composite samples are identified only.	560 m^3 for air filters; and charcoal cartridges; 3-1/2 liters for milk and water.	For routine milk and water generally, 5×10^{-9} µCi/mL for most common fallout radionuclides in a simple spectrum. Filters for LTHMP suspended solids, 6×10^{-9} µCi/mL. Air filters and charcoal cartridges, 0.04×10^{-12} µCi/mL.
Gross beta on air filters	Low-level end window, gas flow proportional counter with a 12.7 cm diameter window (80 µg/cm^2).	30	Samples are counted after decay of naturally-occurring radionuclides and, if necessary, extrapolated to midpoint of collection in accordance with $t^{-1.2}$ decay or an experimentally-derived decay.	560 m^3	0.5×10^{-12} µCi/ sample.
$^{89+90}Sr$	Low-background thin-window, gas-flow, proportional counter.	50	Chemical separation by ion exchange. Separated sample counted successively; activity calculated by simultaneous solution of equations.	1.0 liter for milk or water. 0.1 to 1 kg for tissue.	$^{89}Sr = 5 \times 10^{-9}$ µCi/mL $^{90}Sr = 2 \times 10^{-9}$ µCi/mL

(Continued)

TABLE 31. (Continued)

TYPE OF ANALYSIS	ANALYTICAL EQUIPMENT	COUNTING PERIOD (min)	ANALYTICAL PROCEDURES	SAMPLE SIZE	APPROXIMATE DETECTION LIMIT*
^{3}H	Automatic liquid scintillation counter with output printer.	300	Sample prepared by distillation.	4 mL for water.	300 - 700 x 10^{-9} µCi/mL†
^{3}H Enrichment (Long-Term Hydrological Samples)	Automatic scintillation counter with output printer.	300	Sample concentrated by electrolysis followed by distillation.	250 mL for water.	10 x 10^{-9} µCi/mL
$^{238+239}Pu$	Alpha spectrometer with silicon surface barrier detectors operated in vacuum chambers.	1000-4000	Water sample or acid-digested filter or tissue samples separated by ion exchange, electroplated on stainless steel planchet.	1.0 liter for water; 0.1 to 1 kg for tissue; 5000 to 10,000 m^3 for air.	^{238}Pu = 0.08 x 10^{-9} µCi/mL $^{239+240}Pu$ = 0.04 x 10^{-9} µCi/mL for water. For tissue samples, 0.04 pCi per total sample for all isotopes; 5 x 10^{-17} to 10 x 10^{-17} µCi/mL for plutonium on air filters.
^{85}Kr, ^{133}Xe, ^{135}Xe	Automatic liquid scintillation counter with output printer.	200	Separation by gas chromatography; dissolved in toluene "cocktail" for counting.	0.4 to 1.0 m^3 for air.	^{85}Kr, ^{133}Xe, ^{135}Xe = 4 x 10^{-12} µCi/mL

* *The detection limit is defined as the smallest amount of radioactivity that can be reliably detected, i.e., probability of Type I and Type II error at 5 percent each (DOE81).*

** *Gamma Spectrometry using either an intrinsic germanium (IG), or lithium-drifted germanium diode (Ge(Li)) detector.*

† *Depending on sample type.*

Chapter 9. Radiation Protection Standards for External and Internal Exposure

S. C. Black

SECTION 9.1. DOSE EQUIVALENT COMMITMENT

For stochastic effects in members of the public, the following limits are used:

	Effective Dose Equivalent*	
	Dose mrem/yr	mSv/yr
Occasional annual exposures**	500	5
Prolonged period of exposure	100	1

* *Includes both effective dose equivalent from external radiation and committed effective dose equivalent from ingested and inhaled radionuclides.*

** *Occasional exposure implies exposure over a few years with the provision that over a lifetime the average exposure does not exceed 100 mrem (1 mSv) per year (ICRP-39).*

SECTION 9.2. CONCENTRATION GUIDES

ICRP-30 lists Derived Air Concentrations (DAC) and Annual Limit on Intake (ALI)(ICRP79). The ALI is the secondary limit and can be used with assumed breathing rates and ingested volumes to calculate concentration guides. The concentration guides (CG's) in Table 32 were derived in this manner and yield the committed effective dose equivalent (50 year) of 100 mrem/yr for members of the public.

SECTION 9.3. EPA DRINKING WATER GUIDE

In 40 CFR 141 (reference CFR88) the EPA set allowable concentrations for continuous controlled releases of radionuclides to drinking water sources. Any single or combination of beta and gamma emitters should not lead to exposures exceeding 4 mrem/yr. For tritium this is 2.0×10^{-5} μCi/mL (740 Bq/L) and for ^{90}Sr is 8×10^{-9} μCi/mL (0.3 Bq/L).

TABLE 32. ROUTINE MONITORING FREQUENCY, SAMPLE SIZE, MDC AND CONCENTRATION GUIDES

NUCLIDE	SAMPLING FREQUENCY	LOCATIONS	SAMPLE SIZE	COUNT TIME	CONCENTRATIONS GUIDE*		MDC	MDC (% CG)
Air Surveillance Network			m^3	Minutes	Bq/m^3	μCi/mL	mBq/m^3	
^{7}Be	1/wk	all	560	30	1700	4.7×10^{-8}	17	1×10^{-3}
^{95}Zr	1/wk	all	560	30	12	3×10^{-10}	4.1	4×10^{-2}
^{95}Nb	1/wk	all	560	30	110	3×10^{-9}	1.8	2×10^{-3}
^{99}Mo	1/wk	all	560	30	110	3×10^{-9}	1.5	2×10^{-3}
^{103}Ru	1/wk	all	560	30	58	1.5×10^{-9}	1.8	3×10^{-3}
^{131}I	1/wk	all	560	30	4	1×10^{-10}	1.8	4×10^{-2}
^{132}Te	1/wk	all	560	30	17	5×10^{-10}	1.8	1×10^{-2}
^{137}Cs	1/wk	all	560	30	12	3×10^{-10}	1.8	2×10^{-2}

(Continued)

TABLE 32. (Continued)

NUCLIDE	SAMPLING FREQUENCY	LOCATIONS	SAMPLE SIZE	COUNT TIME	CONCENTRATIONS GUIDE*		MDC	MDC (% CG)
Air Surveillance Network			m^3	Minutes	Bq/m^3	$\mu Ci/mL$	mBq/m^3	
^{140}Ba	1/wk	all	560	30	120	3×10^{-9}	4.8	4×10^{-3}
^{140}La	1/wk	all	560	30	120	3×10^{-9}	2.6	2×10^{-3}
^{141}Ce	1/wk	all	560	30	52	1.4×10^{-9}	3.0	6×10^{-3}
^{144}Ce	1/wk	all	560	30	1.2	3×10^{-11}	12	1.0
^{238}Pu	1/mo	all	2400	1000	5×10^{-4}	1×10^{-14}	1.5×10^{-3}	0.32
Gross Beta	1/wk	all	560	30	2×10^{-2}	5×10^{-13}	0.11	6×10^{-1}
^{3}H	1/wk	17	5	150	4.6×10^{3}	1.2×10^{-7}	148	3×10^{-3}
^{85}Kr	1/wk	17	0.4	200	2.2×10^{4}	6.2×10^{-7}	148	6×10^{-4}
^{133}Xe	1/wk	17	0.4	200	1.8×10^{4}	4.9×10^{-7}	370	2×10^{-3}
^{135}Xe	1/wk	17	0.4	200	2.3×10^{3}	6.2×10^{-8}	370	2×10^{-2}
Water Surveillance Network (LTHMP)**			Liters	Minutes	Bq/L	$\mu Ci/mL$	Bq/L	
^{3}H	1/mo	all	1	300	740	2×10^{-5}	12	1.6
$^{3}H^{+}$ (enriched tritium)	1/mo	all	0.25	300	740	2×10^{-5}	0.37	5×10^{-2}
^{89}Sr	1st time	all	1	50	16	4.4×10^{-7}	0.18	1.1
^{90}Sr	1st time	all	1	50	0.8	2.2×10^{-8}	0.074	9.2
^{137}Cs	1/mo	all	1	100	3.3	8.8×10^{-8}	0.33	10
^{226}Ra	1st time	all	1	1000	1.4	3.9×10^{-8}	0.037	2.6
^{234}U	1st time	all	1	1000	8.2	2.2×10^{-7}	0.0035	0.04
^{235}U	1st time	all	1	1000	10	2.8×10^{-8}	0.0035	0.035
^{238}U	1st time	all	1	1000	10	2.8×10^{-8}	0.0035	0.035
^{238}Pu	1st time	all	1	1000	6.2	1.7×10^{-8}	0.003	0.05
$^{239+240}Pu$	1st time	all	1	1000	4.1	1.1×10^{-8}	0.002	0.05
Gamma	1/mo	all	3.5	30	—	—	0.18	<0.2

(Continued)

TABLE 32. (Continued)

NUCLIDE	SAMPLING FREQUENCY	LOCATIONS	SAMPLE SIZE	COUNT TIME	CONCENTRATIONS GUIDE*		MDC	MDC (% CG)
Milk Surveillance Network			Liters	Minutes	Bq/L	μCi/mL	Bq/L	
^{3}H	1/mo	all	3.5	300	12×10^{4}	3×10^{3}	12	0.01
^{131}I	1/mo	all	3.5	100	41	1×10^{6}	0.18	0.44
^{137}Cs	1/mo	all	3 5	100	160	4×10^{6}	0.33	0 2
^{89}Sr	1/mo	all	3.5	50	820	2×10^{5}	0.18	0 02
^{90}Sr	1/mo	all	3.5	50	40	1×10^{6}	0.074	0.18
Gamma	1/mo	all	3.5	50	—	—	0.18	<0.2
Dosimetry Network			Number		Exposure Guide		MDA	
TLD (Personnel)	1/mo	61	1	—	100mR		2mR	2
TLD (Station)	1/qtr	154	3-6	—	—		2mR	—
PIC	weekly	28	2016	—	—		2μR/hr	—

* *ALI and DAC values from ICRP-30 modified to 1 mSv annual effective dose equivalent for continuous exposure. Te and I data corrected to 2 g thyroid, greater milk intake, and smaller volume of air breathed annually (1 year-old infant).*

** *For tritium, Sr and Cs the concentration guide is based on Drinking Water Regs. (4 mrem/yr).*

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Appendix 2. Glossary of Terms (NRC81)

Definitions

background radiation	The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of humans and animals. It is also called natural radiation. The usually quoted average individual exposure from background radiation is 125 millirem per year in mid-latitudes at sea level.
beta particle (ß)	A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A positively charged beta particle is called a positron. Large amounts of beta radiation may cause skin burns, and beta emitters are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal or plastic.
becquerel (Bq)	A unit, in the International System of Units (SI), of measurement of radioactivity equal to one nuclear transformation per second.
cosmic radiation	Penetrating ionizing radiation, both particulate and electromagnetic, originating in space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, account for about 45 to 50 millirem of the 125 millirem background radiation that an average individual receives in a year.
curie (Ci)	The basic unit used to describe the rate of radioactive disintegration. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium; named for Marie and Pierre Curie, who discovered radium in 1898.
dosimeter	A portable instrument for measuring and registering the total accumulated dose to ionizing radiation.
half-life	The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical halflife.
ionization	The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperatures, electrical discharges, nuclear radiation, and x-rays can cause ionization.
ionization chamber	An instrument that detects and measures ionizing radiation by measuring the electrical current that flows when radiation ionizes gas in a chamber.
isotope	One of two or more atoms with the same number of protons, but different numbers of neutrons in their nuclei. Thus, ^{12}C, ^{13}C and ^{14}C are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, ^{12}C and ^{13}C are stable, ^{14}C is radioactive).
minimum detectable concentration (MDC)	The smallest amount of radioactivity that can be reliably detected with a probability of Type I and Type II error at 5% each (DOE81).
millirem (mrem)	A one-thousandth part of a rem. (See rem.)

milliroentgen (mR)	A one-thousandth part of a roentgen. (See roentgen.)
noble gas	A gaseous element that does not readily enter into chemical combination with other elements. An inert gas.
personnel monitoring	The determination of the degree of radioactive contamination on individuals using survey meters, or the determination of radiation dosage received by means of dosimetry methods.
picocurie (pCi)	One trillionth part of a curie.
quality factor	The factor by which the absorbed dose is to be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiations, the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than other types.
rad	Acronym for radiation absorbed dose. The basic unit of absorbed dose of radiation. A dose of one rad means the absorption of 100 ergs (a small but measurable amount of energy) per gram of absorbing material.
radioisotope	An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation.
radionuclide	A radioisotope.
rem	Acronym of roentgen equivalent man. The unit of dose of any ionizing radiation that produces the same biological effect as a unit of absorbed dose of ordinary X-rays. (See quality factor.)
roentgen (R)	A unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, German scientist who discovered X-rays in 1895.
scintillation (detector or counter)	The combination of phosphor, photomultiplier tube, and associated counter electronic circuits for counting light emissions produced in the phosphor by ionizing radiation.
sievert (Sv)	A unit, in the International System of Units (SI), of dose equivalent which is equal to one joule per kilogram (1 Sv equals 100 rem).
terrestrial radiation	The portion of natural radiation (background) that is emitted by naturally occurring radioactive materials in the earth.
tritium	A radioactive isotope of hydrogen that decays by beta emission. It's half-life is about 12.5 years.
X-rays	Penetrating electromagnetic radiation (photon) having a wavelength that is much shorter than that of visible light. These rays are usually produced by excitation of the electron field around certain nuclei. In nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and to those originating in the electron field of the atom as X-rays. These rays are sometimes called roentgen rays after their discoverer, Wilhelm K. Roentgen.