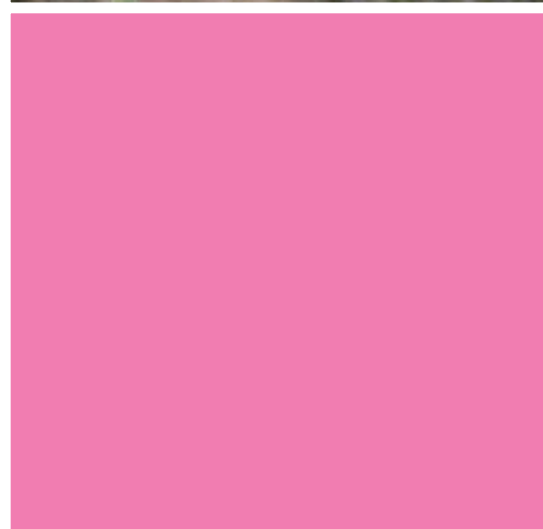
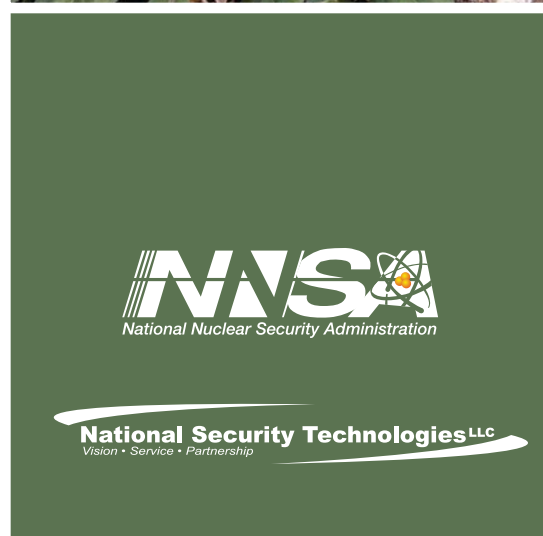
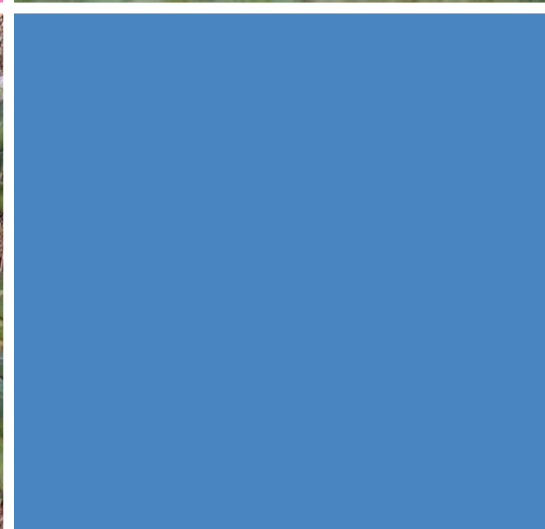




DOE/NV/25946--790-SUM



# Nevada Test Site Environmental Report Summary



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The information presented in this document is explained in greater detail in the *Nevada Test Site Environmental Report 2008* (DOE/NV/25946--790). A compact disc of this document is included on the back inside cover. This document can also be downloaded from the National Nuclear Security Administration Nevada Site Office at <http://www.nv.doe.gov/library/publications/environmental.aspx>.

For more information about the Nevada Test Site's Environmental Report, contact Pete Sanders at (702) 295-1037 or [sanders@nv.doe.gov](mailto:sanders@nv.doe.gov).

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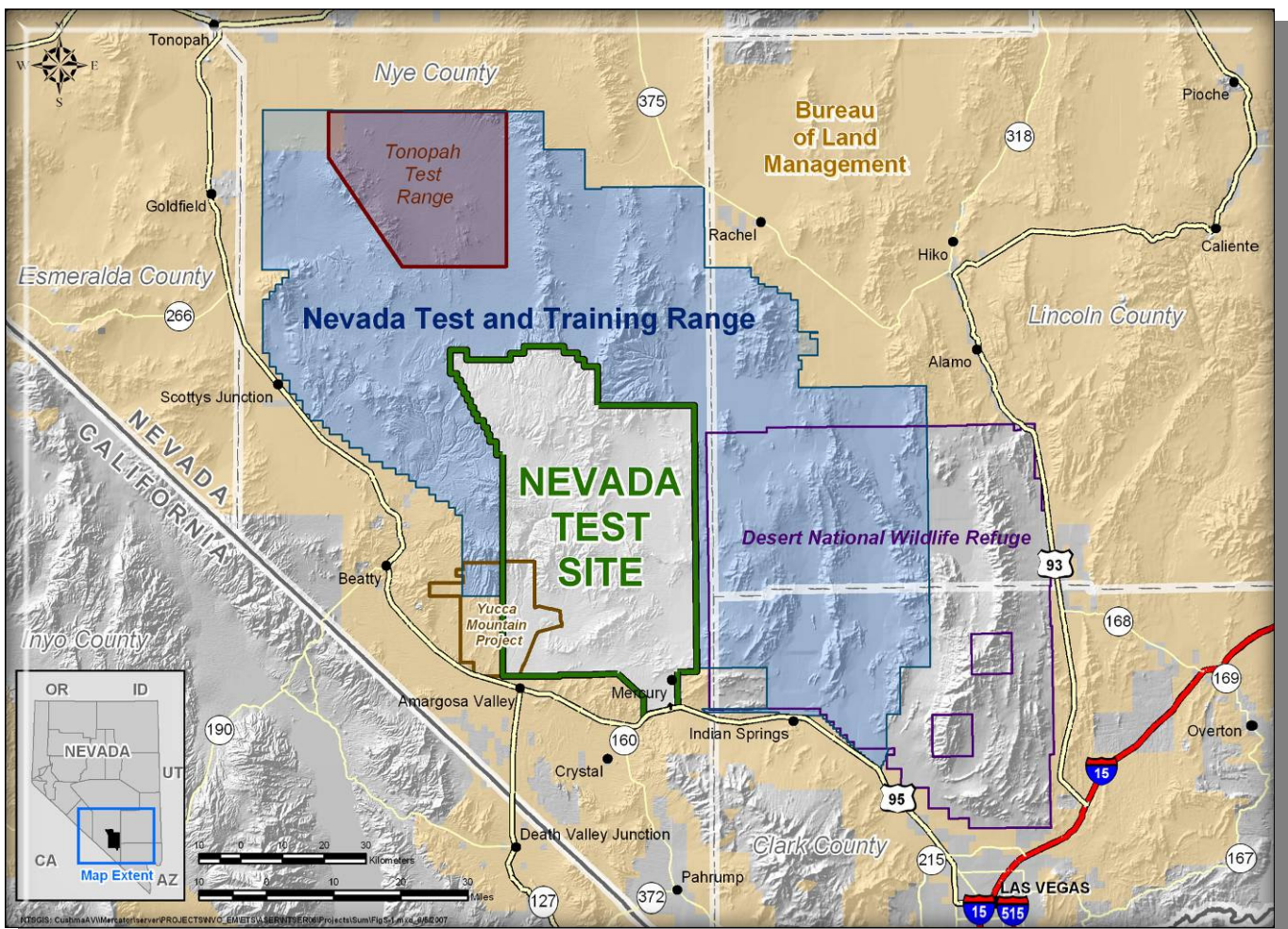


# *Nevada Test Site*

## *Environmental Report Summary 2008*

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) directs the management and operation of the Nevada Test Site (NTS). The NTS is the nation's historical testing site for nuclear weapons from 1951 through 1992 and is currently the nation's unique site for ongoing national security-related missions and high-risk operations. NNSA/NSO strives to provide to the public an understanding of the current activities on the NTS, including environmental monitoring and compliance activities aimed at protecting the public and the environment from radiation hazards and from nonradiological impacts. This document is a summary of the Nevada Test Site Environmental Report (NTSER) for calendar year 2008 (see attached compact disc on inside back cover). The NTSER is a comprehensive report of environmental activities performed at the NTS and offsite facilities over the previous calendar year. It is prepared annually to meet the requirements and guidelines of the U.S. Department of Energy (DOE) and the information needs of NNSA/NSO stakeholders. To provide an abbreviated and more readable version of the NTSER, this summary report is produced. This summary does not include detailed data tables, monitoring methods or design, a description of the NTS environment, or a discussion of all environmental program activities performed throughout the year. The reader may obtain a hard copy of the full NTSER as directed on the inside front cover of this summary report.

The NTS is located about 65 miles northwest of Las Vegas. The approximately 1,375-square mile site is one of the largest restricted access areas in the United States. It is surrounded by federal installations with strictly controlled access as well as by lands that are open to public entry.



## NTS History

Between 1940 and 1950, the area now known as the NTS was part of the Las Vegas Bombing and Gunnery Range. In 1950, the NTS was established as the primary location for testing the nation's nuclear explosive devices. Such testing took place from 1951 to 1992.

Tests conducted through the 1950s were predominantly atmospheric tests. These involved a nuclear explosive device detonated while on the ground surface, on a steel tower, suspended from tethered balloons, dropped from an aircraft, or placed on a rocket. Several tests were categorized as "safety experiments" and "storage-transportation tests," involving the destruction of a nuclear device with non-nuclear explosives. Some of these tests resulted in dispersion of plutonium in the test vicinity. One of these test areas, Project 57, lies just north of the NTS boundary on the Nevada Test and Training Range (NTTR). Other tests, involving storage-transportation, were conducted at the north end of the NTTR (Double Tracks) and on the Tonopah Test Range (TTR) (Clean Slates I, II, and III). All nuclear device tests are listed in *United States Nuclear Tests, July 1945 through September 1992* (U.S. Department of Energy, Nevada Operations Office, 2000, DOE/NV--209, Rev. 15).

The first underground test, a cratering test, was conducted in 1951. The first totally contained underground test was in 1957. Testing was discontinued during a moratorium that began October 31, 1958, but was resumed in September 1961 after tests by the Union of Soviet Socialist Republics began. Since late 1962, nearly all tests have been conducted in sealed vertical shafts drilled into Yucca Flat and Pahute Mesa or in horizontal tunnels mined into Rainier Mesa. From 1951 to 1992, a total of 828 underground nuclear tests were conducted at the NTS. Approximately one-third of these tests was detonated near or below the water table.

Five earth-cratering (shallow-burial) tests were conducted over the period of 1962 through 1968 as part of the Plowshare Program that explored peaceful uses of nuclear explosives. The first and highest yield Plowshare crater test, Sedan, was detonated at the northern end of Yucca Flat on the NTS. The second-highest yield crater test was Schooner, located in the northwest corner of the NTS. Mixed fission products, tritium, and plutonium from these tests were entrained in the soil, ejected from the craters, and deposited on the ground surrounding the craters.

Other nuclear-related experiments at the NTS included the Bare Reactor Experiment-Nevada series in the 1960s. These tests were performed with a 14-million electron volt neutron generator mounted on a 1,527-foot steel tower used to conduct neutron and gamma-ray interaction studies on various materials and assess radiation doses experienced by the nuclear bomb survivors of Hiroshima and Nagasaki. In addition, from 1959 through 1973 a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests were conducted in Area 25, and a series of tests with a nuclear ramjet engine was conducted in Area 26. The test released mostly gaseous radioactivity (radio-iodines, radio-xenons, radio-kryptons) and some fuel particles due to erosion of the metal cladding on the reactor fuel; these releases resulted in negligible deposition on the ground.

### NTS - Continental Test Site

After the end of World War II, the United States tested nuclear weapons at Bikini Atoll and Enewetak in the Marshall Islands of the Central Pacific.

In June 1950, with the outbreak of hostilities in Korea and U.S. relations with the Soviet Union continuing to deteriorate, the search began for a continental test site to overcome the difficulties with remoteness and security experienced with testing in the Pacific. The final choices included Dugway Proving Ground–Wendover Bombing Range in western Utah, Alamogordo–White Sands Guided Missile Range in south-central New Mexico, and a North Site and a South Site on the Las Vegas Bombing and Gunnery Range in southern Nevada.

On December 18, 1950, President Truman approved the recommendations of Los Alamos testing officials and the Atomic Energy Commission, christening the South Site on the Las Vegas Bombing and Gunnery Range as the nation's continental test site. It is called the Nevada Proving Ground.

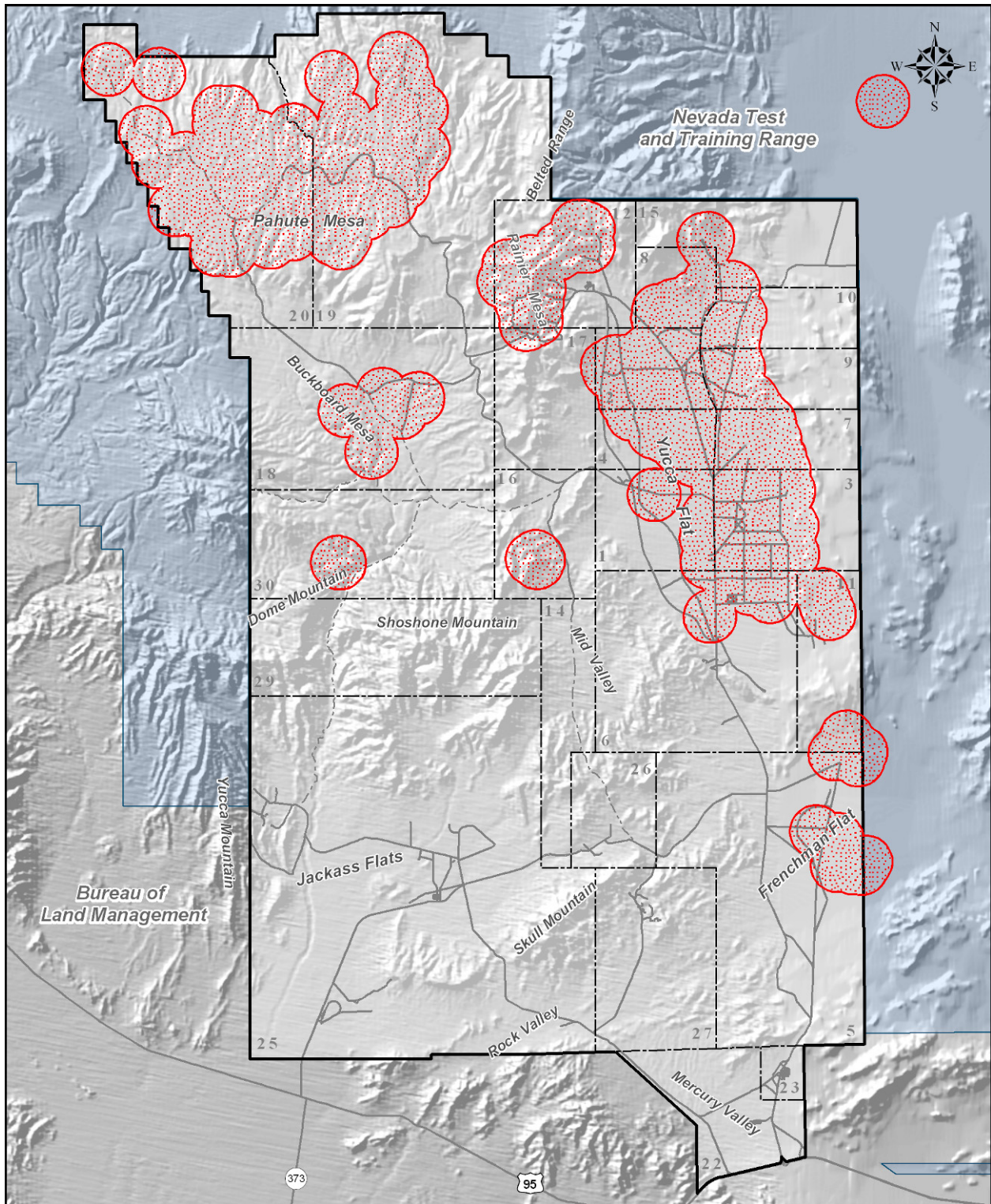
On Saturday, January 27, 1951, an Air Force B-50D bomber dropped a 1-kiloton yield nuclear bomb over Frenchman Flat. It was the world's tenth nuclear detonation and was the first NTS test.

On September 23, 1992, the last underground nuclear test was conducted on the NTS after which Congress imposed a moratorium on nuclear weapons testing.

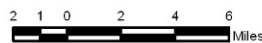
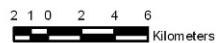
Since 1951, a total of 100 atmospheric and 828 underground nuclear weapons tests were conducted at the NTS.

Source: T. R. Fehner and F. G. Gosling, 2000. *Origins of the Nevada Test Site*, DOE/MA-0518, History Division, Executive Secretariat, Management and Administration, U.S. Department of Energy.





- Historic Nuclear Testing Area
- Primary Road
- Secondary Road
- NTS Operational Areas
- NTS Boundary

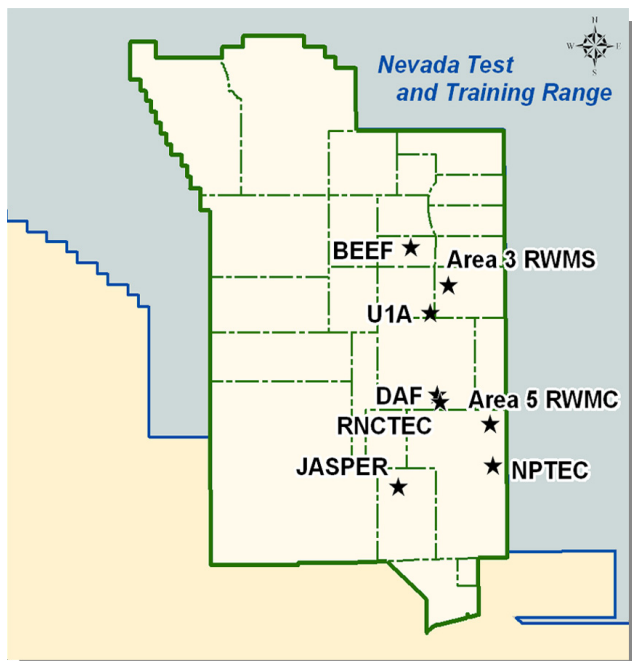


**Historic Nuclear Testing Areas**

## The NTS Now

Los Alamos, Lawrence Livermore, and Sandia National Laboratories are the principal organizations that sponsor and implement experimental programs at the NTS. The three major NTS missions include National Security, Environmental Management, and Stewardship of the NTS. During the conduct of all missions and their programs, NNSA/NSO complies with applicable environmental and public health protection regulations and strives to manage the land and facilities at the NTS as a unique and valuable national resource. In 2008, National Security Technologies, LLC (NSTec), was the Management and Operations contractor accountable for the successful execution of work and ensuring that work was performed in compliance with environmental regulations.

NTS activities in 2008 continued to be diverse, with the primary goal being to ensure that the existing U.S. stockpile of nuclear weapons remains safe and reliable. Facilities that support this mission include the U1a Facility, the Big Explosives Experimental Facility (BEEF), the Device Assembly Facility (DAF), and the Joint Actinide Shock Physics Experimental Research (JASPER) Facility. Facilities that support the Homeland Security program include the new Radiological/Nuclear Countermeasures Test and Evaluation Complex (RNCTEC), which became operational in 2009. Facilities that support the Waste Management Program include the Area 5 Radioactive Waste



Management Complex (RWMC) and the Area 3 Radioactive Waste Management Site (RWMS). Other NTS activities include demilitarization activities; controlled spills of hazardous material at the Nonproliferation Test and Evaluation Complex (NPTEC) (formerly known as the Hazardous Materials Spill Center); remediation of contaminated sites; processing of waste destined for the Waste Isolation Pilot Plant in Carlsbad, New Mexico, or the Idaho National Laboratory in Idaho Falls, Idaho; disposal of radioactive and mixed waste; and environmental research.

## NTS Missions and Their Programs

### National Security

**Stockpile Stewardship Program** – Conducts high-hazard operations in support of defense-related nuclear and national security experiments.

**Homeland Security Program** – Provides support facilities, training facilities, and capabilities for government agencies involved in counterterrorism activities, emergency response, first responders, national security technology development, and nonproliferation technology development.

**Test Readiness Program** – Maintains the capability to resume underground nuclear weapons testing, if directed.

### Environmental Management

**Environmental Restoration Program** – Characterizes and remediates the environmental legacy of nuclear weapons and other testing at the NTS and offsite locations and develops and deploys technologies that enhance environmental restoration.

**Waste Management Program** – Manages and safely disposes of low-level waste received from DOE- and U.S. Department of Defense-approved facilities throughout the United States and mixed low-level waste generated in Nevada by NNSA/NSO, and safely manages and characterizes hazardous and transuranic wastes for offsite disposal.

### Stewardship of the NTS

**Facilities and Infrastructure** – Maintains the buildings, roads, utilities, and facilities required to support all NTS programs and to provide a safe environment for NTS workers.



## Legacy Contamination

**Groundwater** – Areas of known and potential groundwater contamination on the NTS due to underground nuclear testing are called Underground Test Area (UGTA) Corrective Action Units. It is estimated that 300 million curies (Ci) of radiation were released underground during 828 nuclear tests. The total amount of radiation deposited below the groundwater table is approximately 60 million Ci, based on the last decay-corrected calculation from 1992. Since there is no feasible technology available that would allow for the cleanup of deep, extensive groundwater contamination, the strategy of the Environmental Management Program is to identify contaminant boundaries and implement an effective long-term monitoring system.

**Soil** – Radioactively contaminated surface soils directly resulting from nuclear weapons testing occur at approximately 100 sites on and around the NTS. Closure of these sites is conducted in accordance with the Federal Facility Agreement and Consent Order (FFACO) and upon approval by the State of Nevada. Corrective actions required to complete closure range from removal of soil to closure in place with restricted access controls, such as fencing and posting.

**Air** – Airborne radioactive contamination from the resuspension of contaminated soils at legacy sites and from current activities (such as waste management) is monitored continuously on and off the NTS. Since the cessation of atmospheric nuclear testing, the annual amounts of radiation released into the air from the NTS have ranged from 48 to 2,200 Ci for tritium, 0.0018 to 0.40 Ci for plutonium, and 0.039 to 0.049 Ci for americium. These emissions cannot be distinguished from the background airborne radiation measured in communities surrounding the NTS.

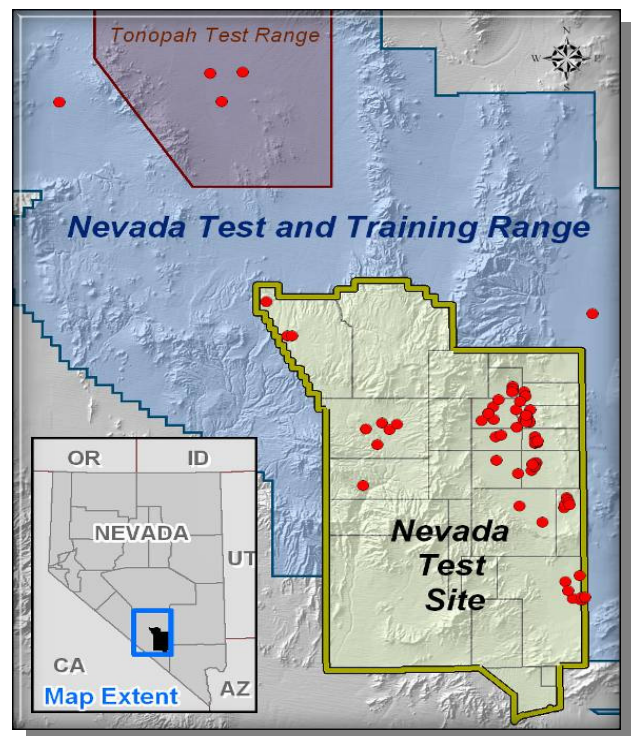
**Structures/Materials** – There are approximately 1,850 sites where facilities, equipment, structures, and/or debris were contaminated by historic nuclear research, development, and testing activities. The responsibility for remediating these Industrial Sites belongs to the Environmental Restoration Project. As of December 31, 2008, 1,736 sites have been approved for final completion in accordance with the FFACO and approved by the State of Nevada.

**Waste Disposal** – Low-level and mixed low-level radioactive waste have been generated by historic nuclear research, development and testing activities, and environmental cleanup activities. More than 1.37 million cubic yards of this waste have been safely disposed at the Area 3 and Area 5 Radioactive Waste Management Sites as of December 31, 2008. The estimated total amount of radioactivity at the time of disposal was 14.04 million Ci. The radioactive content of the disposed waste decays over time at a varied rate depending on the radionuclide.

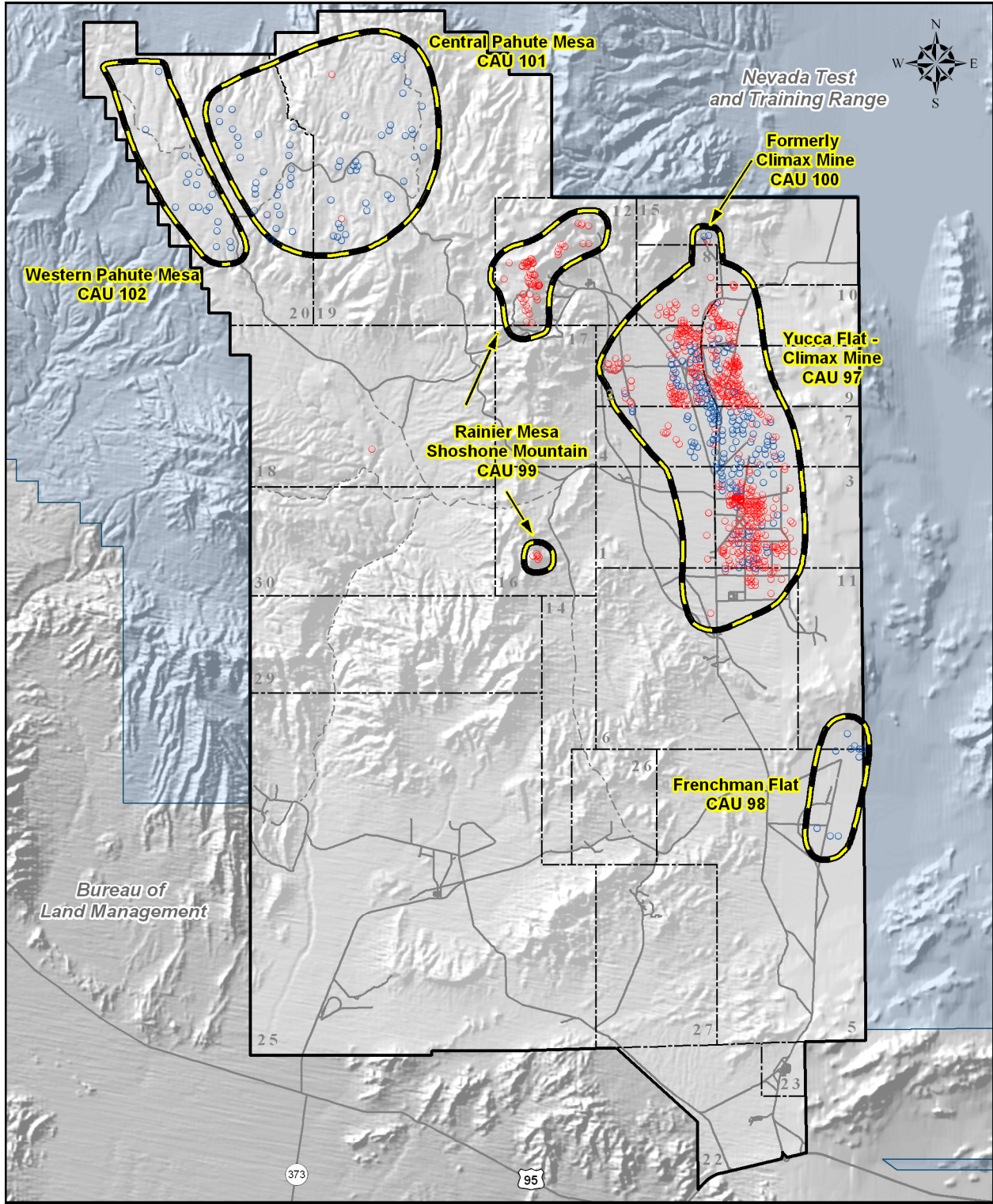
## The Legacy of NTS Nuclear Testing

Approximately one-third of the 828 underground nuclear tests on the NTS was detonated near or below the water table resulting in the contamination of groundwater in some areas. In addition, the 100 atmospheric nuclear tests conducted on the NTS and numerous nuclear-related experiments resulted in the contamination of surface soils, materials, equipment, and structures, mainly on the NTS. The NNSA/NSO Environmental Management Mission was established to address this legacy of contamination. Within Environmental Management, the Environmental Restoration Project is responsible for remediating contaminated sites, and the Waste Management Project is responsible for safely managing and disposing radioactive waste.

The primary regulatory driver of the Environmental Restoration Project is the Federal Facility Agreement and Consent Order (FFACO) between the State of Nevada, DOE, and U.S. Department of Defense. The FFACO identifies Corrective Action Units (CAUs), which are groupings of Corrective Action Sites (CASs) that delineate and define areas of concern for contamination. Approximately 2,800 CASs have been identified, many of which have already been remediated and/or closed. The public is kept informed of Environmental Management activities through periodic newsletters, exhibits, and fact sheets, and Environmental Management provides the opportunity for public input via the Community Advisory Board, consisting of 15–20 citizen volunteers from Nevada.



Locations of Soil Contamination on and off the NTS



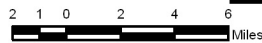
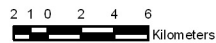
NTS GIS Product ID: 20090302-02-P018-R01

**Location of Underground Nuclear Tests**

- Tests with no expected interaction with the regional groundwater system\* (Vadose Zone)
- Tests having potential interaction with the regional groundwater system\* (Saturated Zone)

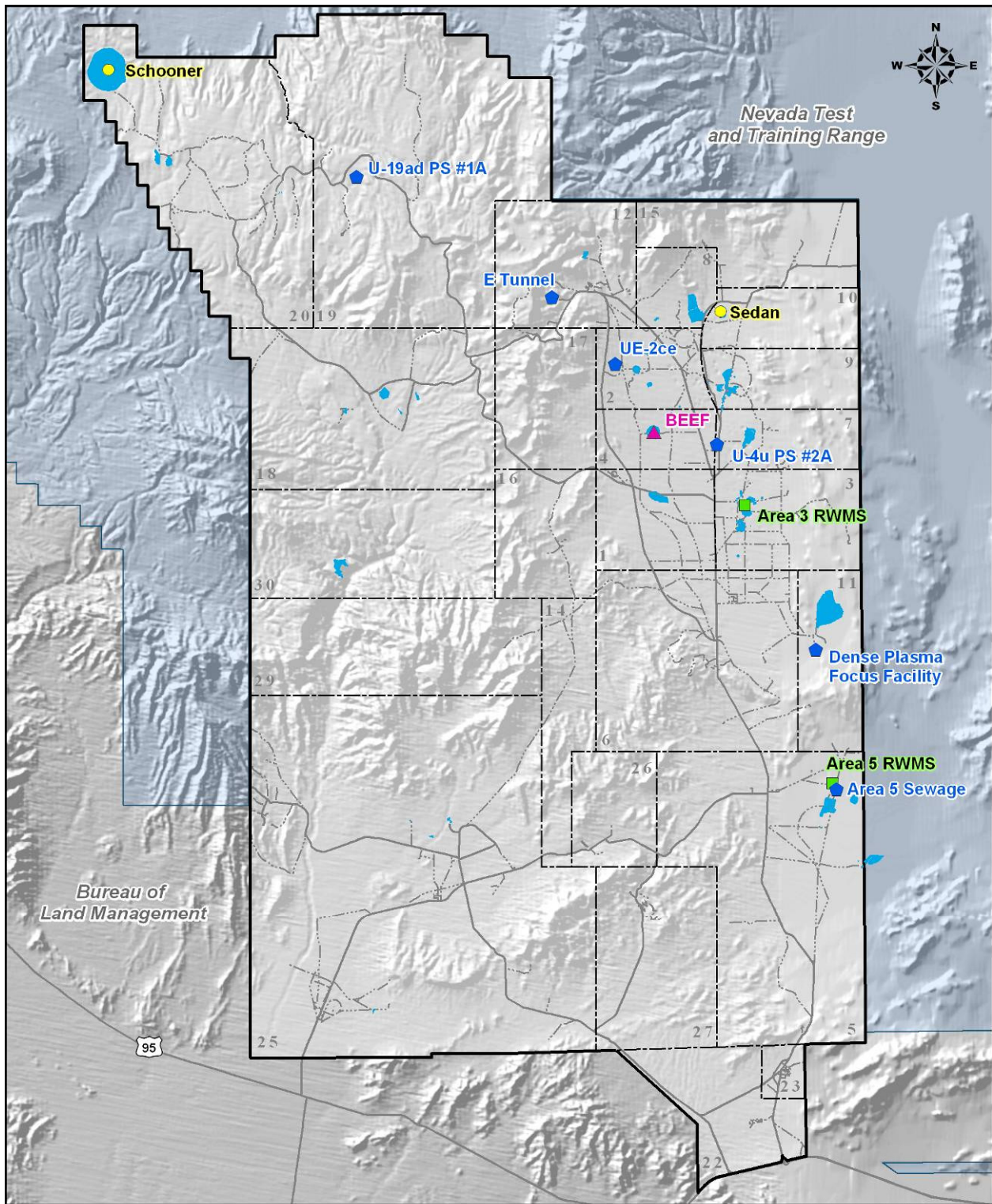
\*Groundwater interaction potential derived from DOE/NV--464 UC-700, 1997.

- CAU Boundary
- Primary Road
- - - Secondary Road
- - - NTS Operations Area
- NTS Boundary

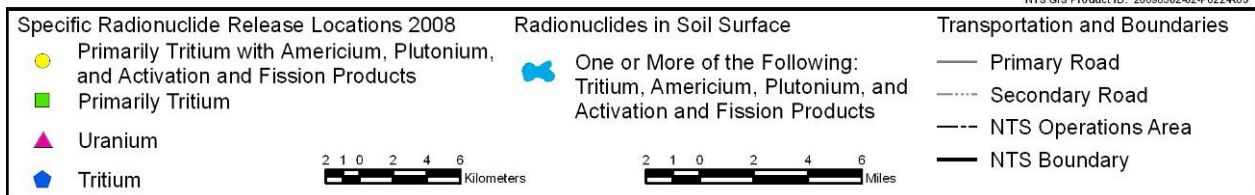


**Areas of Potential Groundwater Contamination on the NTS**





NTS GIS Product ID: 20090302-02-P022-R03



Sources of Radiological Air Emissions on the NTS

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## Understanding Radiation

Radiation is energy that travels through matter or space in the form of waves or high-speed particles. Light, heat, and sound are types of radiation. Ionizing radiation is a very high-energy form of electromagnetic radiation. Ionizing radiation are particles or rays given off by unstable atoms as they are converted, or decay, into more stable atoms. Ionizing radiation may be found everywhere. Almost all exposure to ionizing radiation comes from natural sources (82 percent in the United States). These sources include cosmic radiation from outer space, terrestrial radiation from materials like uranium and radium in the earth, and naturally occurring radioactive elements (i.e., radionuclides) in our food,

*Curie (Ci) is the traditional measure of radioactivity based on the observed decay rate of 1 gram of radium. One curie of radioactive material will have 37 billion disintegrations in 1 second.*

water, and the aerosols and gases in the air we breathe. Exposures to man-made radiation in our everyday life come from smoking cigarettes, traveling on airplanes, and having medical X-rays. For the public surrounding the NTS, less than 1 percent of their total radiation exposure is now attributable to past or current NTS activities.

### Forms of Radiation

**Alpha** particles are heavy, positively charged particles given off by some decaying atoms. Alpha particles can be blocked by a sheet of paper. Atoms emitting alpha particles are hazardous only if they are swallowed or inhaled.

**Beta** particles are electrons or positrons (positively charged electrons) ejected from the nucleus of a decaying atom. More penetrating than alpha radiation, beta particles can pass through several millimeters of skin. A sheet of aluminum only a fraction of an inch thick will stop beta radiation. Beta particles can damage skin, but are most hazardous if the beta-emitting atoms are swallowed or inhaled.

**Gamma** rays are waves of pure energy similar to X-rays, light, microwaves, and radio waves. Gamma rays are emitted by certain radionuclides when their nuclei transition from a higher to a lower energy state. They can readily pass into the human body. They can be almost completely blocked by about 40 inches of concrete, 40 feet of water, or a few inches of lead. Gamma rays can be both an external and internal hazard.

**X-rays** are a more familiar form of electromagnetic radiation, usually with a limited penetrating power, typically used in medical or dental examinations. Television sets, especially color, give off soft (low-energy) X-rays; thus, they are shielded to greatly reduce the risk of radiation exposure.

**Neutrons** are uncharged heavy particles contained in the nucleus of every atom heavier than ordinary hydrogen. They induce ionization only indirectly in atoms that they strike, but can damage body tissues. Neutrons are released, for example, during the fission (splitting) of uranium atoms in the fuel of nuclear power plants. They can also be very penetrating. In general, efficient shielding against neutrons can be provided by materials containing hydrogen, such as water. Like gamma rays, neutrons are both an external and internal hazard.

## Understanding Radiation Dose

Dose is a generic term to describe the amount of radiation a person receives. The energy deposited indicates the number of molecules disrupted. The energy the radiation deposits in tissue is called the absorbed dose. The units of measure of absorbed dose are the rad or the gray. The biological effect of radiation depends on the type of radiation (alpha, beta, gamma, or X-ray) and the tissues exposed. A measure of the biologic risk of the energy deposited is the dose equivalent. The units of dose equivalent are called

rems or sieverts. In this report, the term dose is used to mean dose equivalent measured in rems. A thousandth of a rem is called a millirem, abbreviated as mrem. An average person in the United States receives about 300 mrem each year from natural sources and an additional 60 mrem from medical procedures, consumer products, and activities. Whether or not there is a “safe” radiation dose equivalent is a controversial subject. Because the topic has yet to be settled scientifically, regulators



Radionuclides Detected on the NTS				
	Name*	Abbreviation	Primary Type(s) of Radiation	Major NTS Source
Man-Made	Americium-241	<sup>241</sup> Am	Alpha, gamma	In soil at and near legacy sites of aboveground nuclear testing. Detected in soil and air.
	Cesium-137	<sup>137</sup> Cs	Beta, gamma	
	Plutonium-238	<sup>238</sup> Pu	Alpha	
	Strontium-90	<sup>90</sup> Sr	Beta	
	Plutonium-239+240	<sup>239+240</sup> Pu	Alpha	In soil at and near legacy sites of plutonium dispersal experiments. Detected in soil and air.
	Tritium	<sup>3</sup> H	Beta	In groundwater in areas of underground nuclear tests, in surface ponds used to contain contaminated groundwater, in soil at nuclear test locations, in waste packages buried in pits at waste management sites. Detected in groundwater and air.
Naturally Occurring	Be-7	<sup>7</sup> Be	Gamma	Produced by interactions between cosmic radiation from the sun and the earth's upper atmosphere. Detected in air.
	Potassium-40	<sup>40</sup> K	Beta, gamma	Naturally occurring in the earth's crust. Detected in groundwater, soil, and air.
	Radium-226	<sup>226</sup> Ra	Alpha, gamma	
	Thorium-232	<sup>232</sup> Th	Alpha**	
	Uranium-234	<sup>234</sup> U	Alpha**	
	Uranium-235	<sup>235</sup> U	Alpha, gamma**	
Uranium-238	<sup>238</sup> U	Alpha**		

\*The number given with the name of the radionuclide is the atomic mass number and is the number of protons and neutrons together in the nucleus of the atom. Radionuclides with the same number of protons are the same element and radionuclides of the same element are called isotopes of one another. Plutonium and uranium each have several radioactive isotopes that are detected on the NTS.

\*\*The type of radiation may also include beta and gamma emitted from progeny or daughter radionuclides produced by the natural decay of the original or parent radionuclide listed.

take a conservative approach and assume that there is no such thing as a 100 percent safe dose equivalent, and it is assumed that the risk of developing an adverse health effect (such as cancer) is proportionate to the amount of radiation dose. Many human activities increase our exposure to radiation over and above the average background radiation dose of 300 mrem per year. These activities include, for example, uranium mining, airline travel, and operating nuclear power plants. Regulators balance the benefit of these activities to the risk of increasing radiation exposures above background, and as a result, set dose limits for the public and workers specific to these activities. The DOE has set the dose limit to the public from exposure to DOE-related nuclear activities to 100 mrem/yr. This is the same public dose limit set by the U.S. Nuclear Regulatory Commission (NRC) and recommended by the International Commission on Radiological Protection and the National Commission on Radiological Protection and Measurements.

The NRC has set the dose limit for radiation workers to 5 rem/yr. There is no regulatory standard for radiation dose limits to workers or the public across industries, states, or countries.

Common Doses to the Public	
Source/Activity	Average Dose/Year (or as noted)
Five-hour jet plane ride	3 mrem
Building materials	4 mrem
Chest X-ray	8 mrem
Cosmic	30 mrem
Soil	35 mrem
Internal to our body	40 mrem
Mammogram	138 mrem
Radon gas	200 mrem
CT scan	2,500 mrem
Smoking 20 cigarettes/day	5,300 mrem to a smoker's lung
One cancer treatment	5,000,000 mrem to the tumor

Source: <<http://hss.energy.gov/HealthSafety/WSHP/radiation/Radiation-final-6-20.pdf>>, accessed on 5/14/2009

## Monitoring NTS Radiation and Pathways of Exposure to the Public

The release of man-made radionuclides from the NTS has been monitored since the first decade of atmospheric testing. After 1962 when nuclear tests were conducted only underground, the radiation exposure to the public surrounding the NTS was greatly reduced. Underground nuclear testing nearly eliminated atmospheric releases of radiation, but resulted in the contamination of groundwater in some areas of the NTS. After the 1992 moratorium on nuclear testing, radiation monitoring focused on detecting airborne radionuclides that are resuspended with historically contaminated soils on the NTS and on detecting man-made radionuclides in groundwater.

There are three *pathways* in this dry desert environment by which man-made radionuclides from the NTS might reach the surrounding public:

**Air Transport Pathway** – Members of the public may inhale or ingest radionuclides that are resuspended by the wind from known contaminated sites on the NTS. However, such resuspended radiation measured off and on the NTS is much lower than natural background radiation in all areas accessible to the public.

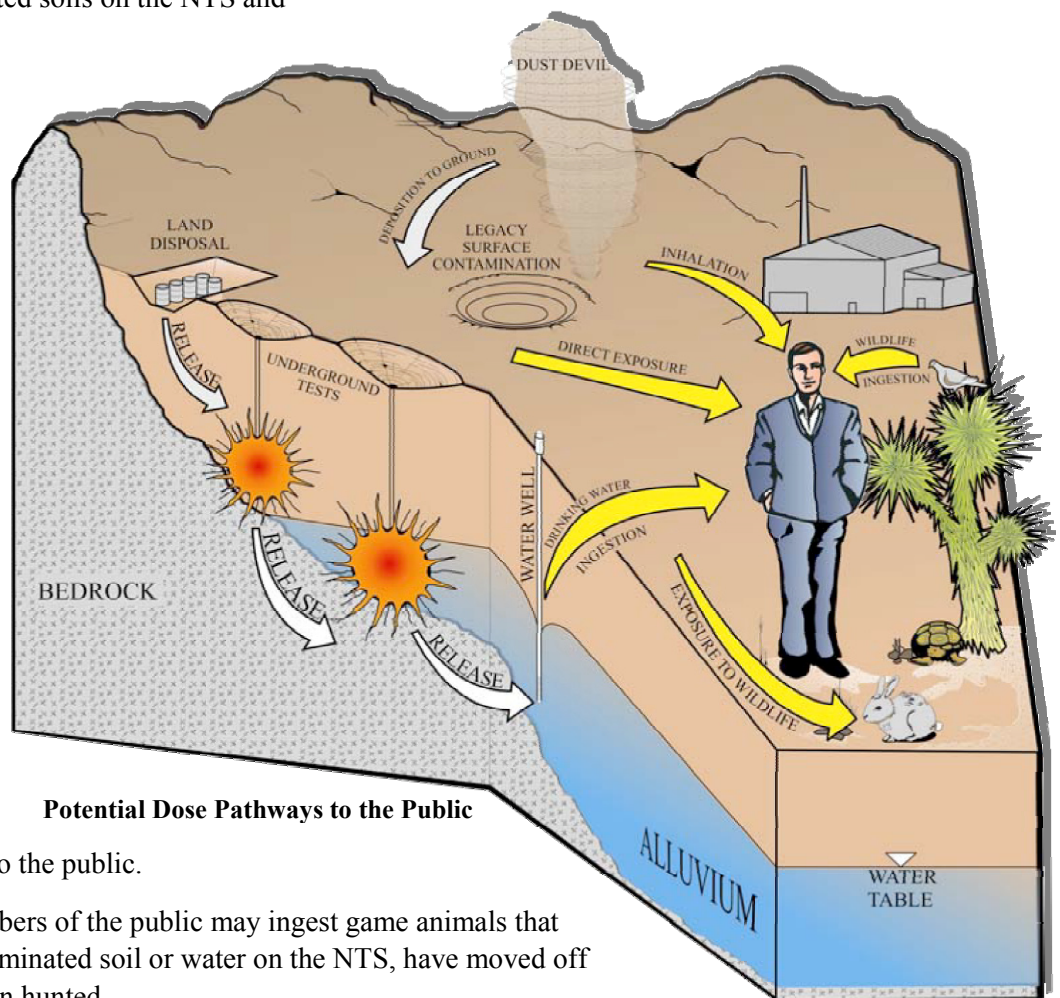
**Ingestion Pathway** – Members of the public may ingest game animals that have been exposed to contaminated soil or water on the NTS, have moved off the NTS, and have then been hunted.

**Groundwater Pathway** – Drinking contaminated groundwater is currently not a possible pathway for public exposure given the restricted public access to the NTS and the location of known contaminated groundwater on the NTS. No man-made radionuclides occur in drinking water sources monitored off the NTS, and no drinking water wells on the NTS have measurable levels of man-made radionuclides. Only the groundwater from monitoring wells drilled near underground tests on the NTS show radioactive contamination.

### Public Dose Limits for NTS Radiation

**10 mrem/yr** – This is the dose limit to the public (above natural background) from just the air transport pathway, as specified by the Clean Air Act National Emission Standards for Hazardous Air Pollutants (NESHAP).

**100 mrem/yr** – This is the dose limit to the public (above natural background) from all possible pathways combined, as specified by DOE Order DOE O 5400.5, “Radiation Protection of the Public and the Environment.”





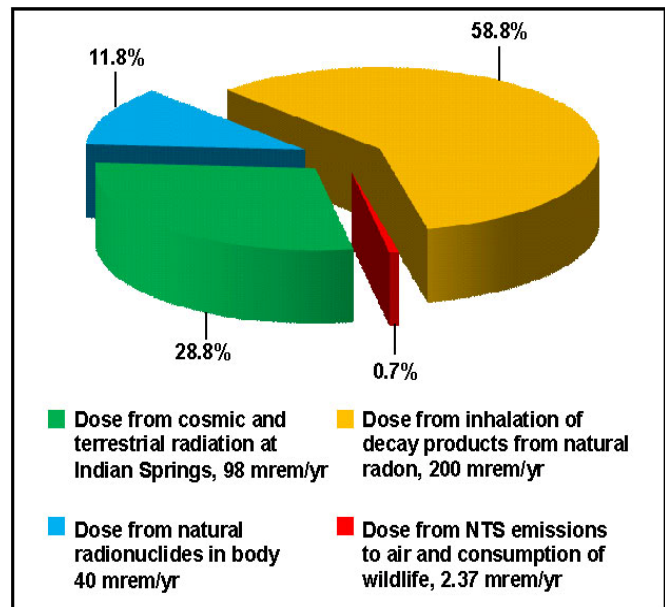
## Estimated 2008 Radiation Dose to the Public from NTS Operations

**Inhalation** – Compliance with radiation dose limits to the general public from the air transport pathway is demonstrated using air sampling results from six onsite “critical receptor” sampling stations. The radionuclides detected at four or more of the NTS critical receptor samplers were  $^{241}\text{Am}$ ,  $^{238}\text{Pu}$ ,  $^{239+240}\text{Pu}$ ,  $^{233+234}\text{U}$ ,  $^{235+236}\text{U}$ ,  $^{238}\text{U}$ , and  $^3\text{H}$ . The uranium isotopes are attributed to naturally occurring uranium. As in previous years, the 2008 data from the six critical receptor samplers show that the NESHAP dose limit to the public of 10 mrem/yr was not exceeded. The Schooner critical receptor station, in the far northwest corner of the NTS, had the highest concentrations of radioactive air emissions, yet an individual residing at this station would experience a dose from air emissions of only 1.9 mrem/yr. This annual dose is 19 percent of the NESHAP public dose limit. No one resides at this location, and the dose at offsite populated locations (12 to 50 miles) from the Schooner station would be much lower due to wind dispersion.

**Ingestion** – NTS game animals include pronghorn antelope, mule deer, chukar, Gambel’s quail, mourning doves, cottontail rabbits, and jackrabbits. Small game animals from different contaminated NTS sites are trapped each year and analyzed for their radionuclide content. These results are used to construct worst-case scenarios for the dose to hunters who might consume these animals if the animals moved off the NTS. In 2008, a mourning dove and two cottontail rabbits were sampled near the Schooner Crater. Based on these samples, the highest dose to a member of the public was estimated to be 0.47 mrem for the person who consumed 20 cottontail rabbits and 20 doves.

**Groundwater** — there is no NTS radiation dose to the public from this pathway. Annual monitoring continues to verify that no contaminated groundwater has migrated beyond the NTS boundaries into surrounding water supplies used by the public.

**Direct Exposure** – No members of the public are expected to receive direct gamma radiation that is above background levels as a result of NTS operations. Areas accessible to the public, such as the main entrance gate, had direct gamma radiation exposure rates comparable to natural background rates from cosmic and terrestrial radiation.



Percents of Total Dose to the Public from Natural Background Sources and from the NTS

### 2008 Dose to the Public from All Pathways

**2.37 mrem/yr** – This is the maximum dose to the public from inhalation, ingestion, and direct exposure pathways that is attributable to NTS operations. It is well below the dose limit of 100 mrem/yr established by DOE O 5400.5 for radiation exposure to the public from all pathways combined. This total dose estimate is indistinguishable from natural background radiation experienced by the public residing in communities surrounding the NTS.

## Radioactive Air Emissions

NTS radioactive emissions are monitored on site to determine the public dose from inhalation (shown on page 11) and to ensure compliance with NESHAP under the Clean Air Act. A network of 19 air sampling stations and a network of 109 thermoluminescent dosimeters (TLDs) are located throughout the NTS (see map on page 13), mainly within those numbered operational areas where historic nuclear testing has occurred or where current radiological operations occur. NTS air sampling stations monitor tritium in water vapor, man-made radionuclides, and gross alpha and beta radioactivity in airborne particulates. The TLD stations monitor direct gamma radiation exposure.

Range in Average Concentrations of Man-Made Radionuclides in Air Samples on the NTS in 2008			
Radionuclide	Concentration ( $10^{-15}$ $\mu\text{Ci/mL}$ ) <sup>(a)</sup>		
	Limit <sup>(b)</sup>	Lowest Average	Highest Average
<sup>241</sup> Am	1.9	-0.00007	0.012
<sup>3</sup> H	1,500,000	90	279,870
<sup>238</sup> Pu	2.1	-0.00075	0.0051
<sup>239+240</sup> Pu	2.0	0.0016	0.073

(a) The scale of concentration units for radionuclides shown in the table have been standardized to  $10^{-15}$  microcuries per milliliter ( $\mu\text{Ci/mL}$ ). This scale may differ from those reported in detailed radionuclide-specific data tables in the NTSER

(b) The concentration established by NESHAP as the compliance limit.

Radioactive emissions are also monitored at stations in selected towns and communities within 240 miles of the NTS by the independent Community Environmental Monitoring Program (CEMP), which is coordinated by the Desert Research Institute (DRI) of the Nevada System of Higher Education under contract with NNSA/NSO. Its purpose is to provide monitoring for radionuclides that may be released from the NTS. A network of 29 CEMP stations are used (see map on page 14). The CEMP stations monitor gross alpha and beta radioactivity in airborne particulates using low-volume particulate air samplers, penetrating gamma radiation using TLDs, gamma radiation exposure rates using pressurized ion chamber (PIC) detectors, and meteorological parameters using automated weather instrumentation (MET stations).

### Concentration of Man-Made Radionuclides –

Several man-made radionuclides were detected at NTS air sampling stations in 2008: <sup>241</sup>Am, <sup>3</sup>H, <sup>238</sup>Pu, and <sup>239+240</sup>Pu. None, however, exceeded concentration limits established by the Clean Air Act. The highest average level of <sup>241</sup>Am and <sup>239+240</sup>Pu was detected at Bunker 9-300 in Area 9, located within an area of known soil contamination from past nuclear tests. No one station appeared to be consistently higher than the rest for <sup>238</sup>Pu. The highest average level of tritium was detected at Schooner, site of the second-highest yield Plowshare cratering experiment on the NTS where tritium-infused ejecta surrounds the crater.

No man-made radionuclides were detected above minimum detectable concentrations in the air samples from the JASPER Facility. A calculated 0.060 Ci of depleted uranium was released during operations at the BEEF. No radiological releases occurred at U1a or DAF.

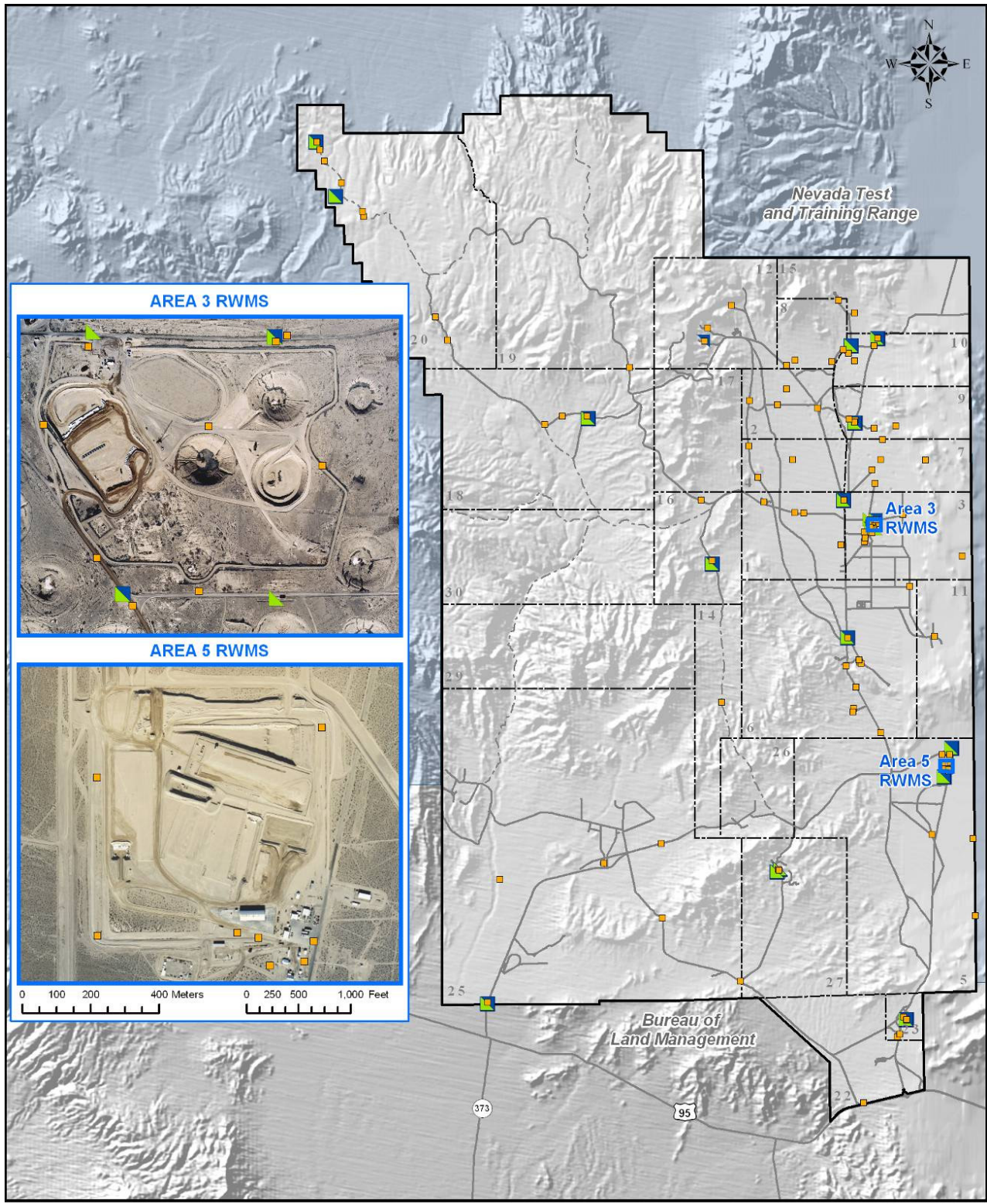
No airborne radioactivity related to any NTS operations was detected at the CEMP stations during 2008. No man-made gamma-emitting radionuclides were detected. Naturally occurring radioactive beryllium (<sup>7</sup>Be) was detected in most air particulate samples.

**Total Quantity of Man-Made Radionuclides –** The total amounts (measured in Ci) of man-made radionuclides that were emitted to the air from all sources on the NTS in 2008 was estimated to be 440 Ci for tritium, 0.047 Ci for <sup>241</sup>Am, 0.050 Ci for <sup>238</sup>Pu, 0.29 Ci for <sup>239+240</sup>Pu, and 0.60 Ci for depleted uranium. Over the past 10 years, total emissions have ranged from 160 to 564 Ci for tritium, 0.039 to 0.049 Ci for <sup>241</sup>Am, and 0.24 to 0.39 Ci for <sup>239+240</sup>Pu. Emissions of <sup>238</sup>Pu are estimated to have remained consistent at about 0.050 Ci over the same time frame.

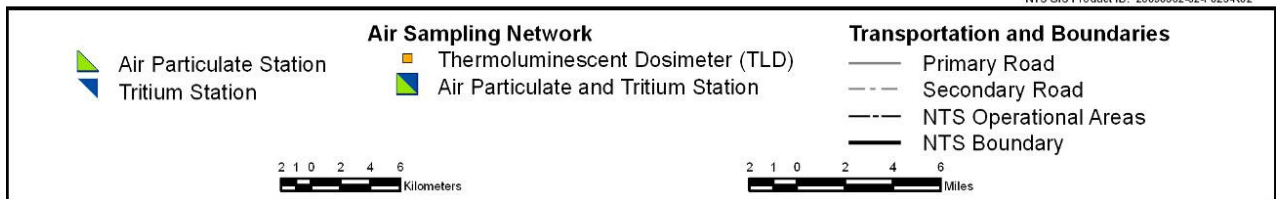
Estimated Quantity of Man-Made Radionuclides Released into the Air from the NTS in 2008 (in Curies)				
Tritium ( <sup>3</sup> H)	Americium ( <sup>241</sup> Am)	Plutonium ( <sup>238</sup> Pu)	Plutonium ( <sup>239+240</sup> Pu)	Depleted Uranium
440	0.047	0.050	0.29	0.060

Plutonium and americium sources are legacy sites of past nuclear testing on the NTS where these radionuclides are in surface soils that can become re-suspended by wind.



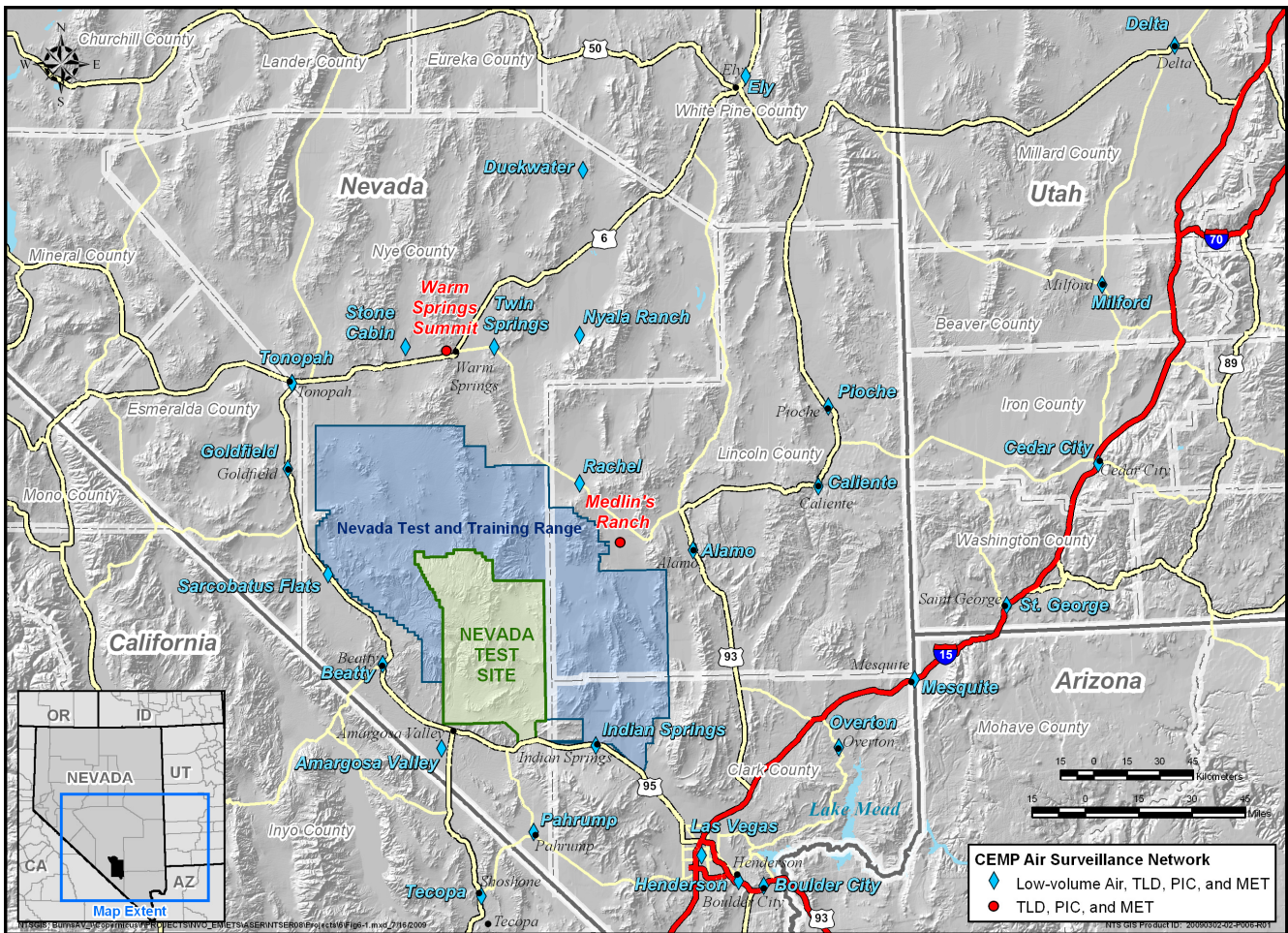


NTS GIS Product ID: 20090302-02-P023-R02



2008 NTS Air Sampling Network





2008 CEMP Air Surveillance Network

**Gamma Radiation Exposure** – Ten of the NTS TLD stations are located where radiation effects from NTS operations are negligible, and therefore measure only natural background levels of gamma radiation from cosmic and terrestrial sources. In 2008, the mean measured background level from the ten stations was 116 milliroentgens per year (mR/yr). This is well within average background levels observed in other parts of the U.S. of similar elevation above sea level. Background radiation varies not only by elevation but by the amounts of natural radioactive materials in soil and rock in different geographic regions.

The highest estimated mean annual gamma exposure measured at a TLD station on the NTS was 705 mR/yr at Schooner, one of the legacy Plowshare sites on Pahute Mesa. The lowest was 59 mR/yr in Mercury at the fitness track. The mean annual gamma exposure at 17 TLD locations near the Area 3 and Area 5 RWMSs was 138 mR/yr. At the 35 TLD locations near known legacy sites (including Schooner), it was 253 mR/yr.

The CEMP offsite TLD and PIC results remained consistent with previous years' background radiation

*Direct exposure to gamma radiation is measured at 109 TLD stations on the NTS. Exposure is reported in units called milliroentgens (mR).*

*Generally, a 1 mR gamma exposure from the most common external radionuclides produces a 1 mrem dose.*

levels and are also well within average background levels observed in other parts of the U.S. and with the 116 mR/yr level measured on the NTS. The highest total annual gamma exposure measured off site, based on the PIC detectors, was 176 mR/yr at Warm Springs Summit, Nevada (at 6,290 feet elevation). The lowest offsite rate, based on the PIC detectors, was 73 mR/yr at Pahrump, Nevada (at 2,639 feet elevation).

**2008 NTS Background Gamma Radiation**  
**116 mR/yr** – This is the background radiation measured at 10 TLD stations in areas isolated from past and present nuclear activities.



Average Direct Radiation Measured in 2008		
Location	Elevation Above Sea Level (feet)	Radiation Exposure (mR/yr)
NTS - Schooner TLD station	5,660	705
NTS - 35 Legacy Site TLD stations (includes Schooner)	3,077–5,938	253
Warm Springs Summit, Nevada CEMP PIC station	7,570	176
Twin Springs, Nevada PIC station	5,146	170
NTS - 17 Waste Operation TLD stations	3,176–4,021	138
NTS - 10 Background TLD stations	2,755–5,938	116
St. George, Utah PIC station	2,688	83
Pahrump, Nevada PIC station	2,639	73
NTS Mercury Fitness Track TLD station	3,769	59

Average Background Radiation of Selected U.S. Cities (Excluding Radon)		
City	Elevation Above Sea Level (feet)	Radiation (mR/yr)
Denver, CO	5,280	164.6
Wheeling, WV	656	111.9
Rochester, NY	505	88.1
St. Louis, MO	465	87.9
Portland, OR	39	86.7
Los Angeles, CA	292	73.6
Fort Worth, TX	650	68.7
Richmond, VA	210	64.1
Tampa, FL	0	63.7
New Orleans, LA	39	63.7

Source: <<http://www.wrcc.dri.edu/cemp/Radiation.html>> "Radiation in Perspective," August 1990, as accessed on 4/2/2009

## Nonradioactive Air Emissions

The release of air pollutants is regulated on the NTS under a Class II air quality operating permit. Class II permits are issued for "minor" sources where annual emissions must not exceed 100 tons of any one criteria pollutant or 10 tons of any one of the 189 hazardous air pollutants (HAPs), or 25 tons of any combination of HAPs. Common sources of such air pollutants on the NTS include particulates from construction, aggregate production, surface disturbances, fugitive dust from driving on unpaved roads, fuel-burning equipment, open burning, fuel storage facilities, and chemical release tests conducted at the NPTEC on Frenchman Flat playa in Area 5.

An estimated 6.05 tons of criteria air pollutants were released on the NTS in 2008. The majority of the emissions were nitrogen oxides from diesel generators. Total air emissions of lead, also a criteria pollutant, was 4.56 pounds (0.002 tons). The quantity

Estimated Quantity of Pollutants Released into the Air from NTS Operations in 2008	
<b>Criteria Air Pollutants:</b>	<b>Tons</b>
Particulate Matter (PM10) <sup>(a)</sup>	0.22
Carbon Monoxide (CO)	0.94
Nitrogen Oxides (NOx)	3.36
Sulfur Dioxide (SO <sub>2</sub> )	0.06
Volatile Organic Compounds (VOC)	0.60
<b>Hazardous Air Pollutants (HAPs)</b>	<b>0.09</b>
<b>Lead</b>	<b>0.002</b>
(a) Particulate matter equal to or less than 10 microns in diameter	

of HAPS released in 2008 was 0.09 tons. No emission limits for any air pollutants were exceeded.

## Offsite Radiological Monitoring of Groundwater

NNSA/NSO's comprehensive radiological environmental monitoring program includes sampling and analysis of groundwater and natural springs off of the NTS to determine if groundwater contamination from past nuclear testing poses a current threat to public health and the environment. In 2008, NSTec conducted radiological monitoring of 10 non-potable NNSA/NSO wells drilled for hydrogeologic investigations including groundwater flow modeling. Most were in Oasis Valley (ER-OV labeled wells, see map on page 17). No offsite springs were sampled in 2008.

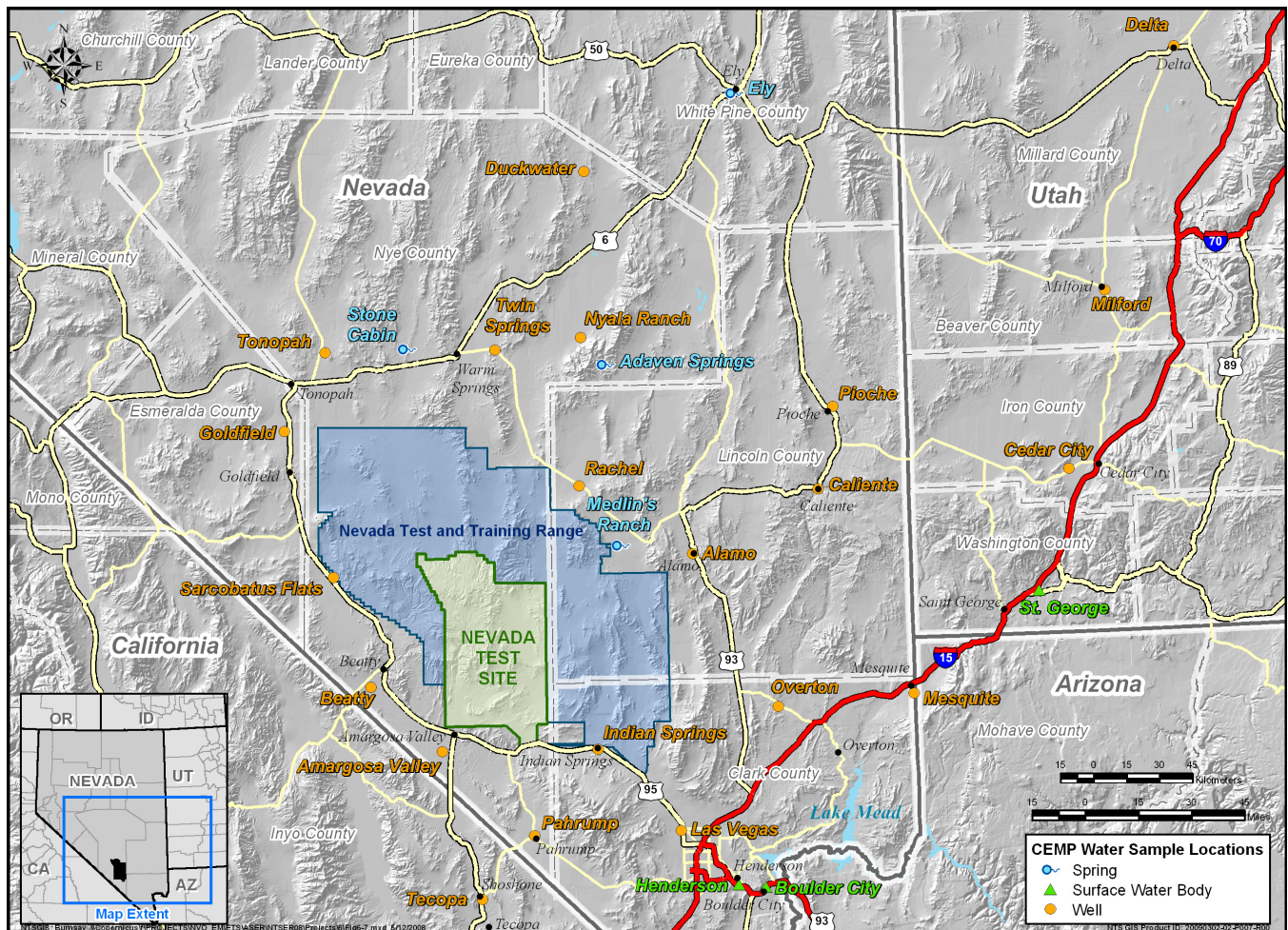
The DRI, through the CEMP, is tasked by NNSA/NSO to provide independent verification of the tritium concentrations in some of the offsite groundwater wells, municipal water supply systems, and springs used for water supplies in areas surrounding the NTS. Samples collected by DRI provide a comparison to the results obtained by NSTec. In 2008, the CEMP offsite water sampling locations included 21 wells, 3 surface water supply systems, and 4 springs located in selected towns and communities within 240 miles from the NTS (see map below).

NSTec offsite water samples are analyzed for tritium, man-made gamma-emitting radionuclides, and gross alpha and gross beta radioactivity. Tritium is the sole radionuclide for which CEMP water sample analyses are run.

**20,000 pCi/L – This is the EPA-established concentration limit for tritium in drinking water.**

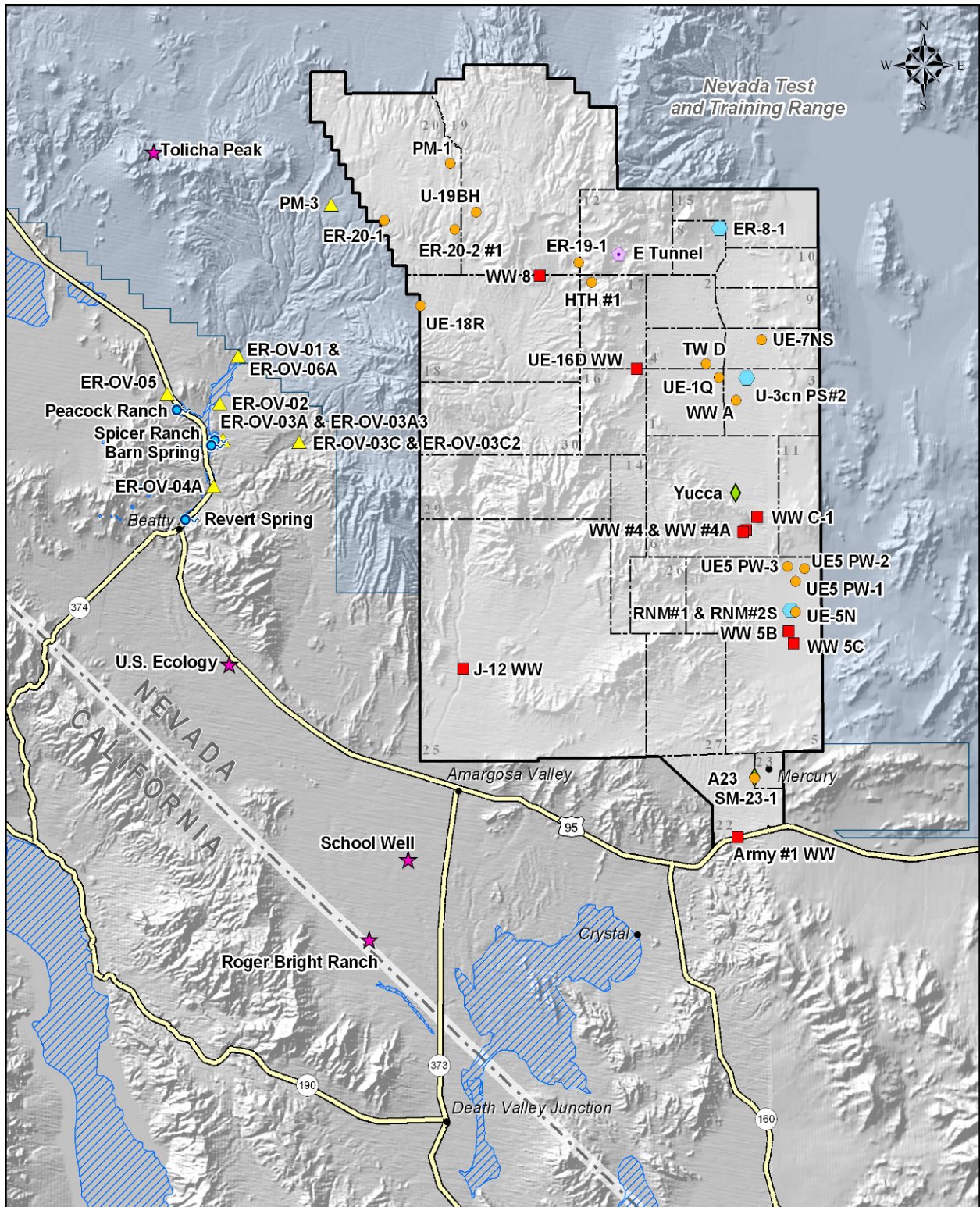
All water samples from the offsite springs, wells, and surface water supplies monitored by NSTec and the CEMP had levels of tritium either below laboratory background levels or at very low detectable levels (<25 picocuries per liter [pCi/L]). The very low detectable levels represent residual tritium persisting in the environment that originated from global atmospheric nuclear testing.

No offsite springs or wells contained any man-made gamma-emitting radionuclides.



2008 CEMP Water Monitoring Locations





NTSGIS: burmsav\_1\Copernicus\PROJECTS\NVO\_EMETSASER\WTSER07\Projects\Sum\FigS-10.mxd\_6/25/2008



2008 NSTec Water Monitoring Locations

Range in Groundwater Tritium Levels Measured Off the NTS in 2008	
	pCi/L
Offsite Supply Wells (CEMP)	-0.3 to 5.4
Offsite Springs/ Surface Waters (CEMP)	-0.8 to 24.1
Offsite NNSA/NSO Monitoring Wells (NSTec)	-10.8 to 21.9

Most offsite wells and all offsite spring samples contained detectable gross alpha and gross beta activity that is most likely from natural sources. All levels were less than the U.S. Environmental Protection Agency (EPA) limits set for drinking water (15 pCi/L for gross alpha and 50 pCi/L for gross beta), except Barn Spring. This spring's measured gross alpha activity was  $19 \pm 2.4$  pCi/L.

**Offsite groundwater monitoring indicates that there has been no offsite migration of man-made radionuclides from underground contamination areas on the NTS.**

## Onsite Radiological Monitoring of Groundwater

Radioactivity in onsite groundwater and surface waters of the NTS is monitored annually in order to (1) ensure that NTS drinking water is safe, (2) determine if permitted facilities on the NTS are in compliance with permit discharge limits for radionuclides, (3) estimate radiological dose to onsite wildlife using natural and man-made water sources, and (4) determine if groundwater is being protected from disposed radioactive wastes at the Area 3 and Area 5 RWMSs. In 2008, the onsite water monitoring network consisted of 5 potable and 4 non-potable water supply wells, 14 monitoring wells, 1 tritiated water containment pond system, and 2 sewage lagoons (see map on page 17).

**Water Supply Wells** – The 2008 data continue to indicate that underground nuclear testing has not impacted the NTS drinking water supply network. None of the onsite water supply wells had detectable concentrations (i.e., above minimum detectable concentration [MDC]) of tritium or detectable concentrations of man-made gamma-emitting radionuclides. The gross alpha and gross beta radioactivity detected in potable water supply wells represent the presence of naturally occurring radionuclides and did not exceed EPA drinking water limits.

**No drinking water wells on the NTS contained detectable tritium or man-made gamma-emitting radionuclides.**

Range in Groundwater Tritium Levels Measured On the NTS in 2008	
	pCi/L
Onsite Supply Wells	-19.5 to 10.6
Onsite Monitoring Wells	-10.7 to 356*
*Four onsite monitoring wells had tritium levels above MDCs, and all four are within 1 kilometer (0.6 miles) of underground nuclear tests.	

**Monitoring Wells** – Some migration of radionuclides from the underground test areas to NTS monitoring wells has occurred, although the migration distances appear to be very short. Four onsite monitoring wells (PM-1, UE-7NS, U-19BH, and WW A) had detectable concentrations of tritium in 2008 ranging from 31 to 356 pCi/L, all well below the drinking water limit of 20,000 pCi/L. Each of these monitoring wells is located within 0.6 miles of an historical underground nuclear test; all have consistently had detectable levels of tritium in past years, and no trend of rising tritium concentrations in these wells has been observed since 2000. The other ten monitoring wells had tritium levels below their MDCs which ranged from -10.7 to 12.1 pCi/L.

No man-made radionuclides were detected by gamma spectroscopy analyses at concentrations above detection limits in any of the monitoring wells in 2008. All of the 14 monitoring wells had measurable gross alpha and gross beta levels, which are likely from natural sources. One of the monitoring wells (U-19BH) had gross alpha and gross beta activity above the EPA limits for drinking water, which is likely from man-made radionuclides.



**Containment Ponds** – A series of five constructed ponds collect and hold water discharged from E Tunnel in Area 12 where nuclear testing was conducted in the past. The water is perched groundwater that has percolated through fractures in the tunnel system. Monitoring of the effluent waters from E Tunnel is conducted to determine if radionuclides or other contaminants exceed the allowable contaminant levels regulated under a state water pollution control permit. Tritium concentrations in tunnel effluent waters in 2008 were lower than the permit limit. The E Tunnel containment ponds are fenced and posted with radiological warning signs. Given that the ponds are available to wildlife, game animals are sampled by NSTec to assess the potential radiological dose to humans via ingestion of game animals exposed to these ponds and to evaluate the radiological impacts to wildlife.

<b>2008 Monitoring Results for E Tunnel Effluent Waters Pertaining to Water Pollution Control Permit NEV 96021</b>		
<b>Parameter</b>	<b>Permit Limit (pCi/L)</b>	<b>Average Measured Concentration (pCi/L)</b>
Tritium	1,000,000	577,000
Gross Alpha	35	8.6
Gross Beta	100	42.3

Tritiated water is also pumped into lined sumps during studies conducted by the Underground Test Area (UGTA) Sub-Project. This sub-project’s mission is to characterize the groundwater beneath the NTS and adjacent lands for the purpose of developing analytical models to predict groundwater movement and contaminant transport. To do this, suitable wells are drilled and existing drill holes are re-completed in the vicinity of some underground tests and at other locations on the NTS. If the tritium level exceeds 200,000 pCi/L in water purged from a well during drilling, re-completion, or sampling operations, contaminated water is pumped from the wells and diverted to lined sumps (containment ponds) for evaporation, as required by the State. During 2008, water containing tritium was pumped from four known contaminated drill holes and diverted to lined sumps. The highest tritium levels were 21 million pCi/L in groundwater samples from the pumped drillhole U4u PS #2a.

**Permitted Sewage Lagoons** – Two permitted sewage lagoons (Area 6 Yucca and Area 23 Mercury) were sampled in 2008 and analyzed for tritium, gross alpha and beta activity, and gamma-emitting radionuclides. As during previous years, none of the lagoon samples contained detectable levels of the analytes.

## **Onsite Nonradiological Monitoring of Drinking Water and Wastewater**

NNSA/NSO operates a network of six permitted wells that comprise three permitted public water systems on the NTS that supply the drinking water needs of NTS workers and visitors. NNSA/NSO also hauls potable water to work locations at the NTS that are not part of a public water system. Monitoring results for 2008 indicated that water samples from the three public water systems and from the potable water hauling trucks met the National Primary and Secondary Drinking Water Standards.

Industrial discharges on the NTS are limited to the two operating sewage lagoon systems, Area 6 Yucca and Area 23 Mercury. Under the conditions of the state operating permit, liquid discharges to these sewage lagoons were tested quarterly in 2008 for biochemical oxygen demand, pH, and total suspended solids. Sewage lagoon pond waters were also sampled once in 2008 for a suite of toxic chemicals. All sewage lagoon water measurements were within permit limits.

The discharge water from the E Tunnel complex is sampled annually under the state water pollution control permit NEV 96021 for 14 nonradiological contaminants, which are mainly metals. In 2008, none of the contaminants were detected at levels that exceeded permit limits.

### ***NTS Drinking Water***

***The public water systems that supply drinking water to NTS workers and visitors meet all National Primary and Secondary Drinking Water Standards.***

## Environmental Restoration

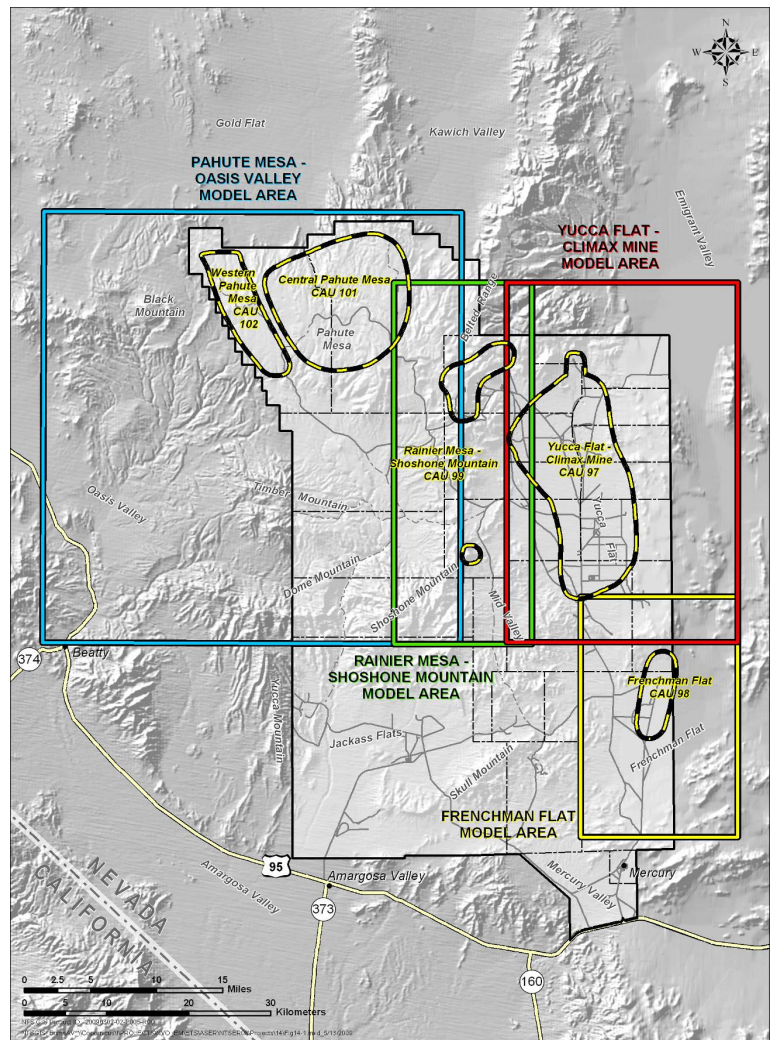
In April 1996, the DOE, U.S. Department of Defense, and the State of Nevada entered into an FFACO to address the environmental restoration of historic contaminated sites at the NTS, parts of TTR, parts of the Nevada Test and Training Range, the Central Nevada Test Area, and the Project Shoal Area. Appendix VI of the FFACO, as amended (February 2008), identifies a work scope and milestone schedule for the cleanup and safe closure of the contaminated aboveground sites and for the field investigations and model development necessary to characterize the underground sites.

In 2008, 70 contaminated aboveground sites were closed safely. These aboveground sites consist of facilities and land, and are referred to as Industrial Sites.

The UGTA Sub-Project investigates the areas where local or regional groundwater contamination has occurred. These areas have been organized into five UGTA CAUs. Hydrogeologic studies use existing data from past testing and data obtained from drilling and testing newly constructed deep wells and from recompleting or rehabilitating existing wells.

Extensive progress was made in 2008 toward the development of hydrologic models describing groundwater flow and possible radionuclide transport from the UGTA CAUs into groundwater underlying public lands outside the boundaries of the NTS. This involved completing the final draft of the Phase I Flow and Transport Model and the Phase II Corrective Action Investigation Plan for the Central and Western Pahute CAUs and completing the compilation, analysis, and documentation of all hydrologic and transport parameters that will be used to build the flow model for the Rainier Mesa/Shoshone Mountain CAU.

The Central and Western Pahute CAUs Phase I Flow and Transport model predicts the migration of tritium and carbon-14 off the NTS within 50 years of the first nuclear detonation (1966) in the Pahute Mesa-Oasis Valley Model Area. It predicts that contamination above the Safe Drinking Water Act standard for



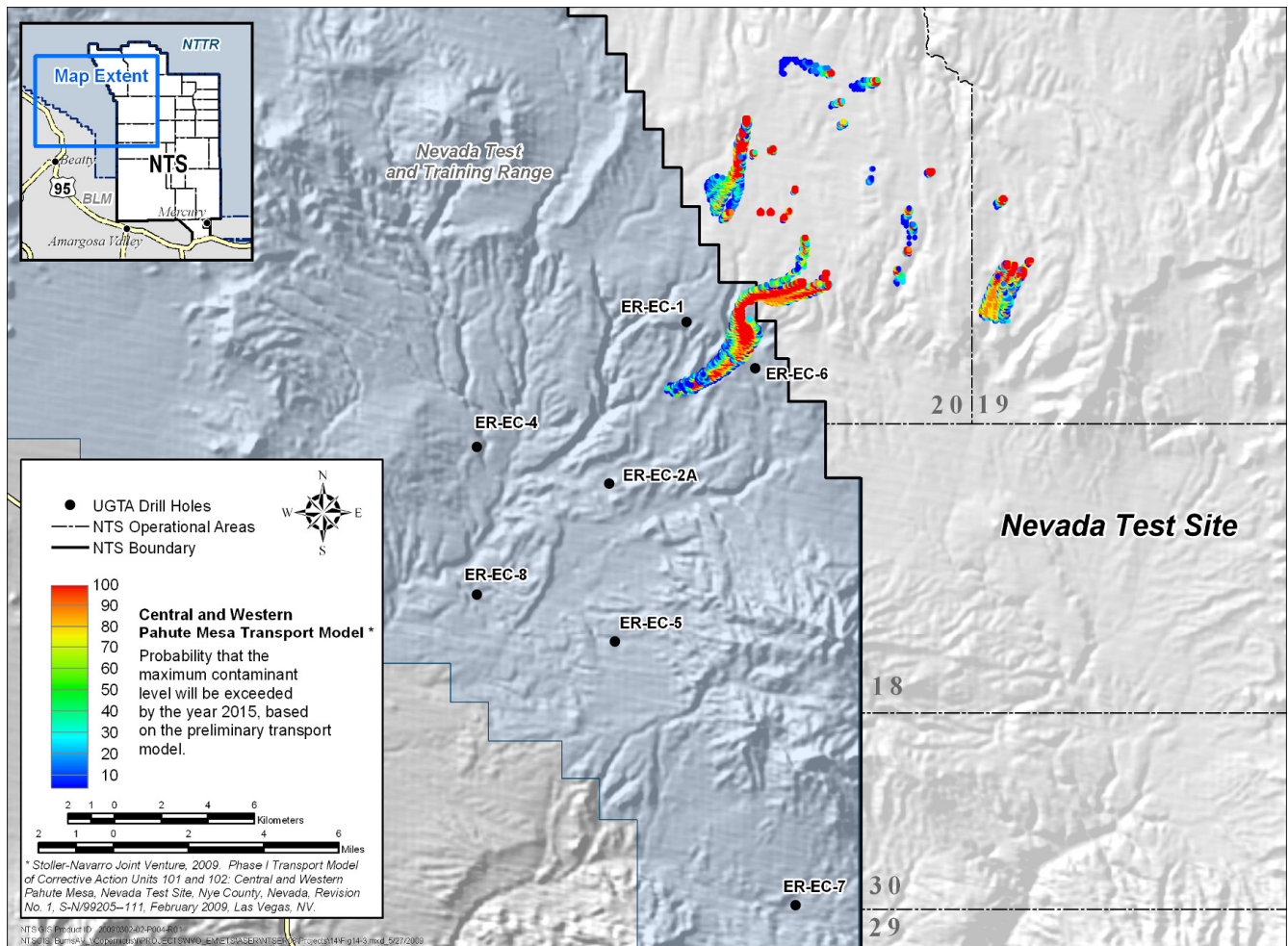
Location of UGTA Sub-Project CAUs and model areas

tritium of 20,000 pCi/L should be present off the NTS (see figure on next page). However, well sampling results have not detected the presence of man-made radionuclides downgradient of Pahute Mesa in any of the seven UGTA wells on the NTT.

A new well drilling campaign will drill nine wells during the next three years to gather further data for establishment of a long-term monitoring system. The UGTA Sub-Project selected 12 proposed locations for the new wells. The well drilling campaign began in May 2009. Continued well drilling and data collection will improve and refine the transport model for this area.

*The most significant environmental work performed by NNSA/NSO each year is the cleanup of sites contaminated by past DOE operations and the hydrogeological investigations supporting the characterization of underground nuclear contamination areas.*





**Results of Phase I Central and Western Pahute Mesa transport model**

## Pollution Prevention and Waste Minimization

Pollution prevention and waste minimization activities on the NTS result in reductions to the volume and/or toxicity of waste generated on site. In 2008, a reduction of 295 tons of hazardous wastes was realized. The largest proportion of this reduction came from shipments of lead acid batteries (115.5 tons), bulk used oil (84 tons), and lead scrap metal (80.8 tons) to offsite vendors for recycling.

A reduction of 342.3 tons of solid wastes was realized in 2008. The largest proportion of this reduction came from shipping 177.1 tons of mixed paper and cardboard and 92.6 tons of ferrous scrap metal to a vendor for recycling and shipping 49.1 tons of food wastes from the NTS cafeterias to a local pig farm.

## Cultural Resources

DRI archeologists completed archival research and field surveys for six proposed NNSA/NSO projects on the NTS and the NTTR in 2008. No cultural

resources eligible to the National Register of Historic Places were found during the field surveys.

The National Historic Preservation Act requires federal agencies to identify and maintain the integrity of historic properties under their jurisdiction. In 2008, 15 such properties on the NTS were visited to meet this requirement: 5 temporary camps, 3 dual component camps (prehistoric and historic), 3 historic structures, 1 historic cabin, 1 prehistoric processing locality, 1 cave site, and 1 historic residential base. Only 2 sites were moderately affected by visitor traffic, and the other 13 sites were all in a good state of preservation, though sustaining normal weathering.

Other field projects included photo-documentation of structures in Areas 3 and 23 and site visits to three tower locations in Areas 2 and 3 and four nuclear test locations in Areas 18 and 20. Archival research was conducted for the historic test locations Russet, Raritan, Little Feller II, and T-4.

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## Endangered Species Protection

The desert tortoise is protected as a threatened species under the Endangered Species Act and it occurs in suitable habitat on the southern third of the NTS. Activities conducted in desert tortoise habitat must comply with the terms and conditions of a Biological Opinion issued to NNSA/NSO by the U.S. Fish and Wildlife Service. In 2008, biologists conducted surveys for 18 projects within the distribution range of the desert tortoise. No desert tortoises were accidentally injured or killed, nor were any found, captured, or displaced from project sites. No desert tortoises were accidentally killed along roads in 2008. A cumulative total of 311 acres of desert tortoise habitat on the NTS has been disturbed since the desert tortoise was listed as threatened in 1992.

## Ecological Monitoring

Numerous species, considered by federal and state agencies to be sensitive or important to track, are known to occur on the NTS and include 19 plants, 1 mollusk, 2 reptiles, over 250 birds, and 26 mammals. Biologists continued to monitor some of these species in 2008, which included two plant species, western red-tailed skinks, western burrowing owls, bats, mule deer, and mountain lions. As a result, the documented distribution patterns of these species on the NTS have been increased, and other species new to the NTS have been recorded. Six out of ten recorded bird mortalities in 2008 were attributed to NNSA/NSO activities.



Western burrowing owl with identification bands (Photo by W. K. Ostler, June 20, 2007)

Biologists continued to work in cooperation with Southern Nevada Health District personnel to determine if mosquitoes on the NTS carry West Nile Virus. As in previous years, no infected mosquitoes were found.

The Habitat Restoration Monitoring Program surveyed seven closed Environmental Restoration sites on the TTR and one on the NTS that had been revegetated in 1999 or 2000. Plant cover and density were higher in 2008 than in previous years, and there were no significant declines in the cover or density of those perennial shrubs and forbs that had been seeded. An annual vegetation survey to determine wildland fire hazards was conducted. Roadside areas that had the highest risk of wildland fires in 2008 were in Areas 29 and 30.

Chemical release test plans for two activities at NPTEC in Area 25 were reviewed. No monitoring of plants or animals downwind of the tests was needed due to the low volumes and/or low toxicity of the chemicals being released.



All cover photos taken by W. Kent Ostler, Senior Scientist, NSTec

Front cover page (left to right):

*Mirabilis pudica*, Frenchman Flat, April 20, 2004  
*Agave utahensis*, Mercury Ridge, May 24, 2004  
*Camissonia boothii*, Pahute Mesa, May 19, 2004  
*Oenothera caespitosa*, Frenchman Flat, March 23, 2005  
*Opuntia pulchella*, Kawich Canyon, June 7, 2005  
*Yucca schidigera*, Mercury Valley, June 24, 2003

Back cover page (left to right):

*Mimulus bigelovii*, Rock Valley, June 24, 2003  
*Cleome lutea*, Buckboard Mesa, July 1, 2004  
*Camissonia boothii*, Pahute Mesa, May 19, 2004  
*Camissonia brevipes*, Fortymile Canyon, April 28, 2004  
*Calochortus flexuosus*, Mid Valley, April 4, 2004  
*Camissonia megalantha*, Cane Springs, June 12, 2003



For more information, contact:

U.S. Department of Energy  
 National Nuclear Security Administration  
 Nevada Site Office  
 Office of Public Affairs  
 P.O. Box 98518  
 Las Vegas, NV 89193-8518  
 phone: 702-295-3521  
 fax: 702-295-0154  
 email: nevada@nv.doe.gov  
<http://www.nv.doe.gov>

