Chapter
9

Nevada Test Site

History and Mission

The Nevada Test Site (NTS) was established in 1951. The primary mission of the site was to conduct field-testing of nuclear explosives in connection with the research and development of nuclear weapons.[1] The site currently also serves as a major low-level waste disposal facility for both on-site and offsite generated defense low-level waste.[2]

Testing at NTS was conducted in two distinct eras: the atmospheric testing era (1951-1958) of 100 atmospheric tests and the underground testing era (1961-1992), when 825 underground tests occurred.[3] Each underground test involved a complex series of activities including the assembly of nuclear devices, the drilling of test shafts to conduct tests, the construction of metal canisters to hold the device and its respective diagnostic equipment, and the assembly of diagnostic equipment.[4]

The majority of United States testing of nuclear explosives occurred at NTS with only 126 tests occurring elsewhere, primarily in the Pacific.[5]

The current mission of the site includes:

- National security;
- Environmental Management;
- Technology diversification;
- Stewardship of the NTS.[6]

Location and Land

NTS is located approximately 65 miles northwest of Las Vegas, Nevada in the Amargosa Valley and 20 miles east of the California border. (See Figure 1.) In recent years, the population of Las Vegas has mushroomed. As of the year 2000 census, the resident population of Las Vegas proper was 460,728, with an additional 794,778 living in the suburbs, and an estimated

115,575 persons in the Strip[7]. In addition, approximately 97,950 tourists arrive daily for a total of 35,849,691 tourists annually.[8] NTS is also 25 miles east of Death Valley, a major tourist attraction with 500,000 visitors annually.[9] NTS is situated on 1,350 square miles (864,000 acres) of primarily undeveloped desert and mountainous terrain. Nellis Air Force Range, a federally owned and restricted area, borders the site on three sides. This area provides a buffer zone between the test area and land that is open to the public. Due to the size of the site, the perimeter is not fenced. (See Figure 2.)

Major activities at the site include maintaining the ability to conduct full-scale underground nuclear weapons tests during the current sub-critical (without a sustained nuclear chain reaction) testing period, performing environmental restoration actions, and researching the Yucca Mountain high-level waste repository project. At NTS, the DOE also conducts nuclear emergency response team activities, operates a DOE LLW disposal facility, conducts sub critical nuclear tests, and evaluates offsite monitoring of nuclear treaty compliance.[10]

Number of people living within 50 miles of the Nevada Test Site: Approximately 166,428[11]

Employees at the Nevada Test Site: Approximately 2,350 employees as of 1997[12]

Every nuclear weapons test created the equivalent of a single radioactive waste dump. There are many inactive and active radioactive waste dump sites at NTS containing millions of curies of uranium, thorium, cobalt, tritium, as well as plutonium and other radionuclides. The two active radioactive waste sites at NTS are Area 3 and Area 5. Many other waste sites have been used at NTS, but are no longer active. These contaminated sites require remediation. (See Figure 3.)

Area 3. Area 3 comprises 125 acres and is located in Yucca Flat, about 23 miles north of Mercury, NV. Both underground and atmospheric tests occurred at Yucca Flat.[13] It is now a dumpsite. "This area is used for bulk and unpackaged low-level waste. This site is comprised of four subsidence craters with areas between the craters excavated to make two oval-shaped landfill units."[14]

Area 5. Area 5 consists of 723 acres and is located in Frenchman's Flat, about 12 miles north of Mercury. The first nuclear detonation at the Nevada Test Site took place in Area 5 in 1951.[15] An engineered shallow landfill facility in Area 5 is called the Radioactive Waste Management Site and is used for the disposal of low-level waste, generated both on and offsite. This site contains large quantities of alpha-emitting waste. Since the 1980s, NTS stopped accepting TRU waste and mixed waste for storage. [16]

Area 25 (Yucca Mountain Site). A potentially huge high-level radioactive waste site may also be located at NTS in the future. Area 25, otherwise known as Jackass Flats, is an area that since 1979 has undergone evaluation as a geologic repository for the entombment of 77,000 tons of irradiated or spent nuclear fuel for more than 10,000 years.[17] Legislation establishing the repository passed in 2002, though the State of Nevada is still fighting the decision. This high-level radioactive waste from the nation's commercial nuclear utilities would be transported to the site from all over the country.

The initial concept for the proposed repository was for the irradiated fuel to be stored in underground caverns at Yucca Mountain. Due to geologic and hydrologic uncertainties, two concepts have been advanced: to store the irradiated fuel in giant casks above ground while the fuel cools, or to place relatively hot fuel into the repository, in order to drive out any present water. In the post September 11-era and with the growing threat of international terrorism this plan may well be revised again.

Area 25 has been renamed the Yucca Mountain Site and is located in the southwestern corner of the Nevada Test Site, approximately 2 miles north of Amargosa Valley, formerly known as Lathrop Wells, NV. Yucca Mountain is a flat-topped ridge running from north to south and rising about 1000 to 1500 feet above the surrounding terrain. It is approximately 30 miles away from the nuclear weapons testing areas.[18] (See Figure 4.)

Testing onsite has altered the NTS landscape with the creation of craters, drilling of test shafts, and disposal of waste into landfills. Underground testing has created contaminated craters in Yucca Flat, Frenchman Flat, Jackass Flats, and on the Pahute and Rainier Mesas. The test shafts drilled onsite are quite large due to the size of the nuclear weapons canisters. A test hole can be 36 feet in diameter and located at differing depths. Some shots were at 600 feet below the surface, others as deep as 3800 feet beneath the surface. Each explosion creates a large, buried inventory of radioactive waste that must be kept under surveillance for centuries.[19]

The remainder of the site is relatively undisturbed and has served as a buffer zone amidst testing and the rising spread of contamination.[20]

Water Sources

Groundwater is directly affected by the testing of nuclear explosives. About one-third of the 908 underground tests were conducted beneath, near or actually in the water table, resulting in contamination of the groundwater. Groundwater movement is also affected by the draw from the growing Las Vegas area.

Surface Water

Surface water does not appear to be a direct source of contamination to groundwater as the site is predominantly dry. Eight streams flow intermittently during storms. Streams in the vicinity of the site are recharged by snowmelt from nearby mountains and by small amounts of precipitation.

Aquifers

NTS is located in the Death Valley Groundwater Basin, where the complex groundwater flow involves many aquifers and confining units. [21] The two main aquifers beneath NTS are the Lower Carbonate aquifer system and the Cenozoic aquifer system. The Lower Carbonate aquifer is found 500 to 2,000 feet below the surface and contains both confined and unconfined areas of groundwater.[22] The Lower Carbonate aquifer is not present in all areas. It is found primarily in the eastern and southern part of the site. The Cenozoic Aquifer is found mainly beneath Frenchman Flats and the Pahute Mesa.

The Valley-Fill Aquifer is a large aquifer for the region surrounding NTS. However, on-site this aquifer is dominant only in the valleys and is a major source of groundwater in Frenchman Flats. This aquifer is not saturated at all locations beneath the site.[23]

Three groundwater sub basins divide the Death Valley Groundwater Basin: Ash Meadows, Alkali Flat-Furnace Creek Ranch, and the Oasis Valley groundwater sub basins. The eastern portion of the site is located in the Ash Meadows groundwater sub-basin. The Alkali Flat-Furnace Creek Ranch groundwater sub basin includes most of the western portion of the site. The Oasis Valley groundwater sub basin includes the portion of the northwestern corner of the site.

Two sources recharge the groundwater beneath the NTS: underflow from basins in the area and recharge over the upland areas within the NTS boundaries.[24] Fortymile Wash is a basin where precipitation recharges the groundwater near Yucca Mountain. This groundwater flows into the Amargosa Desert basin and then into Death Valley.

The primary source of perched water comes from water traveling down through faults and fractures[25] occurring in the volcanic aquitards (geologic formations that may contain groundwater but are incapable of transferring that water to the surface) that separate the aquifers. Rainier Mesa especially yields perched groundwater. Near Yucca Mountain, the water table is contained in the volcanic aquitards. [26]

Groundwater flow: Northerly estimated at a rate of 256 feet per year for the Cenozoic Aquifer and 730 feet per year for the Lower Carbonate Aquifer[27]

Average Annual Precipitation: Less than 10 inches per year[28]

Plans for the future repository are affected by the groundwater regime. "There are four potential sources of inflow to the volcanic aquifers in the vicinity of Yucca Mountain: 1) lateral flow from volcanic aquifers north of Yucca Mountain, 2) recharge along Fortymile Wash from occasional stream flow, 3) precipitation at Yucca Mountain, 4) upward flow from the underlying carbonate aquifer."[29] The playas in Yucca Flats and Frenchman Flats receive discharge from the eight intermittent streams that only exist during rainstorms. "Despite the evaporation of rainwater, the playas and valley bottoms are not discharge zones for groundwater."[30]

The future of nuclear power rests on the availability of storage space for the waste it creates. Given such high political and economic stakes, the performance and boundaries of the hydrolic regime at NTS is extremely controversial. Many US Geological Survey scientists have been very critical of DOE assertions regarding the water regime.

Contamination

Since the end of atmospheric testing in 1958, nearly all testing has occurred in vertical shafts drilled into Yucca Flat and Pahute Mesa or in horizontal tunnels mined into Rainier Mesa. This testing created hundreds of craters in the surface, plus significant contamination. Yucca Flat contains 300 million curies of contamination in the soil and groundwater along with a "pockmarked" appearance to the surface.

Estimates regarding the number of curies of radioactive material contaminating the subsurface vary tremendously. "Underground nuclear tests have left an estimated 2.8 million curies of strontium-90, 4.5 million curies of cesium-137, and 124,000 curies of plutonium underground."[31] Groundwater contamination, probably from test residues has been documented at the site. Characterization of the full extent of the contamination will take many years to be completed.

Wastes were disposed in landfills and through underground injection into sumps and leach fields. As of 1992, about 14.8 million cubic feet of radioactive waste, containing 9.8 million curies of radioactivity were buried in NTS's many dumpsites.[32] The exact amount of transuranics buried on site is not known. "DOE has not listed the specific amount of soil contaminated by transuranic solid waste, although it does list almost 21,188 cubic feet of retrievable transuranic wastes in storage".[33] In addition, large quantities of transuranics were released during weapons tests.

Many of the old waste sites are no longer in use; some are abandoned waste sites whose exact locations are unknown.[34] It is estimated that 2,965 acres of surface and shallow subsurface soils are contaminated as the result of plutonium-dispersion tests.[35] Mixed fission products have contaminated the subsurface and come from the underground testing activities at NTS. Such weapons testing activities have disrupted the geologic media in four different ways: shallow, borehole, deep vertical, and tunnel tests.

Contaminants of Potential Concern:

Volatile Organic Compounds:
Acetone, chloride, chlorobenzene, methylene, methylene chloride, and xylenes;
Metals:
Cadmium, lead, and silver
Radionuclides:
Antimony, barium, beryllium, cadmium, cesium, cobalt, europium, iodine, iridium, krypton, lanthanum, plutonium, rhodium, ruthenium, sodium, strontium, tritium, and uranium[36]

Little is known about the extent of groundwater contamination at NTS. The direction of the plumes and extent of contamination spreading underground is not clear. However, underground testing of bombs near the aquifer definitely left substantial contamination in and near the subsurface. When a nuclear test is conducted below the water table, groundwater fills the hole that was created by the explosion and becomes contaminated. In addition, the explosions change the configuration of the groundwater, often deepening water levels and spreading contamination further. Some examples of tests that have contributed to the groundwater contamination include the Cheshire Test, tests at the Cambric Site, and the Nash Event.

Prior to the Cheshire Test, the greatest depth of the groundwater in the area was 2000 feet. The nuclear test occurred at 3800 feet. An experiment to gather information after the test, showed contamination in the lower part of the cavity created by the explosion. A test of the Cambric device occurred at 965 feet beneath the surface. In this area the water table is located at 725 feet. Following the test water at a depth of 1100 feet was found contaminated with krypton, chlorine, iodine, and ruthenium. "At the Nash Event, the shot was fired in limestone just above the water table. Samples of the groundwater from a test well 600 feet from the working point showed the presence of radionuclides."[37]

After the 908 underground tests that occurred at NTS, contamination beneath the subsurface is widespread. Detailed characterization of the amount of contamination present in the hundreds of craters, vertical shafts, mines and other sites for underground tests will be required to plan the future remediation actions at the site. Like many of DOE's sites, this is listed as a long-term stewardship site. As with the other sites, DOE has admitted that complete cleanup is impractical. As a result NTS is slated to be monitored for at least a hundred years

Remediation

Some remediation of the subsurface at NTS is expected to be complete in 2014, depending on resources and effectiveness of technology. But the DOE has stated that remediation of subsurface contamination around the nuclear test cavities will not be completed at this time, since there is no technology to remove radioactive contaminants from the subsurface.[38]

If a high-level storage site is located at NTS, the potential for groundwater contamination becomes ever more serious. Some have discussed a warning system to alert residents about future contamination of their wells. Kalynda Tilges of Shundahai Network recommends at least

20 years advance notice to those affected by the traveling groundwater contamination.[39] The DOE will restrict access to the contaminated areas for 100 years.

In characterizing the areas of contamination, a model known as the Frenchman Flat model is used on-site and predicts the boundaries of contamination for up to 1,000 years for NTS.[40] Official reviewers rejected this model. It, and the boundaries are not recognized by the Nevada State Regulators. "Accordingly, institutional control for most of the contaminated soils on NTS proper is assumed by DOE to be "in perpetuity" at the existing boundaries. Thus, it appears that "'clean closure' of most of the contaminated soils on NTS would be cost prohibitive and generally impractical given both current and expected land uses."[41]

A program launched in 1989, known as the Underground Test Area Program (UGTA), was designed to give researchers a better understanding of the contamination of the groundwater and its migration to offsite locations. The goals of the program were to:

- Protect public and workers from exposure to groundwater containing radionuclides;
- Evaluate future migration;
- Establish a long-term groundwater-monitoring network.

In the process of characterizing the contamination, the site has been divided into 5 Corrective Action Units in which the permeability of the soil and extent of contamination are similar to each area. (See Figure 6.) It should be noted that NTS has generated substantial offsite contamination. Millions of curies of cesium-127 and strontium-90 released by the above ground tests remain -- even though over 40 years have elapsed since the cessation of atmospheric testing at NTS in 1961.[42] Although the site is secluded, remediation of the site must be completed to reduce the amount of contamination in soil and water that migrates offsite.

Challenges

Multiple aquifers are present beneath the site. The groundwater system is deep and the subsurface contains more than 300 million curies of radioactive contamination.[43] The complexity of the groundwater system and extent of contamination present a great challenge to the site and the region. Groundwater beneath the site is the only source of drinking water for people living near the NTS area.[44] There is a battle with Las Vegas for purchasing water rights. In essence, southern Nevada is extremely dry and requires the use of groundwater for drinking and irrigation. Due to increases in both population and tourism, plentiful water is a major challenge and battle.

Remediation of the soil and groundwater proves to be complex, if only because current technologies are not adequate by many orders of magnitude to effectively and efficiently remove the contamination. DOE has determined that until such technology becomes available, the subsurface contamination will remain in place. Another challenge is defining the contaminant boundaries and constituents of contamination.

The United States Geologic Survey has designated Yucca Mountain as an area extremely prone to earthquakes. Thirty seismic faults have been identified at Yucca Mountain. [45] The USGS has estimated that quakes of 7 or 8 on the Richter scale are possible. In 1992, an earthquake struck an area 12 miles southeast of Yucca Mountain and caused severe damage. In addition there is a synergistic effect with underground nuclear tests causing as much as 8 feet of displacement along existing faults. This means buried chemical contaminants as well as radionuclides released in underground explosions can move along previously unidentified fractures and faults.[1]

If Yucca Mountain were accepted as a storage site for irradiated fuel, the waste would be stored above the water table. As long as the containers holding waste remain intact, radionuclides would not be released to the environment. However, once the containers start to leak, it is only a matter of time before the contaminants reach the ground water. But given the thousands of years during which containers would have to remain intact, it is likely that integrity will be lost either through catastrophic events or routine wear of cracking and corrosion. "An earthquake occurring along a fault within the repository could increase the likelihood that water would find its way into the facility and speed the dissolution of the containers holding the waste. Fault movement within the repository could also cause waste containers to be breached and release the waste from the repository."[46]

"In addition to earthquakes, the area around Yucca Mountain has a long history of volcanic activity. Yucca Mountain itself consists of material from violent volcanic eruptions a few miles to the north about 11 million years ago. Even if the magma does not reach the surface, it has the potential to enter the repository along fractures or to heat the surrounding layers of underground rock and to cause groundwater to boil away through cracks and fissures."[47] Volcanic activity could easily occur as a result of increased seismic activity. From atop Yucca Mountain, the cones of several volcanoes can easily be observed.

If an earthquake, or volcanic activity resulted in a breach of multiple containers, the effects would be monumental due to the extensive amount of radioactive waste that would be stored in this site. A safe, permanent solution must be found to store these radioactive wastes until, at the very least, they have decayed to stable forms.

[1] US DOE. "Vadose Zone Fact Sheet: Nevada Test Site", September 2000, <http://www.em.doe.gov/vadose/contents.html>.
[2] Nevada Division of Environmental Protection. "Long-term Stewardship at the Nevada Test Site", 1998, http://ndep.state.nv.us/boff/steward.htm#contaminationbase.
[3] Makhijani et al. *Nuclear Wastelands*, IEER, 1995. Takoma Park, Maryland.
[4] NRDC. "US Nuclear Weapons Databook", Volume 3: 63.
[5] Makhijani et al. *Nuclear Wastelands*, 1995: 225.
[6] US DOE. "A Report to Congress on Long-Term Stewardship", DOE/EM-0563, January 2001, Volume II, Site Summaries: 9.
[7] This includes visitors and workers.
[8] Estimated tourists statistics from the Las Vegas Convention and Visitors Authority, 2000.
[9] Death Valley Chamber of Commerce. "Death Valley", <http://www.americanwest.com/deathvalley/index.htm>.
[10] US DOE. "FINAL Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada", DOE/EIS-0243, Volume 1, August 1996.
[11] Estimated from the US Census 2000. <http://factfinder.census.gov/servlet/BasicFactsServlet>.
[12] Schwartz., S.I. "Nevada Test Site", <http://nuclearfiles.org/sites/usweapon1.htm>
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[14] Nevada Division of Environmental Protection. "Long-term Stewardship at the Nevada Test Site", 1998, <http://ndep.state.nv.us/boff/steward.htm#contamination>.
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[17] NTS Community Advisory Board. <http://www.unlv.edu/Colleges/Urban/cab/twofive.htm>.
[18] Carter, Luther J. "Nuclear Imperative and Public Trust: Dealing with Radioactive Waste", 1987: 170
[19] Coyle et al. *Deadly Defense: Military Radioactive Landfills*, Radioactive Waste Campaign, 1988: 68
[20] NRDC. "US Nuclear Weapons Databook", Volume 3: 63.
[21] US DOE. "Environmental Impact Statement", DOE/EIS-0203, 4.4:
[22] Chapman, J. "Classification of Groundwater at the Nevada Test Site", August 1994, i, 10-11.
[23] Chapman, J. "Classification of Groundwater at the Nevada Test Site", August 1994, i, 11, 12.
[24] US DOE. "A Report to Congress on Long-Term Stewardship", DOE/EM-0563, January 2001, Volume II, Site Summaries: 9.
[25] US DOE. "Draft EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain", DOE/EIS 0250D, July 1999: 3-47.
[26] Chapman, J. "Classification of Groundwater at the Nevada Test Site", August 1994, 10-11.
[27] Chapman, J. "Classification of Groundwater at the Nevada Test Site", August 1994, 16.
[28] US DOE. "Vadose Zone Fact Sheet: Nevada Test Site", September 2000, <http://www.em.doe.gov/vadose/contents.html>.
[29] US DOE. "Draft EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain", DOE/EIS-0250D, July 1999: 3-52.
[30] Chapman, J. "Classification of Groundwater at the Nevada Test Site", August 1994, 33-35.
[31] Makhijani et al. *Nuclear Wastelands*, 1995: 226.
[32] Ibid, p.226.
[33] Ibid: p. 226.
[34] Coyle et al. *Deadly Defense: Military Radioactive Landfills*, 1988: 69
[35] US DOE. "Vadose Zone Fact Sheet: Nevada Test Site", September 2000, <http://www.em.doe.gov/vadose/contents.html>.
[36] US Congress, OTA. *Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production*, 1991: 158.
[37] Coyle et al. *Deadly Defense: Military Radioactive Landfills*, 1988: 70.
[38] Liebendorfer, P. & Walker, J. "Long-term Stewardship at the Nevada Test Site", Summer 1998, <http://ndep.state.nv.us/boff/steward.htm#contamination>.

[39] Las Vegas Sun. “Local group urges monitoring of Test Site groundwater”, 06/14/2001, <http://www.lasvegassun.com/sunbin/stories/lv-other/2001/jun/14/511954812.html>.
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[41] Liebendorfer, P. & Walker, J. “Long-term Stewardship at the Nevada Test Site”, Summer 1998, <http://ndep.state.nv.us/boff/steward.htm#contamination>.
[42] Makhijani et al. *Nuclear Wastelands*, 1995: 226.
[43] US DOE. “Vadose Zone Fact Sheet: Nevada Test Site”, September 2000, <http://www.em.doe.gov/vadose/contents.html>.
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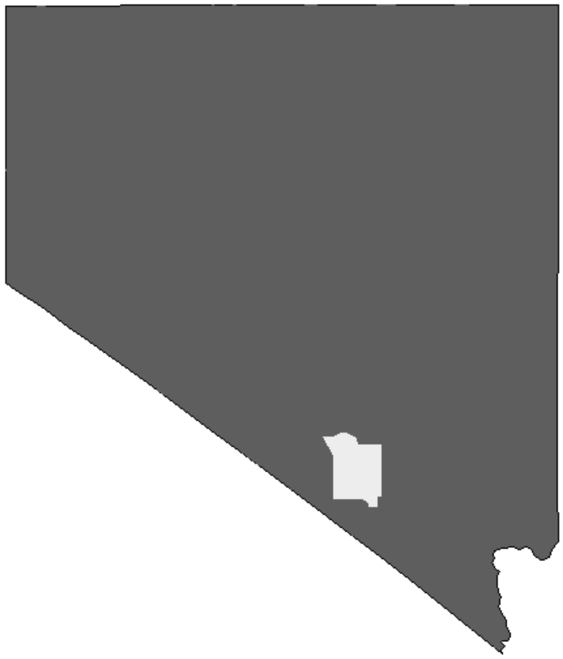

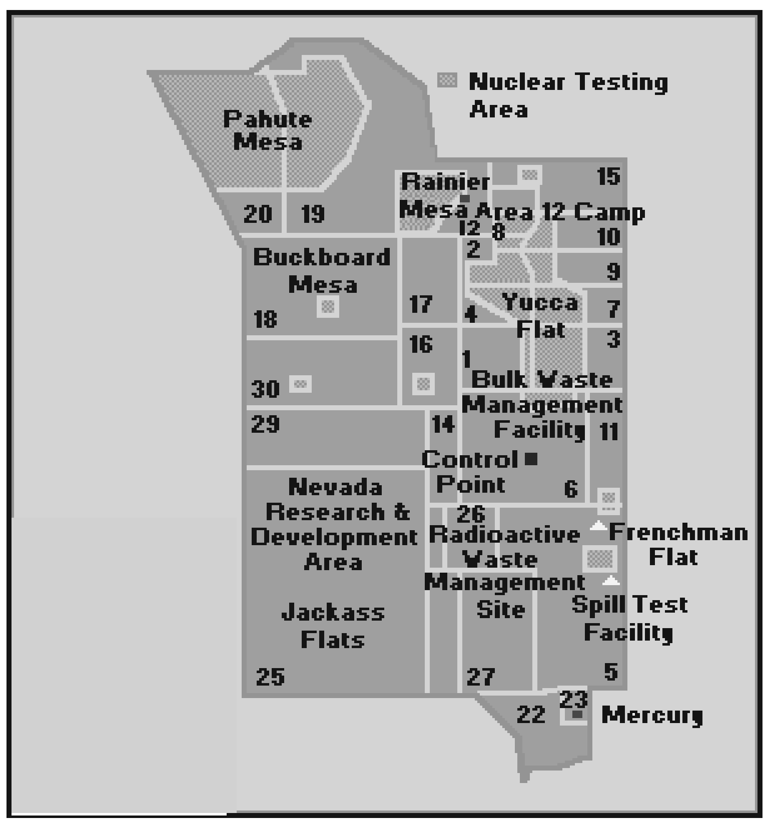

Figure 1: Nevada Test Site Location and Site Map

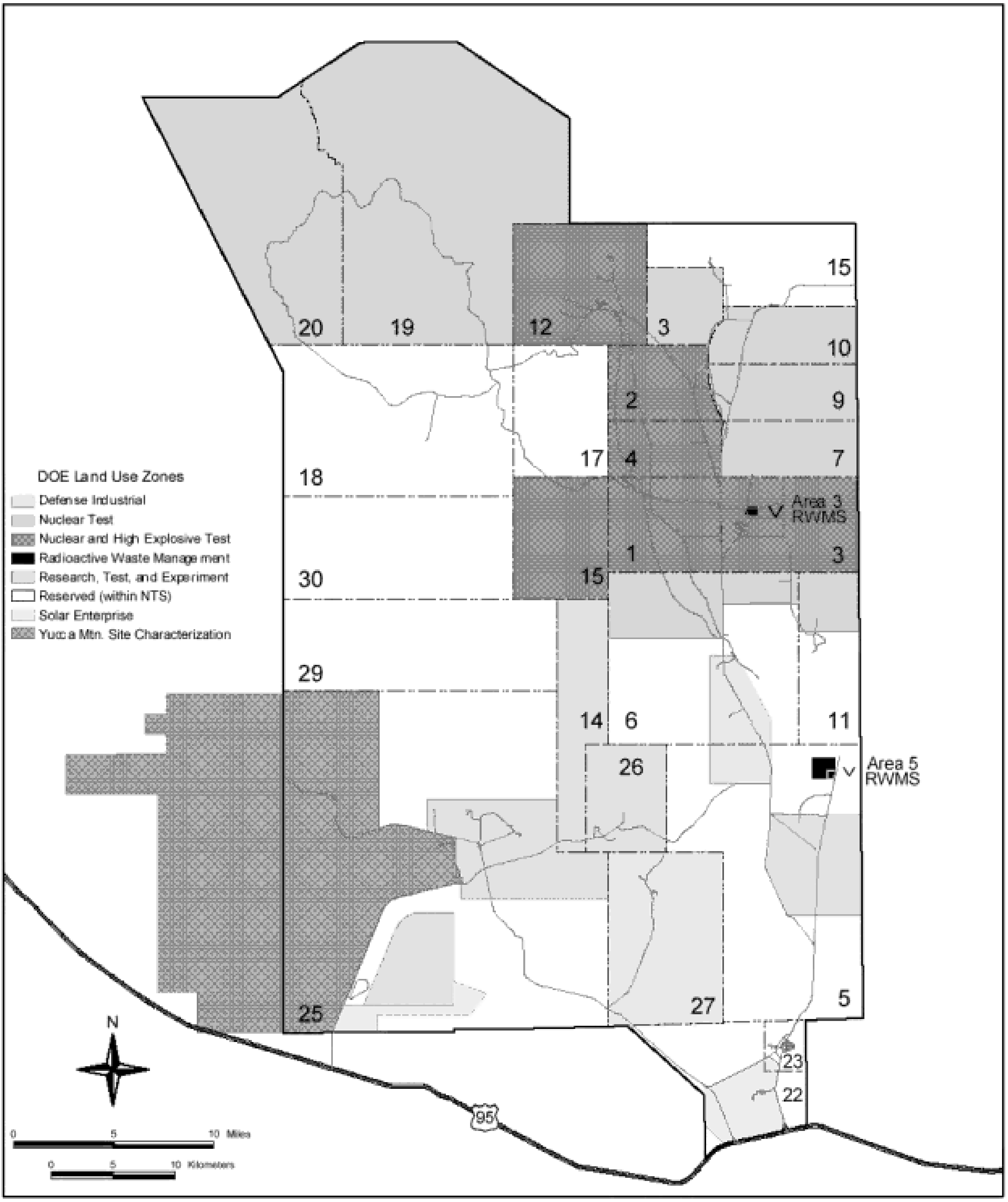

Figure 2: NTS Site Characterization
Source: State of Nevada

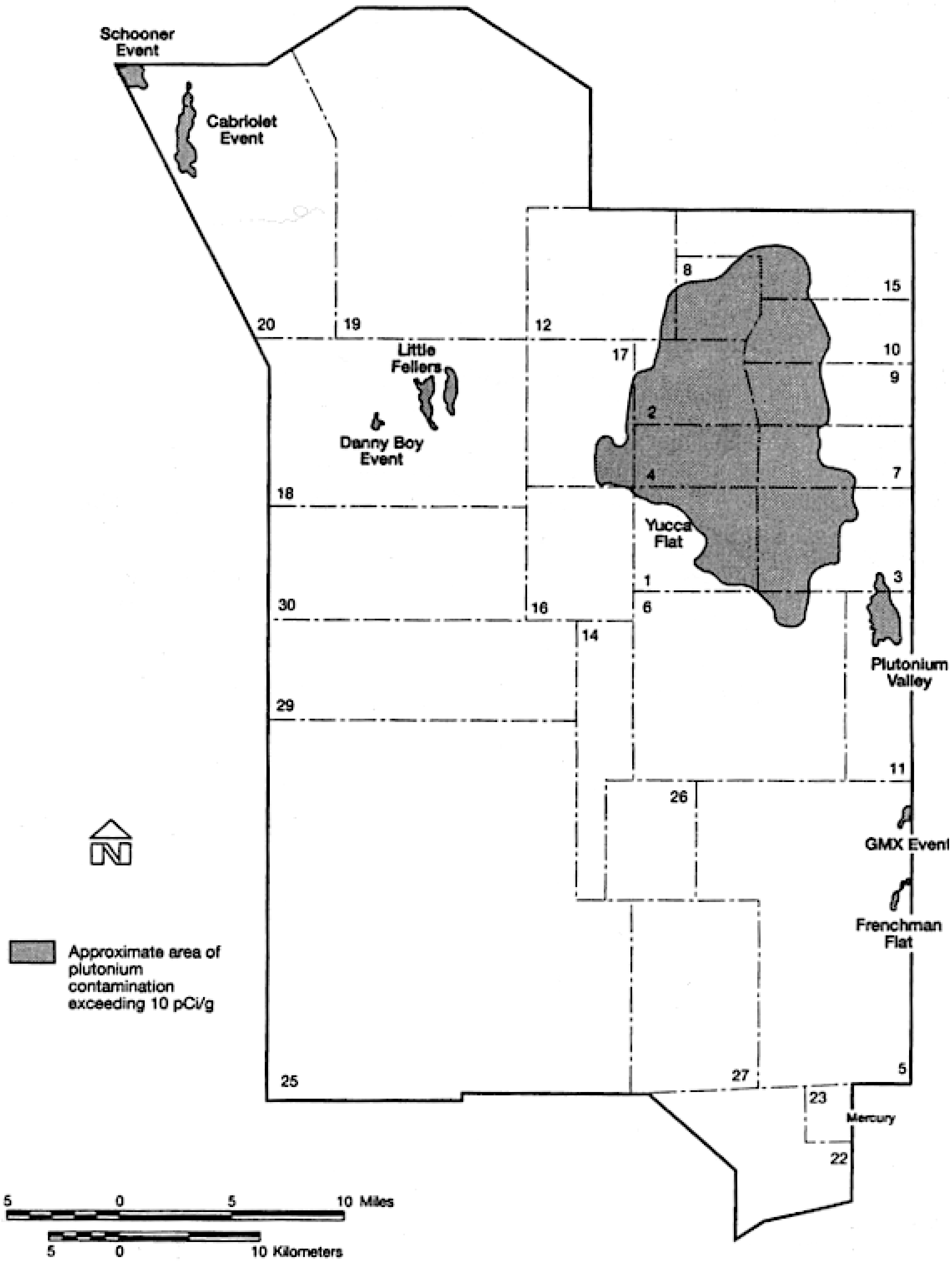

Figure 3: Plutonium Contamination Greater than 1- pCi/g at NTS
Source: State of Nevada

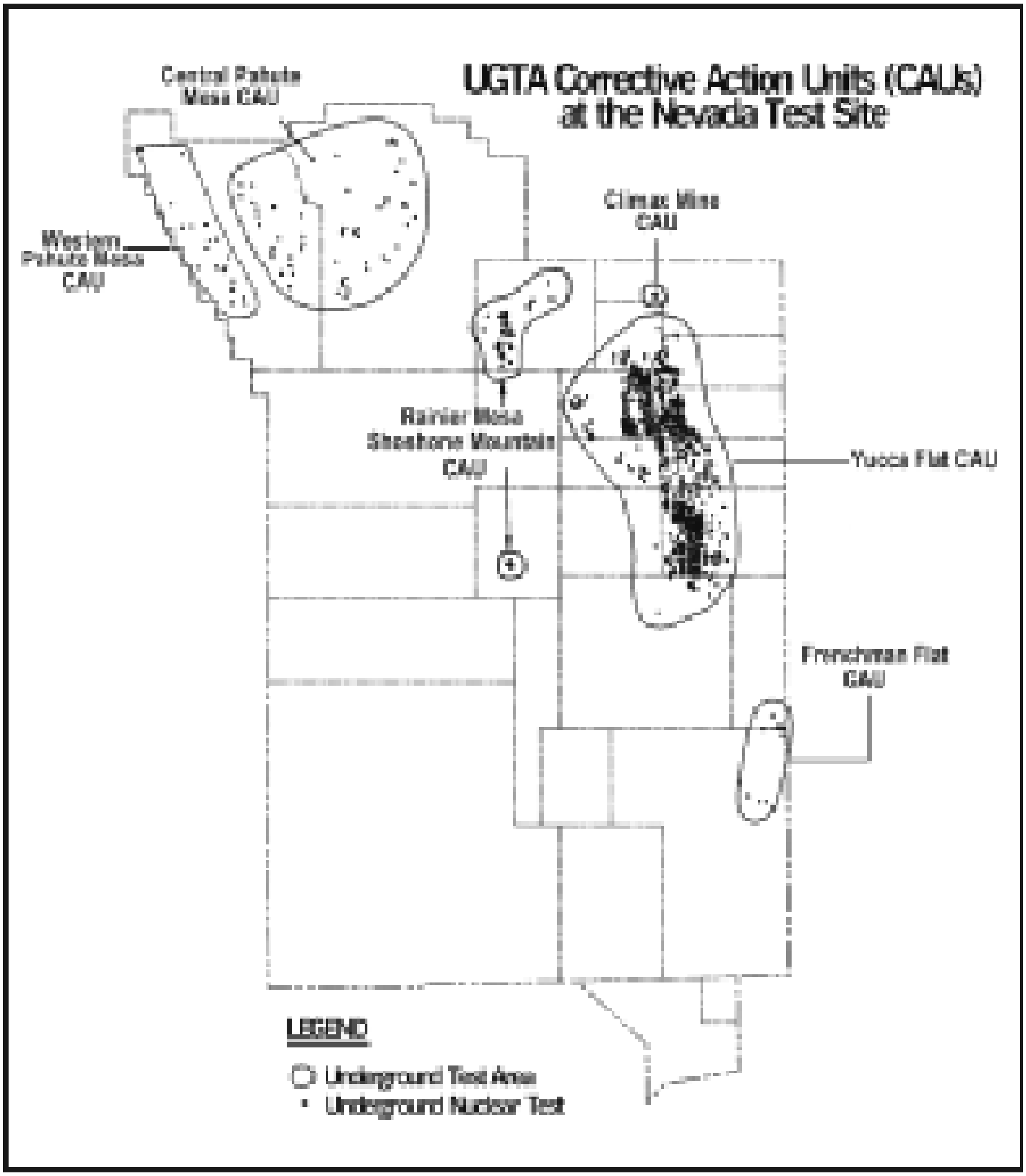

Figure 4: DOE "Corrective Action Units" at NTS
Source:
http://www.nv.doe.gov/programs/envmgmt/blackmtn/PDFs/ERGroundwateratthe NTSFactSheet.pdf