United States
Environmental Protection
Agency

Environmental Monitoring
Systems Laboratory
P.O. Box 93478
Las Vegas NV 89193-3478

EPA/600/4-88/021
DOE/DP/00539/060
June 1988

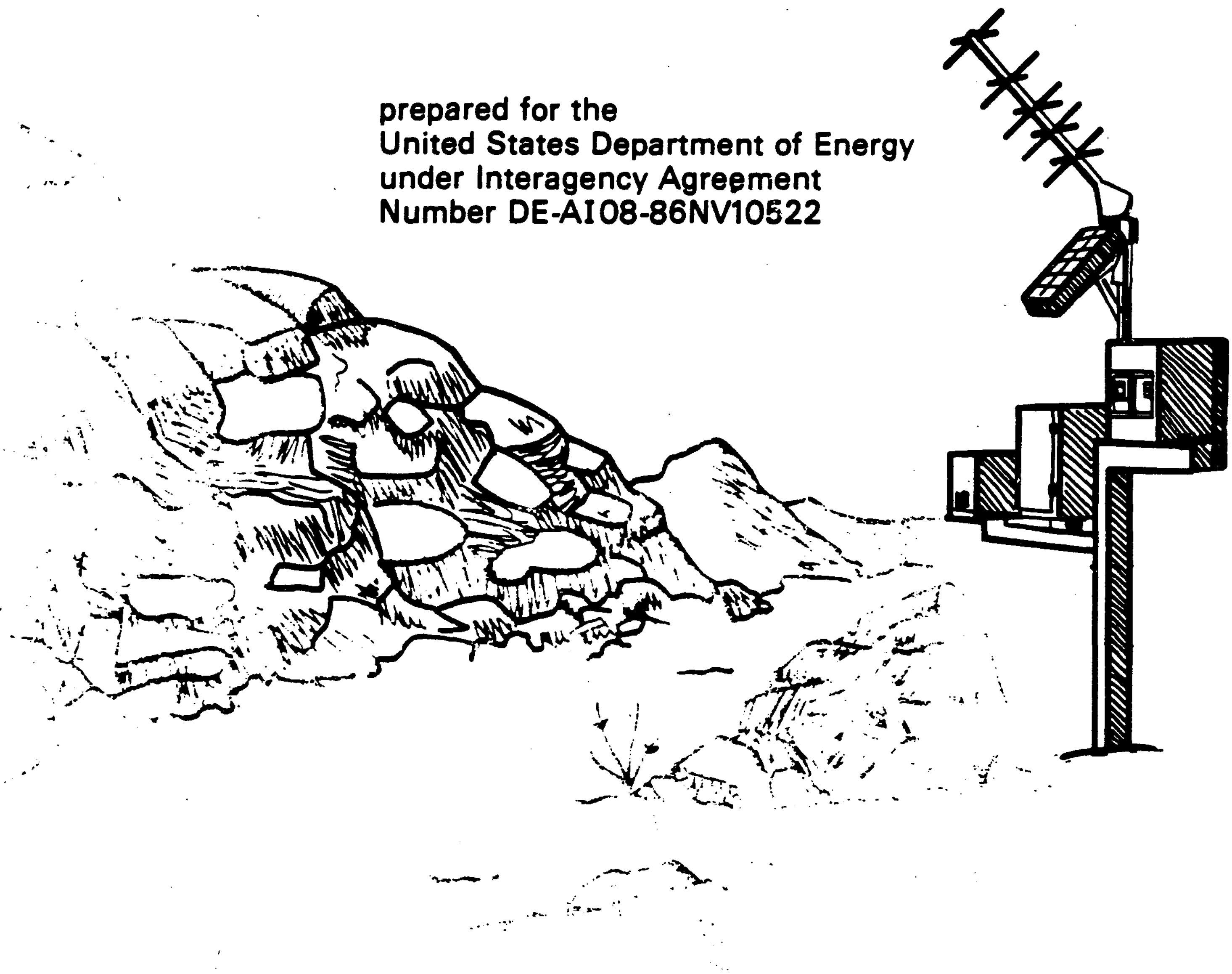
Research and Development

EPA

Off-Site Environmental Monitoring Report

Radiation Monitoring Around United States Nuclear Test Areas 1987

prepared for the
United States Department of Energy
under Interagency Agreement
Number DE-AI08-86NV10522



EPA-600/4-88-021
DOE/DP/00539-060
May 1988

OFF-SITE ENVIRONMENTAL MONITORING REPORT
Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1987

contributors·

C. A. Fontana, N. R. Sunderland
S. C. Black, B. B. Dicey, A. N. Jarvis
D. D. Smith, D. J. Thomé A. A. Mullen, and
Nuclear Radiation Assessment Division

prepared for the
U.S. Department of Energy
under Interagency Agreement
Number DE-AI08-86NV10522

ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
LAS VEGAS, NEVADA 89193-3478

NOTICE

This report has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

The U.S. Atomic Energy Commission (AEC) used the Nevada Test Site (NTS) from January 1951 through January 19, 1975, for conducting nuclear weapons tests, nuclear rocket-engine development, nuclear medicine studies, and other nuclear and non-nuclear experiments. Beginning January 19, 1975, these activities became the responsibility of the newly formed U.S. Energy Research and Development Administration (ERDA). On October 1, 1977 the ERDA was merged with other energy-related agencies to form the U.S. Department of Energy (DOE). Atmospheric nuclear tests were conducted periodically from January 27, 1951, through October 30, 1958, after which a testing moratorium was in effect until September 1, 1961. Since then all nuclear detonations have been conducted underground with the expectation of containment, except for four slightly above-ground or shallow underground tests of Operation Dominic II in 1962 and five nuclear earth-cratering experiments conducted under the Plowshare program between 1962 and 1968.

Prior to 1954, an off-site surveillance program was performed by the Los Alamos Scientific Laboratory and the U.S. Army. From 1954 through 1970 the U.S. Public Health Service (PHS), and from 1970 to the present the U.S. Environmental Protection Agency (EPA) have provided an Off-Site Radiological Safety Program under an Interagency Agreement. The PHS or EPA has also provided off-site surveillance for U.S. nuclear explosive tests at places other than the NTS.

Since 1954, an objective of this surveillance program has been 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. Off-site levels of radiation and radioactivity are assessed by sampling milk, water, and air; by deploying dosimeters; and by sampling food crops, soil, etc., as required. Personnel with mobile monitoring equipment are placed in areas downwind from the test site prior to each test in order to implement protective actions, provide immediate radiation monitoring, and obtain environmental samples rapidly after any release of radioactivity. Since 1962, aircraft have also been deployed to rapidly monitor and sample releases of radioactivity during nuclear tests. Monitoring data obtained by the aircraft crew immediately after a test are used to position mobile radiation monitoring personnel on the ground. Data from airborne sampling are used to quantify the amounts, diffusion, and transport of the radionuclides released.

Beginning with Operation Upshot-Knothole in 1953, a report was published by the PHS summarizing the surveillance data for each test series. In 1959 for reactor tests, and in 1962 for weapons and Plowshare tests, such data were published for those tests that released radioactivity detectable off the NTS.

The reporting interval was changed again in 1964 to semi-annual publication of data for each 6-month period which also included the data from the individual reports.

In 1971, the AEC implemented a requirement, now incorporated into DOE Order 5484.1, that each contractor or agency involved in major nuclear activities provide a comprehensive annual radiological monitoring report. This is the sixteenth annual report in this series; it summarizes the off-site activities of the EPA during CY 1987.

CONTENTS

FIGURES

TABLES

TABLES (Continued)

ABBREVIATIONS, SYMBOLS AND CONVERSIONS

ASN	Air Surveillance Network
AVG	Average
Bq	Becquerel, one disintegration per second
CG	Concentration Guide
Ci	Curie
CP-1	Control Point One
CY	Calendar Year
d	day
DOE	U.S. Department of Energy
DOE/NV	Department of Energy, Nevada Operations Office
EMSL-LV	Environmental Monitoring Systems Laboratory, Las Vegas
EPA	U.S. Environmental Protection Agency
eV	electron volt
g	gram
Gy	Gray, equivalent to 100 rad (1 J/kg)
GZ	Ground Zero
h	hour
HTO	tritiated water
L	liter
LTHMP	Long-Term Hydrological Monitoring Program
m	meter
MDC	Minimum Detectable Concentration
MSL	Mean Sea Level
MSN	Milk Surveillance Network
NGTSN	Noble Gas and Tritium Surveillance Network
NTS	Nevada Test Site
Pa	Pascal - unit of pressure
PIC	Pressurized ion chamber
QA	Quality Assurance
R	Roentgen
rad	unit of absorbed dose, 100 ergs/g
rem	the rad adjusted for biological effect
SD	Standard deviation
Sv	Sievert, equivalent to 100 rem
TLD	thermoluminescent dosimeter

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
Concentration Guides		
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	0.037	Becquerel

SECTION 1

INTRODUCTION

The EMSL-LV operates an Off-Site Radiological Safety Program around the NTS and other sites as requested by the Department of Energy (DOE) under an Interagency Agreement between DOE and EPA. This report, prepared in accordance with DOE orders (DOE85), covers the program activities for calendar year 1987. It contains descriptions of pertinent features of the NTS and its environs, summaries of the EMSL-LV dosimetry and sampling methods, analytical procedures, quality assurance, and the analytical results from environmental measurements. Where applicable, dosimetry and sampling data are compared to appropriate standards for external and internal exposures of humans to ionizing radiation.

SECTION 2

SUMMARY

PURPOSE

It is U.S. Environmental Protection Agency (EPA) policy to protect the general public and the environment from pollution caused by human activities. This includes radioactive contamination of the biosphere and concomitant radiation exposure of the population. To this end and in agreement with U.S. Department of Energy (DOE) policy of keeping radiation exposure of the general public as low as reasonably achievable, the EPA's Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV) conducts an Off-Site Radiological Safety Program around the DOE's Nevada Test Site. This program is conducted under an Interagency Agreement between EPA and DOE. The principal activity at the NTS is testing of nuclear devices, though other related projects are also conducted.

The principal activities of the Off-Site Radiological Safety Program are: routine environmental monitoring for radioactive materials in various media and for radiation in areas which may be affected by nuclear tests; and protective actions in support of the nuclear testing program. These are conducted to document compliance with standards, to identify trends, and to provide information to the public. This report summarizes these activities for CY 1987.

Locations

Most of the radiological safety effort is applied in the areas around the Nevada Test Site (NTS) in south-central Nevada. This portion of Nevada is sparsely settled, 0.5 person/km^2, and has a continental arid climate. The largest town in the near off-site area is Beatty, located about 65 km west of the NTS with a population of about 1,000.

Underground tests have been conducted in several other States for various purposes. At these sites in Alaska, Colorado, New Mexico, and Mississippi, a long-term hydrological monitoring program is conducted to detect any possible radioactive contamination of potable water and aquifers near these sites.

Special Test Support

During CY87, personnel were deployed in support of the 15 announced nuclear tests at the NTS. No radioactivity of NTS origin was detected off site.

Pathways Monitoring

The pathways leading to human exposure to radionuclides (air, water, and food) are monitored by networks of sampling stations. The networks are designed not only to detect radiation from DOE/NV nuclear test areas but also to measure population exposure from other sources. No positive results were obtained by these networks this year that could be attributed to NTS activities.

In 1987 the air surveillance network (ASN) consisted of 30 continuously operating stations surrounding the NTS and 83 standby stations (operated 1 or 2 weeks each quarter) in all States west of the Mississippi River. Other than naturally occurring beryllium-7, the only activity detected by this network was plutonium-239 from worldwide fallout.

The noble gas and tritium sampling network (NGTSN) consisted of 17 stations off site (off the NTS and exclusion areas) in 1987. No NTS-related radioactivity was detected at any off-site station by this network. Tritium concentrations in air remained below Minimum Detectable Concentration (MDC) levels and krypton-85 concentrations continued the upward trend, reflecting the worldwide increase in the use of nuclear technology.

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

The milk surveillance network consisted of 28 sampling locations within 300 km of the NTS and about 122 standby locations in the Western U.S. The tritium concentration in milk was at background levels, and strontium-90 from worldwide fallout continued the slow downward trend observed in recent years.

Other foods analyzed have been mainly meat from domestic or game animals. The radionuclide most frequently found in the edible portion of the sampled animals is cesium-137. However, its concentration has been near the MDC since 1968. Strontium-90 in samples of animal bone remain at very low levels as does plutonium-239 in both bone and liver samples.

External Exposure

External exposure is monitored by a network of thermoluminescent dosimeters (TLD's) at 132 fixed locations surrounding the NTS and by TLD's worn by 58 off-site residents. In a few cases, small exposures of a few millirem (mrem) above the average for the person were measured. Except for several occupational exposures, all such net exposures were very low and were not related to NTS activities. 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.

Internal Exposure

Internal exposure is assessed by whole-body counting supplemented by semi-planar and intrinsic detectors to measure lung burdens of radioactivity. In 1987, counts were made on 230 individuals from the off-site areas around the Nevada Test Site, the EMSL-LV Laboratory, EG&G facilities throughout the United States and members of the general public concerned about possible radiation exposure. No nuclear test related radioactivity was detected. In addition, physical examinations of the off-site residents revealed a normally healthy population consistent with the age and sex distribution of that population.

Community Monitoring Stations

The 15 Community Monitoring Stations became operational in 1982. Each station is operated by a resident of the community who is trained to collect samples and interpret some of the data. Each station is an integral part of the ASN, NGTSN and TLD networks and is also equipped with a pressurized ion chamber system and recording barograph. Samples and data from the stations are analyzed by EMSL-LV and are also interpreted and reported by the Desert Research Institute, University of Nevada. Data from these stations are reported herein as part of the networks in which they participate.

Dose Assessment

Doses were calculated for an average adult living in Nevada using the radionuclides measured in samples collected by the monitoring networks. Using conservative assumptions, the estimated dose would have been about 0.16 mrem (1.6 μSv) for 1987. No radioactivity originating on the NTS was detectable by the monitoring networks; therefore, no dose assessment can be made. However, based on the NTS releases reported in Table 1, atmospheric dispersion calculations (AIRDOS/EPA) indicate that the highest individual dose would have been 0.2 μrem (0.002 μSv), and the dose to the population within 80 km of Control Point One (CP-1) would have been 5.9×10^{-4} person-rem (5.9×10^{-6} person-Sv).

In the unlikely event that a certain mule deer had been collected by a hunter rather than by EPA personnel, that hunter could have received a dose equivalent of 29 mrem (0.29 mSv) if he ate all the liver and meat from the deer.

SECTION 3

DESCRIPTION OF THE NEVADA TEST SITE

Historically, the major programs conducted at the NTS have been nuclear weapons development, proof-testing and weapons safety and effects, testing peaceful uses of nuclear explosives (Plowshare Program), reactor engine development for nuclear rocket and ramjet applications (Projects Rover and Pluto), high energy nuclear physics research, seismic studies (Vela Uniform), and studies of high-level waste storage. During 1986, nuclear weapons development, proof-testing and weapons safety, nuclear physics programs, and studies of high-level waste storage were continued at the NTS. Project Pluto was discontinued in 1964; Project Rover was terminated in January 1973; Plowshare tests were terminated in 1970; Vela Uniform studies ceased in 1973. All nuclear weapons tests after 1962 have been conducted underground. More detail and pertinent maps for the portions of this section are included in Appendix A. Only selected information is presented in this Section.

Site Location

The NTS is located in Nye County, Nevada, with its southeast corner about 90 km northwest of Las Vegas (Figure 1). It has an area of about 3,500 square km and 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 1,800 to 2,300 m above MSL.

The NTS is surrounded on three sides by exclusion areas, collectively named the Nellis Air Force Base Range Complex, which provide 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. Depending upon wind speed and direction at the time of testing, from 2 to more than 6 hours will elapse before any release of airborne radioactivity could pass over public lands.

Climate

The climate of the NTS and surrounding area is variable, due to its variations in altitude and its rugged terrain. Generally, the climate is referred to as continental arid. Throughout the year, there is insufficient precipitation to support the growth of common food crops without irrigation.

As Houghton et al. (Ho75) point out, 90 percent of Nevada's population lives in areas with less than 25 cm of rainfall per year or in areas that would be classified as mid-latitude steppe to low-latitude desert regions.

The wind direction, as measured on a 30 m tower at an observation station about 9 km NNW of Yucca Lake near CP-1, is predominantly northerly except during 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. Wind patterns are often quite different at other locations on the NTS because of local terrain effects and differences in elevation.

Geology and Hydrology

Geological and hydrological studies of the NTS have been in progress by the U.S. Geological Survey and various other organizations since 1956. Because of this continuing effort, the surface and underground geological and hydrological characteristics for much of the NTS are known in considerable detail (see Figure A-1). This is particularly true for those areas in which underground experiments are conducted. A comprehensive summary of the geology and hydrology of the NTS was published in 1975 (Wi75).

The aquifers underlying the NTS vary in depth from about 200 m beneath the surface of valleys in the southeastern part of the site to more than 500 m beneath the surface of highlands to the north. Although much of the valley fill is saturated, downward movement of water is retarded by various tuffs and is extremely slow. The primary aquifer in these formations consists of Paleozoic carbonates that underlie the more recent tuffs and alluviums.

Land Use of NTS Environs

Industry within the immediate off-NTS area includes approximately 40 active mines and mills, oil fields in the Railroad Valley area, and several industrial plants in Henderson, Nevada. The number of employees for

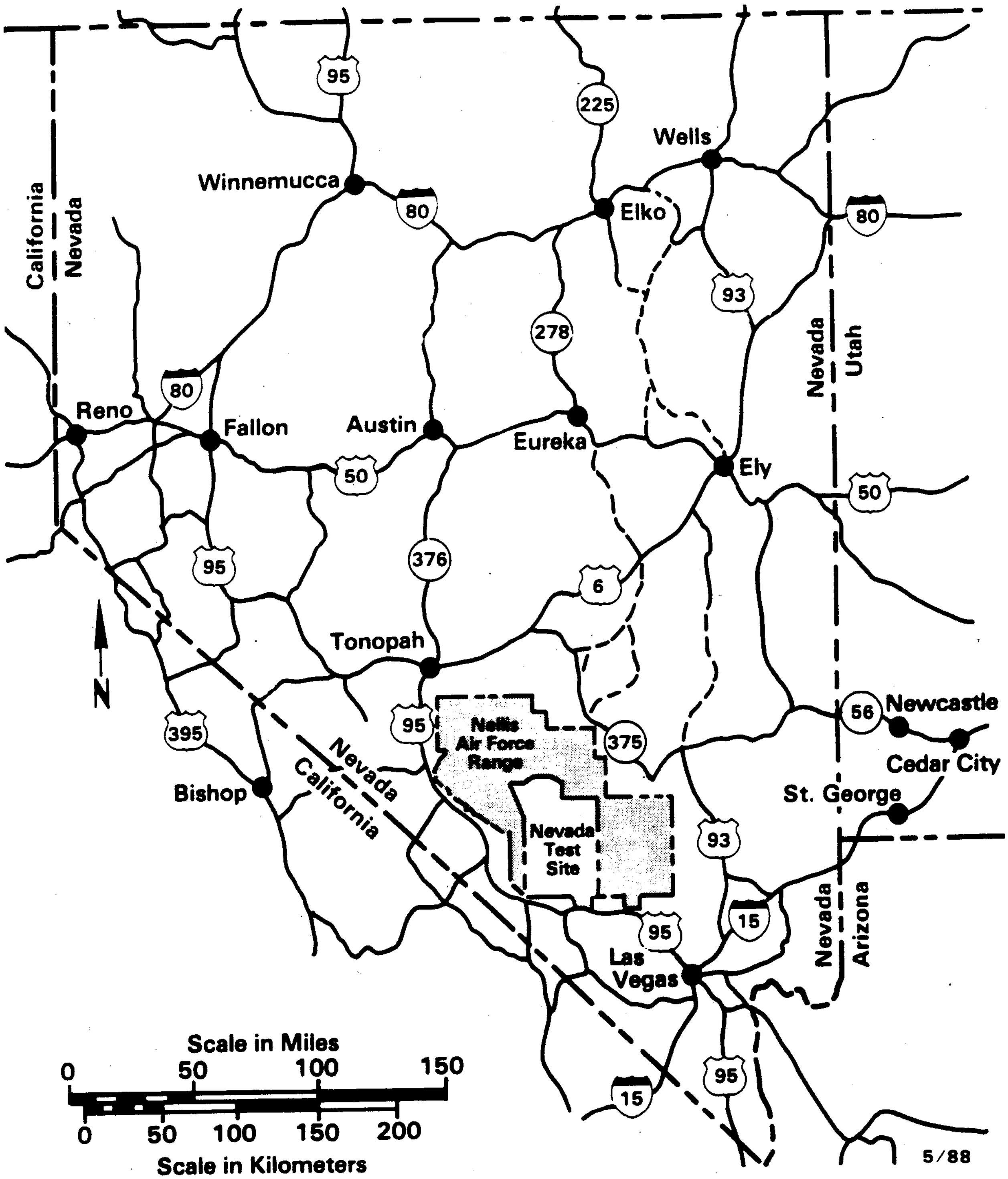


Figure 1. Location of the Nevada Test Site (NTS).

these operations may vary from one person at several of the small mines to several hundred workers for the oil fields north of the NTS and the industrial plants in Henderson. Most of the individual mining operations involve less than 10 workers per mine; however, a few operations employ 100 to 250 workers.

The major body of water close to the NTS is Lake Mead (120 km southeast, Figure A.2), a man-made lake supplied by water from the Colorado River. Lake Mead supplies about 70 percent of the water used for domestic, recreational, and industrial purposes in the Las Vegas Valley. Some Lake Mead water is used in Arizona, southern California, and Mexico. Smaller reservoirs and lakes located in the area are used primarily for irrigation, for watering livestock, and for wildlife refuges.

Dairy farming is not extensive within 300 km of the NTS. As shown in Figures A.4 and A.5 the family cows and goats are distributed in all directions around the NTS, whereas most dairy cows are located to the southeast (along the Muddy and Virgin River valleys and in Las Vegas, Nevada), northeast (Lund), and southwest (near Barstow, California).

Grazing is the most common land use within 300 km of the site. Approximately 600,000 cattle and 200,000 sheep are distributed within the area as shown in Figures A.6 and A.7, respectively. The estimates are based on information supplied by the California Crop and Livestock reporting service (CA85), from 1986 to 1987 agricultural statistics supplied by the Nevada Department of Agriculture (NV86) and 1987 estimates based on 1982 census information supplied by the Utah Department of Agriculture (UT87).

Population Distribution

Excluding Clark County, the major population center (approximately 569,500 in 1986), the population density within a 150 km radius of CP-1 on the NTS is about 0.5 persons per square kilometer. For comparison, the 48 contiguous states (1980 census) had a population density of approximately 29 persons per square kilometer. The estimated average population density for all of Nevada in 1980 was 2.8 persons per square kilometer.

The off-site area within 80 km of the NTS (the area in which the dose commitment must be determined for the purpose of this report) is predominantly rural, Figure A.2. Several small communities are located in the area, the largest being in the Pahrump Valley. This growing rural community, with an estimated population of about 6,000, is located about 72 km south of the NTS CP-1. The Amargosa Farm Area, which has a population of about 850, is located about 50 km southwest of CP-1. The largest town in the near off-site area is Beatty, which has a population of about 1,200 and is located approximately 65 km to the west of CP-1.

AIRBORNE RELEASES OF RADIOACTIVITY AT THE NTS DURING 1987

All nuclear detonations during 1987 were conducted underground and were contained. Although releases of low-level radioactivity occurred during re-entry drilling, seepage through fissures in the soil or purging of tunnel areas. Table 1 shows the total quantities of radionuclides released to the atmosphere, as reported by the DOE Nevada Operations Office (DOE88). Because these releases occurred throughout the year and because of the distance from the points of releases to the nearest sampling station, none of the radioactive material listed in this table was detected off site.

TABLE 1. TOTAL AIRBORNE RADIONUCLIDE EMISSIONS AT THE NTS DURING 1987

Radionuclide	Half-Life (days)	Quantity Released (Ci)
Tritium	4500	126.4
Krypton-85	3990	5.042
Xenon-127	36.4	0.0003
Xenon-133	5.24	44.02
Xenon-133 m	2.2	2.00
Xenon-135	0.38	0.005
Xenon-131 m	11.92	1.0
Xenon (Isotopic mixture unknown)		29.0
Cesium-137	11,030.6	0.000017
Argon-37	34.8	1.0
Iodine (Isotopic mixture unknown)		0.101

SECTION 4

QUALITY ASSURANCE

The goals of the EMSL-LV quality assurance program are to assure the collection and analysis of environmental samples with the highest degree of accuracy and precision obtainable with state-of-the-art instrumentation and to achieve the best possible completeness and comparability given the extent and type of networks from which samples are collected. To meet these goals, it is necessary to devote strict attention to sample collection, sample analysis, and quality assurance procedures.

Sample Collection

The collection of samples is governed by a detailed set of Standard Operating Procedures (SOP's). These SOP's prescribe the frequency and method of collection, the type of collection media, sample containment and transport, sample preservation, sample identification and labeling, and operating parameters for the instrumentation. Sample control is an important segment of these activities as it enables tracking from collection to analysis for each sample and governs the selection of duplicate samples for analysis and the samples chosen for replicate analysis.

These procedures provide assurance that sample collection, labeling and handling are standardized to minimize sample variability due to inconsistency among these variables.

Sample Analysis

All of the networks operated by the EMSL-LV have individual Quality Assurance Project plans. The procedures required by these plans assure that the results of analysis will be of known quality and will be comparable to results obtained elsewhere with equivalent procedures. These Plans are summarized in the following sections.

External Quality Assurance

External QA provides the data from which the accuracy of analysis (a combination of bias and precision) can be determined. Bias is assessed from the results obtained on intercomparison study samples and on samples "spiked" with known amounts of radionuclides. The Off-Site Radiological Safety Program participates in Intercomparison Study Programs that include environmental sample analysis, TLD dosimetry, and whole-body counting. Also, samples which are undisclosed to the analyst are spiked by adding known amounts of radionuclides and then entered into the normal chain of analysis.

Data for precision are collected from duplicate and replicate analyses. At least 10 percent of all samples are collected in duplicate. When analyzed, the data indicate the precision of both sample collection and analysis. Replicate counting of at least 10 percent of all samples yield data from which the precision of counting can be determined.

If the bias and precision data are of sufficient quality (i.e., normalized deviation in Table C.3 is less than 3), then comparability, i.e., comparison of the data with those of other analytical laboratories, can be assessed with confidence. The results of external QA procedures are shown in Appendix C.

Internal Quality Assurance

Internal QA consists of those procedures used by the analyst to assure proper sample preparation and analysis. The principal procedures used are the following:

- Instrument background determinations
- Blank and reagent analyses
- Instrument calibration with known nuclides
- Laboratory control standards analysis
- Performance check-source analysis
- Maintenance of control charts for background and check-source data
- Scheduled instrument maintenance.

These procedures ensure that the instrumentation is not contaminated, is operating properly and that calibration is correct, and that samples carried through the total analytical procedure are accurately analyzed.

Validation

After the results are produced, supervisory personnel examine the data to determine whether or not the analysis is valid. This includes checking all procedures from sample receipt to analytical result with particular attention to the internal QA data and comparison of the results with previous data from similar samples at the same location.

Any variant result or failure to follow internal QA procedures during sample analysis will trigger an internal audit of the analytical procedures and/or a re-analysis of the sample or its duplicate.

Audits

All analytical data are reviewed by personnel of the Dose Assessment Branch for completeness and consistency. Investigations are conducted to resolve any inconsistencies and corrective actions are taken if necessary. SOP's and QA project plans are revised as needed following review of procedures and methodology. The EMSL-LV QA Officer audits the operations periodically.

SECTION 5

RADIOLOGICAL SAFETY ACTIVITIES

The radiological safety activities of the EMSL-LV are divided into two major areas: special test support and routine environmental surveillance that includes pathways monitoring and internal and external exposure monitoring. Both of these activities are designed to detect any increase in environmental radiation which might cause exposure to individuals or population groups so that protective actions may be taken, to the extent feasible. These activities are described in the following portions of this report.

Special Test Support

Before each nuclear test, monitoring personnel are positioned in the off-site areas most likely to be affected should a release of radioactive material occur. They ascertain the locations of residents, work crews and domestic animal herds and obtain information relative to residents in communities and remote areas. These monitors, equipped with radiation survey instruments, gamma exposure-rate recorders, thermoluminescent dosimeters (TLD's), portable air samplers, and supplies for collecting environmental samples, are prepared to conduct a monitoring program as directed from the NTS Control Point (CP-1) via two-way radio communications.

For those tests which might cause ground motion detectable off site, EPA monitors are stationed at locations where hazardous situations might ensue such as underground mines. At these locations, occupants are notified of potential hazards so they can take precautionary measures.

Professional 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 case accidental releases of radioactivity should occur.

An EG&G cloud sampling and tracking aircraft is always flown over the NTS to obtain samples, assess total cloud volume, 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 radiation monitors.

During CY 1987, EMSL personnel were deployed for all underground tests, none of which released radioactivity which could be detected off site.

PATHWAYS MONITORING

The off-site radiation monitoring program includes a pathways monitoring system consisting of air, water and milk surveillance networks surrounding the NTS and a limited animal sampling project. These are explained in detail below.

AIR SURVEILLANCE NETWORK (ASN)

Network Design

The ASN monitors an important route of human exposure to radionuclides, inhalation of airborne materials. The concentration and the source must both be determined if appropriate corrective actions are to be taken. The ASN is designed to monitor the areas within 350 km of the NTS with some concentration of stations in the prevailing downwind direction (Figure 2). The coverage is constrained to those locations having available electrical power and 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 3).

Methods

During 1987 the ASN consisted of 31 continuously operating sampling stations and 83 standby stations. The air sampler at each station was equipped to collect both particulate radionuclides and reactive gases.

Samples of airborne particulates were collected at each active station on 5-cm diameter glass-fiber filters at a flow rate of about 82 m^3 per day. Filters were changed after sampler operation periods of 2 or 3 days (163 to 245 m^3). Activated charcoal cartridges placed directly behind the filters to collect gaseous radioiodine were changed at the same time as the filters. The standby network was activated for 1 to 2 weeks per quarter at most locations. The standby sam-

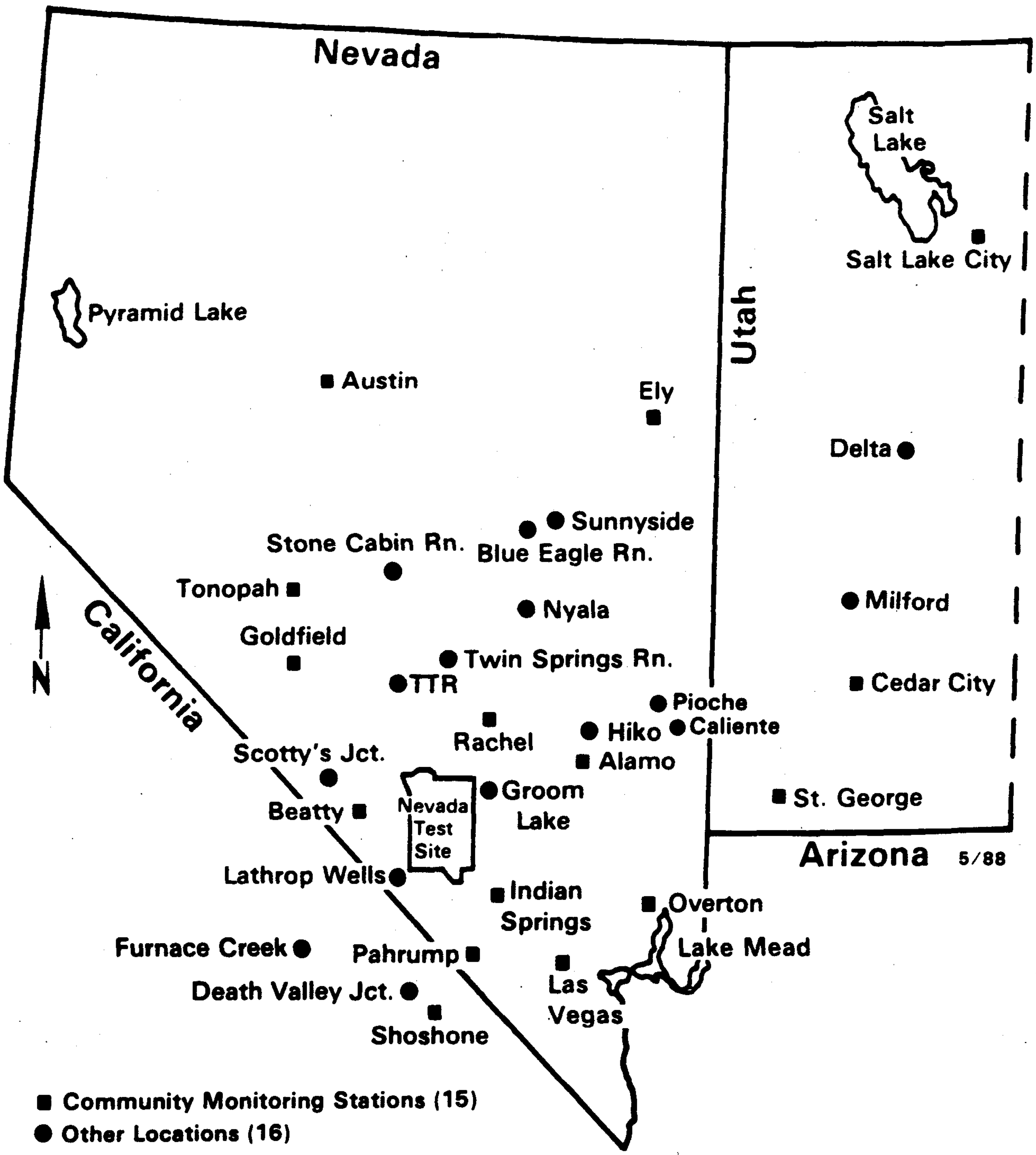


Figure 2. Air Surveillance Network stations (1987).

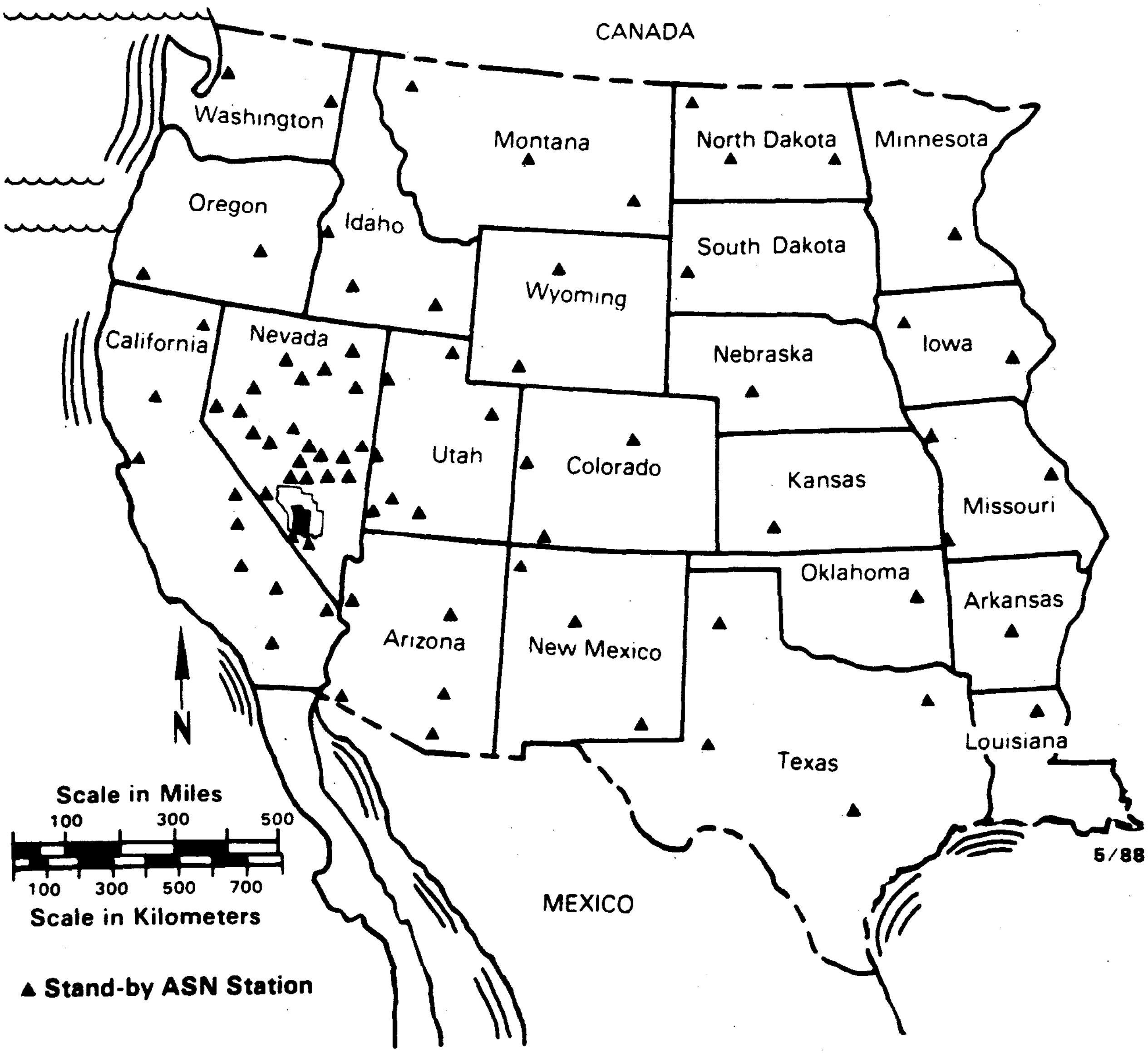


Figure 3. Standby Air Surveillance Network stations (1987).

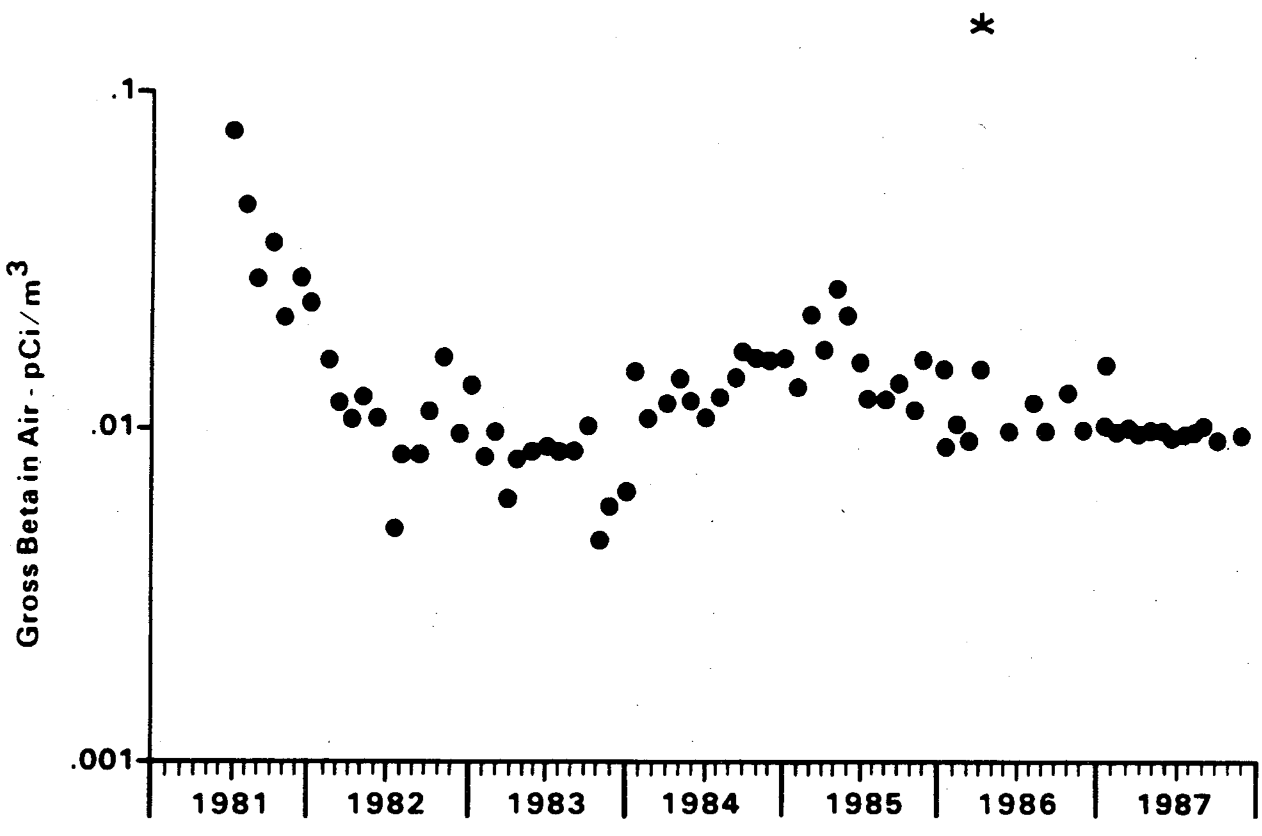
plers are identical to those used in the ASN and are operated by State and municipal health department personnel or by local residents. All air filters and charcoal cartridges were analyzed at the EMSL-LV.

Results

During 1987, no airborne radioactivity related to nuclear testing at the NTS was detected on any sample from the ASN. Throughout the network, beryllium-7 was the only nuclide detected by gamma spectroscopy. The principal means of beryllium-7 production is from spallation of oxygen-16 and nitrogen-14 in the atmosphere by cosmic rays. Appendix Tables E.1 and E.2, summarize the data from the ASN samples. All time-weighted averages (Avg in the tables) are less than 1 percent of the Concentration Guide (Appendix D) for exposure to the general public, however, these guides do not apply to naturally occurring radionuclides.

Two additional analyses are performed on the samples from the ASN: a gross beta analysis of the filters from 5 stations, and plutonium-238 and plutonium-239 analysis of composited filters from 15 states. The results from the plutonium-239 analyses are shown in Appendix Table E.4; plutonium-238 results were all less than the MDC.

The gross beta analysis is used to detect trends in atmospheric radioactivity since this analysis is more sensitive than gamma spectrometry. For this study, three stations north and east of the NTS, and two stations south and west of the NTS are used. The three filters per week from each station are analyzed for gross beta activity after a 7-day delay to decrease the contribution from thoron daughter activity. The data suggest little significant difference among stations and indicate a relatively stable concentration compared to previous years (Figure 4). The maximum concentration measured was 0.053 pCi/m^3, the minimum was <0.001 pCi/m^3, and the arithmetic average was 0.0094 pCi/m^3 (0.35 mBq /m^3). A summary of the data is shown in Appendix Table E.3.



*Elevated concentration attributed to April 1986 accident at Chernobyl, U.S.S.R..

Figure 4. Monthly average gross beta in air samples, 1981-1987.

NOBLE GAS AND TRITIUM SURVEILLANCE NETWORK (NGTSN)

Network design

There are several sources for the radionuclides monitored by this network. Noble gases are emitted from nuclear power plants, propulsion reactors, reprocessing facilities and nuclear explosions. Tritium is emitted from the same sources and is also produced naturally. The monitoring network will be affected by all these sources, but must be able to detect NTS emissions. For this purpose some of the samplers are located close to the NTS and particularly in drainage-wind channels leading from the test areas. In 1987 this network consisted of 17 stations as shown in Figure 5.

Methods

Samples of air are collected by directly compressing air into pressure tanks. The equipment continuously samples air over a 7-day period and stores approximately 1 m^3 of air in the pressure 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 gases. The separate fractions of radioxenon and radiokrypton are dissolved in scintillation cocktails and counted in liquid scintillation counter (see Appendix B).

For tritium sampling, a molecular sieve column is used to collect water from air after it passes through a particulate filter. Up to 10 m^3 of air are passed through the column over a 7-day sampling period. Water adsorbed on the molecular sieve is recovered, and the concentration of tritium in the water (HTO) is determined by liquid scintillation counting (see Appendix B).

Results

The results from the samples collected by the NGTSN are shown in the Appendix (Table E.5) as the maximum, minimum and average concentration for each station. The krypton-85 concentrations ranged from 19 to 34.2 pCi/m^3. A paper presented by Bernhardt et al., (Be73) in a 1973 symposium contained a curve that predicted krypton-85 concentration for the future. This information was used as the basis for an ongoing study of krypton-85 concentrations in air. This actual measurement system began in 1972, so the Bernhardt values for the years 1960, 1965, and 1970 were used to provide a historical reference for the time period preceding the actual measurement of krypton-85 concentrations in air.

Because actual data for the period 1972-1987 have been collected, it is no longer necessary to include the Bernhardt values. These actual data were used to generate a least squares linear regression line. Comparing this equation to the same equation in prior annual reports shows a difference. This is due to the fact that the new equation is based on sixteen consecutive years of actual data (1972-1987) and does not include values given by Bernhardt for 1960, 1965, and 1970.

The concentration over the whole network appeared to have a normal distribution with a mean of 25.5 pCi/m^3 (0.94 Bq/m^3) and a standard deviation of 0.4. The weekly averages plus and minus one standard deviation for the network are shown in Figure 6. This network average concentration, as shown in Table 2 has gradually increased since sampling began in 1972. This increase, observed at all stations, reflects the worldwide increase in ambient concentrations resulting from the increased use of nuclear technology. The increase in ambient krypton-85 concentration was projected by Bernhardt et al., (Be73). However, the measured network average in 1985 is only about 13 percent of the 250 pCi/m^3 (9 Bq/m^3) predicted by Bernhardt. Since nuclear fuel reprocessing is the primary source of krypton-85, the decision of the United States to defer fuel reprocessing may be one reason why krypton-85 levels have not increased as fast as predicted.

Using data from our network (Table 2), the change over time was plotted as shown in Figure 7. Linear regression analysis indicates that the krypton concentration/time relation is pCi/m^3 = 15.49 + 0.66t where t is number of years after 1970. The correlation coefficient, R, is 0.95.

As in the past, tritium concentrations in atmospheric moisture samples from the off-NTS stations were generally below the minimum detectable concentration (MDC) of about 400 pCi/L water (Appendix Table E.5). Negative numbers were statistically derived and are only representative of values which are less than the minimum detectable concentration (MDC). The tritium concentrations observed at off-NTS stations were considered to be representative of environmental background. The mean of the tritium concentrations for all off-site stations was 0.62 pCi/m^3 (23 mBq/m^3) of air. Only six of the 815 collected samples were above the MDC.

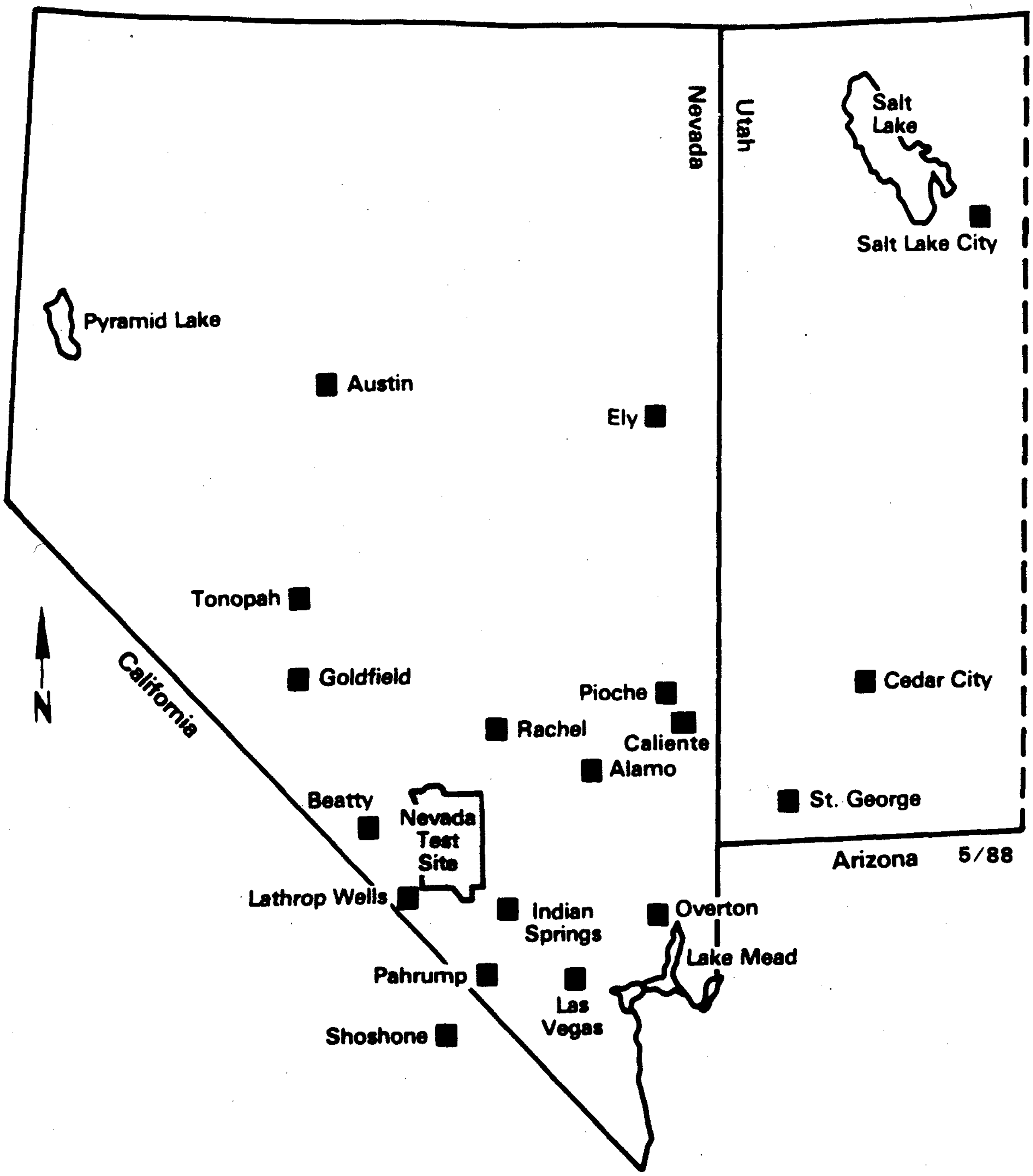


Figure 5. Noble Gas and Tritium Surveillance Network sampling locations.

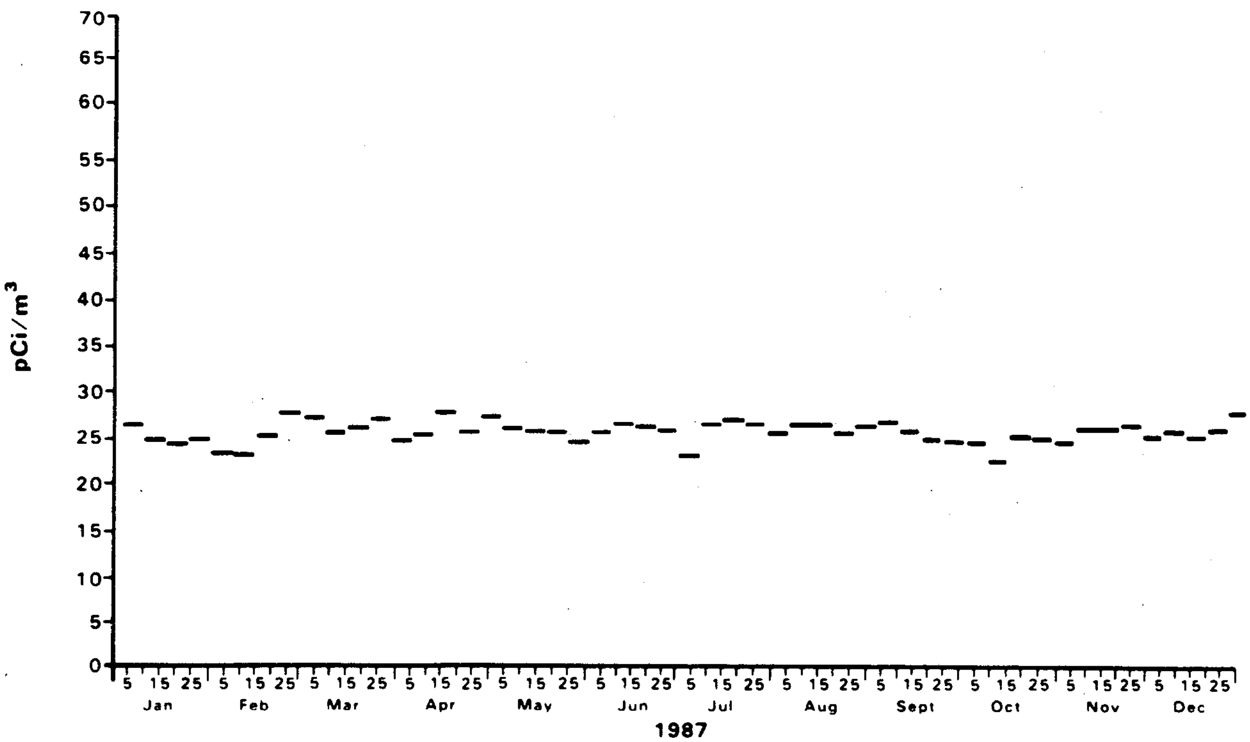


Figure 6. Weekly average krypton-85 concentration in air, 1987 data.

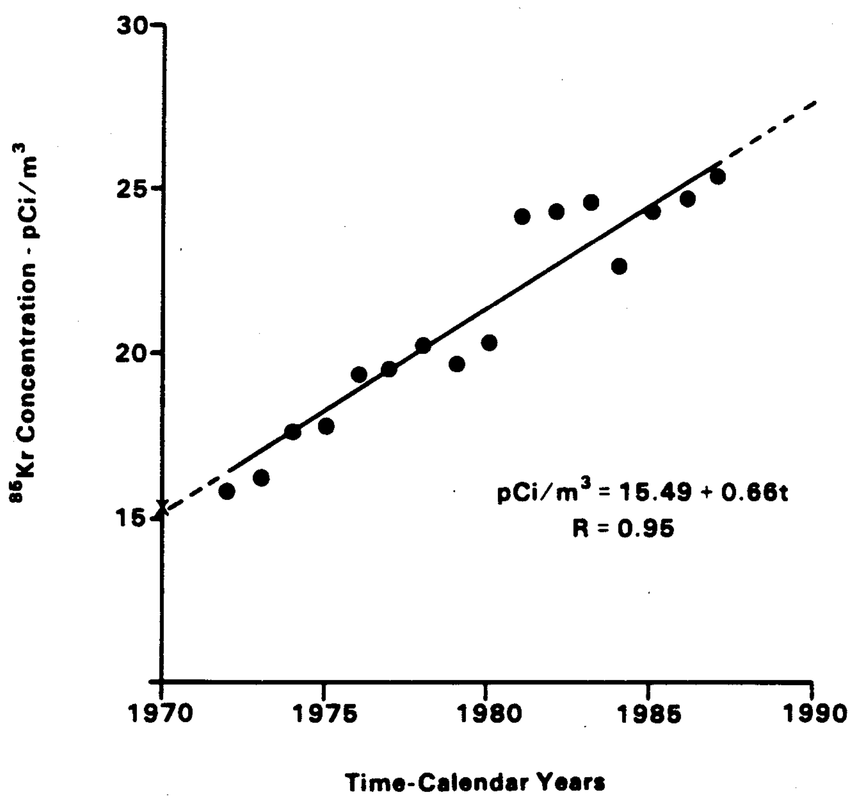


Figure 7. Trend in annual average krypton-85 concentration.

TABLE 2. ANNUAL AVERAGE KRYPTON-85 CONCENTRATIONS IN AIR, 1977-1987

Sampling Locations	Kr-85 Concentrations (pCi/m³)										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Alamo, NV	--	--	--	--	27	24	25	24	24	24	26
Austin, NV	--	--	--	--	--	24	25	23	25	25	25
Beatty, NV	20	20	19	21	24	25	24	23	25	26	26
Diablo and Rachel, NV**	19	20	19	21	24	26	24	22	24	25	25
Ely, NV	--	--	--	--	--	24	25	22	24	26	25
Goldfield, NV	--	--	--	--	--	25	24	24	24	25	25
Hiko, NV*	19	20	19	21	24	26	--	--	--	--	--
Indian Springs, NV	20	20	19	21	24	24	25	22	24	26	26
Mammoth Lakes, CA	--	--	--	--	--	--	--	--	--	--	26
NTS, Mercury, NV*	20	20	19	21	23	--	--	--	--	--	--
NTS, Groom Lake, NV*	19	20	19	21	24	--	--	--	--	--	--
NTS, BJY, NV*	21	22	21	23	26	--	--	--	--	--	--
NTS, Area 12, NV*	19	20	19	21	24	--	--	--	--	--	--
Tonopah, NV	19	20	18	21	25	24	25	23	25	25	26
Las Vegas, NV	20	20	--	--	24	24	24	23	25	25	25
Death Valley Jct., CA*	20	20	19	--	--	--	--	--	--	--	--
NTS, Area 15, NV*	--	--	19	21	25	--	--	--	--	--	--
NTS, Area 400, NV*	--	--	18	21	23	--	--	--	--	--	--
Lathrop Wells, NV	--	--	19	22	24	24	26	22	24	25	25
Pahrump, NV	--	--	--	--	23	24	24	23	25	25	26
Overton, Nev.	--	--	--	--	26	24	25	23	24	25	25
Cedar City, Ut.	--	--	--	--	--	25	24	22	24	24	26
St. George, Ut.	--	--	--	--	--	24	25	23	24	24	25
Salt Lake City, Ut.*	--	--	--	--	--	25	25	25	25	--	--
Shoshone, CA	--	--	--	--	--	25	25	23	24	25	26
NETWORK AVERAGE	20	20	19	21	24	24	25	23	24	25	26

*Stations discontinued
**Station at Diablo was moved to Rachel in March 1979.

LONG-TERM HYDROLOGICAL MONITORING PROGRAM

Tritium and gamma-spectral analysis were done on samples taken from 157 wells, springs, and other sources of water at locations where underground nuclear explosives tests have been conducted. Gamma radioactivity was found in only two sampled locations where cesium-137 had been used in a hydrologic study. The tritium concentrations found during this sampling year were consistent with the levels found in previous years. In only four samples were the tritium concentrations greater than the Drinking Water Standards, and those samples were from wells not accessible to the general public.

Background

Surface- and ground-water sampling and analysis from water sources around the Nevada Test Site (NTS) have been performed for many years. As 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 22 wells on the NTS and the 31 wells in areas around the NTS which are part of this program are shown in Figures 8 and 9 respectively. The locations of the sampling points at other than NTS locations in Nevada, Alaska, Colorado, Mississippi, and New Mexico are shown in Figures E.1 through E.12, in Appendix E.

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, or if the tritium is at detectable concentration, as a duplicate sample. The remaining two samples are collected in 4 L 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. The pH, conductivity, and temperature of the water is measured when the sample is collected.

The tritium and gamma spectrometric analyses are described in the Appendix. For those samples in which the tritium concentration is less than 700 pCi/L (26 Bq/L), an enrichment procedure is performed which reduces the MDC to 10 pCi/L (0.37 Bq/L) from about 300 pCi/L (11 Bq/L). Also, for the first time a water source is sampled, the sample is analyzed for strontium-89 and -90, radium-226, uranium isotopes, and plutonium-238, -239.

For those operations conducted in other states, samples for the LTHMP are collected annually. For the locations on the NTS listed in Table E.6 in Appendix E, 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 a sample for tritium analysis is collected twice per year at about a 6-month interval. During the other 10 months, only a cubitainer of water is collected for analysis by gamma spectrometry. One of the two samples collected for tritium analysis is analyzed by the conventional method, the other by the enrichment method.

Results

The locations at which the water samples were found to contain man-made radioactivity are shown in Table 3 along with the analytical results. For tritium concentrations, only those samples in which the concentration exceeded 0.01 of the Drinking Water Standard (i.e. >200 pCi/L) are shown. The radioactivity in the samples collected from those locations has been reported before.

The results of analysis for all collected samples are shown in Appendix Tables E.6 and E.7 together with the percent of the relevant concentration guide that is listed in Appendix D. There were 11 new sampling locations this year. Only some of the radiochemical results are available at present, as shown in the notes to the tables in the Appendix. None of the samples from the new locations had a detectable concentration of strontium-89 or -90.

Discussion

Although some positive results, that is detectable amounts of man-made radionuclides, are shown for some of the water samples, none of them are expected to result in measurable radiation exposures to residents in the areas where the samples were collected. Specifically, these were as follows:

NTS--Well UE7ns is located on the NTS, a restricted area, and the well is not used as a culinary water source.

Project Gnome--Wells USGS 4 and 8 were used for a hydrological tracer study many years ago so the radionuclides detected were consistent with previous results. These wells are capped and locked to prevent use. Well LRL-7 is expected to show elevated levels of radionuclides as it was used for disposal of contaminated soil and salt. It is also guarded to prevent access.

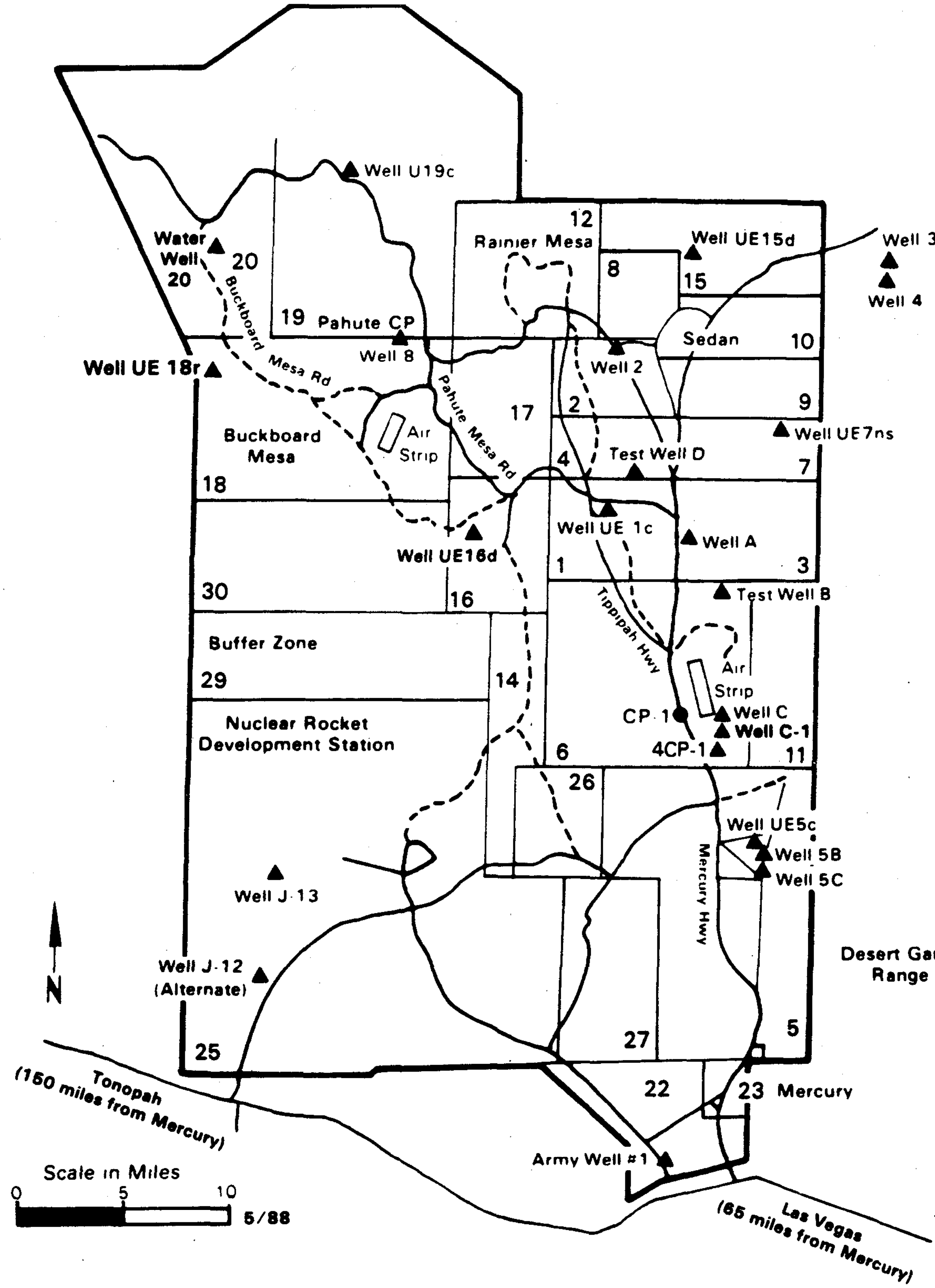


Figure 8. LTHMP sampling locations on the NTS.

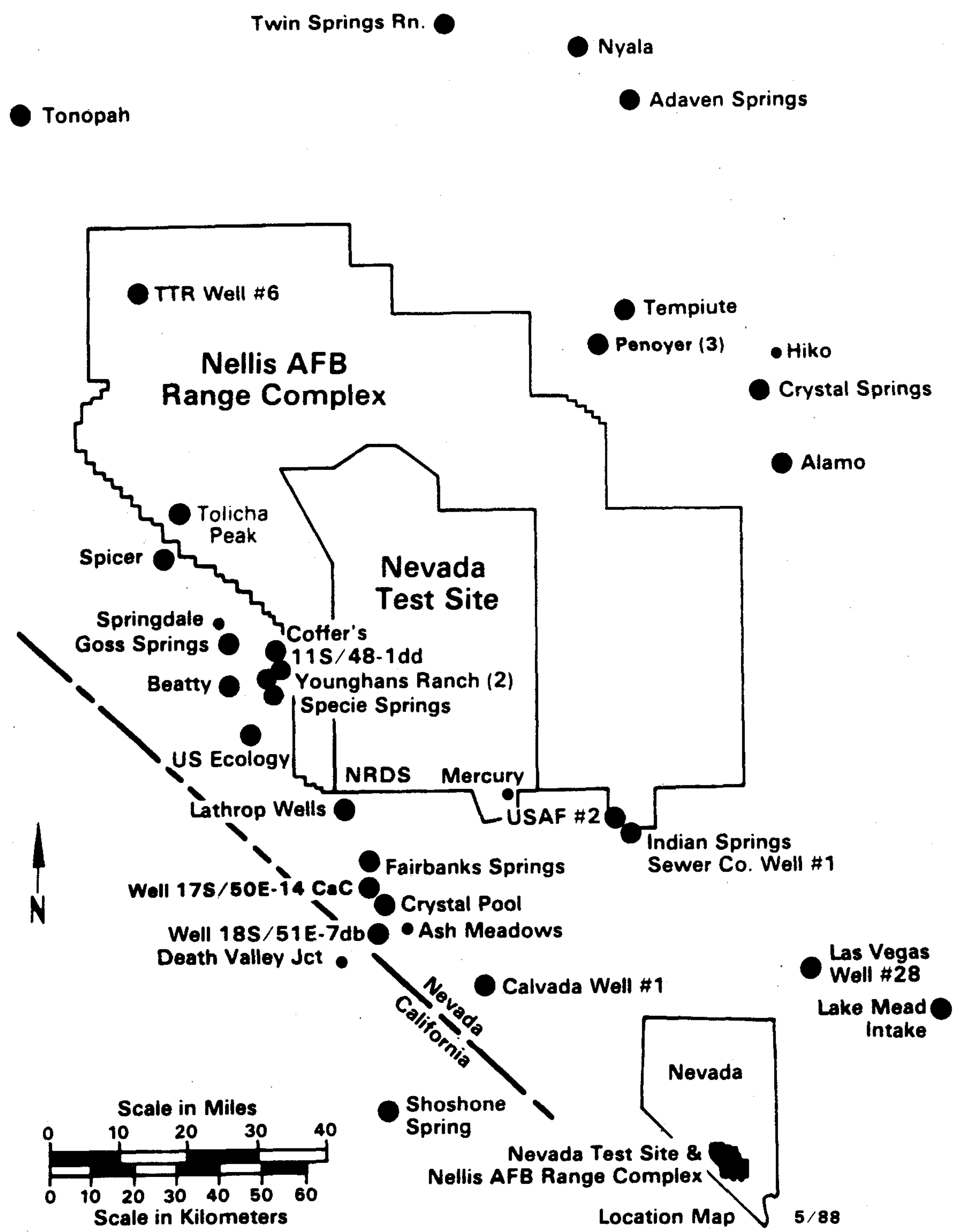


Figure 9. LTHMP sampling locations near the NTS.

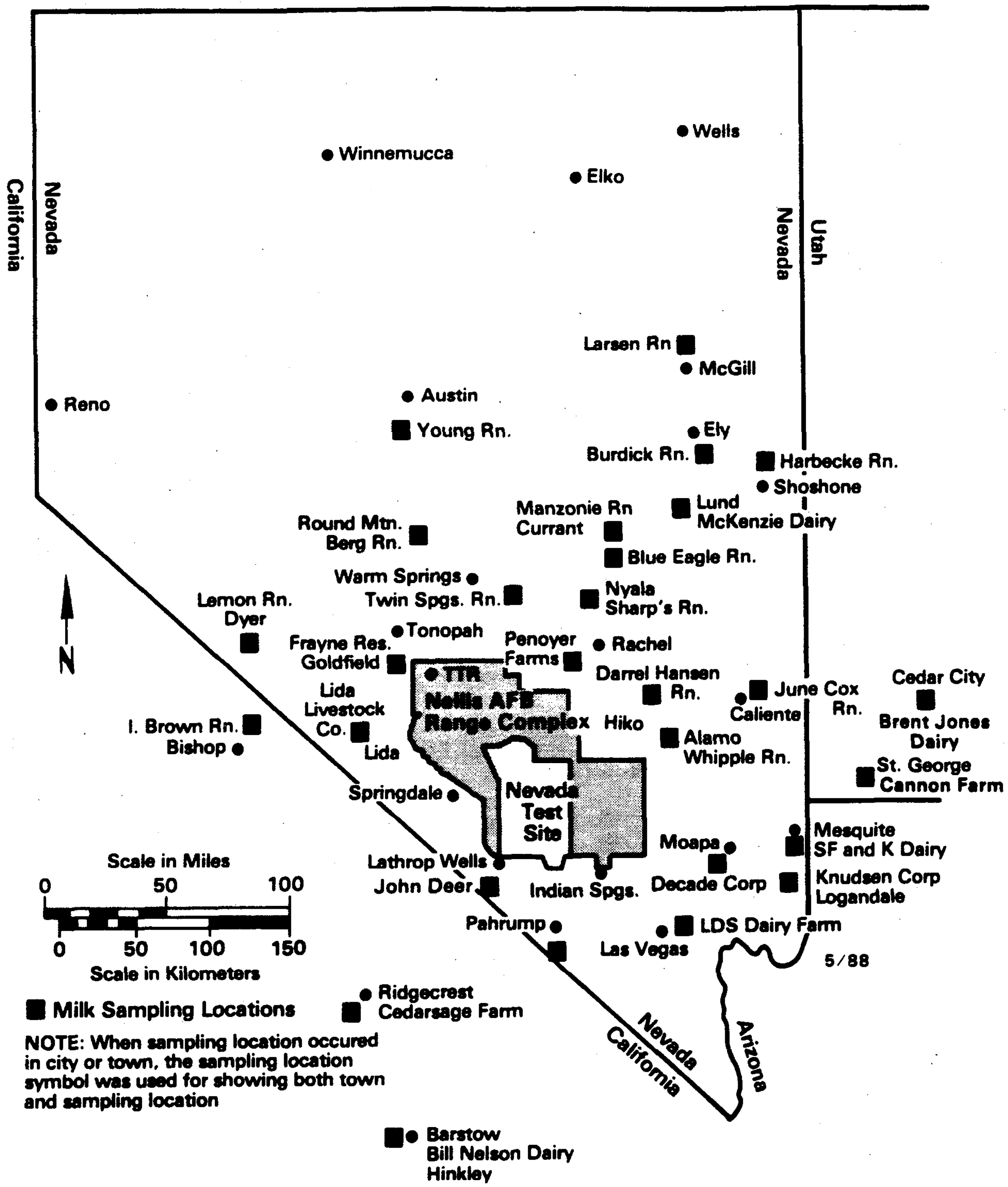


Figure 10. Milk sampling locations within 300 km of the NTS.

TABLE 3. WATER SAMPLING LOCATIONS WHERE SAMPLES CONTAINED MAN-MADE RADIOACTIVITY - 1987

Sampling Location	Type of Radioactivity	Conc. (pCi/L)
NTS, NV		
Well UE7NS	Hydrogen-3	2400-3500
PROJECT GNOME, NM		
USGS Well 4	Hydrogen-3	200,000
USGS Well 8	Hydrogen-3	150,000
	Cesium-137	90
Well LRL-7	Hydrogen-3	16,000
	Cesium-137	200
PROJECT RULISON,		
HAYWARD RANCH	Hydrogen-3	220
PROJECT DRIBBLE, MS		
Well HMH-1 through 11	Hydrogen-3	25-33,000
Well HM-S	Hydrogen-3	11,000
Well HM-L	Hydrogen-3	1,100-1,400
REECo Pit Drainage-B	Hydrogen-3	7,800
REECo Pit Drainage-C	Hydrogen-3	550
PROJECT LONG SHOT, AK		
Stream E of GZ	Hydrogen-3	230
Well GZ, No. 1	Hydrogen-3	2,400
Mud Pit No. 1	Hydrogen-3	250
Mud Pit No. 2	Hydrogen-3	310
Mud Pit No. 3	Hydrogen-3	470

Project Dribble--Wells at this location are on private land, about one mile from the nearest resident and are not sources for drinking water.

Project Alaska--The shallow wells at Project Longshot on Amchitka Island are in an isolated location and are not sources of drinking water.

MILK SURVEILLANCE NETWORK (MSN)

An important pathway for transport of radionuclides to humans is the air-forage-cow-milk chain. This pathway is monitored by EMSL-LV through analysis of milk. The design of the network is based on collections from areas likely to be affected by accidental releases from the NTS as well as from areas unlikely to be so affected. Additional considerations are: 1) a complete ring of stations to cover any NTS release, and 2) samples from major milksheds as well as from family cows. The availability of milk cows or goats sometimes restricts sample collection in certain areas.

Methods

The network consists of two major portions, the MSN at locations within 300 km of the NTS from which samples are collected monthly (Figure 10) and the standby network (SMSN) at locations in all major milksheds west of the Mississippi River (Figure 11)

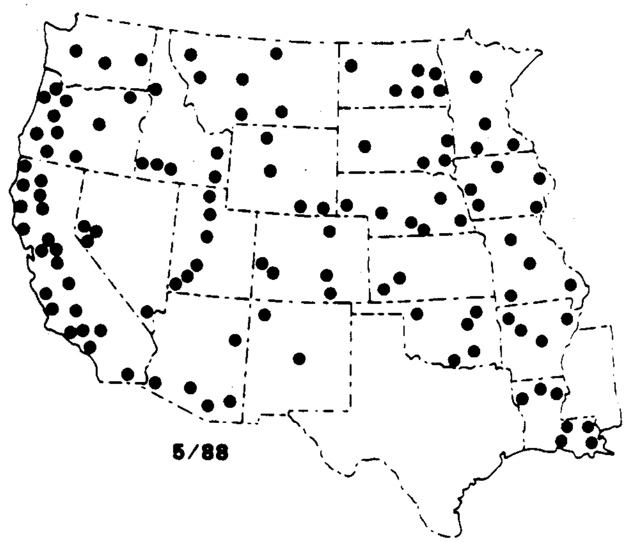


Figure 11. Standby milk surveillance network stations.

from which samples are collected annually. One exception to the latter portion of the network is Texas; the State Health Department performs the surveillance of the milksheds in that State.

The monthly raw milk samples are collected by EPA monitors in 4 L cubitainers and preserved with formaldehyde. The annual milk samples are also collected in cubitainers and preserved with formaldehyde but they are collected by contacting State Food and Drug Administration representatives, after notification of the Regional EPA offices, who arrange for the samples to be mailed to EMSL-LV.

All the milk samples are analyzed first for gamma-emitting nuclides by high-resolution gamma spectrometry and periodically for strontium-89 and strontium-90 by the methods outlined in Appendix B, after a portion of milk is set aside for tritium analysis. Occasionally a milk sample will sour, thus preventing its passage through the ion exchange column and its subsequent strontium analysis; however, the other analyses can generally be performed satisfactorily. For the SMSN, two locations in each State are selected for tritium and strontium analyses.

The analytical results from the 1987 MSN samples are summarized in Appendix Table E.8 where the maximum, minimum, and average concentrations of tritium, strontium-89 and strontium-90 are shown for each sampling location. As shown in Table 4, the average concentrations of tritium and strontium-90 for the whole network are consistent with the network averages for previous years. The results obtained from the standby network are listed in Table E.9. Other than naturally occurring potassium-40, radionuclides were not detected by gamma spectrometry in either the MSN or SMSN samples.

The tritium and strontium-90 concentrations for the whole milk network were plotted versus probits. The tendency of the data to fit one straight line indicates that the data represent a single source, which appears to be atmospheric deposition. These results are consistent with the results obtained for the Pasteurized Milk Network, operated by the Eastern Environmental Radiation Facility in Montogmery, Alabama, shown in Figure 12. The consistently higher results from New Orleans reflect the higher rainfall in that area.

BIOMONITORING PROGRAM

The pathways for transport of radionuclides to man include air, water, and food. Monitoring of air, water, and milk are discussed above. Meat from local animals is a food component that may be a potential route of exposure to off-site residents.

Methods

Samples of muscle, lung, liver, kidney, blood, and bone are collected periodically from cattle purchased from commercial herds

TABLE 4. NETWORK ANNUAL AVERAGE CONCENTRATIONS OF TRITIUM AND STRONTIUM-90 IN MILK, 1975-1987

	Average Concentrations - pCi/L	
Year	H-3	Sr-90
1975	<400	<3
1976	<400	<2
1977	<400	<2
1978	<400	1.2
1979	<400	<3
1980	<400	<2
1981	<400	1.9
1982	<400	1.2
1983	<400	0.8
1984	<400	0.5
1985	<400	0.7
1986	<400	0.6
1987	<400	0.5

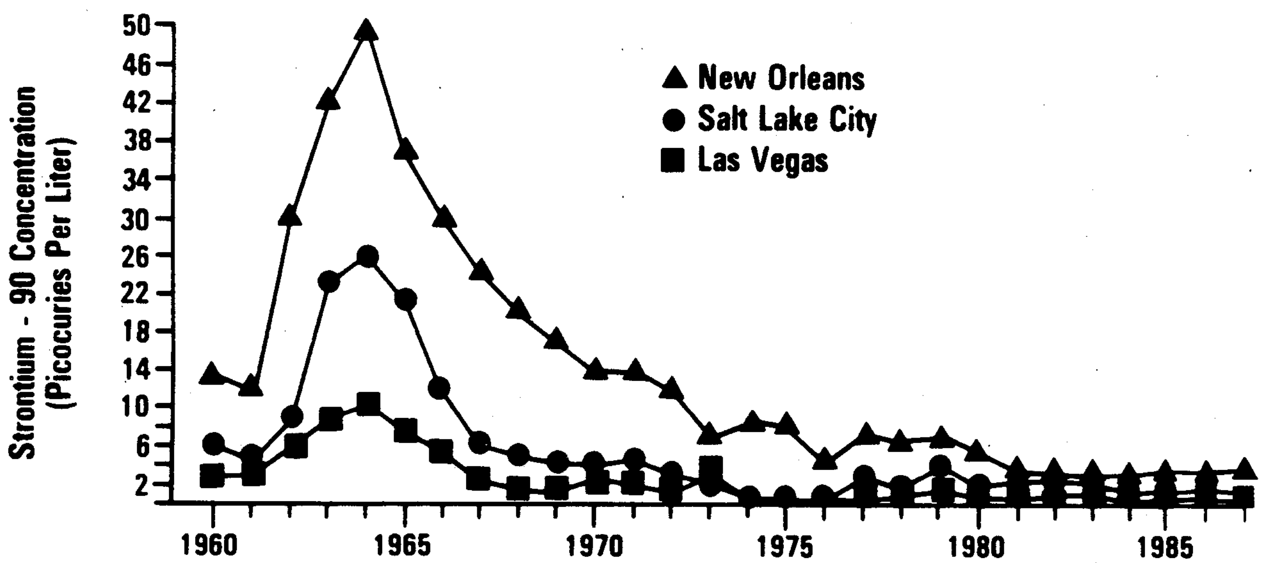


Figure 12. Strontium-90 concentration in Pasteurized Milk Network samples.

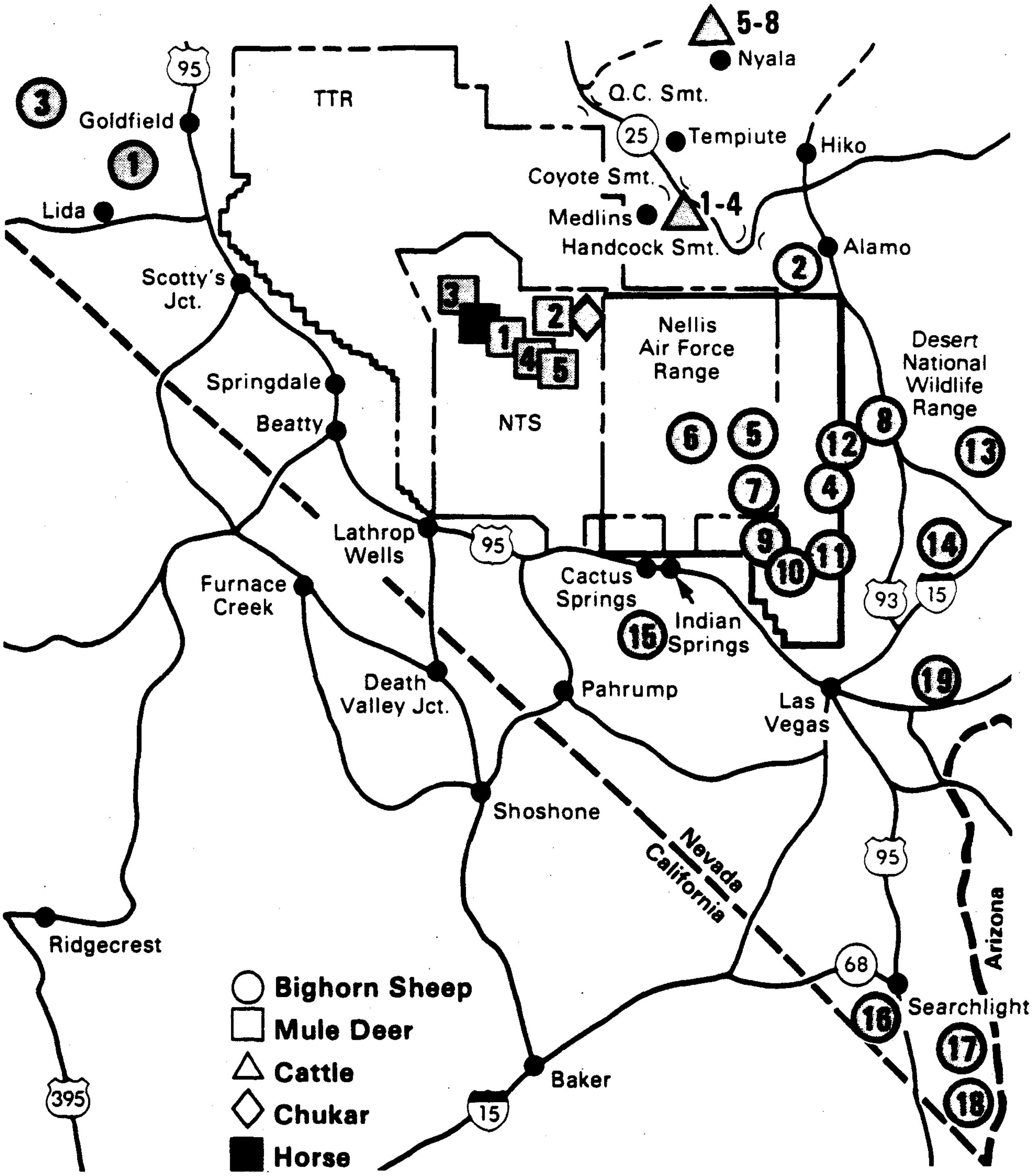


Figure 13. Collection sites for animals sampled, 1987.

that graze areas northeast of the NTS. The soft tissues are analyzed for gamma-emitters. Bone and liver are analyzed for strontium and plutonium and blood/urine or soft tissue is analyzed for tritium. Each November and December, bone and kidney samples from desert bighorn sheep collected throughout southern Nevada (see Figure 13) are donated by licensed hunters and are analyzed. These kinds of samples have been collected and analyzed for up to 30 years to determine long-term trends. During 1987, five NTS mule deer were collected and sampled in the same manner as the cattle.

Results

Analytical data from bones and kidneys collected from desert bighorn sheep during the late Fall of 1986 are presented in Table 5. Tritium was not detected in any of the kidneys. Other than the naturally occurring potassium-40 the only gamma-emitting radionuclide detected was cesium-137 (30 pCi/kg) in the kidneys of two of the sheep. Strontium-90 levels in the bones (average 2.0 pCi/g ash,) are consistent with those reported in recent years (Figure 14).

Counting errors exceeded the reported concentrations of plutonium-238 in all samples of bone ash. Plutonium-239 concentrations in the ash ranged from -0.8 to 18 fCi/g. Only the 18 fCi/g value exceeded the MDC.

Eight beef cattle were sampled during 1987; four from the Sharp Brothers Ranch of Nyala collected in May and four from the Steve Medlin Ranch of Alamo collected in October. Tritium was not detected in any of the blood samples. A muscle sample from one of the Sharp cattle contained 30±10 pCi of Cesium-137 per kilogram. Only naturally occurring gamma-emitters (potassium-40 and beryllium-7) were found in other cattle tissue samples. Strontium-90 in bone ash samples from the Sharp cattle averaged 0.6 pCi per gram of ash. None of the bone or liver samples contained concentrations of plutonium-238 that exceeded the counting error. Plutonium-239 concentrations in the bone ash ranged from 0.0 to 4.2 fCi per gram of ash with a median of 1.9 fCi/g ash and in the liver ash ranged from 6.2 to 13 fCi per gram of ash with a median of 9.4 fCi/g ash. Radiochemical analyses of tissues from the Medlin cattle were not completed at the time of this report.

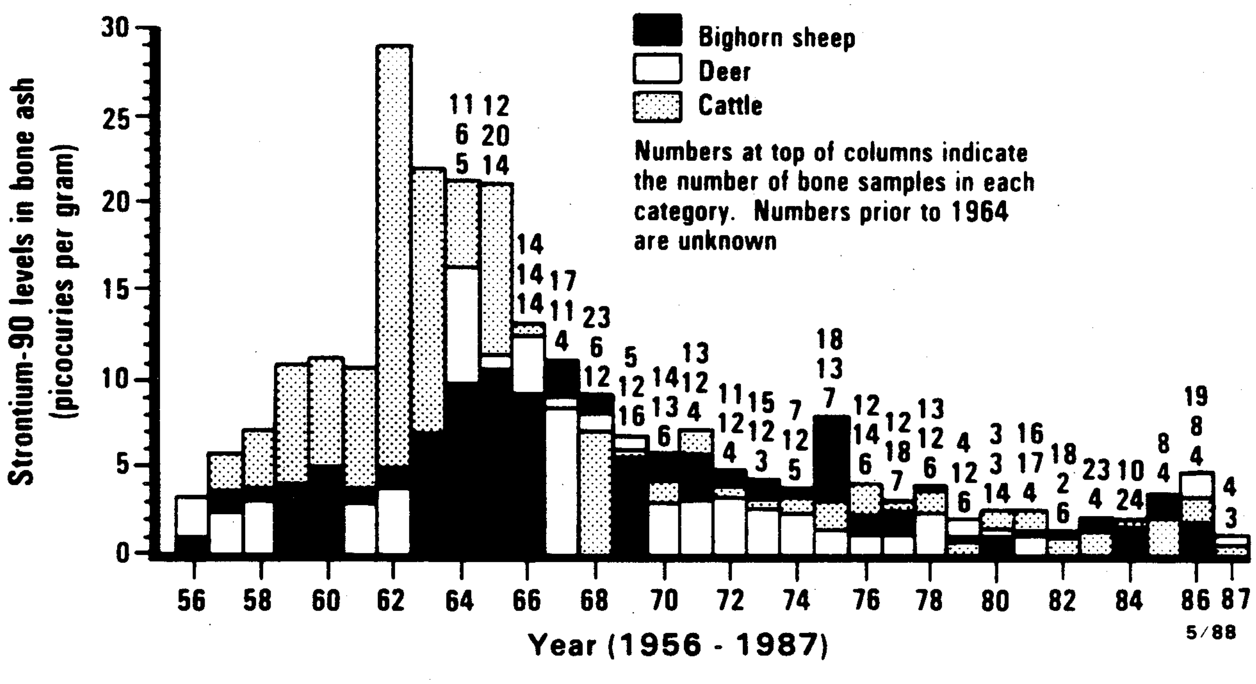


Figure 14. Average strontium-90 concentration in animal bone.

TABLE 5. RADIONUCLIDE CONCENTRATIONS IN DESERT BIGHORN SHEEP SAMPLES - 1986

Bighorn Sheep (Collected Winter 1985)	Bone 90 Sr (pCi/g Ash)	Bone 238 Pu (fCi/g Ash)	Bone 239 Pu (fCi/g Ash)	Kidney K(g/kg)* 3H(pCi/L)†
1	2.1 ± 0.3	1.0 ± 4.0‡	1.0 ± 2.0‡	190 ± 900‡
2	1.8 ± 0.2	0.6 ± 4.0‡	0.8 ± 1.9‡	NS
3	1.6 ± 0.2	-1.3 ± 3.2‡	2.1 ± 2.1‡	-100 ± 900‡ §
4	1.6 ± 0.2	0.8 ± 4.0‡	-0.8 ± 1.3‡	-70 ± 900‡ §
5	2.1 ± 0.3	0.6 ± 4.0‡	0.3 ± 1.7‡	-200 ± 900‡ §
6	1.6 ± 0.2	0 ± 8.0‡	18 ± 5	-90 ± 900‡ §
7	1.2 ± 1.0	-0.6 ± 4.0‡	1.2 ± 1.9‡	30 ± 15 230 ± 900‡
8	2.1 ± 0.3	-2.6 ± 2.6‡	0.7 ± 1.3‡	190 ± 900‡ §
9	1.4 ± 0.3	-0.9 ± 3.0‡	2.6 ± 2.0‡	110 ± 900‡ §
10	1.4 ± 0.2	-1.0 ± 1.7‡	-0.6 ± 0.9‡	30 ± 20 550 ± 900‡
11	1.3 ± 0.2	-1.7 ± 2.8‡	-0.2 ± 1.1‡	380 ± 900‡ §
12	1.6 ± 0.2	0.5 ± 3.0‡	0.9 ± 1.4‡	NS
13	2.2 ± 0.3	1.0 ± 3.3‡	-0.5 ± 1.0‡	-240 ± 900‡ §
14	1.6 ± 0.2	-0.8 ± 1.4‡	0.2 ± 0.9‡	90 ± 900‡ §
15	1.0 ± 0.1	-1.7 ± 2.7‡	1.3 ± 1.5‡	360 ± 940‡ §
16	0.6 ± 0.1	2.5 ± 3.6‡	0.5 ± 1.0‡	140 ± 940‡
17	0.7 ± 0.1	-0.7 ± 3.0‡	0.5 ± 1.3‡	-400 ± 940‡ §
18	0.9 ± 0.1	-0.5 ± 3.2‡	0.5 ± 0.7‡	140 ± 940‡ §
19	0.6 ± 0.1	1.9 ± 3.2‡	-0.2 ± 0.9‡	260 ± 940‡ §
Median	1.6	-0.5	0.5	30 110
Range	0.6 ± 12	-2.6 - 2.5	-0.8 - 18	30 - 30 -400 - 550

* Wet weight
† Aqueous portion of Kidney Tissue
‡ Counting error exceeds reported activity, error term is the MDC.
NS = Not sampled
§ Gamma spectrum negligible

During 1987, wildlife that drank from the waters draining from the tunnel complexes in area 12 of the Nevada Test Site were sampled on a limited basis. Animals sampled included five deer, two chukar and one horse.

Analytical data from the five deer are presented in Table 6. All of the deer except number 3 were collected in the vicinity of the tunnels and the fact that the tritium levels in the four animals ranged from .006 to 41 μCi/L (The highest level was in deer number 4) indicate that they had used the tunnel waters as a water source. Tissues from deer number 3 and its fetus (collected in Echo Peak area of Area 19) did not contain detectable levels of tritium or gamma-emitters other than naturally occurring potasium-40. A wide variety of gamma-emitting radionuclides were found in the rumen contents of deer number 4 (collected while drinking at the T-tunnel ponds). Detectable levels of cesium-137 were also found in the tissues of deer number 4.

The contract laboratory had not completed radiochemical analyses of tissue from deer 4 and 5 in time for this report. Strontium-90 values in the bone ash of the first three animals ranged from 0.5 to 0.7 pCi per gram. None of the tissues contained concentrations of plutonium-238 that exceeded the counting error. None of the bone ash samples contained plutonium-239 concentrations that exceeded the counting errors. Concentrations of plutonium-239 in soft tissues (see Table 6) ranged from 2.8 fCi/g ash in deer number 1 muscle to 26 fCi/g ash in deer number 3 muscle.

The composited internal organs and muscle from the two chukars collected at the T-tunnel ponds (see Table 7) contained a wide variety of gamma-emitting radionuclides. Muscle from a horse in Area 17 did not contain detectable concentrations of gamma-emitting radionuclides other than potassium-40. Tritium concentrations did not exceed the counting error. Radiochemical analyses are still in process.

The tritium and cesium-137 levels found in tissues from wildlife collected in the tunnel areas indicate that the drainage waters are a potential source of exposure to the off-site population which may consume meat from mule deer or migratory fowl. The potential exists that deer may drink from the drainage water as long as the area is unfenced. In the unlikely event that a certain mule deer had been collected by a hunter rather than EPA personnel, that hunter could have received a dose equivalent of 29 mrem (0.29 mSV) if he ate all the meat from the deer.

EXTERNAL EXPOSURE MONITORING

Contributors to "normal background" radiation exposure include medical and dental radiation, naturally occurring radioactivity in soil and building materials, cosmic radiation and radioactive material naturally occurring in our bodies. Many studies indicate that the total background radiation exposure from all sources in the United States ranges from approximately 150 to 300 millirem (mrem) or more per year.

THERMOLUMINESCENT DOSIMETRY NETWORK

The primary method of measuring external radiation exposures is the thermoluminescent dosimeter (TLD). Prior to 1987, a TLD system manufactured by Harshaw was used. In 1987 this system was replaced with a TLD dosimetry system developed by Matsushita Electronics (Panasonic). The current system provides much greater sensitivity and precision than was possible using previous TLD systems or film. This system has an added advantage of tissue-equivalence, which facilitates correlation of measured exposures with the absorbed biological dose equivalent an individual would have received were he continually present at the monitoring locations.

Network Design

The TLD network is designed to measure environmental radiation exposures at a location rather than exposures to a specific individual. This method is generally preferred because of the multiple uncontrollable variables associated with personnel monitoring. Measuring environmental radiation exposures in fixed locations provides a reproducible index which can then be correlated to the maximum exposure an individual would have received were he continually present at that location. In addition to the fixed locations, several individuals residing within and outside estimated fallout zones from past nuclear tests at the NTS have been monitored. These individuals are monitored in part to confirm the validity of correlations between fixed-site environmental radiation measurements and projected exposures to individuals.

A network of environmental stations and monitored personnel has been established in locations encircling the NTS. Monitoring locations are somewhat concentrated in areas corresponding to estimated fallout zones

TABLE 6. RADIONUCLIDE CONCENTRATION IN TISSUES FROM MULE DEER COLLECTED ON THE NEVADA TEST SITE - 1987

Tissue	124-Sb (pCi/g)	125-Sb (pCi/g)	103-Ru (pCi/g)	137-Cs (pCi/g)	106-Ru (pCi/g)	H_3 (µCi/L)	239 Pu fCi/g/ash	238 Pu fCi/g/ash	90 Sr pCi/g/ash
Mule Deer No. 1 Collected 01/21/87									
Thyroid	Gamma Spectrum Negligible								
Kidney	ND	ND	ND	ND	ND	NA	NA	NA	
Liver	ND	ND	ND	ND	ND	NA	4.2±2.8	ND	
Lung	ND	ND	ND	ND	ND	NA	17±17	ND	
Muscle	ND	ND	ND	ND	ND	NA	2.8±2.1	ND	
Blood	NA	NA	NA	NA	NA	0.0065±0.0007	NA	NA	NA
Rumen Contents	ND	ND	ND	ND	ND	NA	29±4	7.8±4.4	NA
Bone	NA	NA	NA	NA	NA	ND	ND	ND	0.7±0.1
Mule Deer No. 2 Road Kill 02/05/87									
Muscle	Gamma Spectrum Negligible					0.0069±0.0005	26±7	ND	NA
Bone	NA	NA	NA	NA	NA	NA	ND	ND	0.5±0.1
Mule Deer No. 3 Collected 05/21/87									
Thyroid	ND	ND	ND	ND	ND	NA	NA	NA	NA
Kidney	ND	ND	ND	ND	ND	NA	NA	NA	NA
Liver	ND	ND	ND	ND	ND	NA	ND	ND	NA
Lung	ND	ND	ND	ND	ND	NA	14±5	ND	NA
Muscle	ND	ND	ND	ND	ND	NA	4.4±3.1	ND	NA
Blood	NA	NA	NA	NA	NA	ND	NA	NA	NA
Rumen Contents	ND	ND	ND	ND	ND	NA	150±40	240±100	NA
Bone	NA	NA	NA	NA	NA	NA	ND	ND	0.7±0.1
Mule Deer No. 4 Collected 07/28/87									
Thyroid	ND	ND	ND	ND	ND	NA	NA	NA	NA
Kidney	ND	ND	ND	0.27±0.04	ND	NA	NA	NA	NA
Muscle	ND	ND	ND	0.09±0.02	ND	NA	IA	IA	NA
Liver	ND	ND	ND	0.09±0.02	ND	NA	IA	IA	NA
Lung	ND	ND	ND	0.12±0.03	ND	NA	IA	IA	NA
Rumen Contents	0.87±0.1	1.5±0.2	0.7±0.4	0.83±0.04	50±0.1	NA	IA	IA	NA
Blood	NA	NA	NA	NA	NA	41.4±0.08	NA	NA	NA
Bone	NA	NA	NA	NA	NA	NA	IA	IA	IA
Mule Deer No. 5 Collected 11/02/87									
Thyroid	Gamma Spectrum Negligible								
Kidney	ND	ND	ND	ND	ND	NA	NA	NA	NA
Muscle	ND	ND	ND	ND	ND	NA	IA	IA	NA
Liver	ND	ND	ND	ND	ND	NA	IA	IA	NA
Lung	ND	ND	ND	ND	ND	NA	IA	IA	NA
Rumen Contents	ND	ND	ND	ND	ND	NA	IA	IA	NA
Blood	NA	NA	NA	NA	NA	0.23±0.002	NA	NA	NA
Bone	NA	NA	NA	NA	NA	NA	IA	IA	IA

ND = Not Detected; NA = Not Analyzed; IA = In Analysis

TABLE 7. RADIONUCLIDE CONCENTRATIONS IN TISSUES COLLECTED FROM NTS CHUKARS

Radionuclide	Internal Organs	Muscle
Co-60 (pCi/Kg)	170±50	
Ru-106 (pCi/Kg)	42,900±940	500±250
Sb-125 (pCi/Kg)	16,000±240	
Cs-137 (pCi/Kg)	460±11	140±40

(Figure 15). This arrangement permits both an estimate of average background exposures and prompt detection of any increase due to NTS activities.

The Panasonic TLD monitoring system utilizes two distinct types of dosimeters, one for personnel, the other for environmental (i.e. stations) monitoring.

Monitoring of EMSL and off-site personnel is accomplished with the Panasonic UD-802 dosimeter. This device contains two elements of $Li_2B_4O_7$:Cu and two of $CaSO_4$:Tm phosphors.

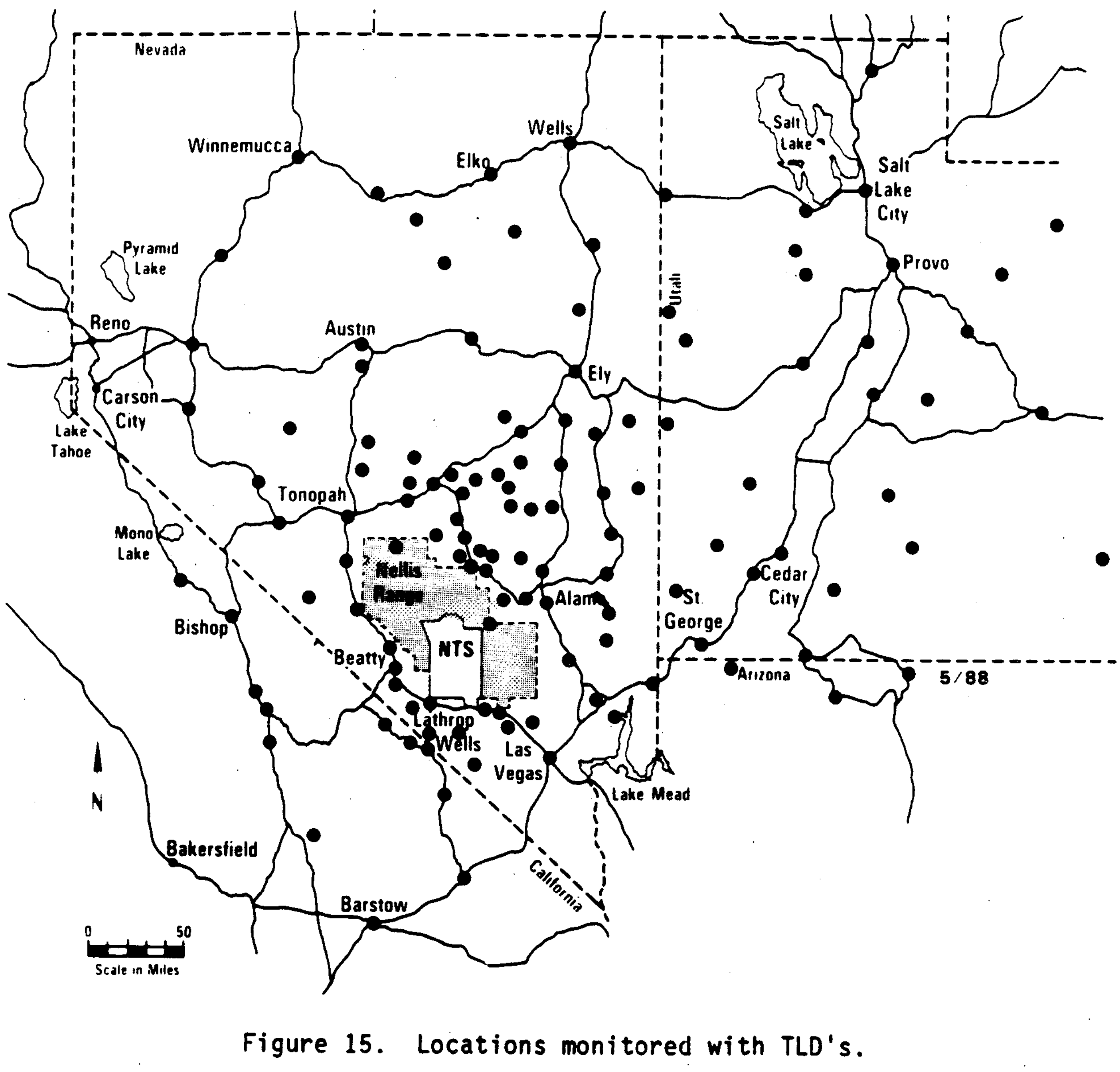


Figure 15. Locations monitored with TLD's.

TABLE 8. ANNUAL OFF-SITE PERSONNEL DOSE 1987 TLD RESULTS

Resident Number	Background Station Location	Net Exposure* (mrem)	Resident Number	Background Station Location	Net Exposure* (mrem)
2	Caliente, NV	7.9	54	Rachel, NV	2.3
3	Blue Jay, NV	0.0	55	Rachel, NV	0.0
6	Indian Springs, NV	6.4	56	Corn Creek, NV	8.0
7	Goldfield, NV	0.0	57	Overton, NV	8.2
8	Twin Springs Ranch, NV	0.0	60	Shoshone, CA	0.0
9	Blue Eagle Ranch, NV	2.5	223	Corn Creek, NV	0.0
10	Complex 1, NV	0.0	232	Hiko, NV	8.9
11	Complex 1, NV	0.0	233	Ely, NV	3.3
13	Koyen's Ranch, NV	3.6	248	Penoyer Farms, NV	0.0
14	Medlin's Ranch, NV	0.0	249	Austin, NV	0.0
15	Medlin's Ranch, NV	0.0	264	Rachel, NV	2.2
18	Nyala, NV	2.5	280	Alamo, NV	10.0
19	Goldfield, NV	0.0	292	Death Valley Junction, CA	11.1
21	Beatty, NV	3.4	293	Pioche, NV	0.0
22	Alamo, NV	3.1	295	Currant, NV	0.0
25	Corn Creek, NV	0.0	297	Las Vegas (USDI), NV	0.0
29	Stone Cabin Ranch, NV	0.0	299	Round Mountain, NV	0.0
33	Lathrop Wells, NV	0.0	300	Koyen's Ranch, NV	0.0
34	Furnace Creek, CA	17.6	301	Crystal, NV	3.0
36	Pahrump, NV	4.5	302	Gabbs, NV	0.0
37	Indian Springs, NV	6.8	303	Tonopah, NV	0.0
38	Beatty, NV	9.1	304	Death Valley Junction, CA	0.0
40	Goldfield, NV	0.0	305	Gabbs, NV	6.1
42	Tonopah, NV	0.0	307	Mina, NV	0.0
44	Cedar City, UT	5.1	326	Las Vegas (USDI), NV	0.0
45	St. George, Ut	4.9	327	Tonopah, NV	0.0
47	Ely, NV	0.0	329	Austin, NV	0.0
49	Las Vegas (UNLV), NV	16.7	331	Death Valley Junction, CA	0.0
52	Salt Lake City, UT	8.4	332	Lathrop Wells, NV	0.0

*None of the reported exposures apparently greater than zero represent a statistically significant increase above background.

The four elements are behind 14, 300, 300, and 1000 mg/cm[2] filtration, respectively. Three of the filters are plastic and one is plastic and lead. This filter arrangement and combination of very thin phosphors facilitates characterization of radiation incident to the dosimeter by energy and type. In addition, because $Li_2B_4O_7$:Cu is tissue equivalent, a properly calibrated UD-802 dosimeter makes possible a direct correlation between an individual's radiation exposure and the absorbed dose equivalent.

Monitoring of EMSL and off-site stations is accomplished with the Panasonic UD-814 dosimeter. This device contains one element of $Li_2B_4O_7$:Cu and three replicate $CaSO_4$:Tm phosphors. One element has a filter of 14 mg/cm[2] of plastic. The other three are filtered by 1000 mg/cm[2] of plastic and lead. The UD-814 dosimeter is designed primarily to monitor ambient radiation exposure levels at a fixed station. Therefore, three replicate $CaSO_4$:Tm phosphors are used to provide excellent statistics and extended response range. Limited energy discrimination and radiation type characterization is possible with this dosimeter. Element number 1 does make possible some discrimination of beta or low energy photon radiation in the presence of high energy photon (gamma) fields. Unlike the UD-802 personnel dosimeter, exposures measured with the UD-814 are normally not converted into an absorbed dose equivalent.

RESULTS OF TLD MONITORING

Off-Site Personnel

During 1987 a total of 58 individuals living in areas surrounding the Nevada Test Site were provided with personnel TLD dosimeters. As noted, these dosimeters serve both to monitor the absorbed dose equivalent received by a specific individual in the course of day-to-day activities and to confirm that the off-site station (environmental) TLDs are providing a valid estimate of the radiation exposure an individual would receive if continually present at the specified station location.

Off-site personnel exposures are corrected to account for known natural background radiation levels at the off-site environmental monitoring station closest to each individual's residence. As shown in Table 8 each individual's net annual exposure above background is calculated. Following prior convention, energy and type of radiation is not reported. All exposures are in effect presumed to be due to gamma and hence numerically equivalent to absorbed dose.

The mean net dose to monitored off-site personnel for 1987 was 3.6 millirem (mrem). Reported values ranged from zero to 16.7 mrem. All reported net exposures were within the range of average exposures received attributable to natural background radiation.

Off-Site Stations

A total of 132 off-site stations were monitored during all or part of 1987. The environmental radiation levels at these stations was measured using Panasonic UD-814 dosimeters. The following table summarizes the results obtained from these TLDs.

The annual reported adjusted dose equivalent (mrem/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. When an annual exposure is calculated from measured daily rates corrected for actual exposure time, there is excellent correlation with the nominal 365-day exposure rate reported in Table E.10 of Appendix E.

Comparison with Direct Exposure Measurements

When calculated TLD exposures are compared with results obtained from the Pressurized Ionization Chamber network a 21% difference is found. This difference is attributed primarily to the energy response of the two systems. PIC's have greater sensitivity to lower energy gamma radiation; therefore, PIC's normally record higher apparent exposure rates than do TLD's.

Table 9 shows that the average annual dose rate for the Dosimetry Network is consistent with the Network average established in 1975. Annual doses decreased from 1971 to 1975 with a leveling trend since 1975, except for a high bias in the 1977 results attributed to mechanical readout problems. The trend shown by the Network average is indicative of the trend exhibited by individual stations, although this average is also affected by the mix of stations at different altitudes (note Figure 16).

Because of the great range in the results, 41 to 166 mrem, an average for the whole area monitored may be inappropriate for estimating individual exposure. This would be particularly true if the exposure of a particular resident were desired. Since environmental radiation exposure can vary markedly with both altitude and the natural

TABLE 9. DOSIMETRY NETWORK SUMMARY FOR THE YEARS 1971 - 1987

Environmental Radiation Dose Rate (mrem/y)			
Year	Maximum	Minimum	Average
1971	250	102	160
1972	200	84	144
1973	180	80	123
1974	160	62	114
1975	140	51	94
1976	140	51	94
1977	170	60	101
1978	150	50	95
1979	140	49	92
1980	140	51	90
1981	142	40	90
1982	139	42	88
1983	140	42	87
1984	133	35	85
1985	142	40	85
1986	135	40	85
1987	166	41	89

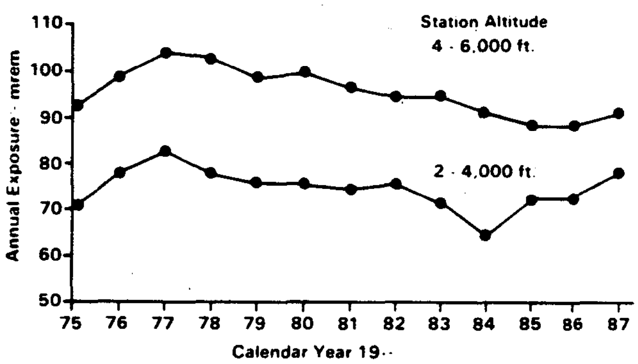


Figure 16. Average annual TLD exposure as a function of station altitude.

radioactivity in the soil, and since the altitude of the TLD station location is relatively easy to obtain, the measured dose rates for 1975 to 1987 were plotted as a function of altitude. As most of Nevada lies between 2,000 and 6,000 feet above mean sea level, this range was split into two sections for plotting purposes. The results, shown in Figure 16, indicate that the average exposure at altitudes between 4,000 and 6,000 feet is about 17 mrem/yr (0.17 mSv/yr) higher than that at altitudes between 2,000 and 4,000 feet, although both curves follow the same trend as the overall averages listed in Table 7. Thus, if an individual does not live near a monitored location, an estimate of exposure could be based on the altitude of his residence rather than on the average for the whole area monitored.

PRESSURIZED ION CHAMBER (PIC) NETWORK

These gamma-ray ratemeters are located at the 15 Community Monitoring Stations identified on Figure 2 plus stations at Caliente Complex I, Furnace Creek, Lathrop Wells, Mammoth Lake, Medlin's Ranch, Nyala, Pioche, Stone Cabin Ranch, Tikaboo Valley, Twin Springs, and Uhaldes' Ranch. The output of each PIC is displayed on both a paper tape and a digital readout, so the station manager can observe the response. The data is also stored on cassette tapes, which are read into a computer at EMSL-LV each week. The computer output consists of tables containing hourly, daily, and weekly summaries of the maximum, minimum, average, and standard deviation of the gamma exposure rate.

The data for 1987 are displayed in Table 10 as the average μR/hr and annual mrem from each station. When these data are compared to the TLD results for the same 23 stations, it is found that the PIC exposure is about 21% higher than the TLD exposure. This is attributed primarily to the differences in energy response of the two systems. PIC's have greater sensitivity to lower energy gamma radiation; therefore, PIC's normally record higher apparent exposure rates than do TLD's.

TABLE 10. PRESSURIZED ION CHAMBER READINGS - 1987

Station Location	No. of Hourly Values	Exposure Rate, μR/H* Max	Min	Avg ± 1 Sd	mrem/Yr
Alamo, NV	7914	18.1	11.1	13.2 ± 0.17	116
Austin, NV	6804	26.3	14.7	19.6 ± 0.89	172
Beatty, NV	7275	20.7	11.0	17.0 ± 0.20	149
Caliente, NV	1126	19.8	13.4	14.7 ± 0.25	129
Cedar City, UT	8730	21.6	7.7	10.7 ± 0.27	94
Complex 1, NV	7586	26.5	12.2	16.2 ± 0.30	142
Ely, NV	8117	17.5	10.0	12.5 ± 0.21	110
Furnace Creek, CA	6487	14.3	5.0	9.4 ± 1.41	82
Goldfield, NV	8055	24.1	7.7	16.1 ± 1.18	141
Indian Springs, NV	7788	15.7	5.9	9.2 ± 0.15	80
Las Vegas, NV (UNLV)	6920	9.7	5.0	6.4 ± 0.20	56
Lathrop Wells, NV	7970	18.5	10.0	14.2 ± 0.13	124
Mammoth Lake, CA	3964	22.0	10.0	17.7 ± 0.21	155
Medlins Ranch, NV	7572	24.1	11.1	16.0 ± 0.18	140
Nyala, NV	5542	18.7	9.0	13.0 ± 0.29	114
Overton, NV	7787	16.3	7.3	9.4 ± 0.29	82
Pahrump, NV	6876	16.4	4.6	7.8 ± 0.17	68
Pioche, NV	7975	18.8	10.0	12.9 ± 0.24	116
Rachel, NV	6375	23.4	10.1	17.1 ± 0.25	150
Salt Lake City, UT	6901	19.9	7.4	10.1 ± 1.21	88
Shoshone, CA	6783	23.0	11.0	11.8 ± 0.29	103
St. George, UT	8064	18.8	5.5	9.0 ± 0.27	79
Stone Cabin Ranch, NV	5990	21.3	15.9	17.5 ± 0.43	153
Tonopah, NV	7802	21.9	12.2	17.2 ± 0.32	151
Twin Sprgs Ranch, NV	6771	20.7	11.1	16.8 ± 0.33	147
Uhaldes Ranch, NV	6256	22.4	8.5	17.3 ± 0.32	152

*The MAX and MIN values are obtained from the instantaneous readings.

INTERNAL DOSIMETRY

Internal exposure was monitored in 230 individuals from the off-site areas around the Nevada Test Site, the EMSL-LV Laboratory, EG&G facilities throughout the U.S. and members of the general public concerned about possible radiation exposure. No significant gamma radiation was detected in whole body counts although trace amounts of fission products, attributable to the Chernobyl-4 accident in the U.S.S.R., were found in individuals returning from extended stays in Europe. No low energy gamma-emitting radionuclides with energies ranging from 10 to 300 KeV were detected in lung counts. Nearly all bioassy determinations for tritium showed concentrations in the range of background levels measured in water, and reflected only natural exposure.

Internal Exposure Monitoring

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 such body-burdens: whole-body counting and urinalysis.

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 two shielded examination vaults, in one vault a single intrinsic coaxial detector positioned over an adjustable chair allows detection of gamma radiation with energies ranging from 60 KeV to 2.5 MeV in the whole body. The other vault contains an adjustable chair with two detectors mounted above the chest area, two intrinsic planar detectors were used until the latter part of the year when they were replaced by two intrinsic semi-planar detectors.

Network Design

This activity consists of two portions, an Off-Site Human Surveillance Program and a Radiological Safety Program. The design for the Off-Site Human Surveillance Program is 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 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.

Methods

The Off-Site Human Surveillance Program was initiated in December 1970 to determine levels of radioactive nuclides 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 1986, 16 of these families (37 individuals) were still active in the program together with 7 families added in recent years. When the Community Monitoring Station Network was started in 1982, the families of the station managers were added to the program. These families are counted in the winter and summer of each year. The geographical locations of the families which participated in 1987 are shown in Figure 17.

These persons travel to the EMSL-LV where a whole-body 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 (3-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 then be requested for use by their family physician.

As reported in previous years, medical examination of the off-site families revealed a generally healthy population. In regard to the blood examinations and thyroid profiles, no abnormal results were observed which could be attributed to past or present NTS testing operations.

Analysis for internally deposited radionuclides is also performed for EPA, the DOE contractor employees, and for other workers who may be occupationally exposed as well as for concerned members of the general public. Results of counts on individuals from Las Vegas and other cities are used for comparison.

The Quality Control Program utilizes daily equipment checks and internal calibrations with NBS traceable radionuclides. Calibration phantoms are exchanged between this facility and other whole-body counting facilities across the nation for intercomparison studies. As part of this program, an English volunteer subject who had received intravenous injections of radionuclides, was counted at this facility. He makes visits to a limited number of whole-body counting facilities for intercalibration of low energy gamma emitting radionuclides each year.

Results

During 1987, a total of 246 germanium, and 500 planar/semi-planar spectra were obtained from 230 individuals, of whom 81 were participants on the Off-Site Human Surveillance Program. Also, 1665 spectra for calibrations and background were generated. Cesium-137 is generally the only fission product detected. As a result of worldwide fallout following the Chernobyl accident, trace amounts of cesium-137, cesium-134, and cobalt-60 were detected in a limited number of individuals, mainly those contractor personnel flown in from California or people stationed in Europe. Several ranchers actively involved in farming also showed a trace of these radionuclides. In general, the spectra were representative of normal background for people and showed only naturally occurring potassium-40. No transuranic nuclides were

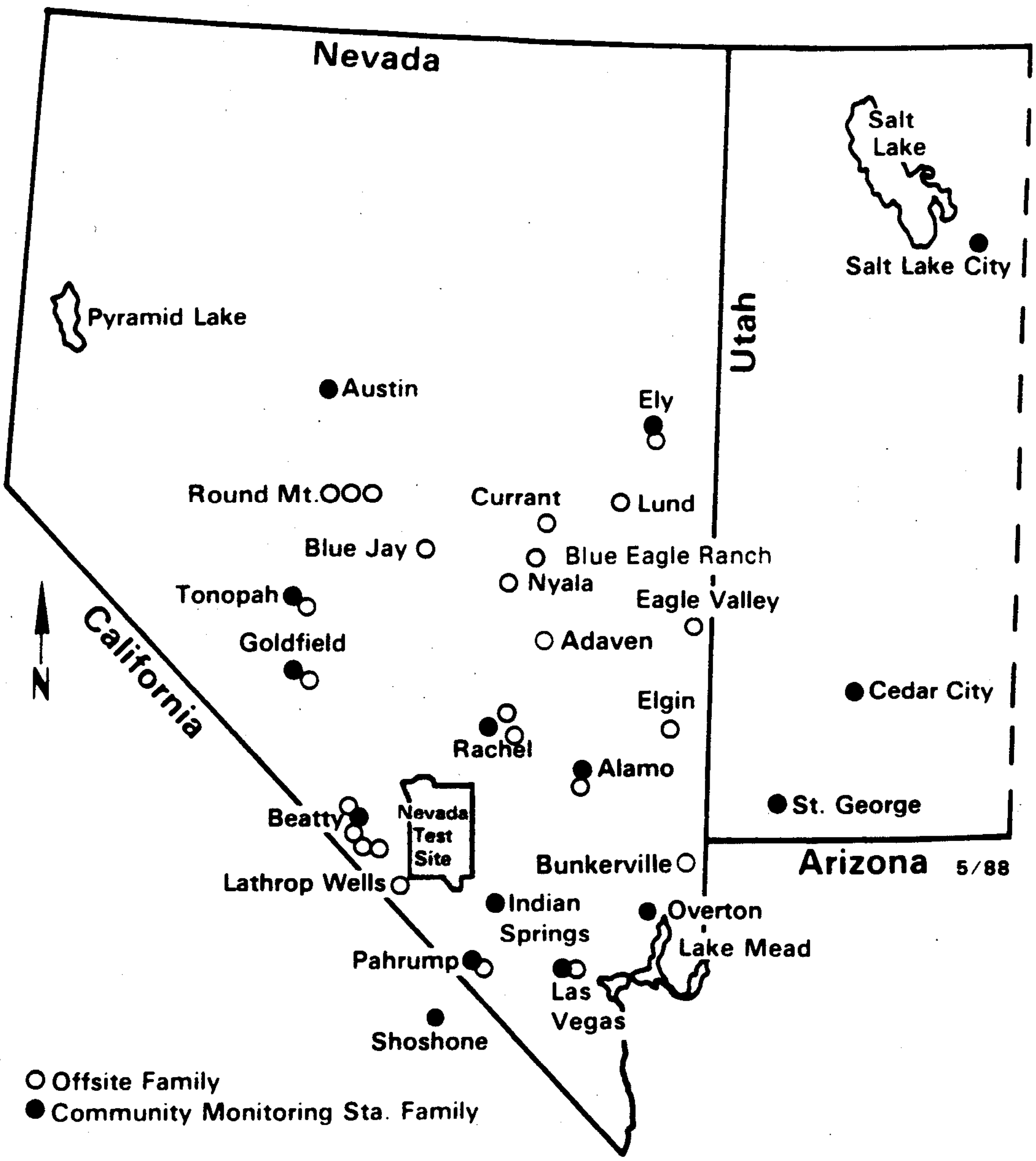


Figure 17. Location of families in the Off-Site Human Surveillance Program.

detected in any lung counting data. The subject from AERE, Harwell, England had a body burden of radium-226 from an accidental intake in 1939, intravenously administered barium-133 and strontium-85, plus cesium-134 and -137 received from travel in Yugoslavia prior to coming to the U.S. Our results showed good correlation with the results from other whole-body counting facilities and we were able to detect radionuclide concentration in some areas of the body with better sensitivity than the other facilities. The subject gave us the opportunity to investigate levels in bones of the skull, wrists, ankles, and pelvis as well as in the soft tissue of the liver and lungs. The radionuclides were found to have been deposited assymetrically in bone. It is not clear why this occurred but it is possible that because of his age, he is in his eighties, the blood flow might have been less in some areas. Ultrasound studies were not able to explain these anomalies. If the pattern of deposition is not unique then the positioning of detectors is very critical and the ability to position detectors reproducibly at various altitudes is essential. The present state-of-the-art detectors and analyzer systems allow reliable measurements and results at which we could only conjecture a few years ago.

Whole-body and lung counts were performed on subjects from the Southern California Edison Nuclear Power Plant at San Onofre. The new semi-planar detectors were installed for these counts and calibrated with tissue equivalent lung calibration sets impregnated with various uranium enrichments. These lung sets were obtained from Lawrence Livermore National Laboratory and were used in our tissue equivalent lung phantom. The use of these detectors, in this instance tested their use in the Off-Site Human Surveillance Program.

Bioassay results for the Off-Site Human Surveillance Program showed that the concentration of tritium in urine samples from the off-site residents varied from 0 to 1840 pCi/L (0 to 68 Bq/L) with an average value of 184 pCi/L (6.8 Bq/L). Nearly all the concentrations measured were in the range of background levels measured in water and reflect only natural exposure. The source for the high value (a Las Vegas, Nevada resident) is unknown but is not attributed to NTS activities. The tritium concentrations in urine samples from EPA employees had a range of 0 to 1190 pCi/L (0-44 Bq/L). The highest tritium concentration was found in urine from an employee at the San Onofre Nuclear Power Plant but it was below the maximum permissible body burden.

SECTION 6

PUBLIC INFORMATION AND COMMUNITY ASSISTANCE PROGRAMS

In addition to its many monitoring and data analysis activities, the NRD provides a comprehensive program designed to provide information and assistance to individual citizens, organizations, and local government agencies in communities in the environs of the NTS. During 1987, activities included: participation in public hearings; "town hall" meetings; a high school radiation science program; claims investigations; updating of emergency response; continued support of Community Monitoring Stations; and a variety of tours, lectures, and presentations.

Public Hearings

A Congressional Oversight Hearing on the Health Effects of Underground Nuclear Testing was held by the House Subcommittee on Energy and Environment in Salt Lake City, Utah on September 25, 1987. Testimony was given by two NRD staff members. They described the criteria that must be met prior to testing a nuclear device as well as the extensive monitoring, surveillance, and analytical activities carried out by the EMSL-LV to ensure that releases of radioactivity from the NTS will be detected and reported.

Town Hall Meetings

The "town hall" meetings, which have been conducted since 1982, were continued in 1987. These meetings provide an opportunity for attendees to meet directly with EPA and DOE personnel, ask questions, and express their concerns concerning nuclear testing. During a typical meeting, the procedures used and the safeguards taken during any test are described, the monitoring and surveillance networks are explained, and the proposed High Level Waste Repository at Yucca Mountain discussed. During 1987, meetings were held in the 10 communities listed below. Attendance varied from 8 to 100 with an average of 30 participants per meeting.

Town Hall Meetings

Bridgeport, California	March 18
Hawthorne, Nevada	March 19
Leeds, Utah	April 22
Minersville, Utah	April 23
Round Mountain, Nevada	May 14
Austin, Nevada	July 13
Goldfield, Nevada	July 16
Logandale, Nevada	September 16
Ivins, Utah	November 18
Bloomington, Utah	November 19

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 problems with domestic animals and wildlife to determine whether or not radiation exposure may be involved.

Several animal investigations were conducted during 1987, by the NRD veterinarian, in response to requests from citizens. These included evaluations of: a skin condition, symptomatic of a mange mite infestation, observed on a number of dogs at a breeding kennel; a growth on the eyelid of a yearling bull; and a necrotic mass, tentatively diagnosed as a melanoma or squamous cell carcinoma, on a horse. In each case, the owners were advised to take their animals to a practicing veterinarian for confirmatory diagnosis or additional treatment. None of the conditions observed was related to nuclear radiation.

NTS Tours

To complement the "town-hall" meetings and to familiarize Nevada citizens with both the DOE testing program at the NTS and the Environmental Monitoring Program conducted by the EPA, tours are arranged for business and community leaders from towns in the environs of the NTS, as well as for government employees and the news media. Between January and October 1987, the following tours were sponsored by the EPA:

Citizens of Beatty	January 14
National Park Service	January 29
EPA Newcomers	February 12-13
EPA Newcomers	February 25-26
Ely Residents	May 19-20
Alamo, Rachel, and Las Vegas	May 27-28
Goldfield Residents	August 31-September 1
Utah News Media	September 17-18
EPA Employees and Family Members	October 29

High School Science Program

The High School Radiation Science Program was conceived by the NRD staff in 1986, to provide a service to schools in communities in the environs of the NTS. The aim of this program being to supplement the high school program with an activity involving the interaction between students, teachers and NRD personnel. Following the reactor accident at Chernobyl, USSR in April 1986, the need for such a program became obvious as indicated by recurring indications of misunderstanding of ionizing radiation by both the media and the public. In response, the NRD staff put together a program designed to help students better understand radiation and radioactivity and to provide them with some of the basic knowledge required to make sound decisions concerning the many societal issues arising from the use and disposal of radioactive materials.

Beginning in October 1986, and continuing through 1987, an NRD staff member began teaching radiation concepts to students in high school chemistry, biology, physics, and general science classes. The instructor spends 4 or 5 days in each school. During this time he presents lecture-demonstrations and conducts several laboratory exercises, designed to introduce students to background radiation measurement techniques. During 1987, the program was presented in the schools listed below:

Beatty High School, Beatty, NV	January 20-23
Tonopah High School, Tonopah, NV	February 20-23
Death Valley High School, Shoshone, CA	April 20-24
Indian Springs High School, Indian Springs, NV	November 2-6
White Pine High School, Ely, NV	December 7-11

Other Activities

Personnel from the EMSL-LV addressed other groups during 1987, as listed below:

March 11 — A talk about radiation was given to students at the Twin Springs Ranch Elementary School.

March 19 — A lecture, concerning the Nuclear Waste Problem and the Nuclear Waste Policy Act, was presented to an American Government class at Bonanza High School.

September 1 — Deer migration study slides were shown at the Soil Conservation Office in Caliente, NV.

December 9 — A slide presentation describing the deer migration studies was presented at the meeting of the Caliente Sportsmen's Club.

Emergency Response

As a result of continued population growth in the off-site communities, there is an increasing need for assistance from and coordination with both state and local agencies in order to implement the protective actions that may be needed if an underground nuclear test accidently released radioactive contaminants into the environment. Therefore, during 1987, there has been a continuing dialogue between the EMSL-LV staff and the State of Nevada's Division of Emergency Management as well as with the local and county officials responsible for emergency planning. As a result, the radiological appendicies to the emergency response plans of Clark, Esmeralda, Lincoln, Nye and White Pine counties in Nevada and Inyo County, California were updated into the DOE Master Plan for emergency response.

In a continuing effort to provide and improve personal dosimetry to citizens living in communities in the environs of the Nevada Test Site, plans were developed to replace existing film badges with thermolominescent dosimeters. The necessary TLDs were ordered and are currently being calibrated prior to their distribution to communities in California, Nevada, and Utah. The dosimeters will be issued by county or state personnel in the unlikely event of a significant release of radioactive materials from the NTS.

COMMUNITY MONITORING STATIONS

In 1981 DOE and EPA established a network of 15 Community Monitoring Stations in the off-site areas in order to increase public awareness about radiation monitoring activities. The DOE, through an interagency agreement with EPA, sponsors the program and contracts with Desert Research Institute (DRI) to manage the stations, and 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 radiological surveillance methods by the University of Utah. These stations continued to be maintained by NRD personnel during 1987. Samples were collected and analyzed at the EMSL-LV. DRI provides data interpretation to the communities involved and pays the station operators for their services.

Each station contains one of the samplers for the ASN, NGTSN and Dosimetry networks discussed earlier, plus a pressurized ion chamber (PIC) and recorder for immediate readout of external gamma exposure, and a recording barograph. 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 data. The data from these stations are included in the tables in Appendix E with the other data from the appropriate networks. Table 10 contains a summary of the PIC data.

Experimental telemetry equipment was installed at three monitoring stations during 1987 in an attempt to expedite environmental measurement data acquisition and improve environmental monitoring activities. With this electronic equipment gamma exposure measurements, acquired by the pressurized ion chambers, can be transmitted via satellite directly to the EMSL-LV and to the NTS. Since tests with the experimental equipment proved successful, plans call for the installation of satellite telemetry equipment at all of the Community Monitoring Stations plus 9 other locations in Nevada and Utah by mid-1988.

DOSE ASSESSMENT

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 1. 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 7710 individuals. The individual with the maximum exposure from airborne NTS radioactivity would have been living at Medlin's Ranch which is NNE from the NTS. That maximum exposure was 0.2 µrem (2×10^{-3} µSv). The population exposure within 80 km would have been 5.9×10^{-4} person-rem (5.9×10^{-6} person-Sv).

During calendar year 1987 there were four sources for possible radiation exposure to the population of Nevada, all of which produced negligible exposures. The four sources were:

- Normal releases of radioactivity from the NTS, including that from drillback and purging activities;
- Radioactivity in migratory animals that was accumulated during residence on the NTS;
- World-wide distributions such as strontium-90 in milk, krypton-85 in air, etc.; and
- Background radiation due to natural sources such as cosmic radiation, natural radioactivity in soil, and beryllium-7 in air.

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

Estimated Dose from Worldwide Fallout

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

Tritium (.62 pCi/m^3 of air [23 mBq/m^3])
Krypton-85 (25.5 pCi/m^3 of air [0.9 Bq/m^3])
Strontium-90 (1.8 pCi/L in milk [67 mBq/L])
Xenon-133 (1 pCi/m^3 of air [37 mBq/m^3])
Cesium-137 (30 pCi/kg beef muscle [1.1 Bq/kg])
Plutonium-239 (110 fCi/kg beef liver, [4.1 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 248 g/day, when liver consumption is subtracted this is 78.7 kg/yr.

The dose conversion factors are based on the ALI divided by 5000 to convert to becquerels/mrem, then converted to mrem/pCi:

Hydrogen-3 (6.2×10^{-8} mrem/pCi)
Strontium-90 (1.8×10^{-4} mrem/pCi)
Cesium-137 (4.5×10^{-5} mrem/pCi)
Plutonium-239 (9×10^{-4} mrem/pCi)
Krypton-85 (1.5×10^{-3} mrem/yr per pCi/m^3)
Xenon-133 (6.2×10^{-4} mrem/yr per pCi/m^3)

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

0.62 pCi/m^3 x 8400 m^3/yr x 6.2×10^{-8} mrem/pCi x 10^3 µrem/mrem = 0.32 µrem

Also:

Stronium-90 ($1.8 \times 160 \times 1.8 \times 10^{-4} \times 10^{-3}$ = 52 µrem)
Cesium-137 ($30 \times 78.7 \times 4.5 \times 10^{-5} \times 10^{-3}$ = 106 µrem)
Plutonium-239 (110 fCi/kg x 11.8 kg x 10^{-3} pCi/fCi x 9 x 10^{-3} = 1.2 µrem)

These sum to an annual dose equivalent of 0.16 mrem.

Estimated Dose from Radioactivity in NTS Deer

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

Tissue	H-3	Cs-137	Pu-239
Liver (pCi/kg)	1×10^7	90	0.05
Muscle (pCi/kg)	1×10^7	90	0.113

Based on past data, in the unlikely event that one such deer was collected by a hunter in off-site areas. With 3 pounds of liver and 100 pounds of meat and the radionuclide concentrations listed above, the dose equivalents could be:

Liver: 1.36 kg $([1 \times 10^7 \times 6.2 \times 10^{-8}]+[90 \times 4.5 \times 10^{-5}]+[0.5 \times 9 \times 10^{-4}])$ = 0.85 mrem and for muscle, a similar calculation yields 28.4 mrem. Thus, approximately 29 mrem would be delivered to one individual consuming the stated quantity of meat and assuming no radioactivity was lost in food preparation.

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 (potassium-40, uranium and thorium daughters, etc.), there is a contribution from beryllium-7 that is formed in the atmosphere by cosmic ray interactions with oxygen and nitrogen. The annual average Be-7 concentration measured by our air surveillance network was 0.07 pCi/m^3. With a dose conversion factor for inhalation of 2.6×10^{-7} mrem/pCi, this equates to 0.15 µrem, a negligible quantity when compared with the PIC measurements that vary from 56 to 172 mrem, depending on location.

Summary

For an individual with the highest exposure to NTS effluent, that is someone living at the Medlin's Ranch, the NTS exposure, plus that due to world-wide fallout plus background would add to: 2×10^{-3} mrem + 0.16 mrem + 140 mrem = 140.2 mrem (1.4 mSv). Both the NTS and worldwide distributions contribute a negligible amount of exposure compared to background. If that same individual used the NTS deer meat without sharing it with someone else, the exposure would increase to 140.16 + 29 = 169 mrem (1.69 mSv).

SECTION 8

REFERENCES

ANSI75 American National Standards Institute, Inc., 1975, "American National Standard Performance Testing and Procedural Specifications for Thermoluminescent Dosimetry (Environmental Applications)." ANSI N545-1975.

Be73 Bernhardt, D. E., A. A. Moghissi and J. A. Cochran, 1973, Atmospheric Concentrations of Fission Product Noble Gases, pp. 4-19, in Noble Gases, CONF-730915.

Bl84 Black, S. C. and D. D. Smith, 1984, "Nevada Test Site Experimental Farm Summary Report 1963-1981". EPA 600/4-84-066, DOE/DP/0539-052. U. S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

CA85 California, 1985, personal communication from California county agents.

DOE85a U.S. Department of Energy, 1985, Amendment to DOE Order 5480.1A, Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities.

DOE85 U.S. Department of Energy, 1985, Environmental Protection, Safety, and Health Protection Information Reporting Requirements. Order DOE 5484.1.

DOE88 U.S. Department of Energy, 1988, personal communication from Health Physics Division, DOE/NV, Las Vegas, NV.

EPA81 U.S. Environmental Protection Agency, 1981, "Environmental Radioactivity Laboratory Intercomparison Studies Program 1978-1979." EPA-600/4-81-004. Environmental Monitoring and Support Laboratory, Las Vegas, Nevada. (Available from U.S. Department of Commerce, NTIS, Springfield, VA 22161.)

EPA86 U.S. Environmental Protection Agency, 1986, "Off-Site Monitoring for the Mighty Oak Nuclear Test." EPA 600/4-86-030. Environmental Monitoring Systems Laboratory, Las Vegas, Nevada. (Available from the U.S. Environmental Protection Agency.)

ERDA77 U.S. Energy Research and Development Administration, 1977, "Final Environmental Impact Statement, Nye County, Nevada." Nevada Operations Office, Las Vegas, NV, Report ERDA-1551. (Available from U.S. Department of Commerce, NTIS, Springfield, VA 22161.)

Gi79 Giles, K. R., 1979, "A Summer Trapping Method for Mule Deer." EMSL-LV-0539-27. U. S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

Gi85 Giles, K. R. and J. Cooper, 1985, "Characteristics and Migration Patterns of Mule Deer on the Nevada Test Site," U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory Report EPA-60/4-85-030 (DOE/DP/00539-054).

Ho75 Houghton, J. G., C. M. Sakamoto, and R. O. Gifford, 1975, "Nevada's Weather and Climate." Special Publication 2. Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada, Reno, Nevada. pp. 69-74.

ICRP75 International Commission in Radiological Protection, 1975, Report of the Task Group on Reference Man, Report ICRP-23.

ICRP77 International Commission in Radiological Protection, 1977, Recommendations of the ICRP, Report ICRP-26.

ICRP79 International Commission in Radiological Protection, 1979, Radionuclide Releases to the Environment: Assessment of Dose to Man, Report ICRP-29.

ICRP79 International Commission in Radiological Protection, 1979, Limits for Intake of Radionuclides by Workers, Report ICRP-30, 3 parts.

Ja81 Jarvis, A. N. and L. Siu, 1981, Environmental Radioactivity Laboratory Intercomparison Studies Program - FY 1981-82, EPA-600/4-81-004, U.S. EPA, Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

NPS80 National Park Service, 1980, personal communication with Chief Ranger R. Rainer, Death Valley National Monument, Death Valley, California.

NCRP71 National Council on Radiation Protection and Measurements, 1971, Basic Radiation Protection Criteria. NCRP Report No. 39.

NCRP75 National Council on Radiation Protection and Measurements, 1975, Natural Background Radiation in the United States. NCRP Report No. 45.

NV86 Nevada Department of Agriculture, 1986, "Nevada Agricultural Statistics 1985." Nevada Crop and Livestock Reporting Service, Reno, Nevada.

Pi82 Patzer, R. G. and M. E. Kaye, 1982, "Results of a Human Surveillance Program in the Off-Site Area Surrounding the Nevada Test Site." Health Phys. 43:791-801.

Qu68 Quiring, R. E., 1968, "Climatological Data, Nevada Test Site, Nuclear Rocket Development Station (NRDS)." ERLTM-ARL-7. ESSA Research Laboratories, Las Vegas, Nevada.

Sm81 Smith, D. D. and V. E. Andrews, 1981, Selected Radioisotopes in Animal Tissues: ^{90}Sr and ^{137}Cs Measurements from 1956 to 1977. U. S. Environmental Protection Agency Report EPA-600/3-81-027 (DOE/DP/00539-040). Las Vegas, Nevada.

Sm84 Smith, D. D. and S. C. Black, 1984, Animal Investigation Program for the Nevada Test Site 1957-1981, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory Report EPA 600/6-84-020, Las Vegas, Nevada.

UT87 Utah Department of Agriculture, 1987, "Utah Agricultural Statistics, 1987." State of Utah Department of Agriculture, Salt Lake City, Utah.

Wi75 Winograd, I. J. and W. Thordarson, 1975, Hydrogeologic and hydrochemical framework, south-central Great Basin, Nevada-California, with special reference to the Nevada Test Site, USGS Professional Paper 712-C, Denver, Colorado.

APPENDIX A

SITE DATA

SITE DESCRIPTION

A summary of the uses of the NTS and its immediate environs is included in Section 3 of this report. More detailed data and descriptive maps are contained in this Appendix.

Location

The NTS is located in Nye County, Nevada, with its southeast corner about 90 km northwest of Las Vegas (Figure 1 in main report). It has an area of about 3,500 square km and 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 1,800 to 2,300 m above MSL.

The NTS is surrounded on three sides by exclusion areas, collectively named the Nellis Air Force Range, which provide 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. Depending upon wind speed and direction, from 2 to more than 6 hours will elapse before any release of airborne radioactivity could pass over public lands.

Climate

The climate of the NTS and surrounding area is variable, due to its variations in altitude and its rugged terrain. Generally, the climate is referred to as continental arid. 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 of dry condition, developed by Doppen, is further subdivided on the basis of temperature and severity of drought. Table A.1 (Ho75) 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 high (low) temperatures at the lower altitudes are around 50°F (25°F) in

TABLE A.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	Percent 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.

January and 95°F (55°F) in July, with extremes of 120°F and -15°F. Corresponding temperatures on the plateaus are 35°F (25°F) in January and 80°F (65°F) in July with extremes of 115°F and -30°F.

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.

Geology and Hydrology

Two major hydrologic systems shown in Figure A.1 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 southwestward toward the Ash Meadows Discharge Area.

Land Use of NTS Environs

Figure A.2 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. For example, 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 NTS Control Point-1 (CP-1). Many of the residents grow or have access to locally grown fruits and vegetables.

Many recreational areas, in all directions around the NTS (Figure A.2) 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 utilized throughout the year except for the winter months. Camping and fishing locations to the southeast, south, and southwest are utilized throughout the year. The hunting season is from September through January.

Population Distribution

Figure A.3 shows the current population of counties surrounding the NTS based on 1980 census figures. Excluding Clark County, the major population center (approximately 536,000 in 1984), the population density within a 150 km radius of the NTS is about 0.5 persons per square kilometer. For comparison, the 48 contiguous states (1980 census) had a population density of approximately 29 persons per square kilometer. The estimated average population density for Nevada in 1980 was 2.8 persons per square kilometer.

The off-site area within 80 km of the NTS (the 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

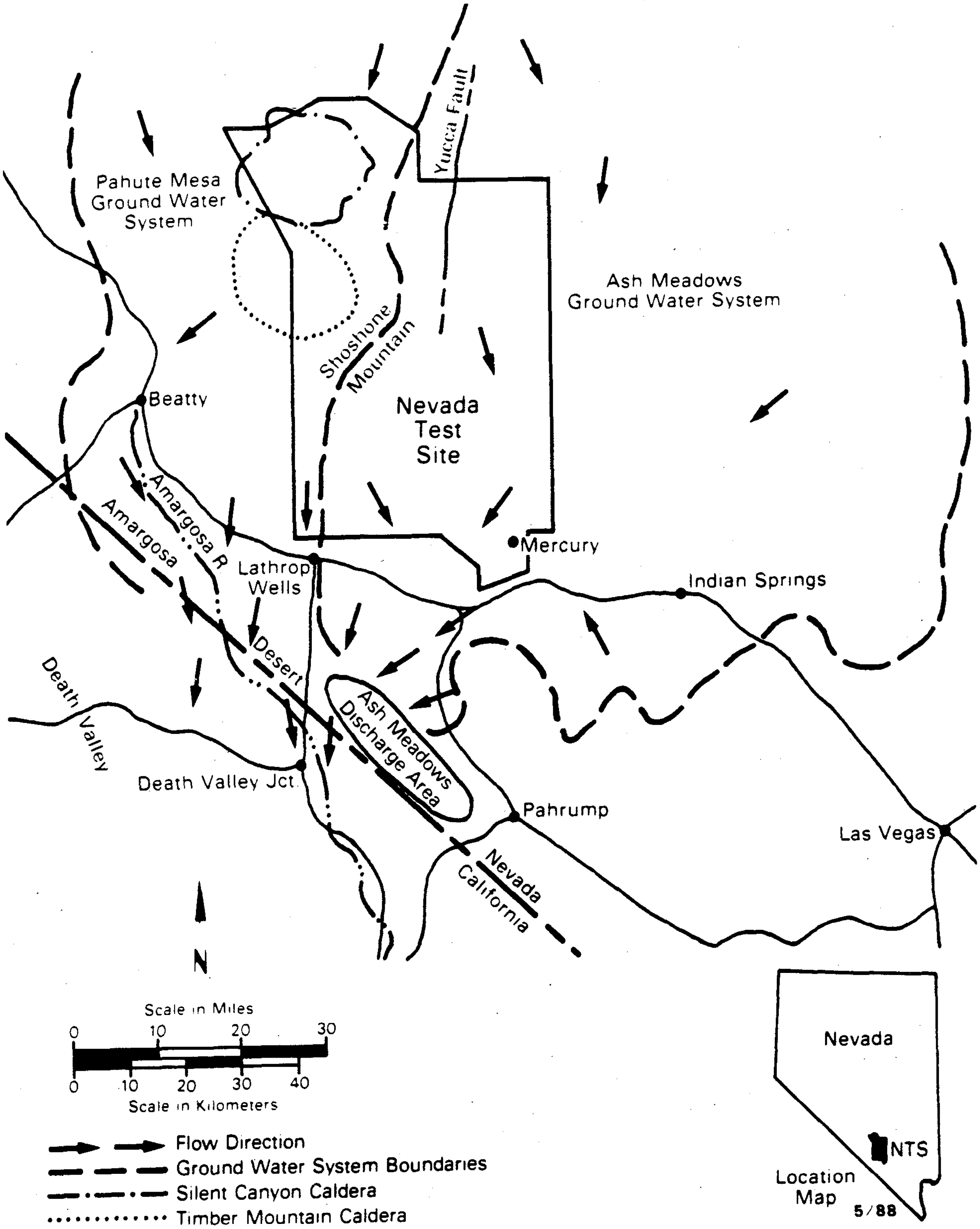


Figure A.1. Ground-water flow systems around the Nevada Test Site.

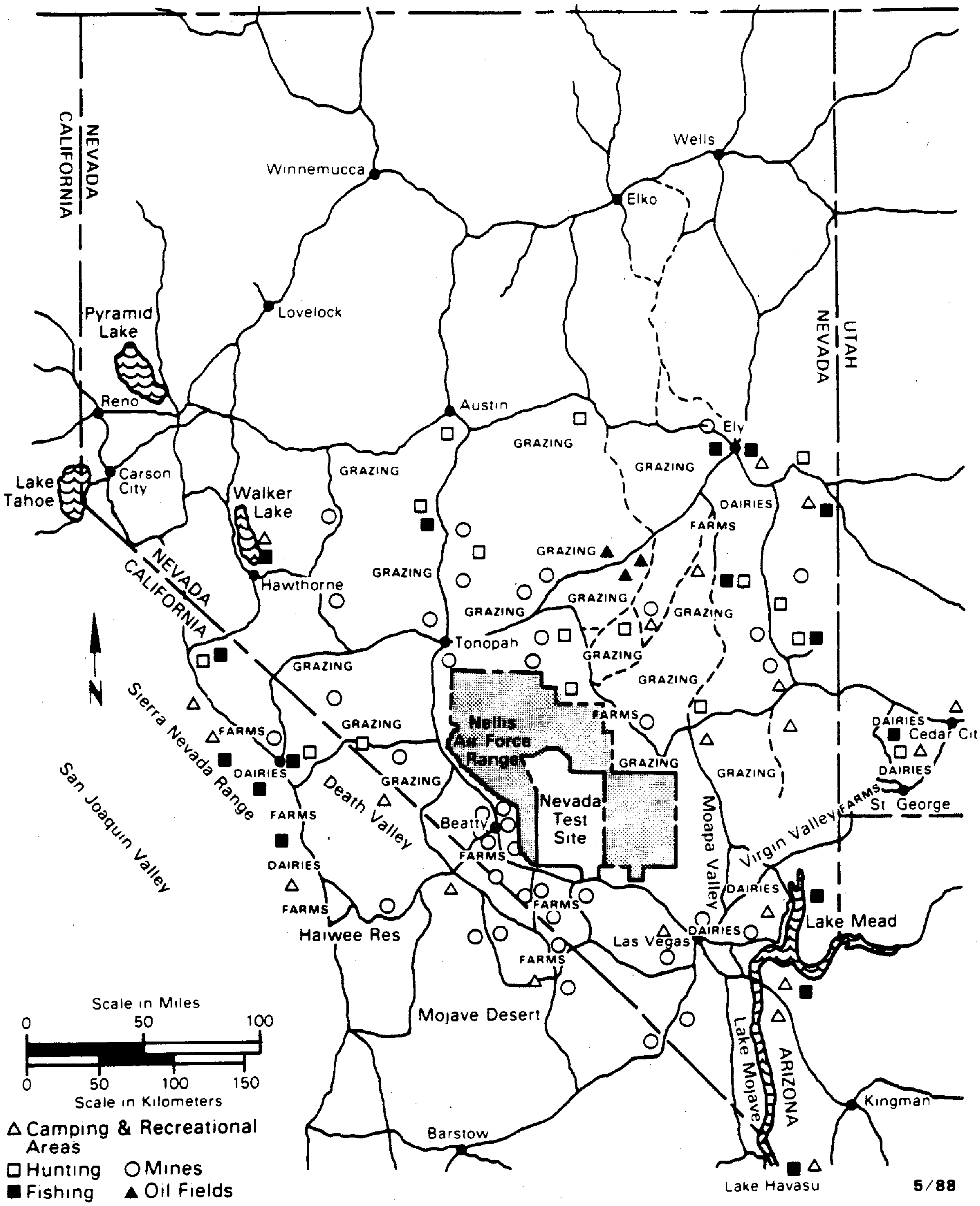


Figure A.2. General land use within 300 km of the Nevada Test Site.

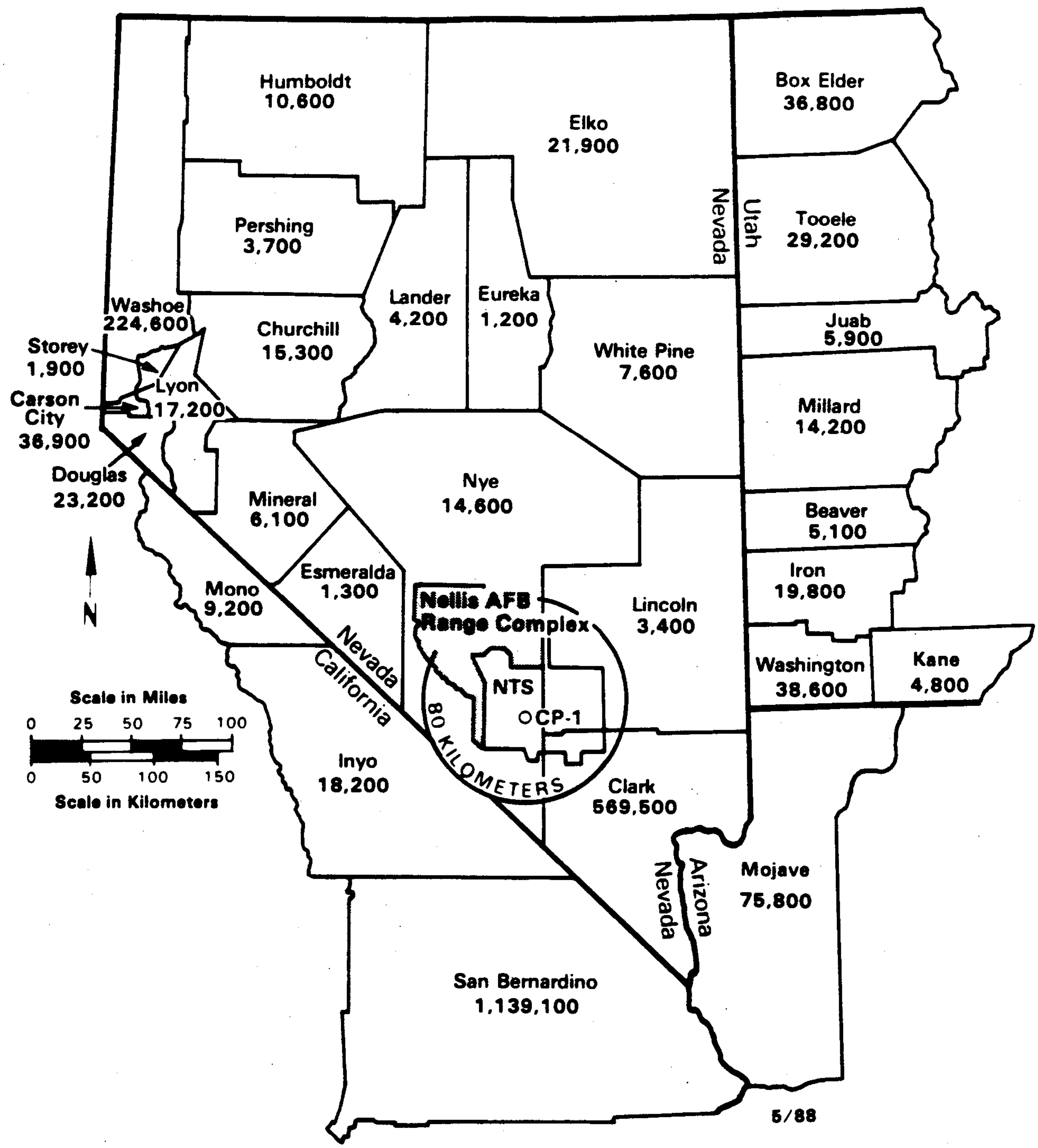


Figure A.3. Population of Arizona, California, Nevada, and Utah Counties near the Nevada Test Site (1980).

of about 5,500, is located about 72 km south of the NTS CP-1. The Amargosa Farm Area, which has a population of about 1,200, is located about 50 km southwest of CP-1. The largest town in the near-offsite area is Beatty, which has a population of about 1,000 and is located approximately 65 km to the west of CP-1. A report by Smith and Coogan was published in 1984 which summarizes the population distribution within selected rural areas out to 200 kilometers from the Control Point on the NTS.

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The National Park Service (NPS80) 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 largest town and contiguous populated area (about 40 square miles) in the Mojave Desert is Barstow, located 265 km south-southwest of the NTS, with a 1983 population of about 36,000. The next largest populated area is the Ridgecrest-China Lake area, which has a current population of about 25,000 and is located about 190 km southwest of the NTS. The Owens Valley, where numerous small towns are located, lies about 50 km west of Death Valley. The largest town in Owens Valley is Bishop, located 225 km west-north-west of the NTS, with a population of about 5,300 including contiguous populated areas.

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 population of 11,300. The next largest town, Cedar City, with a population of 10,900, 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 town in the area is Kingman, located 280 km southeast of the NTS, with a population of about 9,300. Figures A.4 through A.7 show the domestic animal populations in the counties near the NTS.

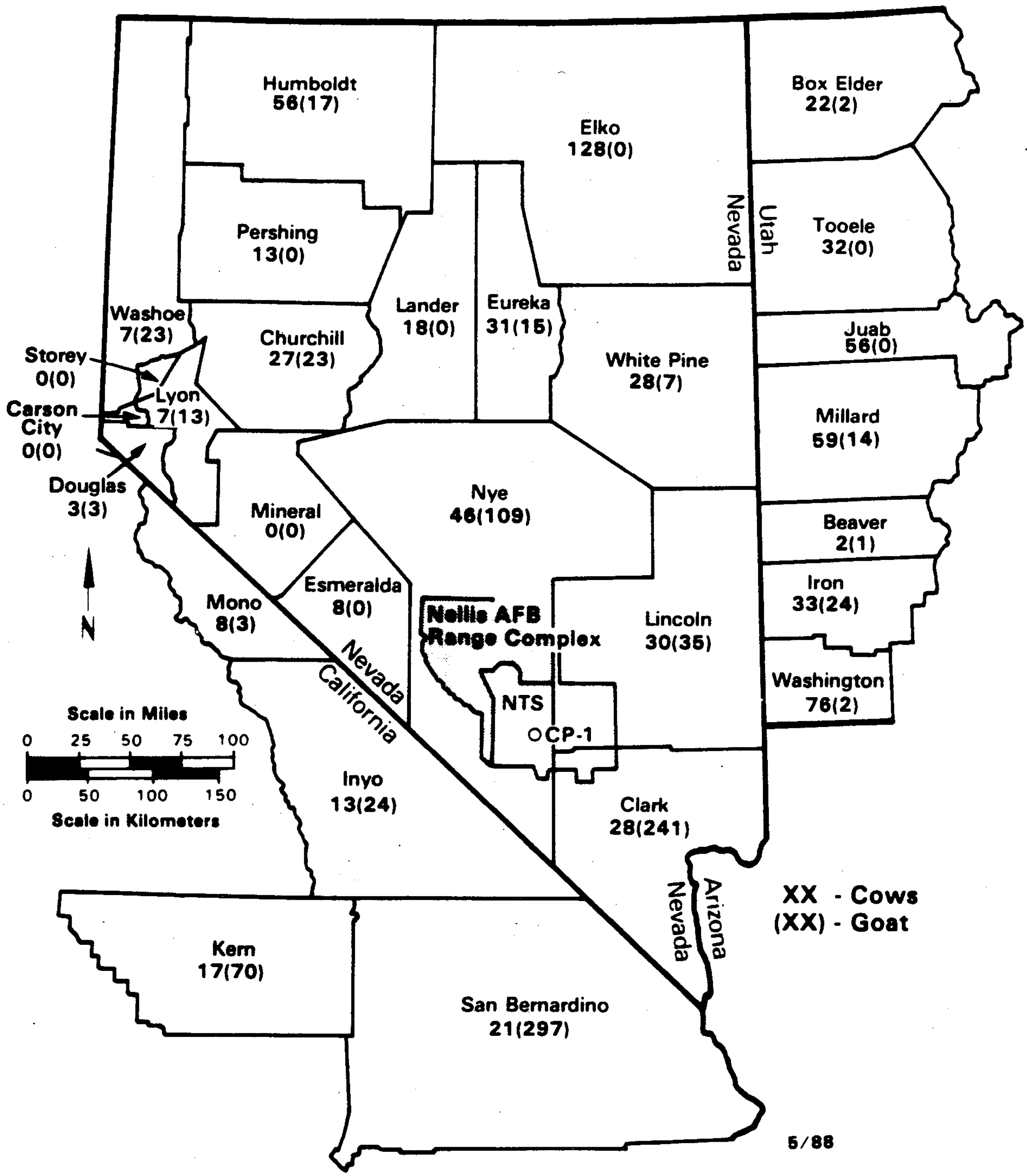


Figure A.4. Distribution of family milk cows and goats, by county (1987).

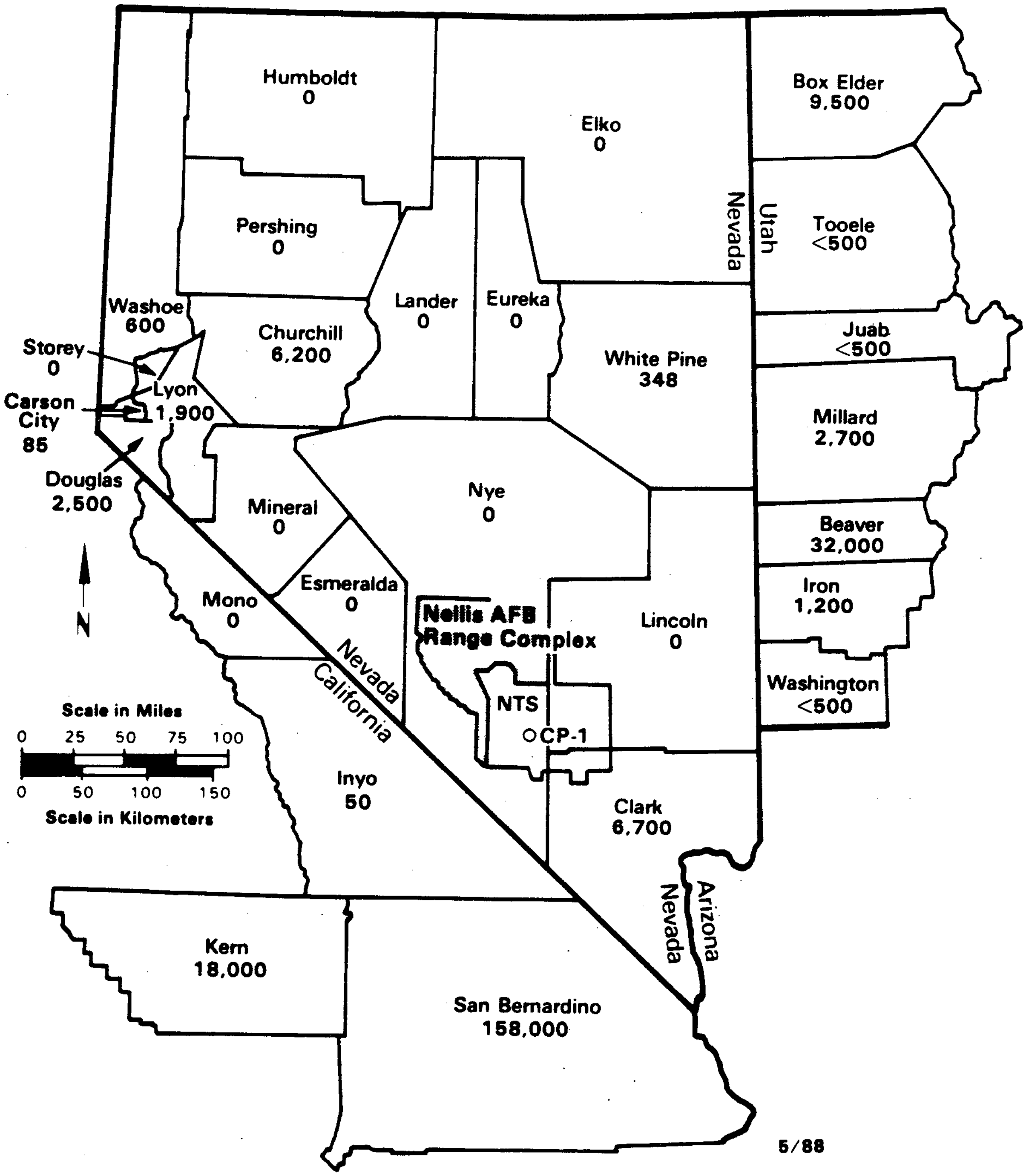


Figure A.5. Distribution of dairy cows, by county (1987).

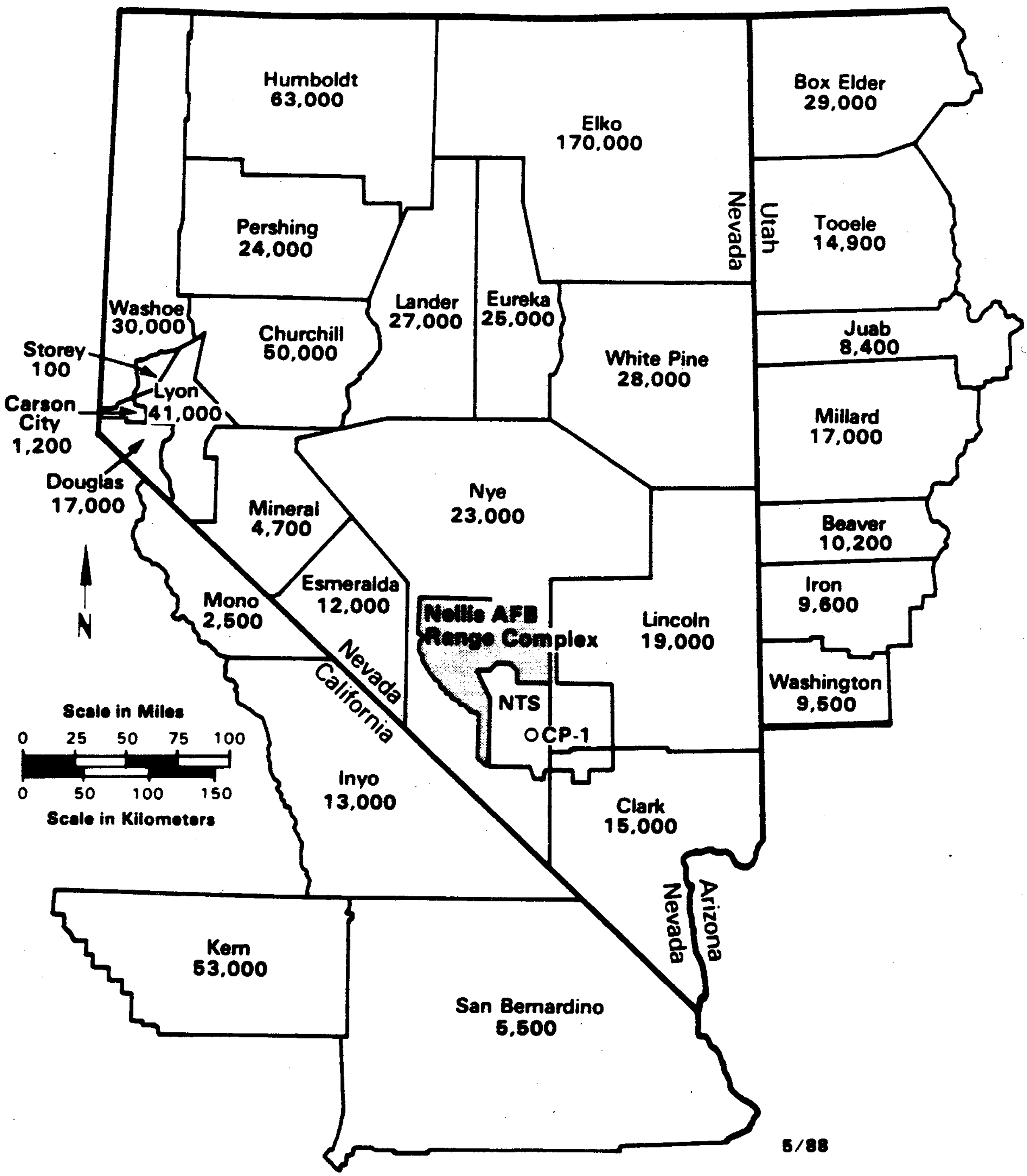


Figure A.6. Distribution of beef cattle, by county (1987).

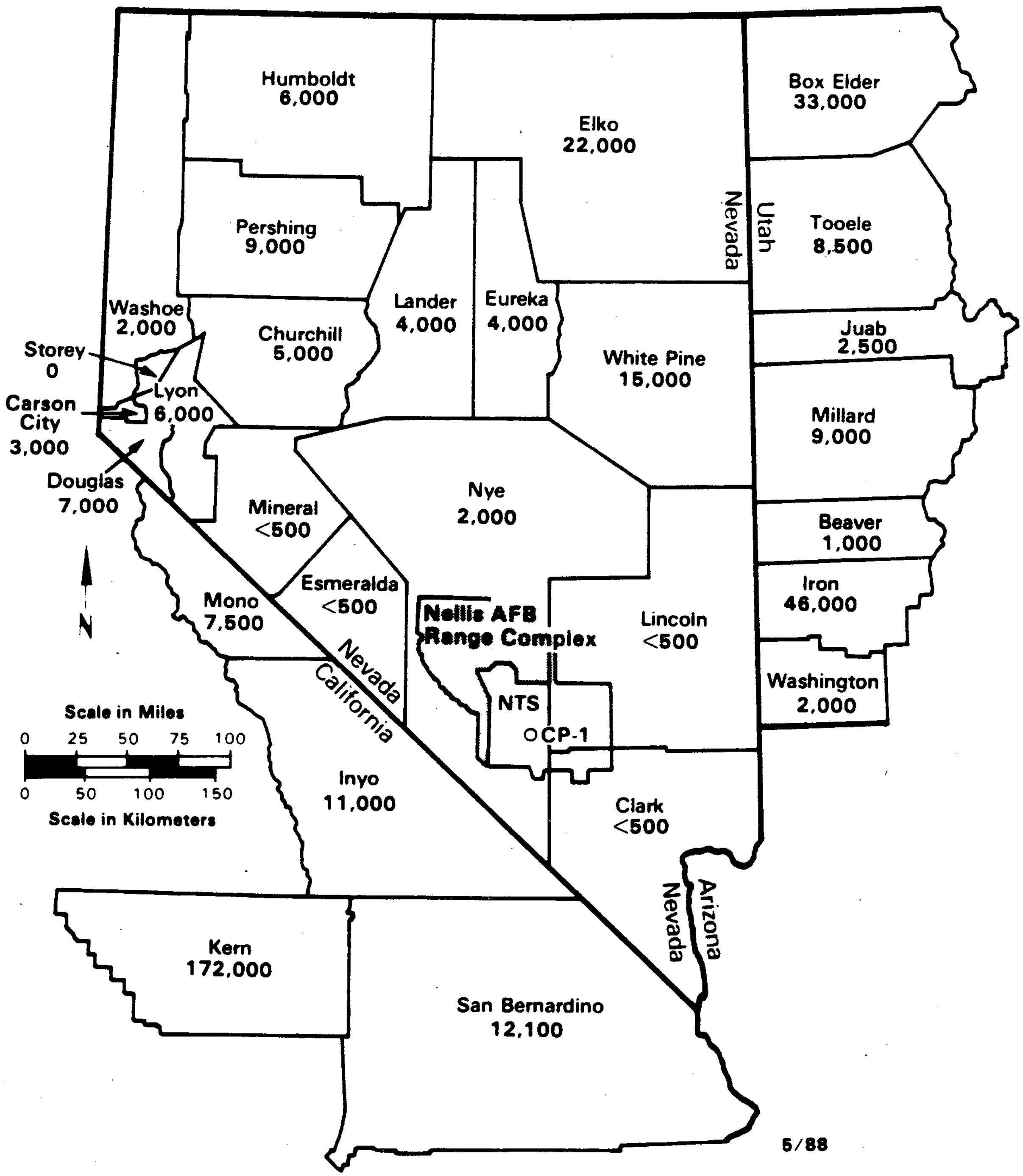


Figure A.7. Distribution of sheep, by county 1987.

APPENDIX B

SAMPLE ANALYSIS PROCEDURES

ANALYTICAL PROCEDURES

The procedures for analyzing samples collected for offsite surveillance are described by Johns et al. in "Radiochemical Analytical Procedures for Analyses of Environmental Samples" (EMSL-LV-0539-17, 1979) and are summarized in Table B.1.

TABLE B.1. SUMMARY OF ANALYTICAL PROCEDURES

Type of Analysis	Analytical Equipment	Counting Period (min)	Analytical Procedures	Sample Size	Approximate Detection Limit*
IG Ge(Li) Gamma Spec trometry**	IG or Ge(Li) detector calibrated at 0.5 keV/channel (0.04 to 2 MeV range) individual detector efficienceis ranging from 15% to 35%.	Air charcoal cartridges and individual air filters, 30 min; air filter composites, 1200 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.	120-370 m^3 for air filters; and charcoal cartridges; 3-1/2 liters for milk and water.	For routine milk and water generally, 5 pCi/L for most common fallout radionuclides in a simple spectrum. Filters for LTHMP suspended solids, 6 pCi/L. Air filters and charcoal cartridges, 0.04 pCi/m^3.
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-occuring radionuclides and, if necessary, extrapolated to midpoint of collection in accordance with $t^{-1.2}$ decay or an experimentally-derived decay.	120-370 m^3	0.5 pCi/sample.

(continued)

TABLE B.1. (Continued)

Type of Analysis	Analytical Equipment	Counting Period (min)	Analytical Procedures	Sample Size	Approximate Detection Limit*
Sr-89-90	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. 0.1-1 kg for tissue.	Sr-89 = 5 pCi/L Sr-90 = 2 pCi/L
H-3	Automatic liquid scintillation counter with output printer.	200	Sample prepared by distillation.	4 ml for water.	400 pCi/L
H-3 Enrichment (Long-Term Hydrological Samples)	Automatic scintillation counter with output printer.	200	Sample concentrated by electrolysis followed by distillation.	250 ml for water.	10 pCi/L
Pu-238,239	Alpha spectrometer with 450 mm, 300-μm depletion depth, depth, silicon surface barrier detectors operated in vacuum chambers.	1000-1400	Water sample or acid-digested filter or tissue samples separated by ion exchange, electroplated on stainless steel planchet.	1.0 liter for water; 0.1-1 kg for tissue; 5,000-10,000 m^3 for air.	Pu-238 = 0.08 pCi/L Pu-239 = 0.04 pCi/L for water. For For tissue samples, 0.04 pCi per total sample for all isotopes; 5-10 aCi/m^3 for plutonium on air filters.
Kr-85, Xe-133, Xe-135	Automatic liquid scintillation counter with output printer.	200	Separation by by gas chromatography; dissolved in toluene "cocktail" for counting.	0.4-1.0 1.0 m^3 for air.	Kr-85, Xe-133, Xe-135 = 4 pCi/m^3

*The detection limit is defined as 3.29 sigma where sigma equals the counting error of the sample and Type I error = Type II error = 5 percent. (J. P. Corley, D. H. Denham, R. E. Jaquish, D. E. Michels, A. R. Olsen, D. A. Waite, A Guide for Environmental Radiological Surveillance at U.S. Dept. of Energy Installations, July 1981, Office of Operational Safety Report DOE/EP-0023, U.S. DOE, Washington, D. C.)

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

APPENDIX C

QUALITY ASSURANCE PROCEDURES

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 the analysis of duplicate or replicate samples from the ASN, the NGTSN, the LTHMP, and the Dosimetry Network. As the radioactivity concentration in samples collected from the LTHMP and the MSN are below detection levels, most duplicate samples for these networks are prepared from spiked solutions. The NGTSN samples are generally split for analysis.

At least 30 duplicate samples from each network are normally collected and analyzed over the report period. Since three TLD cards consisting of two TLD chips each are used at each station of the Dosimetry Network, no additional samples were necessary. Table C-1 summarizes the sampling information for each surveillance network.

To estimate the precision of a methodology, the standard deviation of replicate results is needed. Thus, for example, the variance, s^2, of each set of replicate TLD results (n=6) was estimated from the results by the standard expression,

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

where k = number of sets of replicates.

Since duplicate samples were collected for all other sample types, the variances, s^2, for these types were calculated from $s^2 = (0.886R)^2$, where R is the absolute difference between the duplicate sample results. For small sample sizes, this estimate of the variance is statistically efficient* and certainly more convenient to calculate than the standard expression. The standard deviation is obtained by taking the square root.

---

*Snedecor, G. W., and W. G. Cochran. Statistical Methods. The Iowa State University Press, Ames, Iowa, 6th Ed. 1967, pp. 39-47.

TABLE C.1. SAMPLES AND ANALYSES FOR DUPLICATE SAMPLING PROGRAM - 1987

Surveillance Network	Number of Sampling Locations	Samples Collected This Year	Sets of Duplicate Samples Collected	Number Per Set	Sample Analysis
ASN	113	8,627	288	2	Gross beta, γ Spectrometry
NGTSN	19	810 (NG) 816 (H3)	145 97	2	Kr-85, H-3, H_2O, HTO
Dosimetry	150	726	726	4-6	Effective dose from gamma
MSN	22	238	78	2	K-40, Sr-89, Sr-90, H-3
LTHMP	199	799	139	2	H-3

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

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

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

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

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

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 C.2 for those analyses for which there were adequate data.

*Freund, J. E. Mathematical Statistics. Prentice Hall, Englewood, New Jersey, 1962, pp 189-235.

TABLE C.2. SAMPLING AND ANALYTICAL PRECISION - 1987

Surveillance Network	Analysis	Sets of Replicate Samples Evaluated	Coefficient of Variation (%)
ASN	Be-7	6	70
	Gross β	29	33
NGTSN	Kr-85	46	9.4
	HTO	*	31
	H_2O	97	34
Dosimetry	TLD	511	9.8
MSN	K-40	55	18
	Sr-90	11	20
LTHMP	H-3	45	30
	H-3+	76	13

*Estimate of precision was calculated from the errors in the H-3 conventional analysis and the measurement of atmospheric moisture (H_2O).

To estimate the precision of counting, approximately 10 percent of all samples are counted a second time. These are unknown to the analyst. Since all such replicate counting gave results within the counting error, the precision data in Table C.2 represents errors principally in analysis.

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 C.3, 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 separately (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 cause other than normal statistical variations that contributed to the difference between the measured values and the known value. As shown by this table, all of the analyses were within the control limit.

TABLE C.3. EPA QUALITY ASSURANCE INTERCOMPARISON RESULTS - 1987

Analysis	Month	Mean of Replicate Analyses (pCi/L)	Known Value (pCi/L)	Normalized Deviation from Known Concentration
Alpha	Apr	15.4	14.0	-1.6
	Aug	10.5	10.0	-0.1
	Oct	28.5	28.0	NA
	Nov	6.3	7.0	-0.3
Beta	Apr	45.3	43.0	0.9
	Aug	30.3	30.0	0.9
	Oct	75.2	72.0	NA
	Nov	18.6	19.0	-0.9
Chromium-51	Jun	39.2	41.0	3.7
	Oct	68.8	70.0	NA
Cobalt-60	Feb	50.4	50.0	-0.3
	Apr	9.0	8.0	0.3
	Jun	64.8	64.0	1.4
	Oct	16.4	15.0	NA
Cesium-134	Feb	54.8	59.0	-1.6
	Apr	18.2	20.0	-0.5
	Jun	36.7	40.0	0.2
	Oct	24.4	25.0	NA
Cesium-137	Feb	87.3	87.0	-1.3
	Apr	9.2	8.0	0.1
	Jun	79.5	80.0	0.8
	Aug	10.7	10.0	0.3
	Oct	51.8	51.0	NA
Tritium	Feb	4155.6	4209.0	0.6
	Apr	5620.6	5620.0	-0.6
	Jun	2784.8	2895.0	0.5
	Oct	4386.3	4492.0	-0.3
Iodine-131	Feb	8.5	9.0	1.9
	Apr	7.2	7.0	3.3
	Jun	62.0	59.0	1.8
	Aug	47.2	48.0	1.3
	Dec	26.6	26.8	0.8
Potassium	Jun	1755.0	1525.0	5.3

(continued)

TABLE C.3. Continued

Analysis	Month	Mean of Replicate Analyses (pCi/L)	Known Value (pCi/L)	Normalized Deviation from Known Concentration
Plutonium-239	Apr	15.3	16.7	NA
	Oct	5.2	5.3	-1.5
Radium-226	Apr	3.8	3.9	-0.2
	Oct	4.7	4.8	NA
Radium-228	Apr	4.2	4.0	NA
	Oct	4.7	4.8	NA
Ruthenium-106	Feb	95.0	100.0	-3.0
	Jun	72.5	75.0	1.7
	Oct	60.2	61.0	NA
Strontium-89	Jan	23.3	25.0	-1.4
	Apr	17.4	19.0	0.1
	Jun	63.7	69.0	1.5
	Aug	38.9	41.0	-0.8
	Oct	75.2	72.0	NA
Strontium-90	Jan	23.3	25.0	0.4
	Apr	10.0	10.0	0.8
	May	19.5	20.0	-0.8
	Aug	9.6	10.0	NA
	Oct	9.9	10.0	-1.2
Uranium	Apr	5.5	5.0	0.0
	Aug	12.4	13.0	-0.4
	Oct	3.4	3.0	0.0
Zinc-65	Feb	93.9	91.0	0.3
	Jun	10.9	10.0	1.0
	Oct	47.2	46.0	NA

TABLE C.4. QUALITY ASSURANCE RESULTS FROM DOE PROGRAM - 1987

Analysis	Month	EMSL-LV Results	EML Results	Ratio EPA/EML
Be-7 in air	Sept	0.873E+03	0.896E+03	0.97
Zr-95 in air	Sept	0.216E+03	0.188E+03	1.15
Sb-125 in air	Sept	0.610E+03	0.963E+03	0.63
Cs-137 in air	Sept	0.280E+03	0.290E+03	0.97
Ce-144 in air	Sept	0.356E+03	0.406E+03	0.88
Pu-239 in air	Sept	0.510E+01	0.523E+01	0.98
K-40 in soil	Sept	0.239E+02	0.200E+02	1.19
Cs-137 in soil	Sept	0.180E+00	0.211E+00	0.85
Pu-239 in soil	Sept	0.240E-01	0.290E-01	1.17
Cs-137 in tissue	Sept	0.290E+00	0.190E+00	1.53
K-40 in vegetation	Sept	0.169E+03	0.163E+03	1.04
Cs-137 in vegetation	Sept	0.172E+01	0.182E+01	0.95
H-3 in water	Sept	0.184E+02	0.191E+02	0.96
Mn-54 in water	Sept	0.233E+01	0.228E+01	1.02
Co-60 in water	Sept	0.230E+01	0.227E+01	1.01

(continued)

TABLE C.4. Continued

Analysis	Month	EMSL-LV Results	EML Results	Ratio EPA/EML
Sr-90 in water	Sept	0.261E+00	0.252E+00	1.04
Cs-137 in water	Sept	0.223E+01	0.228E+01	0.98
Pu-239 in water	Sept	0.150E+00	0.266E+00	0.56*
Co-57 in water	Sept	0.140E+00	0.142E+00	0.99

*Grand average for all laboratories was 0.185. Therefore, the EMSL-LV result when compared to all other laboratories is 0.15/0.185 = 0.81.

The analytical methods were further checked on by Laboratory participation in the semiannual Department of Energy Quality Assessment Program conducted by the Environmental Measurements Laboratory, New York, N.Y. The results from these tests (Table C.4) indicate that this Laboratory's results were of acceptable quality.

To measure the performance of the contractor laboratory for analysis of animal tissues, a known amount of activity was added to several samples. The reported activity is compared to the known amount in Table C.5. The average bias for plutonium-239 was -24.5 percent. The bias for strontium-90 was a -44 percent for one sample and indeterminate for the other (activity reported was less than naturally present). The average precision determined from two sets of duplicate samples was 150 percent for plutonium-239 and 17 percent for strontium-90.

TABLE C.5. QUALITY ASSURANCE RESULTS FOR THE BIOENVIRONMENTAL PROGRAM - 1987

Sample Type and Shipment Number	Nuclide	Activity Added pCi/g Bone Ash	Activity Reported pCi/g Bone Ash	% Bias+ or Precision‡
		Spiked Samples		
Bone Ash				
Ash C	239Pu	0.082	0.062	-25
74	90Sr	11.2	8.9	-44
Ash D	239Pu	0.086	0.066	-24
74	90Sr	11.6	1.8	Indeterminate
Ash E	239Pu	0	0.9**	
74	90Sr	0	2.3	
Ash F	239Pu	0	-0.0003**	
74	90Sr	0	2.8	
Duplicate Samples				
Bov-1	239Pu		0.003	
	90Sr		0.7	
Bov-1 Dup	239Pu		0.0003**	1.5
	90Sr		0.6	0.14
Bov-2	239Pu		0.0004	
	90Sr		0.4	
Bov-2 Dup	239Pu		0.003	1.4
	90Sr		0.5	0.2

+ Bias (B) = Recovery -1; where recovery is $\frac{x_1}{u}$

and x_1 = net activity reported
u = activity added

‡ Precision $(C_v) = 2\left(\frac{x_1 - x_2}{x_1 + x_2}\right) \times \frac{1}{1.128}$ where x_1 = first value
x_2 = second value

**Counting error exceeds reported activity

APPENDIX D

RADIATION PROTECTION STANDARDS FOR EXTERNAL AND INTERNAL EXPOSURE

DOE EQUIVALENT COMMITMENT

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

	Effective Dose Equivalent*	
	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 proviso that over a lifetime the average exposure does not exceed 100 mrem (1 mSv) per year (ICRP-39).

CONCENTRATION GUIDES

ICRP-30 lists Derived Air Concentrations (DAC) and Annual Limits of Intake (ALI). 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 D-1 were derived in this manner and yield the committed effective dose equivalent (50 year) of 100 mrem/yr for members of the public.

EPA DRINKING WATER GUIDE

In 40 CFR 141 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 20,000 pCi/L (740 Bq/L) and for strontium-90 is 8 pCi/L (0.3 Bq/L).

TABLE D.1. ROUTINE MONITORING FREQUENCY, SAMPLE SIZE, MDC AND CONCENTRATION GUIDES

Nuclide	Sampling Frequency	Locations	Sample Size	Count Time	Concentration Guide*		MDC	MDC as % CG
Air Surveillance Network			m^3	minutes	Bq/m^3	nCi/m^3	mBq/m^3	
Be-7	3/wk	all	160-240	30	2000	50	17	8E-4
Zr-95	3/wk	all	160-240	30	20	0.6	4.1	2E-2
Nb-95	3/wk	all	160-240	30	100	3	1.8	2E-3
Mo-99	3/wk	all	160-240	30	100	3	1.5	2E-3
Ru-103	3/wk	all	160-240	30	60	2	1.8	3E-3
I-131	3/wk	all	160-240	30	4	0.1	1.8	4E-2
Te-132	3/wk	all	160-240	30	18	0.5	1.8	1E-2
Cs-137	3/wk	all	160-240	30	10	0.4	1.8	2E-2
Ba-140	3/wk	all	160-240	30	100	3	4.8	5E-3
La-140	3/wk	all	160-240	30	100	3	2.6	3E-3
Ce-141	3/wk	all	160-240	30	50	1	3.0	6E-3
Ce-144	3/wk	all	160-240	30	1	0.03	12	1.2
Pu-239	3/wk	all	1120	1000	9E-4	2E-5	1.48E-3	2E-1
Gross Beta	3/wk	all	160-240	30	2E-2	0.4E-4	0.11	6E-1

(continued)

TABLE D.1. Continued

Nuclide	Sampling Frequency	Locations	Sample Size	Count Time	Concentration Guide*		MDC	MDC as % CG
Noble Gas Tritium in Air			m^3	Minutes	Bq/m^3	nCi/m^3	mBq/m^3	
H-3	1/wk	17	5	200	7000	190	148	2E-3
Kr-85	1/wk	17	0.4	200	1E5	3000	148	2E-4
Xe-133	1/wk	17	0.4	200	2E4	480	148	7E-4
Xe-135	1/wk	17	0.4	200	2E3	60	148	7E-3
Water Surveillance Network (LTHMP)			Liters	Minutes	Bq/L	pCi/L	Bq/L	
H-3	1/mo	all	1	200	7E2	2E4	12	1.7
H-3 (Enrich)	1/mo	all	0.1	200	7E2	2E4	0.37	5E-2
Sr-89	1st time	all	1	50	600	2E4	0.18	0.03
Sr-90	1st time	all	1	50	0.3	8	0.074	25
Cs-137	1/mo	all	1	100	160	3E3	0.33	0.3
Ra-226	1st time	all	1	1000	5	100	NA	
U-234	1st time	all	1	1000	20	500	NA	
U-235	1st time	all	1	1000	20	600	NA	
U-238	1st time	all	1	1000	20	600	NA	
Pu-238	1st time	all	1	1000	10	400	0.003	0.03

(continued)

TABLE D.1. Continued

Nuclide	Sampling Frequency	Locations	Sample Size	Count Time	Concentration Guide*		MDC	MDC as % CG
Water Surveillance Network (LTHMP)			Liters	Minutes	Bq/L	pCi/L	Bq/L	
Pu-239	1st time	all	1	1000	10	300	0.002	0.02
Gamma	1/mo	all	3.5	30	--	--	0.18	<0.2
Milk Surveillance Network								
H-3	1/mo	all	3.5	200	8E4	2E6	12	2E-2
Cs-137	1/mo	all	3.5	100	100	3E3	0.33	0.3
Sr-89	1/mo	all	3.5	50	600	2E4	0.18	3E-2
Sr-90	1/mo	all	3.5	50	40	1E3	0.074	0.2
Gamma	1/mo	all	3.5	50	--	--	0.18	<0.2
Dosimetry Network			Number		Exposure Guide		MDA	
TLD (Personnel)	1/mo	50	2	--	100mR		2mR	2
TLD (Station)	1/qtr	130	6	--	--		2mR	--
Ion Chamber	weekly	23	2016	--	--		2μR/hr	--

Na - Not Available
*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).

APPENDIX E

DATA SUMMARY FOR THE MONITORING NETWORKS

TABLE E.1. SUMMARY OF ANALYTICAL RESULTS FOR AIR SURVEILLANCE NETWORK CONTINUOUSLY OPERATING STATIONS - 1987

SAMPLING LOCATION	NO. DAYS DETECTED /SAMPLED	RADIO-NUCLIDE	RADIOACTIVITY CONC. (pCi/m^3) MAX	MIN	AVG*
DEATH VALLEY JCT CA	14.9/294.8	7BE	0.81	0.31	0.025
FURNACE CREEK CA	56.6/355.6	7BE	1.9	0.22	0.092
SHOSHONE CA	30.6/347.6	7BE	0.87	0.17	0.041
ALAMO NV	49.1/360.9	7BE	1.5	0.19	0.070
AUSTIN NV	20.0/364.3	7BE	0.64	0.41	0.026
BEATTY NV	24.6/358.7	7BE	1.2	0.23	0.040
STONE CABIN RANCH NV	10.0/355.6	7BE	0.76	0.29	0.012
ELY NV	21.0/361.6	7BE	1.2	0.28	0.030
GOLDFIELD NV	16.8/362.6	7BE	0.73	0.31	0.023
GROOM LAKE NV	39.0/357.0	7BE	0.92	0.11	0.027
HIKO NV	20.9/365.5	7BE	1.2	0.29	0.030
INDIAN SPRINGS NV	24.1/362.8	7BE	0.96	0.32	0.035
LAS VEGAS NV	41.1/361.5	7BE	1.2	0.18	0.067
LATHROP WELLS NV	27.4/359.9	7BE	2.1	0.14	0.057
NYALA NV	10.0/362.0	7BE	1.8	0.60	0.028

(CONTINUED)

TABLE E.1. CONTINUED

SAMPLING LOCATION	NO. DAYS DETECTED /SAMPLED	RADIO-NUCLIDE	RADIOACTIVITY CONC. (pCi/m^3) MAX	MIN	AVG*
OVERTON NV	23.6/356.9	7BE	0.79	0.28	0.032
PAHRUMP NV	35.5/359.7	7BE	0.97	0.092	0.037
PIOCHE NV	16.0/361.4	7BE	0.63	0.35	0.022
SCOTTY'S JCT NV	43.0/366.0	7BE	0.91	0.25	0.055
SUNNYSIDE NV	19.6/361.2	7BE	0.79	0.29	0.026
RACHEL NV - ROBINSON TRAILER P	28.3/350.3	7BE	0.95	0.14	0.035
TONOPAH NV	10.9/362.0	7BE	2.6	0.14	0.030
TTR NV	156.6/346.0	7BE	0.45	0.053	0.092
FALLINI'S (TWIN SPGS) RANCH NV	26.8/353.9	7BE	1.8	0.19	0.047
CEDAR CITY UT	48.1/364.6	7BE	1.2	0.27	0.063
DELTA UT	24.2/355.2	7BE	0.58	0.17	0.022
MILFORD UT	20.5/350.6	7BE	2.0	0.43	0.041
ST GEORGE UT	39.6/365.9	7BE	1.4	0.22	0.058
SALT LAKE CITY UT	66.0/363.9	7BE	1.6	0.25	0.11

* AVERAGE MEANS TIME WEIGHTED AVERAGE OVER SAMPLING TIME.

THE FOLLOWING STATIONS HAD NEGLIGIBLE GAMMA-SPECTRA:
CURRANT NV - BLUE EAGLE RANCH

TABLE E.2. SUMMARY OF ANALYTICAL RESULTS FOR AIR SURVEILLANCE NETWORK STANDBY STATIONS OPERATED 1 OR 2 WEEKS PER QUARTER - 1987

SAMPLING LOCATION	NO. DAYS DETECTED /SAMPLED	RADIO-NUCLIDE	RADIOACTIVITY CONC. (pCi/m^3) MAX	MIN	AVG*
KINGMAN AZ	2.0/26.2	7BE	0.81	0.81	0.062
WINSLOW AZ	2.0/28.0	7BE	0.49	0.49	0.035
YUMA AZ	2.1/37.6	7BE	0.32	0.32	0.017
LITTLE ROCK AR	2.2/28.2	7BE	0.39	0.39	0.030
BAKER CA	3.0/29.0	7BE	1.5	1.5	0.15
BISHOP CA	4.0/24.1	7BE	0.46	0.46	0.077
RIDGECREST CA	2.1/33.6	7BE	0.41	0.41	0.025
DENVER CO	3.0/28.1	7BE	0.34	0.34	0.036
GRAND JUNCTION CO	2.1/30.2	7BE	0.38	0.38	0.027
IOWA CITY IA	3.0/34.7	7BE	0.67	0.67	0.057
MONROE LA	2.0/27.9	7BE	0.68	0.68	0.049
ST JOSEPH MO	8.8/35.3	7BE	0.29	0.29	0.071
KALISPELL MT	3.0/28.1	7BE	0.63	0.63	0.066
ADAVEN (CANFIELD'S RANCH) NV	1.8/37.1	7BE	0.94	0.94	0.045
CRYSTAL NV	1.1/23.3	7BE	0.35	0.35	0.017
CALIENTE NV	24.4/135.7	7BE	1.4	0.21	0.10
CURRIE NV	3.0/28.6	7BE	0.23	0.23	0.025
LOVELOCK NV	2.0/26.7	7BE	0.31	0.31	0.023
LUND NV	3.1/26.3	7BE	0.60	0.60	0.070
WINNEMUCCA NV	3.1/30.2	7BE	0.54	0.54	0.056
ALBUQUERQUE NM	2.0/28.6	7BE	0.57	0.57	0.040

(CONTINUED)

TABLE E.2. CONTINUED

SAMPLING LOCATION	NO. DAYS DETECTED /SAMPLED	RADIO-NUCLIDE	RADIOACTIVITY CONC. (pCi/m^3) MAX	MIN	AVG*
CARLSBAD NM	8.9/27.9	7BE	0.30	0.26	0.085
MUSKOGEE OK	4.0/28.0	7BE	0.17	0.17	0.025
MIDLAND TX	2.1/27.9	7BE	0.66	0.66	0.049
BRYCE CANYON UT	1.9/24.1	7BE	0.30	0.30	0.024
PAROWAN UT	2.0/33.0	7BE	0.73	0.73	0.045
WENDOVER UT	5.0/32.0	7BE	0.57	0.34	0.068

*AVG MEANS TIME-WEIGHTED AVERAGE OVER SAMPLING TIME.

THE FOLLOWING STATIONS HAD NEGLIGIBLE GAMMA-SPECTRA:

GLOBE AZ
TUCSON AZ
ALTURAS CA
CHICO CA
INDIO CA
LONE PINE CA
NEEDLES CA
SANTA ROSA CA
CORTEZ CO
MOUNTAIN HOME ID
NAMPA ID
POCATELLO ID
FORT DODGE IA
DODGE CITY KS
MINNEAPOLIS MN
CLAYTON MO
JOPLIN MO
GREAT FALLS MT
MILES CITY MT
BISMARK ND
FARGO ND
WILLISTON ND
NORTH PLATTE NE
SHIPROCK NM
AMARGOSA FARM AREA NV
BATTLE MOUNTAIN NV
BLUE JAY NV
CLARK STATION NV
CURRANT NV - ANGLE WORM RANCH
DUCKWATER NV
ELKO NV
EUREKA NV
FALLON NV
GEYSER RANCH NV
MESQUITE NV
RENO NV
ROUND MOUNTAIN NV
WARM SPRINGS NV
WELLS NV
MEDFORD OR
BURNS OR
RAPID CITY SD
AMARILLO TX
AUSTIN TX
TYLER TX
ENTERPRISE UT
GARRISON UT
LOGAN UT
VERNAL UT
SEATTLE WA
SPOKANE WA
ROCK SPRINGS WY
WORLAND WY

TABLE E.3. 1987 SUMMARY OF GROSS BETA ANALYSES FOR AIR SURVEILLANCE NETWORK

SAMPLING LOCATION	NO. DAYS SAMPLED	RADIOACTIVITY CONC. (pCi/m^3) MAX	MIN	AVG
SHOSHONE CA	347.6	0.030	0.00052	0.0090
LAS VEGAS NV	361.5	0.026	0.00023	0.0090
DELTA UT	355.2	0.030	0.00024	0.0097
MILFORD UT	336.9	0.053	0.00030	0.010
ST GEORGE UT	365.9	0.037	0.00020	0.0091

TABLE E.4. SUMMARY OF PLUTONIUM CONCENTRATIONS AT SELECTED AIR SURVEILLANCE NETWORK STATIONS - 1987

SAMPLING LOCATION	NO. DAYS SAMPLED	RADIO-NUCLIDE	RADIOACTIVITY CONC. (aCi/m^3)* MAX	MIN	AVG	PERCENT CONC. GUIDE
WINSLOW/TUCSON, AZ	48.7	238PU	19	-17	-3.2	<0.01
	48.7	239PU	12	-12	2.2	0.01
BISHOP/RIDGECREST, CA	57.7	238PU	12	-8.5	0.36	<0.01
	57.7	239PU	7.2	-5.3	2.4	0.01
DENVER/CORTEZ, CO	57.2	238PU	12	-14	-1.2	<0.01
	57.2	239PU	20	-2.8	7.7	0.04
NAMPA/MOUNTAIN HOME, ID	57.5	238PU	27	-6.9	4.4	0.02
	57.5	239PU	16	-5.4	3.3	0.02
CLAYTON/JOPLIN, MO	37.2	238PU	20	-6.3	3.8	0.02
	37.2	239PU	3.0	-3.2	-0.67	<0.01
GREAT FALLS/MILES CITY, MT	60.2	238PU	11	-1.9	4.3	0.02
	60.2	239PU	4.1	-3.7	1.6	<0.01
LAS VEGAS, NV	361.6	238PU	22	-10	-1.1	<0.01
	361.6	239PU	7.2	-8.1	1.8	<0.01
LATHROP WELLS, NV	360.9	238PU	15	-10	-0.59	<0.01
	360.9	239PU	8.6	-5.7	-0.78	<0.01
RACHEL, NV - ROBINSON TRAILER P	354.0	238PU	11	-14	-2.9	<0.01
	354.0	239PU	14	-2.3	2.9	0.01
ALBUQUERQUE/CARLSBAD, NM	56.5	238PU	19	-8.9	3.5	0.02
	56.5	239PU	5.4	-1.8	1.1	<0.01
BISMARCK/FARGO, ND	58.7	238PU	20	-6.3	0.72	<0.01
	58.7	239PU	1.4	-9.2	-2.5	<0.01
BURNS/MEDFORD, OR	53.3	238PU	19	-10	4.5	0.02
OR	53.3	239PU	39	-23	-3.6	<0.01
AUSTIN/AMARILLO, TX	60.8	238PU	-0.92	-25	-9.0	<0.01
	60.8	239PU	12	-1.6	3.4	0.02
LOGAN/VERNAL, UT	63.9	238PU	-0.93	-17	-11	<0.01
	63.9	239PU	8.6	-12	-4.8	<0.01

(CONTINUED)

TABLE E.4. CONTINUED

SAMPLING LOCATION	NO. DAYS SAMPLED	RADIO-NUCLIDE	RADIOACTIVITY CONC. (aCi/m^3)* MAX	MIN	AVG	PERCENT CONC. GUIDE
SALT LAKE CITY, UT	338.1	238PU	16	-7.6	-0.023	<0.01
	338.1	239PU	3.5	-4.6	-0.70	<0.01
SEATTLE/SPOKANE, WA	56.0	238PU	11	-7.6	-0.39	<0.01
	56.0	239PU	4.3	-1.7	2.3	0.01
WORLAND/ROCK SPRINGS, WY	55.7	238PU	4.9	-5.6	-0.40	<0.01
	55.7	239PU	6.9	-4.0	0.60	<0.01

*ALL RESULTS LESS THAN MDC. DEPENDING UPON GEOMETRY OF ANALYSIS AND COUNTING TIMES, MDC'S VARIED FROM -0.09 to 48 aCi/m^3.

TABLE E.5. SUMMARY OF ANALYTICAL RESULTS FOR THE NOBLE GAS AND TRITIUM SURVEILLANCE NETWORK - 1987

SAMPLING LOCATION	NUMBER SAMPLES POSITIVE/ NEGATIVE	RADIONUCLIDE	RADIOACTIVITY CONC. (pCi/m^3)* MAX	MIN	AVG	PERCENT CONC. GUIDE+
MAMMOTH LAKES CALIF.	22/2	85KR	29	22	26	0.03
	24/0	133XE	8.3	-6.2	1.5	<0.01
SHOSHONE, CALIF.	50/2	85KR	31	19	26	0.03
	50/2	133XE	7.1	-7.8	0.77	<0.01
	49/0	3H IN ATM. M.*	0.65	-0.37	0.095	-
	49/0	3H AS HTO IN AIR	6.7	-5.3	0.63	<0.01
ALAMO, NEV.	47/5	85KR	30	21	26	0.03
	46/6	133XE	9.3	-13	1.1	<0.01
	47/2	3H IN ATM. M.*	0.80	-0.86	0.076	-
	47/2	3H AS HTO IN AIR	7.5	-6.6	0.63	<0.01
AUSTIN, NEV.	39/13	85KR	31	21	25	0.02
	39/13	133XE	15	-10	0.89	<0.01
	46/3	3H IN ATM. M.*	0.75	-0.52	0.10	-
	46/3	3H AS HTO IN AIR	3.2	-3.1	0.50	<0.01
BEATTY, NEV.	39/13	85KR	30	21	26	0.03
	40/12	133XE	33	-14	1.1	<0.01
	48/0	3H IN ATM. M.*	0.84	-0.46	0.10	-
	48/0	3H AS HTO IN AIR	6.1	-2.6	0.64	<0.01
CALIENTE, NEV.	17/0	3H IN ATM. M.*	1.3	-0.43	0.032	-
	17/0	3H AS HTO IN AIR	7.0	-4.1	-0.082	<0.01
ELY, NEV.	48/4	85KR	30	20	25	0.03
	47/5	133XE	20	-11	1.9	<0.01
	48/1	3H IN ATM. M.*	0.77	-0.72	0.090	-
	47/2	3H AS HTO IN AIR	14	-6.6	0.97	<0.01
GOLDFIELD, NEV.	42/10	85KR	29	21	25	0.03
	47/5	133XE	26	-16	1.8	<0.01
	46/3	3H IN ATM. M.*	0.65	-0.87	0.058	-
	46/3	3H AS HTO IN AIR	3.9	-3.4	0.23	<0.01
INDIAN SPRINGS, NEV.	42/11	85KR	34	20	26	0.03
	44/9	133XE	27	-7.0	0.98	<0.01
	49/0	3H IN ATM. M.*	0.64	-0.33	0.13	-
	49/0	3H AS HTO IN AIR	8.4	-2.3	0.88	<0.01

(CONTINUED)

TABLE E.5. CONTINUED

SAMPLING LOCATION	NUMBER SAMPLES POSITIVE/ NEGATIVE	RADIONUCLIDE	RADIOACTIVITY CONC. (pCi/m^3)* MAX	MIN	AVG	PERCENT CONC. GUIDE+
LAS VEGAS, NEV.	47/5	85KR	30	20	26	0.03
	48/4	133XE	7.3	-6.9	1.1	<0.01
	49/0	3H IN ATM. M.*	0.61	-0.83	0.060	-
	49/0	3H AS HTO IN AIR	4.2	-6.2	0.50	<0.01
LATHROP WELLS, NEV.	46/6	85KR	30	20	25	0.02
	44/8	133XE	7.7	-15	0.24	<0.01
	47/2	3H IN ATM. M.*	1.1	-0.56	0.17	-
	47/2	3H AS HTO IN AIR	16	-4.4	1.3	<0.01
OVERTON, NEV.	47/5	85KR	33	20	25	0.03
	48/4	133XE	16	-12	0.49	<0.01
	47/2	3H IN ATM. M.*	0.88	-0.68	0.049	-
	47/2	3H AS HTO IN AIR	17	-11	0.92	<0.01
PAHRUMP, NEV.	50/1	85KR	30	21	26	0.03
	49/2	133XE	18	-7.4	1.0	<0.01
	49/0	3H IN ATM. M.*	0.63	-0.42	0.043	-
	49/0	3H AS HTO IN AIR	3.3	-5.2	0.092	<0.01
PIOCHE, NEV.	9/0	85KR	29	25	26	0.03
	9/0	133XE	9.7	-5.4	-0.18	<0.01
	48/1	3H IN ATM. M.*	1.2	-0.89	0.12	-
	48/1	3H AS HTO IN AIR	4.9	-4.7	0.82	<0.01
RACHEL, NEV.	44/7	85KR	29	20	25	0.03
	47/4	133XE	9.2	-13	0.35	<0.01
	46/3	3H IN ATM. M.*	0.51	-0.76	0.050	-
	46/3	3H AS HTO IN AIR	5.6	-5.7	0.29	<0.01
TONOPAH, NEV.	45/6	85KR	30	20	26	0.03
	43/8	133XE	9.3	-9.5	1.8	<0.01
	48/1	3H IN ATM. M.*	0.69	-0.68	0.078	-
	48/1	3H AS HTO IN AIR	5.0	-3.5	0.77	<0.01
CEDAR CITY, UTAH	42/10	85KR	31	21	26	0.03
	44/8	133XE	15	-7.2	1.5	<0.01
	48/1	3H IN ATM. M.*	0.72	-1.0	0.036	-
	48/1	3H AS HTO IN AIR	5.6	-5.5	0.30	<0.01

(CONTINUED)

TABLE E.5. CONTINUED

SAMPLING LOCATION	NUMBER SAMPLES POSITIVE/ NEGATIVE	RADIONUCLIDE	RADIOACTIVITY CONC. (pCi/m^3)* MAX	MIN	AVG	PERCENT CONC. GUIDE+
ST GEORGE, UTAH	41/10	85KR	31	20	25	0.02
	42/9	133XE	13	-11	0.41	<0.01
	41/8	3H IN ATM. M.*	0.69	-0.35	0.078	-
	41/8	3H AS HTO IN AIR	6.1	-3.1	0.60	<0.01
SALT LAKE CITY, UTAH	43/9	3H IN ATM. M.*	0.65	-0.87	0.12	-
	43/9	3H AS HTO IN AIR	4.8	-8.9	0.70	<0.01

* CONCENTRATIONS OF TRITIUM IN ATMOSPHERIC MOISTURE (ATM. M.) ARE EXPRESSED AS pCi PER ML OF WATER COLLECTED.

+ CONCENTRATION GUIDES USED ARE FOR EXPOSURE TO A SUITABLE SAMPLE OF THE POPULATION IN AN UNCONTROLLED AREA.

TABLE E.6. LTHMP TRITIUM RESULTS FOR THE MONTHLY NTS NETWORK FOR 1987

SAMPLING LOCATION	NO. SAMPLES	TRITIUM CONCENTRATION (pCi/L) MAX	MIN	AVG	PERCENT CONC. GUIDE
WELL 1 ARMY	10	15	-6.4	0.43	<0.01
WELL 2	12	12	-4.2	1.8	<0.01
WELL 3	12	14	-4.9	3.8	0.02
WELL 4	12	12	-7.5	0.44	<0.01
WELL 4 CP-1	11	18	-6.1	1.9	<0.01
WELL 5C	10	7.5	-4.0	0.42	<0.01
WELL 8	12	16	-5.5	2.2	0.01
WELL 20	11	18	-3.0	4.7	0.02
WELL A	12	51	13	27	0.1
WELL B TEST	8	160	120	140	0.7
WELL C	12	49	7.2	23	0.1
WELL J-13	11	4.4	-8.9	-1.9	<0.01
WELL U19C	11	8.9	-5.7	1.1	<0.01
WELL UE7NS	9	3500	2400	2800	10
WELL UE18R	9	8.6	-3.8	2.6	<0.02

TABLE E.7. TRITIUM RESULTS FOR THE LONG-TERM HYDROLOGICAL MONITORING PROGRAM - 1987

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
<u>NEVADA TEST SITE NETWORK</u>			
SHOSHONE, CA	01/07	23 ± 210*	0.1
SHOSHONE SPRING	06/02	0 ± 7.8*	<0.01
ADAVEN, NV	05/06	68 ± 8	0.3
ADAVEN SPRING	10/01	41 ± 230*	0.2
	11/01	67 ± 8	0.3
ALAMO, NV	04/07	7.2 ± 8.3*	0.04
WELL 4 CITY	09/08	-250 ± 250*	<0.01
ASH MEADOWS, NV			
CRYSTAL POOL	02/19	3.7 ± 5.6*	0.02
	07/10	86 ± 200*	0.4
FAIRBANKS SPRINGS	03/11	4.5 ± 8.1*	0.02
	08/10	260 ± 260*	1
WELL 17S-50E-14CAC	02/19	-4.2 ± 8.6*	<0.01
	07/10	86 ± 200*	0.4
WELL 18S-51E-7DB	02/19	3.8 ± 8.8*	0.02
	07/10	45 ± 200*	0.2
BEATTY, NV			
SPECIE SPRINGS	01/13	56 ± 8	0.3
	08/13	180 ± 260*	0.9
TOLICHA PEAK	02/18	-2.9 ± 8.3*	<0.01
	07/09	-9.6 ± 200*	<0.01
USECOLOGY	01/06	4.1 ± 11*	0.02
WELL 11S-48-1DD COFFERS	02/18	-3.1 ± 9.3*	<0.01
	07/09	79 ± 200*	0.4
WELL 12S-47E-7DBD CITY	03/12	7.7 ± 8.1*	0.04
	08/12	320 ± 260*	2
WELL ROAD D SPICERS	02/18	-1.7 ± 8.3*	<0.01
	07/09	-89 ± 200*	<0.01

(CONTINUED)

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
BEATTY, NV			
YOUNGHANS RCH	04/07	160 ± 200*	0.8
	05/06	48 ± 8	0.2
	06/02	0.80 ± 8.1*	<0.01
	07/10	9.1 ± 8.9*	0.05
	08/13	10 ± 10*	0.05
	10/07	5.5 ± 9.6*	0.03
	11/06	4.4 ± 9.1*	0.02
BOULDER CITY NV	03/19	120 ± 9	0.6
LAKE MEAD INTAKE	08/14	310 ± 260*	2
CLARK STATION NV	05/15	25 ± 8	0.1
WELL 6 TTR	10/14	99 ± 230*	0.5
HIKO NV	04/08	0.67 ± 11*	<0.01
CRYSTAL SPRINGS	09/02	-140 ± 250*	<0.01
INDIAN SPRINGS NV			
WELL 1 SEWER COMPANY	01/07	-2.7 ± 8.6*	<0.01
	06/02	-220 ± 250*	<0.01
WELL 2 US AIR FORCE	01/07	9.4 ± 12*	0.05
	06/02	-82 ± 250*	<0.01
LAS VEGAS, NV	01/12	98 ± 210*	0.5
WELL 28 WATER DISTRICT	06/08	0.80 ± 8.0*	<0.01
LATHROP WELLS, NV	01/09	3.0 ± 8.6*	0.01
CITY 15S-50E-18CDC	06/04	330 ± 250*	2
NYALA, NV	04/01	6.9 ± 8.2*	0.03
SHARP'S RANCH	09/08	-37 ± 250*	<0.01
OASIS VALLEY, NV	03/12	7.7 ± 8.3*	0.04
GOSS SPRINGS	08/13	220 ± 260*	1
PAHRUMP, NV	05/07	21 ± 8	0.1
WELL 3 CALVADA	10/16	70 ± 230*	0.3
RACHEL, NV			
HEIZER'S COMPLEX	06/16	31 ± 8	0.2 (1)

(CONTINUED)

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
RACHEL, NV			
WELLS 7 AND 8 PENOYER	04/13	3.5 ± 8.2*	
WELL 13 PENOYER	04/13	2.1 ± 8.2*	0.01
WELL PENOYER CULINARY	02/03	-0.72 ± 8.4*	
	07/08	100 ± 200*	
TEMPIUTE, NV	01/13	120 ± 210*	0.6
UNION CARBIDE WELL	06/02	0.81 ± 8.0*	<0.01
TONOPAH, NV	05/14	24 ± 8	0.1
CITY WELL	10/15	130 ± 230*	0.6
WARM SPRINGS, NV	04/01	3.1 ± 8.8*	0.02
TWIN SPRINGS RANCH	09/08	89 ± 250*	0.4
NTS, NV			
WELL 5B	02/06	35 ± 230*	0.2
	07/09	-5.5 ± 9.5*	<0.01
WELL C-1	02/05	73 ± 230*	0.4
	07/08	4.3 ± 9.3*	0.02
WELL D TEST	03/10	94 ± 200*	0.5
	08/19	5.9 ± 10*	0.03
WELL UE1C	03/10	54 ± 200*	0.3
	08/18	7.0 ± 9.9*	0.04
WELL UE15D	02/05	85 ± 230*	0.4
	06/10	-3.2 ± 7.9*	<0.01
WELL UE16D	02/05	-100 ± 230*	<0.01
	07/08	10 ± 9*	0.05

(CONTINUED)

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
BACKGROUND SAMPLES - AMCHITKA, AK			
AMCHITKA AK			
CLEVENGER LAKE	08/27	35 ± 8	0.2 (2)
CONSTANTINE SPRING	08/27	56 ± 8	0.3
DUCK COVE CREEK	08/27	29 ± 8	0.1
JONES LAKE	08/27	25 ± 8	0.1
RAIN SAMPLE	08/29	17 ± 8	0.08
	08/29	15 ± 8	0.08
	09/01	25 ± 8	0.1
SITE D HYDRO EXPLORE HOLE	08/28	63 ± 8	0.3
WELL ARMY 1	08/27	44 ± 7	0.2
WELL ARMY 2	08/28	26 ± 7	0.1
WELL ARMY 4	08/28	63 ± 7	0.3
PROJECT CANNIKIN - AMCHITKA, AK			
AMCHITKA AK			
CANNIKIN LAKE (NORTH END)	08/28	38 ± 8	0.2
CANNIKIN LAKE (SOUTH END)	08/28	37 ± 8	0.2
DECON POND	08/31	19 ± 9	0.09 (3)
DECON SUMP	08/31	18 ± 9	0.09
DK-45 LAKE	08/28	38 ± 8	0.2
ICE BOX LAKE	08/28	27 ± 8	0.1
PIT SOUTH OF CANNIKIN GZ	08/28	39 ± 9	0.1
WELL HTH-3	08/28	29 ± 9	0.1
WHITE ALICE CREEK	08/28	36 ± 8	0.2

(CONTINUED)

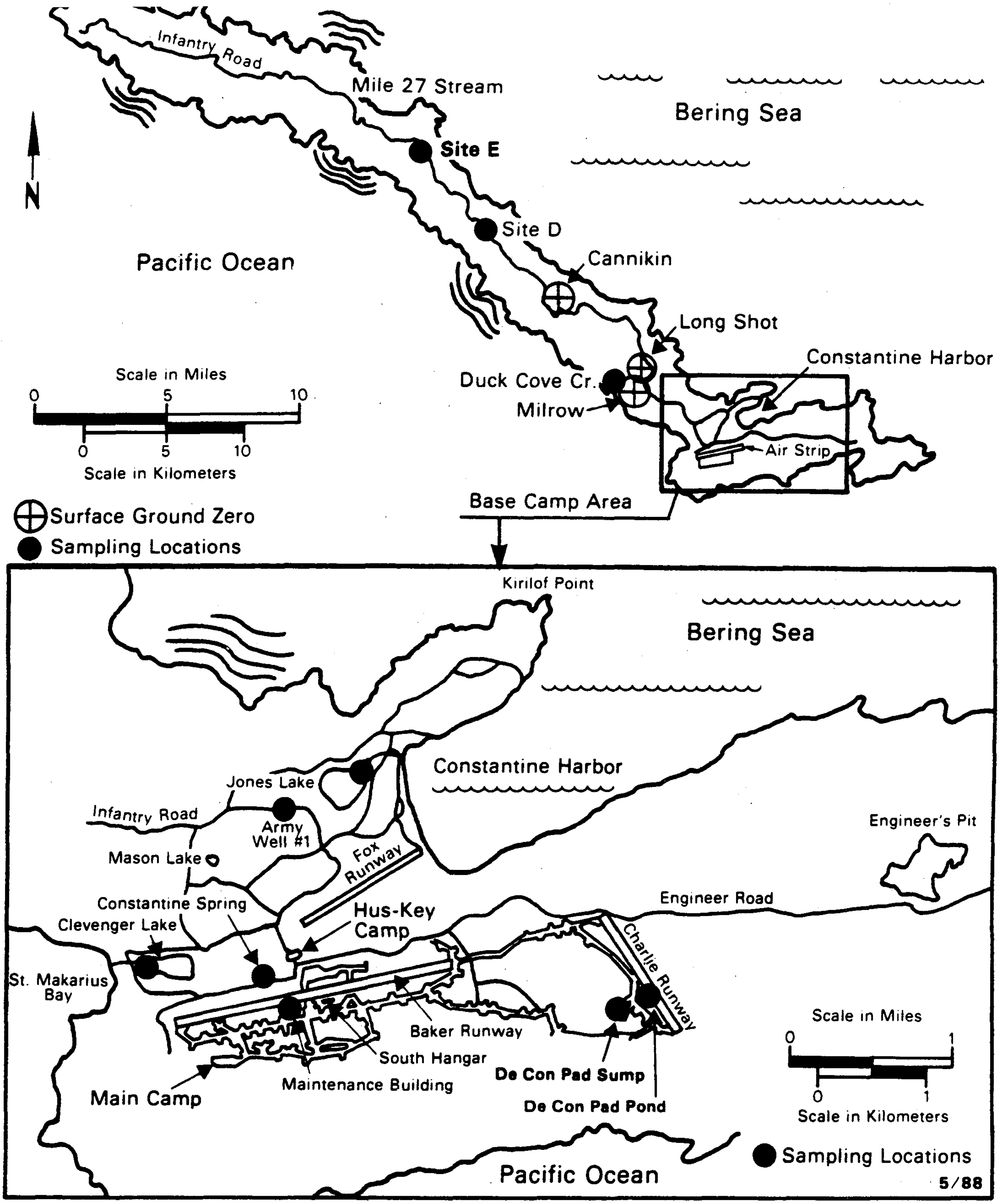


Figure E-1. Amchitka Island and background sampling locations for the LTHMP.

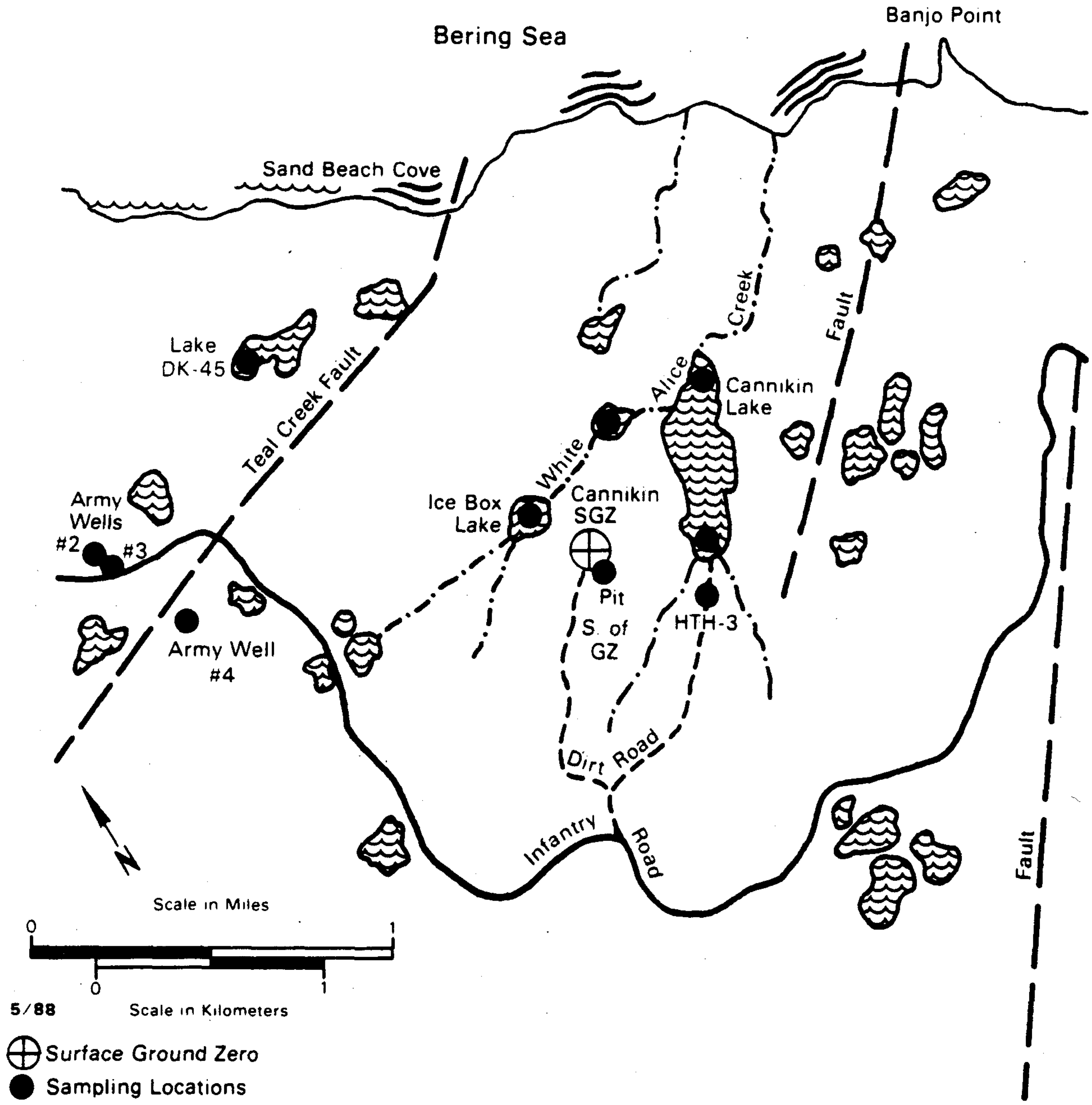


Figure E-2. LTHMP sampling locations for Project Cannikin.

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
PROJECT LONGSHOT - AMCHITKA, AK			
AMCHITKA AK			
LONG SHOT POND 1	08/28	25 ± 8	0.1
LONG SHOT POND 2	08/28	28 ± 8	0.1
LONG SHOT POND 3	08/28	41 ± 8	0.2
MUD PIT NO.1	08/28	250 ± 9	1
MUD PIT NO.2	08/28	310 ± 9	2
MUD PIT NO.3	08/28	470 ± 10	2
REED POND	08/28	28 ± 8	0.1
STREAM EAST OF LONGSHOT	08/28	230 ± 9	1
WELL EPA-1	08/28	67 ± 10	0.3
WELL GZ NO. 1	08/28	2400 ± 230	10
WELL GZ NO. 2	08/28	22 ± 9	0.1
WELL WL-2	08/28	76 ± 9	0.4
PROJECT MILROW - AMCHITKA, AK			
AMCHITKA K			
CLEVENGER CREEK	08/27	36 ± 9	0.2
HEART LAKE	08/27	22 ± 8	0.1
WELL W-2	08/27	26 ± 8	0.1
WELL W-3	08/27	29 ± 8	0.1
WELL W-4	08/27	46 ± 9	0.2
WELL W-6	08/27	41 ± 8	0.2
WELL W-7	08/27	48 ± 8	0.2

(CONTINUED)

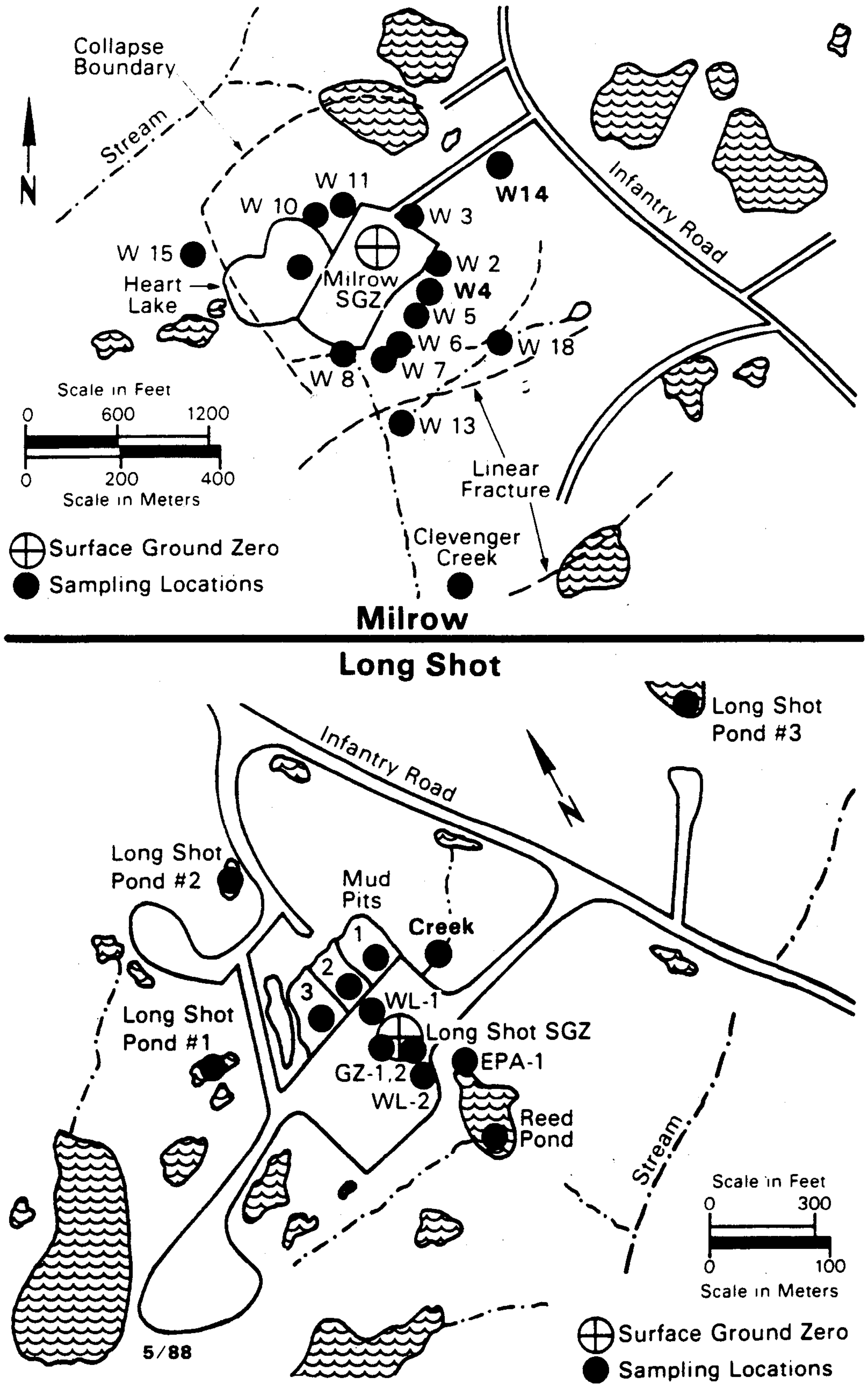


Figure E-3. LTHMP sampling locations for Projects Milrow and Long Shot.

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
PROJECT MILROW - AMCHITKA, AK (CONT)			
AMCHITKA K			
WELL W-8	08/27	43 ± 8	0.2
WELL W-10	08/27	33 ± 9	0.2
WELL W-11	08/27	100 ± 9	0.5
WELL W-13	08/27	53 ± 8	0.3
WELL W-14	08/27	18 ± 8	0.09
WELL W-15	08/27	18 ± 8	0.09
WELLS W-5, W-9, W-12 AND W-16, to W-19 NOT SAMPLED			
PROJECT RIO BLANCO - COLORADO			
RIO BLANCO CO			
B-1 EQUITY CAMP	07/25	96 ± 8	0.5
BRENNAN WINDMILL	07/26	11 ± 8*	0.05
CER NO.1 BLACK SULPHUR	07/25	90 ± 8	0.5
CER NO.4 BLACK SULPHUR	07/25	77 ± 8	0.4
FAWN CREEK 1	07/26	70 ± 10	0.4
FAWN CREEK 3	07/26	56 ± 7	0.3
FAWN CREEK 6800FT UPSTR	07/26	62 ± 8	0.3
FAWN CREEK 500FT UPSTRE	07/26	61 ± 7	0.3
FAWN CREEK 500FT DOWNST	07/26	120 ± 8	0.6
FAWN CREEK 8400FT DOWNS	07/26	56 ± 8	0.3
WELL JOHNSON ARTESIAN	07/26	3.6 ± 8.3*	0.2

(CONTINUED)

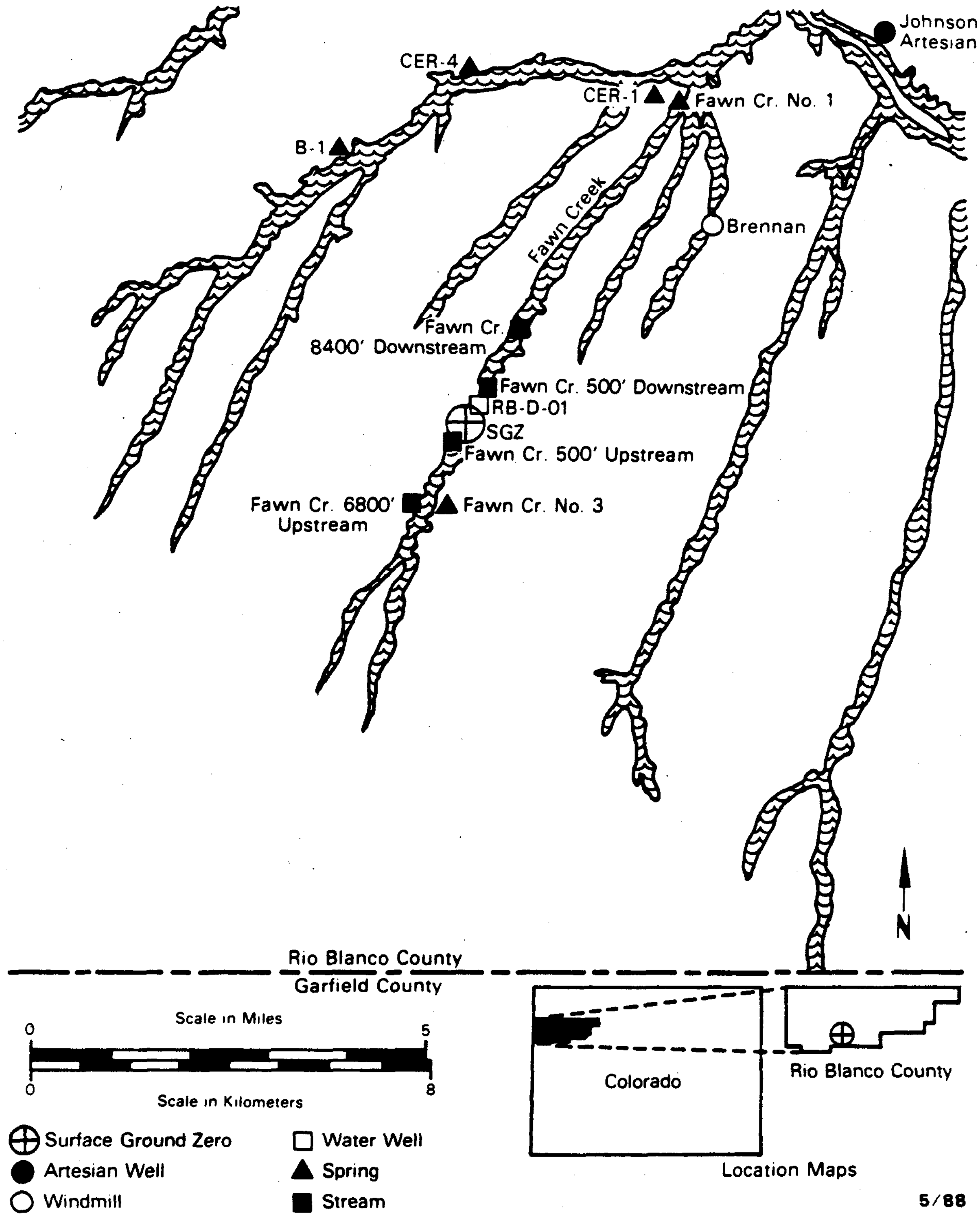


Figure E-4. LTHMP sampling locations for Project Rio Blanco.

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
PROJECT RIO BLANCO - COLORADO (CONT)			
RIO BLANCO CO			
WELL RB-D-01	07/25	2.8 ± 9.7*	0.01
WELL RB-D-03	07/29	3.3 ± 9.1*	0.02 (4)
WELL RB-S-03	07/29	14 ± 8	0.07 (5)
PROJECT RULISON - COLORADO			
GRAND VALLEY, CO			
BATTLEMENT CREEK	07/27	100 ± 8	0.5
CITY SPRINGS	07/27	-0.13 ± 8.2*	<0.01
ALBERT GARDNER RANCH	07/27	170 ± 8	0.8
SPRING 300 YRDS NW OF G	07/27	87 ± 8	0.4
WELL CER TEST	07/27	160 ± 9	0.8
RULISON, CO			
LEE HAYWARD RANCH	07/27	220 ± 8	1
POTTER RANCH	07/27	120 ± 8	0.6
ROBERT SEARCY RANCH	07/27	160 ± 9	0.8
FELIX SEFCOVIC RANCH	07/27	170 ± 8	0.8
PROJECT DRIBBLE - MISSISSIPPI			
BAXTERVILLE, MS			
HALF MOON CREEK	05/07	39 ± 8	0.2
	05/07	48 ± 8	0.2
HALF MOON CREEK OVERFLOW	05/07	46 ± 8	0.2
	05/07	36 ± 8	0.2
LOWER LITTLE CREEK	05/06	53 ± 8	0.3
POND WEST OF GZ	05/07	34 ± 8	0.2
	05/07	41 ± 8	0.2

(CONTINUED)

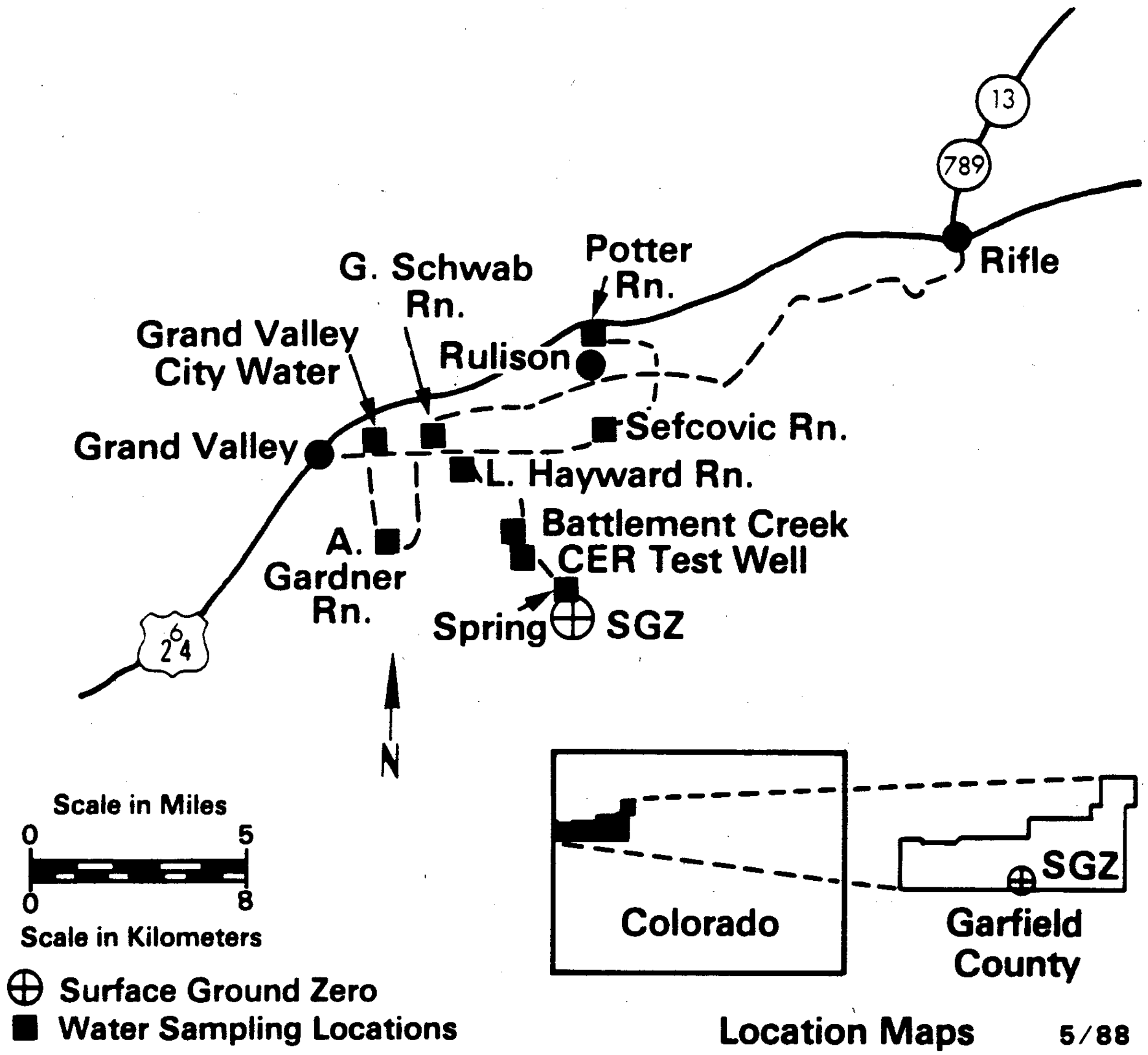


Figure E-5. LTHMP sampling locations for Project Rulison.

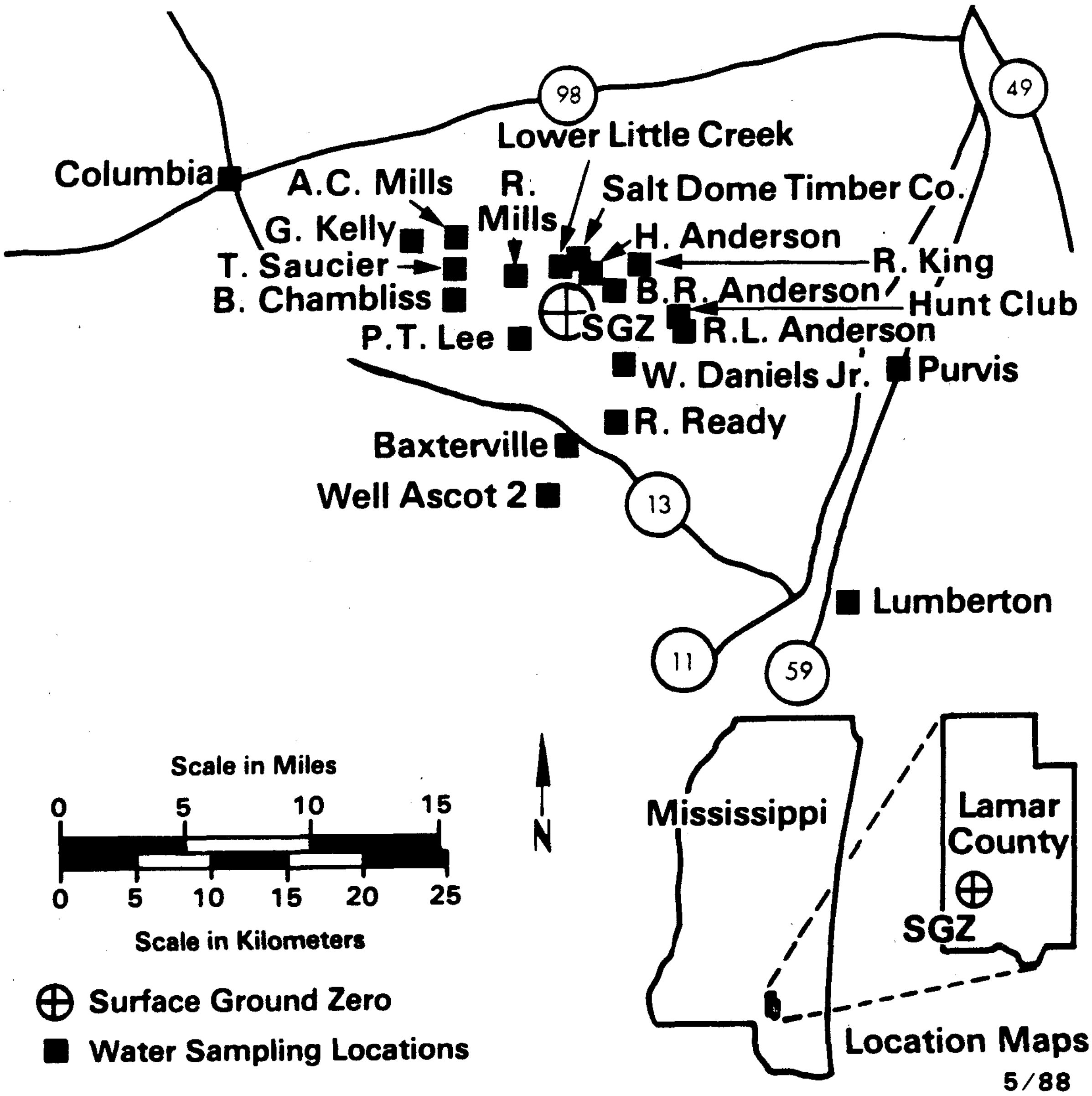


Figure E-6. LTHMP sampling locations for Project Dribble - towns and residences.

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
<u>PROJECT DRIBBLE - MISSISSIPPI</u> (CONT)			
BAXTERVILLE, MS			
REECO PIT DRAINAGE A	05/06	27 ± 9	0.1
REECO PIT DRAINAGE-B	05/06	7800 ± 260	40
REECO PIT DRAINAGE-C	05/06	550 ± 10	3
SALT DOME HUNTING CLUB	05/07	44 ± 8	0.2 (6)
SALT DOME TIMBER CO.	05/06	28 ± 8	0.1
ANDERSON, B. R.	05/07	29 ± 8	0.1
ANDERSON, H.	05/07	34 ± 8	0.2
ANDERSON, R. L.	05/06	44 ± 8	0.2
CHAMBLISS, B.	05/06	7.0 ± 9.6*	0.04
DANIELS, W. JR.	05/06	38 ± 8	0.2
KELLY, G.	05/06	7.3 ± 8.5*	0.04
KING, RHONDA	05/06	26 ± 8	0.1 (7)
LEE, P. T.	05/06	49 ± 9	0.2
MILLS, A. C.	05/06	1.9 ± 8.4*	<0.01
MILLS, R.	05/06	45 ± 8	0.2
READY, R.	05/06	75 ± 8	0.4
SAUCIER, T. S.	05/06	44 ± 8	0.2
WELL ASCOT 2	05/06	39 ± 8	0.2
WELL CITY	05/07	46 ± 8	0.2
WELL E-7	05/08	12 ± 9*	0.06

(CONTINUED)

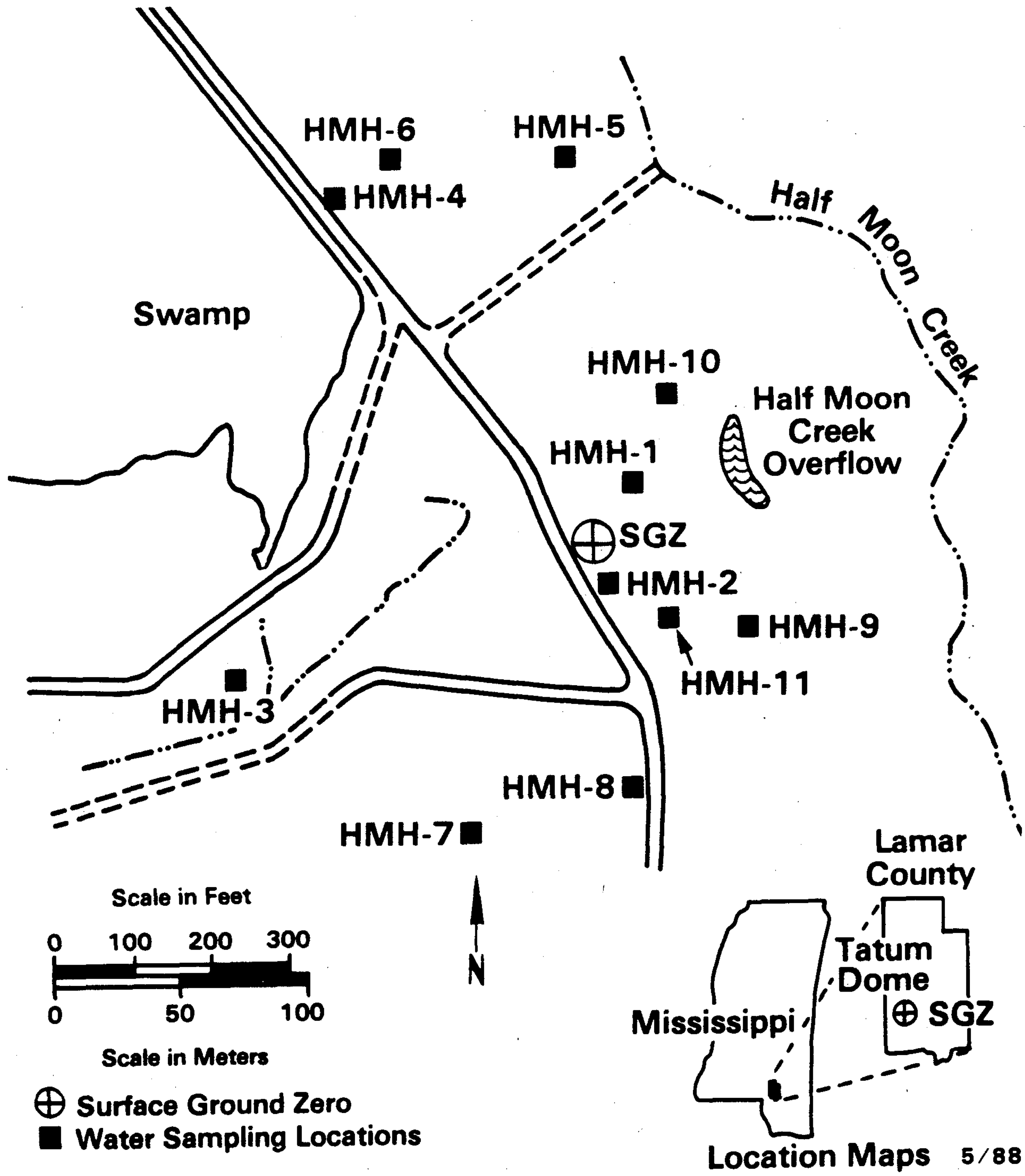


Figure E-7. LTHMP sampling locations for Project Dribble - near GZ.

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
PROJECT DRIBBLE - MISSISSIPPI (CONT)			
BAXTERVILLE, MS			
WELL HM-1	05/07	-0.63 ± 9.1*	<0.01
	05/07	-1.6 ± 10*	<0.01
WELL HM-2A	05/07	4.6 ± 9.1*	0.02
	05/07	3.3 ± 9.8*	0.02
WELL HM-2B	05/07	7.1 ± 9.5*	0.04
	05/07	-2.0 ± 9.3*	<0.01
WELL HM-3	05/07	1.1 ± 9.2*	<0.01
	05/07	-2.3 ± 9.1*	<0.01
WELL HM-L	05/07	1100 ± 210	6
	05/07	1400 ± 210	7
WELL HM-L2	05/07	-4.2 ± 9.3*	<0.01
	05/07	2.5 ± 9.8*	0.01
WELL HM-S	05/07	11000 ± 290	60
	05/07	11000 ± 43	60
WELL HMH-1	05/06	23000 ± 360	100
WELL HMH-2	05/06	33000 ± 410	200
WELL HMH-3	05/06	58 ± 9	0.3
WELL HMH-4	05/06	25 ± 8	0.1
WELL HMH-5	05/06	4700 ± 240	20
WELL HMH-6	05/06	200 ± 10	1
WELL HMH-7	05/06	86 ± 9	0.4
WELL HMH-8	05/06	120 ± 7	0.6
WELL HMH-9	05/06	47 ± 9	0.2
WELL HMH-10	05/06	100 ± 8	0.5

(CONTINUED)

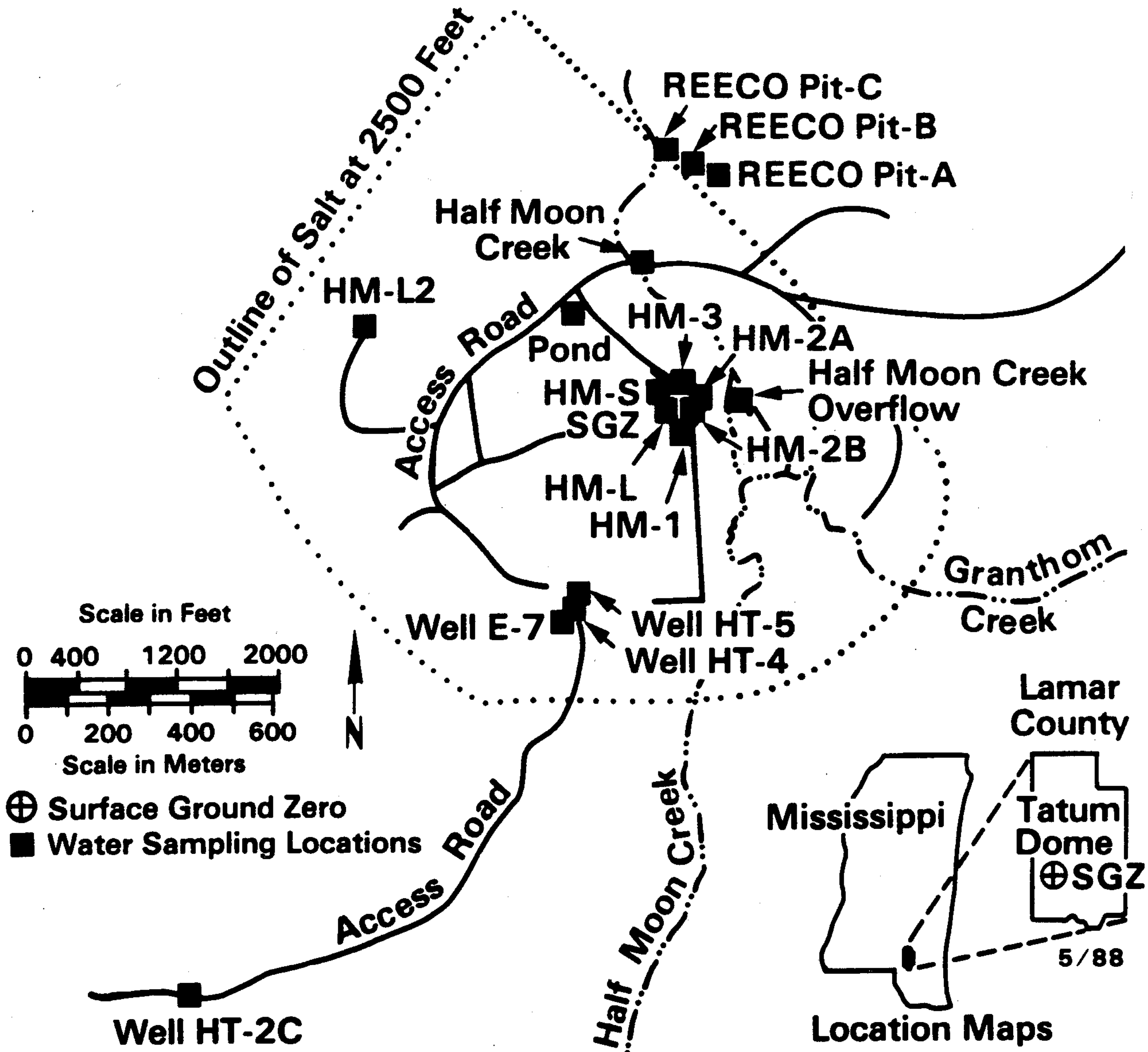


Figure E-8. LTHMP sampling locations for Project Dribble - near Salt Dome.

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
PROJECT DRIBBLE - MISSISSIPPI (CONT)			
BAXTERVILLE, MS			
WELL HMH-11	05/06	410 ± 11	2
WELL HT-2C	05/08	27 ± 8	0.1
WELL HT-4	05/07	22 ± 8	0.1
WELL HT-5	05/08	-3.4 ± 9.3*	<0.01
COLUMBIA, MS			
WELL 64B CITY	05/06	16 ± 9	0.08
LUMBERTON MS			
WELL 2 CITY	05/07	3.1 ± 9.6*	0.02
PURVIS MS			
CITY SUPPLY	05/06	11 ± 9*	0.06
PROJECT FAULTLESS - NEVADA			
BLUE JAY NV			
HOT CREEK RANCH SPRING	10/20	5.2 ± 9.8*	0.03
MAINTENANCE STATION	10/20	3.7 ± 9.6*	0.03
WELL BIAS	10/20	2.8 ± 9.1*	0.01
WELL HTH-1	10/20	3.6 ± 8.8*	0.02
WELL HTH-2	10/20	0.68 ± 8.9*	<0.01

(CONTINUED)

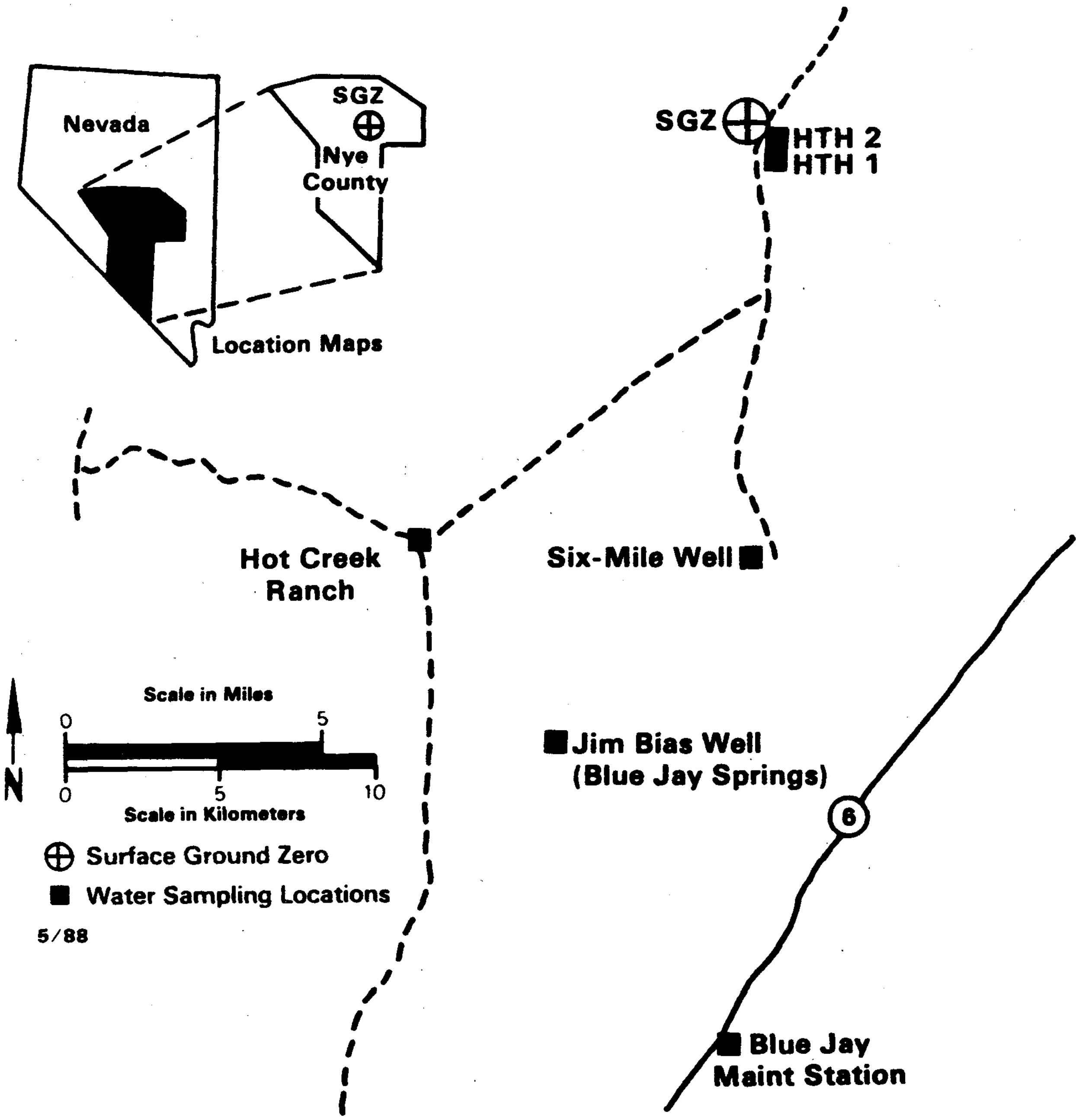


Figure E-9. LTHMP sampling locations for Project Faultless.

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
<u>PROJECT SHOAL - NEVADA</u>			
FRENCHMAN STATION NV			
HUNT'S STATION	03/03	4.4 ± 8.5*	0.02
SMITH/JAMES SPRGS	03/04	74 ± 8	0.4 (8)
SPRING WINDMILL	03/03	-0.15 ± 8.3*	<0.01
WELL FLOWING	03/03	1.3 ± 8.3*	<0.01
WELL HS-1	03/03	0.34 ± 9.3*	<0.01
<u>PROJECT GASBUGGY - NEW MEXICO</u>			
GOBERNADOR NM			
ARNOLD RANCH	07/23	9.5 ± 8.7*	0.05
BIXLER RANCH	07/23	23 ± 8	0.1
BUBBLING SPRINGS	07/21	82 ± 10	0.4
CAVE SPRINGS	07/22	38 ± 8	0.2
CEDAR SPRINGS	07/22	73 ± 8	0.4 (9)
LA JARA CREEK	07/22	62 ± 8	0.3
WELL EPNG 10-36	07/21	34 ± 8	0.2
WELL JICARILLA 1	07/22	-0.96 ± 8.9*	<0.01
WELL 28.3.33.233 (SO)	07/22	73 ± 8	0.4 (10)
POND 30.3.32 (NO)	07/23	59 ± 8	0.3
WINDMILL 2	07/22	8.0 ± 9.4*	0.04

(CONTINUED)

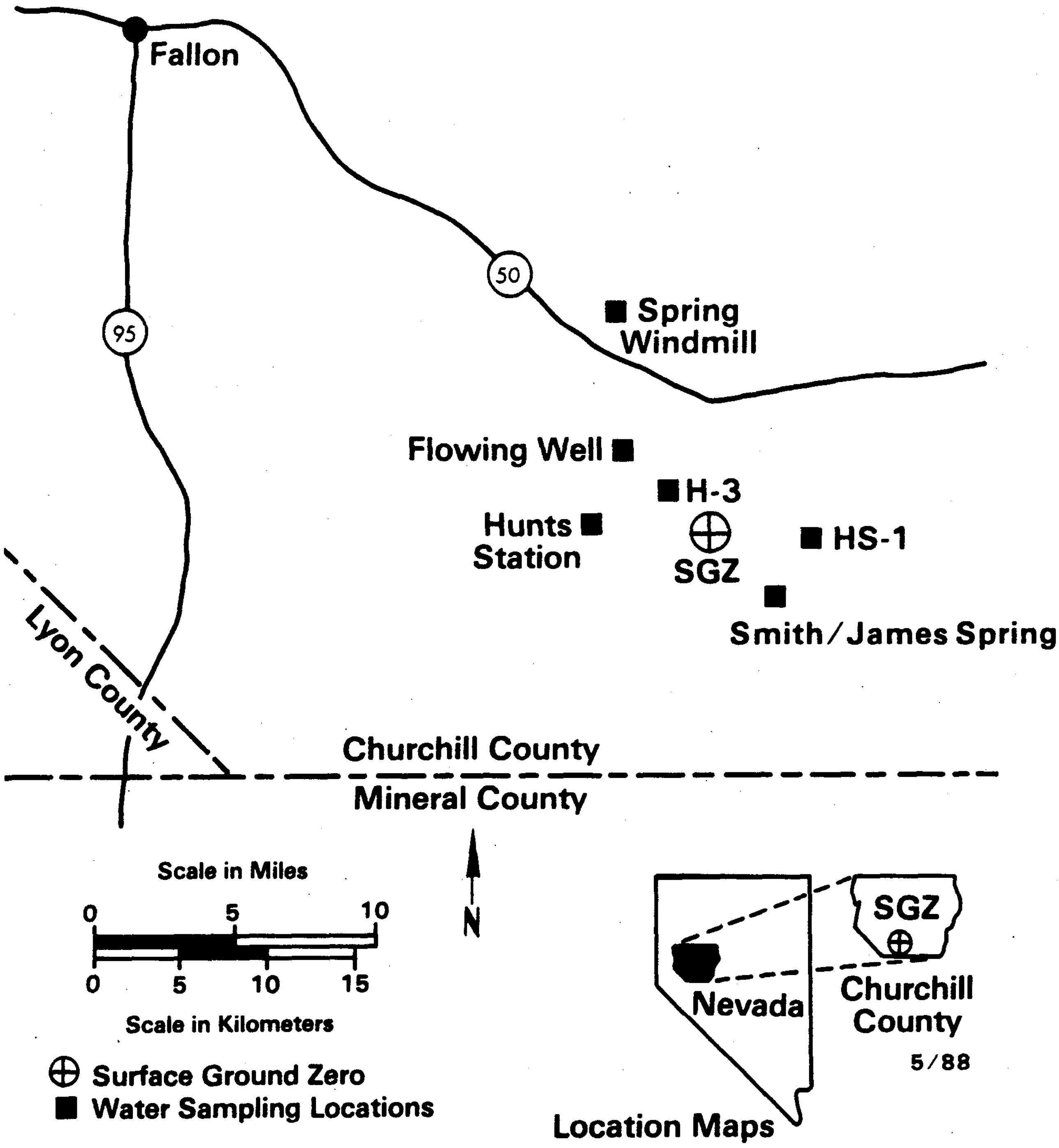


Figure E-10. LTHMP sampling locations for Project Shoal.

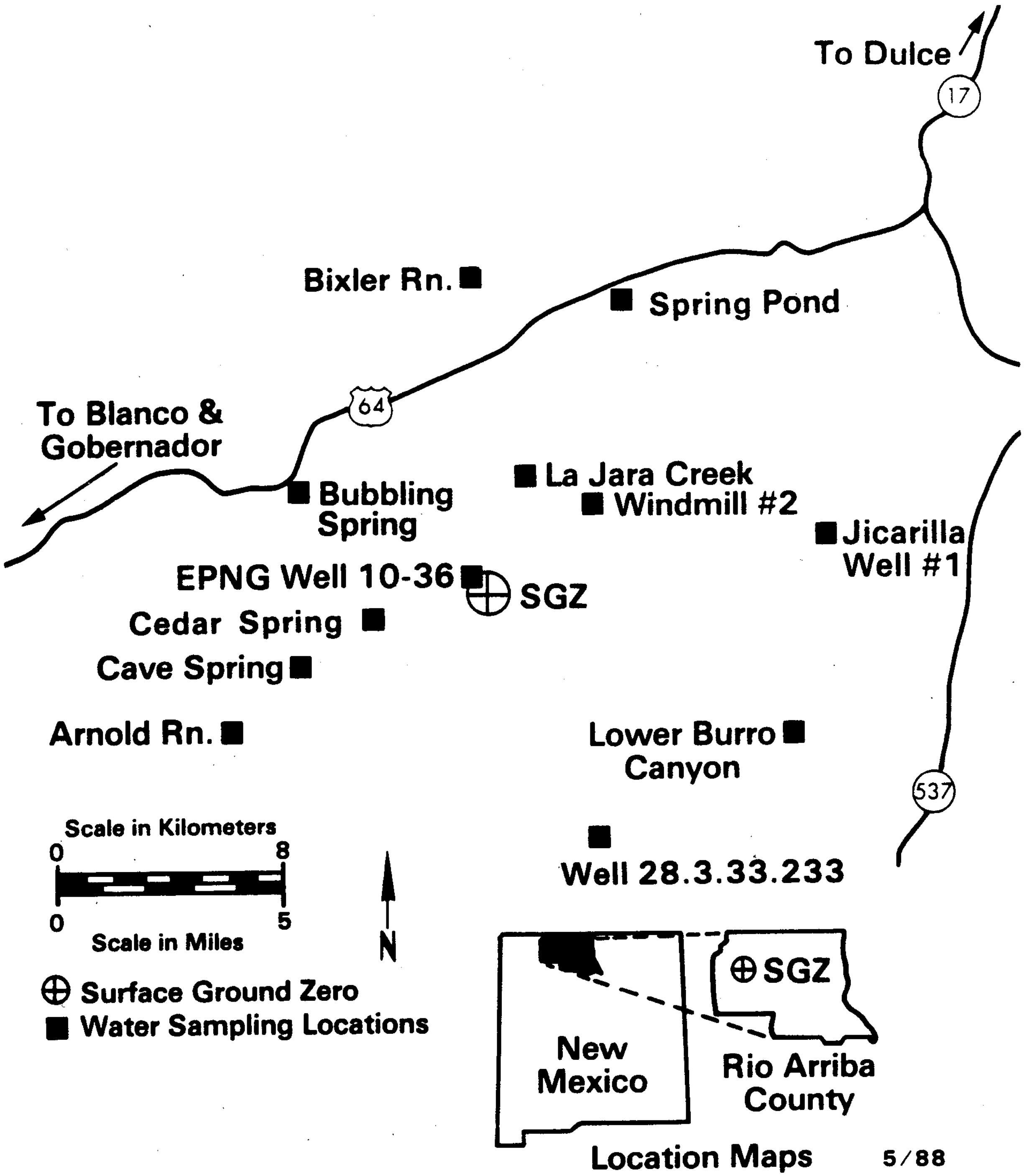


Figure E-11. LTHMP sampling locations for Project Gasbuggy.

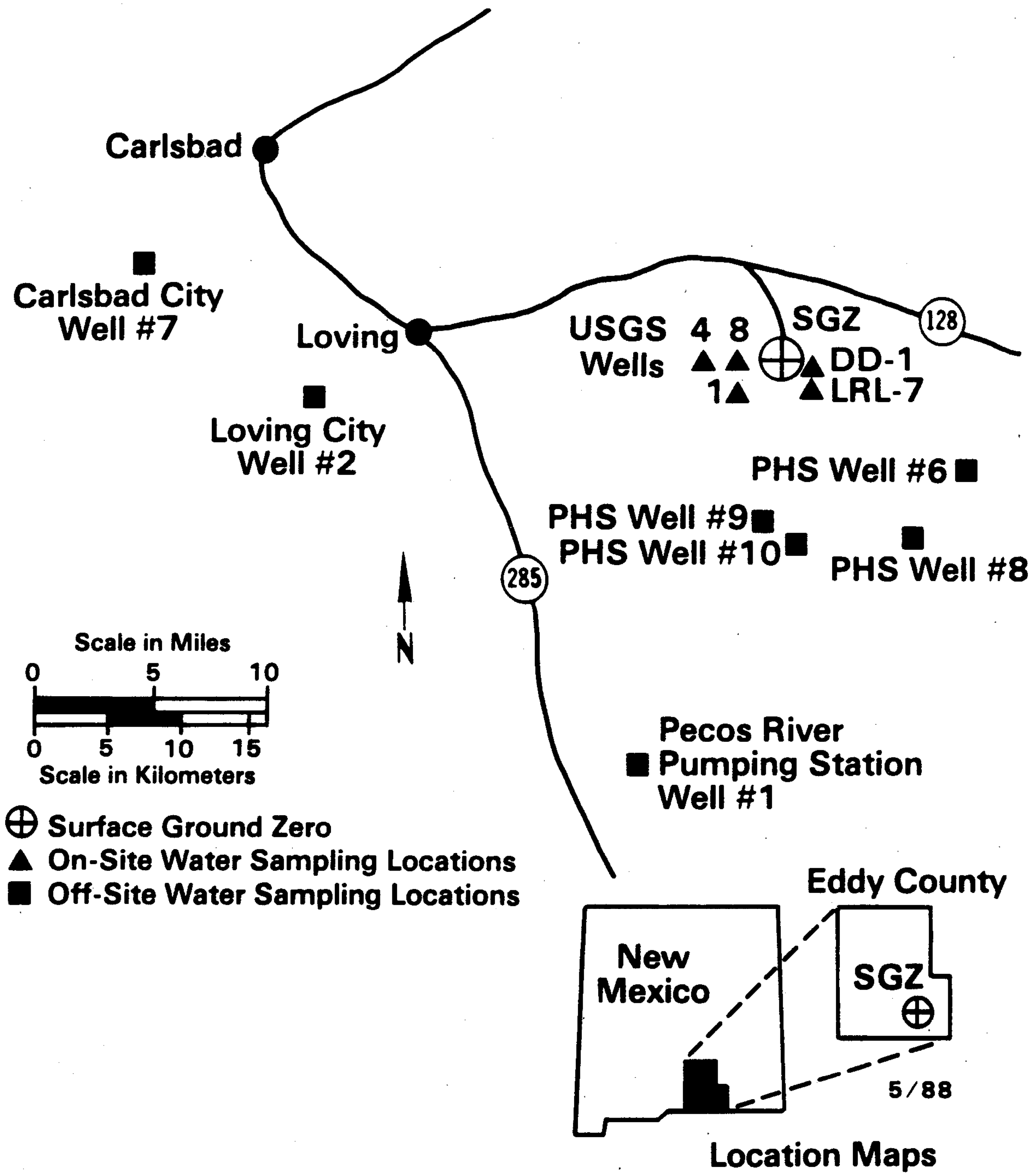


Figure E-12. LTHMP sampling locations for Project Gnome.

TABLE E.7. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE	
PROJECT GNOME - NEW MEXICO				
CARLSBAD, NM				
WELL 7 CITY	05/18	13 ± 9*	0.06	
LOVING, NM				
WELL 2 CITY	05/18	9.7 ± 9.1*	0.05	
MALAGA, NM				
WELL 1 PECOS PUMPING ST	05/18	6.2 ± 9.7*	0.03	
WELL LRL-7	05/17	16000 ± 320	80	(11)
WELL PHS 6	05/16	64 ± 8	0.3	
WELL PHS 8	05/16	22 ± 8	0.1	
WELL PHS 9	05/16	9.9 ± 10*	0.05	
WELL PHS 10	05/16	0.44 ± 9.3*	<0.01	
WELL USGS 1	05/16	1.3 ± 9.9*	<0.01	
WELL USGS 4	05/17	150000 ± 780	700	
WELL USGS 8	05/17	200000 ± 900	1000	(12)

* CONCENTRATION IS LESS THAN THE MINIMUM DETECTABLE CONCENTRATION (MDC).

FOOTNOTES

	ANALYSIS	RESULT	2SIGMA	UNITS
(1)	89SR	0.81	13*	pCi/L
	90SR	0.92	2.7*	pCi/L
	238PU	- 2.5E-09	3.3E-05*	pCi/mL
	239PU	8.2E-06	2.7E-05*	pCi/mL
(2)	89SR	-5.6	5.2*	pCi/L
	90SR	1.5	2.1*	pCi/L
	238PU	-0.012	0.022*	pCi/L
	239PU	-0.008	0.018*	pCi/L

FOOTNOTES (CONT)

	ANALYSIS	RESULT	2SIGMA	UNITS
(3)	89SR	-4.9	4.3*	pCi/L
	90SR	1.4	1.8*	pCi/L
	238PU	0.007	0.014*	pCi/L
	239PU	-0.005	0.012*	pCi/L
	234U	0.012	0.012*	pCi/L
	235U	0.001	0.003*	pCi/L
	238U	0.008	0.009*	pCi/L
(4)	89SR	1.5	7.4*	pCi/L
	90SR	-0.87	2.6*	pCi/L
	234U	35.5	17.5*	fCi/L
	235U	0.9	2.5*	fCi/L
	238U	9.8	9.1*	fCi/L
	238PU	-4.9	14.2*	fCi/L
	239PU	-2.4	11.6*	fCi/L
(5)	89SR	5.0	8.6*	pCi/L
	90SR	-0.80	2.9*	pCi/L
	234U	87	26	fCi/L
	235U	6.2	7.2*	fCi/L
	238U	34	16	fCi/L
	238PU	0	18*	fCi/L
	239PU	-6.4	15*	fCi/L
(6)	89SR	-35	27*	pCi/L
	90SR	3.6	3.1*	pCi/L
	238PU	0.16	0.06	pCi/L
	239PU	-0.02	0.05*	pCi/L
(7)	89SR	-25	26*	pCi/L
	90SR	1.3	2.8*	pCi/L
	238PU	0.009	0.079*	pCi/L
	239PU	0.001	0.065*	pCi/L
(8)	89SR	-39	57*	pCi/L
	90SR	2.0	2.7*	pCi/L
	226RA	0.15	0.06	pCi/L
	234U	26	1	pCi/L
	235U	1.3	0.1	pCi/L
	238U	20	0.8	pCi/L
	238PU	-0.014	0.026*	pCi/L
	239PU	-0.009	0.022*	pCi/L

(CONTINUED)

TABLE E.7. CONTINUED

FOOTNOTES (CONT)

	ANALYSIS	RESULT	2SIGMA	UNITS
(9)	89SR	9.8	12*	pCi/L
	90SR	-0.4	3.9*	pCi/L
	238U	0.2	0.04*	pCi/L
	234U	0.02	0.01*	pCi/L
	238PU	-0.007	0.013*	pCi/L
	239PU	0.009	0.011*	pCi/L
(10)	89SR	4.7	8.2*	pCi/L
	90SR	-0.3	2.6*	pCi/L
	234U	2	0.2*	pCi/L
	235U	0.01	0.01*	pCi/L
	238U	0.8	0.8*	pCi/L
	238PU	-0.008	0.016*	pCi/L
	239PU	-0.006	0.013*	pCi/L
(11)	137CS	200	22	pCi/L
(12)	137CS	90	15	pCi/L

TABLE E.8. SUMMARY OF ANALYTICAL RESULTS FOR THE MILK SURVEILLANCE NETWORK - 1987

SAMPLING LOCATION	NO. OF SAMPLES	RADIO-NUCLIDE	RADIOACTIVITY CONC. (pCi/L)		
			MAX	MIN	AVG
HINKLEY, CA,	4	3H	240	37	120
BILL NELSON DAIRY	2	89SR	0.15	0.021	0.086
	2	90SR	0.83	0.66	0.74
RIDGECREST, CA,	4	3H	170	-31	110
CEDARSAGE FARM	2	89SR	2.8	1.7	2.3
	2	90SR	0.83	0.25	0.54
AUSTIN, NV,	4	3H	420	170	280
YOUNG'S RANCH	1	89SR	-0.78	-0.78	-0.78
	1	90SR	0.91	0.91	0.91
CURRANT, NV,	2	3H	300	270	280
BLUE EAGLE RANCH	1	89SR	-2.0	-2.0	-2.0
	2	90SR	2.0	1.6	1.8
CURRANT, NV,	3	3H	390	300	350
MANZONIE RANCH	1	89SR	-0.35	-0.35	-0.35
	1	90SR	0.92	0.92	0.92
DYER, NV, OZEL LEMON	4	3H	420	24	170
GOLDFIELD, NV, FRAYNE RANCH	2	3H	220	190	210
LAS VEGAS, NV,	4	3H	340	-7.4	140
HEIN HETTINGA DRY (LDS)	3	89SR	2.8	0.54	2.0
	3	90SR	0.75	0.37	0.57
LATHROP WELLS, NV,	2	3H	340	210	270
JOHN DEER RANCH	2	89SR	3.2	-0.86	1.2
	2	90SR	-0.12	-0.94	-0.53
LOGANDALE, NV,	6	3H	340	41	170
KNUDSEN DAIRY	3	89SR	4.7	2.0	3.0
	4	90SR	1.1	-1.2	0.038
LUND, NV,	4	3H	120	-180	14
MCKENZIE DAIRY	3	89SR	2.4	1.7	2.0
	3	90SR	0.32	0.0051	0.20

(CONTINUED)

TABLE E.8. CONTINUED

SAMPLING LOCATION	NO. OF SAMPLES	RADIO-NUCLIDE	RADIOACTIVITY CONC. (pCi/L) MAX	MIN	AVG
MCGILL, NV,	1	3H	550	550	550
LARSEN RANCH	1	89SR	-5.5	-5.5	-5.5
	1	90SR	1.6	1.6	1.6
MESQUITE, NV,	4	3H	180	4.9	91
SPEDA BROTHERS DAIRY	3	89SR	1.8	-8.2	-1.6
	3	90SR	1.7	0.010	0.67
MOAPA, NV,	6	3H	420	0.0	190
ROCKVIEW DAIRIES, INC	2	89SR	1.7	0.93	1.3
	2	90SR	0.64	0.60	0.62
NYALA, NV,	5	3H	290	79	140
SHARP'S RANCH	4	89SR	2.5	-1.6	0.83
	4	90SR	1.2	0.54	0.74
CALIENTE, NV,	4	3H	330	87	190
JUNE COX RANCH	2	89SR	7.6	-0.35	3.6
	2	90SR	0.54	-1.3	-0.35
ROUND MT, NV,	3	3H	250	94	170
BERG'S RANCH	1	89SR	6.3	6.3	6.3
	1	90SR	-1.2	-1.2	-1.2
SHOSHONE, NV,	4	3H	540	150	310
HARBECKE RANCH	2	89SR	0.70	-0.55	0.074
	3	90SR	0.47	0.40	0.44
RACHEL, NV,	5	3H	360	-48	110
PENOYER FARM	1	89SR	-0.53	-0.53	-0.53
	2	90SR	0.82	0.21	0.52
CEDAR CITY, UT,	3	3H	390	100	230
BRENT JONES DAIRY	1	89SR	1.1	1.1	1.1
	2	90SR	0.74	7.1E-10	0.37
ST GEORGE, UT,	3	3H	310	68	210
CANNON FARMS	2	89SR	2.4	0.013	1.2
	2	90SR	0.85	0.38	0.62

TABLE E.9. ANALYTICAL RESULTS FOR THE STANDBY MILK SURVEILLANCE NETWORK - 1987

SAMPLING LOCATION	COLLECTION DATE 1987	CONC. ± 2 SIGMA 3H (pCi/L)	89SR (pCi/L)	90SR (pCi/L)
GAMMA SPECTROMETRY AND RADIOCHEMICAL ANALYSES				
TAYLOR AZ SUNRISE DAIRY	08/10	340 ± 260*	NA	NA
TUCSON AZ-SHAMROCK FOODS-	08/10	78 ± 270*	-1.3 ± 6.6*	0.74 ± 2.1*
LITTLE ROCK AR BORDENS	08/03	79 ± 280*	NA	NA
RUSSELLVILLE AR ARKANSAS TECH UNIV	08/03	64 ± 280*	NA	NA
BAKERSFIELD CA CARNATION DAIRY	08/10	180 ± 270*	NA	NA
WEED CA MEDO-BEL CREAMERY	08/10	160 ± 260*	0.56 ± 4.4*	0.25 ± 1.4*
WILLOWS CA-GLENN MILK PRO	08/24	190 ± 280*	NA	NA
GRAND JCT CO COLORADO WEST DAIRIES	07/23	190 ± 270*	NA	NA
CANON CITY CO-JUNIPER VAL	08/07	430 ± 230	NA	NA
BURLINGTON IA MISS VALLEY MILK PRO	07/22	30 ± 260*	NA	NA
DAVENPORT IA SWISS VALLEY FARMS CO	08/11	110 ± 260*	NA	NA
ATWOOD KS-ATWOOD-CHEESE C	08/10	250 ± 270*	NA	NA
AURORA MO MID-AMERICA DAIRY INC	07/20	170 ± 270*	NA	NA
CHILLICOTHE MO MID-AMERICA DAIRYMEN	07/21	390 ± 240	NA	NA

(CONTINUED)

TABLE E.9. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	3H (pCi/L)	CONC. ± 2 SIGMA 89SR (pCi/L)	90SR (pCi/L)
		GAMMA SPECTROMETRY AND RADIOCHEMICAL ANALYSES		
NORFOLK NE GILLETTE DAIRY	07/29	210 ± 270*	NA	NA
FALLON NV CREAMLAND DAIRY	08/10	NA	0.088 ± 3.9*	0.51 ± 1.3*
ENID OK AMPI GOLDSPOT DIVISION	08/10	180 ± 270*	-1.9 ± 6.0*	1.6 ± 1.8*
MCALESTER OK OK STATE PENITENTIARY	08/11	220 ± 260*	NA	NA
CORVALLIS OR SUNNY BROOK DAIRY	07/27	340 ± 270*	NA	NA
PROVO UT BYU DAIRY PRODUCTS LAB	08/04	98 ± 260*	-1.6 ± 4.8*	0.97 ± 1.5*
SEATTLE WA CONSOLIDATED DAIRY PROD	08/06	210 ± 280*	NA	NA

SAMPLING LOCATION	COLLECTION DATE 1987	SAMPLING LOCATION	COLLECTION DATE 1987
	POTASSIUM-40 WAS THE ONLY GAMMA EMITTER DETECTED AT THE FOLLOWING LOCATIONS		
PIMA AZ PIMA DAIRY	08/10	BATESVILLE AR HILLS VALLEY FOODS	08/03
TEMPE AZ UNITED DAIRYMEN OF AZ	08/10	FAYETTEVILLE AR UNIVERSITY OF ARK	08/03

(CONTINUED)

TABLE E.9. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	SAMPLING LOCATION	COLLECTION DATE 1987
POTASSIUM-40 WAS THE ONLY GAMMA EMITTER DETECTED AT THE FOLLOWING LOCATIONS			
YUMA AZ-COMBS DAIRY	08/11	LAKE MILLS IA LAKE MILLS COOP CRMY	07/28
FERNBRIDGE CA HUMBOLDT CREAMERY	08/11	LEMARS IA WELLS DAIRY	07/27
MANTECA CA-EAST STAR DAIRY	08/10	FOSSTON MN LAND O' LAKES INC	08/26
MODESTO CA FOSTER FARMS DAIRY	08/10	NICOLLET MN DOUG SCHULTZ FARM	08/26
OXNARD CA CHASE BROS DAIRY	08/12	ROCHESTER MN ASSC MILK PRODUCERS	08/26
REDDING CA MCCOLL'S DAIRY PROD	08/10	JACKSON MO MID-AMERICA DAIRYMEN IN	07/22
SAN LUIS OBISPO CA CAL STATE POLY	08/10	JEFFERSON CITY MO CENTRAL DAIRY CO	07/20
SEBASTOPOL CA WM MILLER DAIRY	08/10	BOZEMAN MT DARIGOLD FARMS	07/27
SMITH RIVER CA COUNTRY MAID DAIRY	08/10	GREAT FALLS MT MEADOW GOLD DAIRY	07/29
SOLEDAD CA-CORRECTION TRA	08/10	MISSOULA MT BEATRICE DAIRY PRODUCTS	07/21
TRACY CA DEUEL VOC INST	08/12	GD ISLAND NE MID-AMER DAIRYMN-JIM SA	08/05
COLORADO SPGS CO SINTON DAIRY CO	07/29	NO PLATTE NE MID-AMER DAIRYMEN-R A N	07/31
FT COLLINS CO POUDRE VALLEY DAIRY	07/22	OMAHA NE ROBERTS DAIRY-MARSHALL	09/02
KIMBALLTON IA AMPI RECEIVING STA	07/27		

(CONTINUED)

TABLE E.9. CONTINUED

SAMPLING LOCATION	COLLECTION DATE 1987	SAMPLING LOCATION	COLLECTION DATE 1987

POTASSIUM-40 WAS THE ONLY GAMMA EMITTER DETECTED

AT THE FOLLOWING LOCATIONS

SAMPLING LOCATION	COLLECTION DATE 1987	SAMPLING LOCATION	COLLECTION DATE 1987
SUPERIOR NE MID-AMER DAIRYMN-D FRIT	08/11	MYRTLE POINT OR SAFEWAY STORES INC	08/03
LAS VEGAS NV ANDERSON DAIRY	08/10	PORTLAND OR DARIGOLD FARMS	07/29
RENO NV MODEL DAIRY	08/10	REDMOND OR EBERHARD'S CREAMERY INC	07/28
YERINGTON NV VALLEY DAIRY	08/12	TILLAMOOK OR TILLAMOOK CO CRMY	07/20
CLAREMORE OK SWAN BROS DAIRY	08/03	RAPID CITY SD-GILLETTE DA	08/05
STILLWATER OK OSU DAIRY	08/03	BEAVER UTAH-WESTERN DAIRY	07/23
EUGENE OR ECHO SPRINGS DAIRY	07/27	RICHFIELD UT IDEAL DAIRY	07/28
GRANTS PASS OR VALLEY OF ROGUE DAIRY	07/27	MOSES LAKE WA SAFEWAY STORES INC	08/24
KIAMATH FALLS OR-KLAMATH	07/27	SPOKANE WA CONSOLIDATED DAIRY	08/24
MEDFORD OR DAIRYGOLD FARMS	07/29	CHEYENNE WY DAIRY GOLD FOODS	08/05
MILTON-FREEWATER OR PARENTS DAIRY	07/27	RIVERTON WY-CREME O'WEBER	07/29

* CONCENTRATION IS LESS THAN THE MINIMUM DETECTABLE CONCENTRATION (MDC).

TABLE E.10. SUMMARY OF RADIATION DOSE EQUIVALENTS FROM TLD DATA - 1987

STATION LOCATION	MEASUREMENT PERIOD		DOSE EQUIVALENT RATE (mrem/D)			ANNUAL DOSE EQUIVALENT
	ISSUE	COLLECT	MAX.	MIN.	AVG.	(mrem/Y)
ALAMO, NV	11/06/86	10/30/87	0.30	0.24	0.27	98
AMERICAN BORATE, NV	11/06/86	01/07/88	0.38	0.17	0.28	102
ATLANTA MINE, NV	12/01/86	12/07/87	0.26	0.16	0.23	84
AUSTIN, NV	01/15/87	02/03/88	0.44	0.27	0.35	127
BAKER, CA	12/01/86	11/03/87	0.32	0.21	0.26	93
BARSTOW, CA	12/01/86	11/03/87	0.33	0.23	0.27	100
BATTLE MOUNTAIN, NV	12/03/86	12/15/87	0.25	0.17	0.22	82
BEATTY, NV	11/04/86	01/05/88	0.40	0.19	0.30	109
BISHOP, CA	12/02/86	11/04/87	0.33	0.22	0.28	101
BLUE EAGLE RANCH, NV	12/02/86	01/05/88	0.24	0.13	0.19	70
BLUE JAY, NV	01/15/87	01/06/88	0.40	0.28	0.35	126
BOULDER, UT	12/09/86	12/08/87	0.26	0.16	0.21	78
BRYCE CANYON, UT	12/09/86	12/08/87	0.25	0.14	0.19	71
CACTUS SPRINGS, NV	11/03/86	11/02/87	0.23	0.12	0.18	64
CALIENTE, NV	11/06/86	10/27/87	0.33	0.25	0.29	107
CARP, NV	11/06/86	10/27/87	0.34	0.20	0.26	95
CEDAR CITY, UT	11/05/86	12/07/87	0.22	0.18	0.20	73
CHERRY CREEK, NV	12/02/86	12/10/87	0.33	0.24	0.29	106
CLARK STATION, NV	01/14/87	01/04/88	0.38	0.22	0.29	106
COALDALE, NV	12/04/86	02/09/88	0.32	0.23	0.27	99
COLORADO CITY, AZ	11/04/86	10/27/87	0.24	0.17	0.20	75

(CONTINUED)

TABLE E.10. CONTINUED

STATION LOCATION	MEASUREMENT PERIOD ISSUE	MEASUREMENT PERIOD COLLECT	DOSE EQUIVALENT RATE (mrem/D) MAX.	MIN.	AVG.	ANNUAL DOSE EQUIVALENT (mrem/Y)
COMPLEX 1, NV	12/03/86	10/28/87	0.33	0.26	0.30	108
CORN CREEK, NV	11/03/86	11/02/87	0.17	0.08	0.13	48
CORTEZ RD/HWY 278,NV	12/03/86	12/15/87	0.33	0.25	0.30	110
COYOTE SUMMIT, NV	12/28/86	10/28/87	0.37	0.32	0.35	128
CRESCENT VALLEY, NV	12/03/86	12/15/87	0.27	0.19	0.24	86
CRYSTAL, NV	11/06/86	11/05/87	0.27	0.20	0.23	85
CURRANT,NV	12/02/86	01/06/88	0.35	0.26	0.30	111
CURRIE, NV	12/02/86	12/10/87	0.33	0.24	0.29	107
DEATH VALLEY JCT, CA	11/06/86	01/07/88	0.28	0.07	0.20	74
DELTA, UT	01/08/87	01/05/88	0.23	0.13	0.20	71
DIABLO MAINT STA, NV	01/13/87	01/04/88	0.40	0.26	0.35	127
DUCHESNE, UT	01/06/87	01/07/88	0.20	0.10	0.17	62
DUCKWATER, NV	12/02/86	01/06/88	0.33	0.25	0.29	106
ELGIN, NV	11/06/86	10/27/87	0.42	0.31	0.36	132
ELKO, NV	12/02/86	12/15/87	0.24	0.17	0.22	79
ELY, NV	12/02/86	12/09/87	0.25	0.17	0.22	82
ENTERPRISE, UT	11/05/86	12/07/87	0.37	0.33	0.35	128
EUREKA, NV	01/15/87	01/06/88	0.35	0.20	0.28	104
FALLON, NV	12/03/86	12/14/87	0.24	0.15	0.21	77
FERRON, UT	11/06/86	10/29/87	0.26	0.16	0.20	74
FLYING DIAMND CP, NV	12/04/86	10/30/87	0.23	0.15	0.20	72

(CONTINUED)

TABLE E.10. CONTINUED

STATION LOCATION	MEASUREMENT PERIOD ISSUE	MEASUREMENT PERIOD COLLECT	DOSE EQUIVALENT RATE (mrem/D) MAX.	DOSE EQUIVALENT RATE (mrem/D) MIN.	DOSE EQUIVALENT RATE (mrem/D) AVG.	ANNUAL DOSE EQUIVALENT (mrem/Y)
FURNACE CREEK, CA	11/06/86	01/07/88	0.26	0.03	0.16	58
GABBS, NV	12/04/86	02/09/88	0.24	0.15	0.19	69
GARRISON, UT	12/01/86	12/08/87	0.22	0.13	0.19	70
GEYSER RANCH, NV	12/01/86	12/07/87	0.32	0.22	0.28	104
GOLDFIELD, NV	01/12/87	02/08/88	0.30	0.16	0.23	84
GRANTSVILLE, UT	01/08/87	01/06/88	0.22	0.12	0.18	67
GREEN RIVER, UT	11/06/86	10/28/87	0.28	0.17	0.22	79
GROOM LAKE-NTS, NV	12/28/86	11/05/87	0.28	0.19	0.25	91
GUNNISON, UT	11/06/86	12/08/87	0.25	0.16	0.20	73
HANCOCK SUMMIT,NV	12/28/86	10/29/87	0.43	0.41	0.42	154
HIKO, NV	11/06/86	10/29/87	0.25	0.17	0.21	77
HOT CK RNCH, NV	01/15/87	01/06/88	0.30	0.17	0.24	89
IBAPAH, UT	12/01/86	12/08/87	0.33	0.15	0.28	101
INDEPENDENCE, CA	12/02/86	11/04/87	0.30	0.20	0.27	98
INDIAN SPRINGS, NV	11/03/86	11/02/87	0.19	0.14	0.17	61
JACOB'S LAKE, AZ	11/04/86	10/27/87	0.39	0.28	0.32	116
KANAB, UT	11/04/86	10/27/87	0.20	0.15	0.17	63
KIRKEBY RANCH, NV	12/01/86	12/07/87	0.24	0.13	0.20	73
KOYEN'S RANCH, NV	12/28/86	10/28/87	0.28	0.24	0.26	96
LAS VEGAS (UNLV), NV	12/31/86	01/04/88	0.16	0.10	0.13	49
LAS VEGAS (USDI), NV	12/31/86	01/04/88	0.22	0.16	0.18	67

(CONTINUED)

TABLE E.10. Continued

STATION LOCATION	MEASUREMENT PERIOD ISSUE	MEASUREMENT PERIOD COLLECT	DOSE EQUIVALENT RATE (mrem/D) MAX.	MIN.	AVG.	ANNUAL DOSE EQUIVALENT (mrem/Y)
LAS VEGAS(AIRPRT),NV	12/31/86	01/04/88	0.18	0.14	0.16	58
LATHROP WELLS, NV	11/03/86	01/05/88	0.35	0.11	0.24	88
LAVADA'S MARKET, NV	11/07/86	01/05/88	0.33	0.09	0.23	82
LIDA, NV	01/14/87	02/11/88	0.30	0.17	0.23	85
LOA, UT	12/09/86	12/08/87	0.37	0.27	0.32	117
LOGAN, UT	01/06/87	01/05/88	0.24	0.20	0.22	79
LONE PINE, CA	12/02/86	11/04/87	0.32	0.19	0.27	97
LOVELOCK, NV	12/03/86	12/15/87	0.23	0.22	0.23	83
LUND, NV	12/02/86	12/09/87	0.28	0.17	0.24	87
LUND, UT	12/01/86	12/07/87	0.33	0.24	0.28	104
MAMMOTH LAKES, CA	12/02/86	11/05/87	0.35	0.19	0.30	110
MANHATTAN, NV	01/15/87	02/03/88	0.42	0.27	0.34	124
MESQUITE, NV	11/04/86	10/30/87	0.20	0.13	0.17	63
MILFORD, UT	12/01/86	12/09/87	0.27	0.17	0.22	82
MINA, NV	12/04/86	02/09/88	0.29	0.22	0.25	92
MOAPA, NV	11/04/86	10/27/87	0.22	0.16	0.20	73
MONTICELLO, UT	11/05/86	10/28/87	0.34	0.22	0.27	97
MTN MEADOWS RNCH, NV	01/14/87	01/05/88	0.24	0.11	0.18	66
NASH RANCH, NV	12/04/86	10/30/87	0.25	0.18	0.22	79
NEPHI, UT	01/05/87	01/05/88	0.20	0.10	0.16	59
NYALA, NV	01/14/87	01/05/88	0.27	0.15	0.23	82

(CONTINUED)

STATION LOCATION	MEASUREMENT PERIOD		DOSE EQUIVALENT RATE (mrem/D)			ANNUAL DOSE EQUIVALENT
	ISSUE	COLLECT	MAX.	MIN.	AVG.	(mrem/Y)
OLANCHA, CA	12/01/86	11/04/87	0.30	0.21	0.26	97
OVERTON, NV	11/04/86	10/27/87	0.20	0.14	0.18	64
PAGE, AZ	12/28/86	10/28/87	0.18	0.15	0.17	60
PAHRUMP, NV	11/06/86	11/03/87	0.19	0.14	0.16	58
PAROWAN, UT	12/02/86	12/07/87	0.24	0.15	0.20	71
PENOYER FARMS, NV	12/28/86	10/28/87	0.35	0.31	0.33	121
PINE CREEK RANCH, NV	12/03/86	10/28/87	0.37	0.30	0.33	122
PIOCHE, NV	12/04/86	10/27/87	0.25	0.19	0.22	82
PRICE, UT	12/28/86	10/29/87	0.20	0.17	0.19	69
PROVO, UT	01/06/87	01/05/88	0.22	0.11	0.18	66
QUEEN CITY SMT, NV	01/13/87	01/04/88	0.41	0.30	0.37	133
RACHEL, NV	12/28/86	10/28/87	0.34	0.28	0.32	115
REED RANCH, NV	01/13/87	01/04/88	0.90	0.24	0.45	166
RENO, NV	10/19/87	12/14/87	0.24	0.24	0.24	88
RIDGECREST, CA	12/01/86	11/03/87	0.29	0.18	0.24	89
ROSE RANCH, NV	12/01/86	03/02/87	0.26	0.26	0.26	94
ROUND MT, NV	01/15/87	02/03/88	0.35	0.23	0.29	106
RUBY VALLEY, NV	12/02/86	12/17/87	0.32	0.25	0.30	110
S DESERT COR CTR, NV	11/03/86	11/02/87	0.19	0.14	0.16	59
SALT LAKE CITY, UT	11/06/86	01/04/88	0.32	0.22	0.25	92
SCHURZ, NV	12/04/86	12/14/87	0.30	0.18	0.26	97

(CONTINUED)

TABLE E.10. CONTINUED

STATION LOCATION	MEASUREMENT PERIOD ISSUE	MEASUREMENT PERIOD COLLECT	DOSE EQUIVALENT RATE (mrem/D) MAX.	MIN.	AVG.	ANNUAL DOSE EQUIVALENT (mrem/Y)
SCOTTY'S JCT, NV	01/12/87	01/06/88	0.36	0.16	0.26	97
SHERI'S RANCH, NV	11/07/86	10/30/87	0.34	0.20	0.28	101
SHOSHONE, CA	11/06/86	11/03/87	0.26	0.22	0.24	86
SILVER PEAK, NV	04/09/87	02/09/88	0.26	0.19	0.24	87
SPRINGDALE, NV	11/05/86	01/06/88	0.40	0.17	0.29	106
ST. GEORGE, UT	11/05/86	12/09/87	0.18	0.13	0.16	59
STEWARD RANCH, NV	03/02/87	12/07/87	0.35	0.35	0.35	128
STONE CABIN RNCH, NV	01/14/87	01/05/88	0.38	0.22	0.31	113
SUNNYSIDE, NV	12/04/86	12/09/87	0.19	0.11	0.17	60
TEMPIUTE, NV	12/28/86	10/29/87	0.33	0.29	0.31	114
TIKABOO VALLEY, NV	12/28/86	10/28/87	0.33	0.30	0.32	116
TONOPAH TEST RNG, NV	01/13/87	02/10/88	0.39	0.21	0.32	118
TONOPAH, NV	01/15/87	02/09/88	0.36	0.24	0.30	110
TROUT CREEK, UT	12/01/86	12/08/87	0.25	0.17	0.22	81
TWIN SPRGS RNCH, NV	01/14/87	01/05/88	0.35	0.24	0.31	113
UHALDE'S RNCH, NV	12/03/86	10/28/87	0.34	0.27	0.31	114
USECOLOGY, NV	11/07/86	01/06/88	0.43	0.17	0.30	108
VALLEY CREST, CA	11/06/86	01/07/88	0.20	0.00	0.11	41
VERNAL, UT	01/06/87	01/07/88	0.22	0.12	0.18	66
VERNON, UT	01/08/87	01/06/88	0.24	0.14	0.20	72
WARM SPRINGS, NV	01/14/87	01/04/88	1.11	0.34	0.80	291

(CONTINUED)

TABLE E.10. CONTINUED

STATION LOCATION	MEASUREMENT PERIOD		DOSE EQUIVALENT RATE (mrem/D)			ANNUAL DOSE EQUIVALENT
	ISSUE	COLLECT	MAX.	MIN.	AVG.	(mrem/Y)
WELLS, NV	12/02/86	12/16/87	0.26	0.18	0.24	86
WENDOVER, UT	12/01/86	12/16/87	0.22	0.15	0.20	73
WILLOW SPRGS LDGE,UT	01/08/87	01/06/88	0.20	0.09	0.16	59
WINNEMUCCA, NV	12/03/86	12/15/87	0.26	0.18	0.24	87
YOUNG'S RANCH, NV	01/15/87	02/03/88	0.33	0.18	0.28	101

ADDENDUM

NONRADIOLOGICAL SUPPLEMENT TO THE NTS ENVIRONMENTAL MONITORING REPORT

Prepared by

Industrial Hygiene
Reynolds Electrical and Engineering Co., Inc.

Calendar Year 1987

INTRODUCTION

Nonradiological environmental compliance is primarily the responsibility of the Industrial Hygiene Section of the Environmental Sciences Department, REECo. Among State and Federal regulations of concern are the Clean Water Act; Safe Drinking Water Act (SDWA); Clean Air Act; Resource Conservation and Recovery Act (RCRA); Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); Toxic Substances Control Act (TSCA); and The Solid Waste Disposal Act. Many of the activities regulated by these laws require a permit or notification to operate. The permits or notification to operate are processed by the Industrial Hygiene Section.

Collecting and analyzing environmental samples is another very important Industrial Hygiene Section environmental function. Many different types of samples were collected during CY87, with most of them being analyzed by the Industrial Hygiene Laboratory. However, some hazardous waste and drinking water samples must be sent off site for analysis, because they must be performed by an EPA or State approved laboratory. Several new laboratory instruments purchased this last year should allow the Industrial Hygiene Environmental Laboratory to perform all required environmental analyses by the end of FY88. It is anticipated that EPA Contract Laboratory Equivalency and State certification of the Industrial Hygiene Environmental Laboratory will be achieved within a two year-period (1990).

This report provides CY87 information on the status of environmental permits, environmental sampling performed, and the results of State and Federal inspections.

SUMMARY

During 1987 the NTS was inspected by the State and Federal authorities for compliance with the Clean Air Act and RCRA. No violations were issued by the State as a result of their air pollution inspection, but four deficiencies were noted during the EPA RCRA inspection.

Fourteen sewage lagoon permit applications were submitted to the State, along with information on 41 existing septic tank and leachfield systems. Six new air pollution permits were obtained, to bring REECo's total to 25. The six drinking water systems were permitted for another year, and a current Part A application for mixed waste disposal was amended.

Sampling was done to support the RCRA, CERCLA and TSCA programs, and annual CY reports were submitted to the State for Air Pollution Permits, Hazardous Waste Generation, and polychlorinated biphenyl (PCB) activity.

CLEAN WATER ACT

Sewage Lagoons

Permit Applications were prepared and submitted to the State of Nevada for the following fourteen sewage lagoon systems:

1. Area 2
2. Area 6, CP Compound
3. Area 6, Yucca Lake
4. Area 6, DAF
5. Area 6, CP-72
6. Area 11, Technical Support Facility
7. Area 12, Sewage Plant
8. Area 12, Fleet Operations
9. Area 23, Gate 100
10. Area 23, Mercury
11. Area 25, Central Support
12. Area 25, Engine Test Stand
13. Area 25, Test Cell C
14. Area 25, Reactor Control Point

Water samples were collected from the Area 11 and Area 12 Fleet Operations systems and analyzed for lead, silver and pH (the hazardous waste threshold for lead and silver is 5 mg/L or greater; the pH is hazardous if less than 2 or greater than 12.5). The pH for both samples was 7.5. Concentrations (in mg/L) for lead and silver were 2.7 and 2.0 respectively at Area 11, and 0.02 and 0.01 for Area 12.

Septic Tank's and Leachfields

Information was provided to the State on 41 existing septic tanks and leachfield systems. The State will now advise through DOE/NV which, if any, systems will require permit applications. An application for a permit must be made for all new systems to be constructed; however, most existing systems will be permitted by "grandfather action" without a specific application for permit. No applications for new septic tank systems were submitted.

Permit Status

No permits were issued by the State for either the sewage lagoons for the septic tank systems, and there are no previously permitted systems.

DRINKING WATER

Drinking Water Systems Overview

There are currently six drinking water systems, which utilize eleven wells. The Areas 2, 12, and 23 systems are community systems; while Area 2, 3, 6, and 25 are non-community systems. Community systems sypply residential populations, while non-community systems supply non-residential workplace areas. These systems are all chlorinated by automatic equipment. New or repaired water lines are superchlorinated before being put into service in accordance with American Water Works Association Standards and the Uniform Plumbing Code. Each system is tested monthly for pH, residual chlorine, and bacteria content by Industrial Hygiene Section personnel; and daily chlorine levels are logged by Site Maintenance personnel (Site Maintenance operates the water systems). A water sample for chemical analysis is collected from each well by the Nevada State Health Division at approximately three-year intervals. These chemical analyses were last performed August 1984, and are scheduled again for March 1988.

Permit Status

Each of the six systems has a permit from the State of Nevada which is renewed annually. There were no new permits issued this year, and no amendments were made to any of the existing permits.

Sample Results and Standards Comparison

All systems are sampled monthly for pH, chlorine residual, and bacteria. In all cases the sample results were within the limits prescribed by the SDWA and State of Nevada regulations.

residual chlorine - at least 0.02 ppm
pH - between 6.5 and 8.5
coliform bacteria - <2.2 colonies/100 mL of sample

The table below gives the results of the August 1984 analysis of the community systems wells, and compares the results to the SDWA standards where one exists.

LAST CHEMICAL ANALYSIS OF COMMUNITY SYSTEMS, AUGUST 1984

Chemical Analysis Performed	Maximum Level Allowed	Area 23 System: Army Well	Area 23 System: 5B	Area 23 System: 5C	Areas 2, 8, 12
Calcium	--	45.4	7.4	0.7	7.8
Magnesium	--	21.4	2.2	0.2	1.2

(continued)

Chemical Analysis Performed	Maximum Level Allowed	Area 23 System: Army Well	Area 23 System: 5B	Area 23 System: 5C	Areas 2, 8, 12
pH	--	7.6	8.5	8.9	7.3
Alkalinity	--	222	152	262	67
Sulfate	250 mg/L	23.6	28	13.5	8.3
Chloride	250 mg/L	16	23	9	6
Nitrate	10 mg/L	0.2	2.8	1.6	1.3
Fluoride	1.6 mg/L	1.1	0.9	1.0	0.8
Iron	0.3 mg/L	<.030	.048	<.030	.043
Manganese	0.05 mg/L	.024	<.012	<.012	.019
Total Dissolved Solids	500 units	310	325	374	152
Arsenic	.05 mg/L	.006	.006	.01	<.001
Lead	.05 mg/L	<.002	<.002	<.002	<.002
Selenium	.01 mg/L	<.001	.001	<.001	.002
Barium	1 mg/L	.08	<.012	<.012	<.012
Zinc	5 mg/L	<.007	<.007	<.007	.012
Copper	1 mg/L	<.007	<.007	<.007	<.007
Mercury	.002 mg/L	<.0003	.0007	<.0003	<.0003
Chromium	.05 mg/L	<.029	<.029	<.029	<.029
Cadmium	.01 mg/L	<.007	.003	<.003	.005
Silver	.05 mg/L	<.005	.009	<.005	.010
Turbidity	--	.15	.35	.25	0.2
Color	15 units	<3	<3	3	<3

These sample results show that no analyte exceeded the SDWA maximum allowed levels when the community systems were last sampled by the State Inspector.

Non-community systems need only to meet the nitrate levels of no more than 10 mg/L. All of the NTS systems were below that level when last tested in 1984.

Quality Assurance

The monthly samples are collected in containers supplied by the State and are delivered to a State approved laboratory for analysis. Both the Collection and transportation of the samples are performed by a registration eligible Sanitarian. Nevada does not currently have a registered Sanitarian program, but is in the process of establishing one. REECo Sanitarians will become State Registered when the program is in place.

The three-year chemical samples were collected by a State Environmental

Health Specialist and taken to a State approved laboratory. These laboratories have approved QA programs as part of their State certification.

If any of the analytes are found to be outside the acceptable range, prompt remedial action is taken to correct the problem. These remedial actions and their results are then reported back to the State.

AIR POLLUTION

Permit Status

During CY87 two operating permits and four registration certificates were obtained from the State of Nevada. Three of the registration certificates were for cafeteria boilers added to Area 12 (1) and Area 23 (2). One operating permit was a renewal of a one-year open burning permit for fire training exercises, and the other was for the Area 1 Aggregate Plant, which was moved from Area 5. The fourth registration certification was for a NTS site-wide surface disturbance permit. The surface disturbance permit requires an annual report of all disturbances of five acres or greater. Notification prior to starting the disturbance is not required. The following list gives all air pollution permits which were active at the end of CY87 for which REECo had responsibility for compliance with the permit restrictions.

Permit Number	Facility or Operation	Exp. Date
OP919	Area 3 Portec Aggregate Hopper	12-03-89
OP921	Area 1 Shaker Plant	12-03-89
OP922	Area 1 Rotary Dryer	12-03-89
OP925	Area 23, Bldg. 753 Boiler	12-03-89
OP928	Area 12 Concrete Batch Plant	12-03-89
OP957	Area 2 Portable Stemming	12-03-89
OP958	Area 2 Portable Stemming System	12-03-89
OP1035	Portable Boiler	10-20-90
OP1036	Area 6 Decon Boiler	10-20-90
OP1082	Area 1 Concrete Batch Plant	01-30-91
OP1084	Area 1 Shaker Surface	01-30-91
OP1085	Area 6 Diesel Tanks	02-25-91
OP1086	Mercury Gasoline Tank	02-25-91
OP1087	Mercury Diesel Tank	02-25-91
OP1089	Area 3 Portable Stemming System	02-25-91
OP1090	Area 6 Gasoline Tank	02-25-91
OP1217	Area 1 Portable Crusher	12-03-89
OP1287	Area 1 Aggregate Plant	02-12-92
OP88-3	Open Burning for Training Exercises	09-30-88
RC 974	Area 6 DAF Surface Disturbanc	--
RC 1122	Area 14 Surface Disturbance	--
RC 1367	NTS Surface Disturbance	--
RC 1524	Mercury Cafeteria Boiler	--
RC 1525	Mercury Cafeteria Boiler	--
RC 1526	Area 12 Cafeteria Boiler	--

A report was sent to the State of Nevada on April 15, 1987 which gave the CY86 operating hours and cubic yards produced under those permits which have that reporting requirement (permits number 919, 922, 923, 928, 1082, 1217, and 1287). None of the operating restrictions were exceeded. The CY87 report will be sent in 1988, and will again indicate that no restrictions were exceeded.

Inspection Results

The State of Nevada conducted an inspection of the NTS facilities on January 14 and 15, 1987. No violations were observed, and no Notice of Violation was issued as a result of their inspection. However, the issue of not using water to control the dust from downhole stemming material was raised regarding the Shaker Plant and Area 3 Portable Stemming Facility. The question will be resolved by the State during their next inspection in CY88.

RCRA ACTIVITIES

Permit Status and Inspection

REECo has been assigned EPA Generator Identification Number NV3890090001, and is responsible for the offsite disposal of all hazardous waste generated at the NTS. One off-site shipment of hazardous waste was made on June 16, 1987; the required Hazardous Waste Generator Annual Report was sent to the State of Nevada on February 27, 1987.

On February 11, the EPA conducted a RCRA compliance inspection of the NTS and found four deficiencies:

1. Hazardous waste being temporarily stored greater than 90 days.

2. Insufficient separation between incompatible materials in storage.

3. Storage waste needs protection from the sun.

4. The Closure Plan for Area 23 Hazardous Waste Disposal Site had not been completed.

Item 1 was corrected by obtaining a continuous use contract with a disposal firm to ensure prompt off-site shipment. A proper facility for temporary storage while awaiting off-site shipment is scheduled for construction in 1988 to correct items 2 and 3. The Closure Plan in item 4 is scheduled for submittal to the State of Nevada in January 1988.

Tunnel Pond Sampling

On August 7 water samples were collected from the effluent lines at E, G, P, N, and T tunnels and from two holding ponds at both N and T tunnels. Samples were also collected from the bottom of the holding ponds which contained both soil and sediment. The samples were analyzed by an off site laboratory for metals, volatile organics, and semi-volatile organics.

No volatile or semi-volatile organic primary pollutants were found that are detectable by the EPA approved methods. The metal content of the liquid and soil was normal; there were no metals near the hazardous threshold level. The results indicate that there were no hazardous chemicals in the tunnel effluents or in the tunnel ponds at the time the samples were taken.

Mixed Waste Disposal Permit Application

During 1987 the Part A application for mixed waste disposal at the NTS was amended to include: (1) solid waste disposal at the Area 3 Radioactive Waste Management Site, (2) liquid disposal in the Area 6 Decon Facility Evaporative Pond and, (3) the Area 23 Building 650 leachfield.

Interim Status was granted by the State of Nevada for mixed waste disposal on September 17, 1987. No mixed waste was disposed of during the remainder of the year.

CERCLA ACTIVITIES

The only environmental sampling that was undertaken to comply with CERCLA regulations were soil and swipe samples collected at Sugar Bunker in Area 25. The samples were analyzed by the Industrial Hygiene Environmental Laboratory for beryllium contamination. Swipe samples were taken inside the bunker and on the exterior walls. The soil samples were collected outside around the bunker. All the results were below the detectable limits of 0.2 ppm for the soil samples and .01 g for the swipes.

TSCA ACTIVITIES

REECo has a PCB Identification Number, NVG-PCB-006, issued by the State of Nevada, and is responsible for the off-site disposal of PCB oils and PCB transformers at the NTS. On June 24 an annual report for CY86 was submitted to the State, as required by State Regulations. There was no State or Federal inspection of the NTS for TSCA Compliance during 1987.

During 1987, 141 oil samples were collected at the NTS and analyzed by the Industrial Hygiene Environmental Laboratory for PCB concentration. These oil samples were collected from transformers or barrels of oil awaiting disposal. An additional 56 standard samples were run for quality assurance.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
DOE/DP/0539-060		

4. TITLE AND SUBTITLE	5. REPORT DATE / 6. PERFORMING ORGANIZATION CODE
OFFSITE ENVIRONMENTAL MONITORING REPORT: Radiation Monitoring Around U.S. Nuclear Test Areas, Calendar Year 1987	
7. AUTHOR(S) N. Sunderland, S. Black, C. Fontana, A. Mullen, D. Thome', B. Dicey, A. Jarvis, D. Smith	8. PERFORMING ORGANIZATION REPORT NO. EPA 600/4-88/021
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Monitoring Systems Laboratory Office of Research and Development U. S. Environmental Protection Agency, PO Box 93478 Las Vegas, NV 89193-3478	10. PROGRAM ELEMENT NO. XLUF10 11. CONTRACT/GRANT NO. IAG DE-AI08-86NV10522
12. SPONSORING AGENCY NAME AND ADDRESS U. S. Department of Energy Nevada Operations Office PO Box 98518 Las Vegas, NV 89193-8518	13. TYPE OF REPORT AND PERIOD COVERED Response - 1987 14. SPONSORING AGENCY CODE EPA 600/07

15. SUPPLEMENTARY NOTES

Prepared for the U. S. Department of Energy under Interagency Agreement No. DE-AI08-86NV10522

16. ABSTRACT

This report covers the routine radiation monitoring activities conducted by the Environmental Monitoring Systems Laboratory-Las Vegas in areas which may be affected by nuclear testing programs of the Department of Energy. This monitoring is conducted to document compliance with standards, to identify trends in environmental radiation, and to provide such information to the public. It summarizes these activities for calendar year 1987.

No radioactivity attributable to NTS activities was detectable offsite by the monitoring networks. Using recorded wind data and Pasquill stability categories, atmospheric dispersion calculations based on reported radionuclides releases yield an estimated dose of 5.9×10^{-4} person-rem to the population within 80 km of the Nevada Test Site during 1987. World-wide fallout of Kr-85, Sr-90, Cs-137, and Pu-239 detected by the monitoring networks would cause maximum exposure to an individual of less than 0.16 mrem per year. Plutonium in air was still detectable along with Krypton-85, which continued its gradual increase, as has been reported previously. Cesium and strontium in air were near their detection limits. An occasional net exposure to offsite residents has been detected by the TLD network. On investigation, the cause of such net exposures has been due to personal habits or occupational activities, not to NTS activities.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO THE PUBLIC	UNCLASSIFIED	137
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

☆ U.S. GOVERNMENT PRINTING OFFICE:1988-581-137/70082