Nevada National Security Site

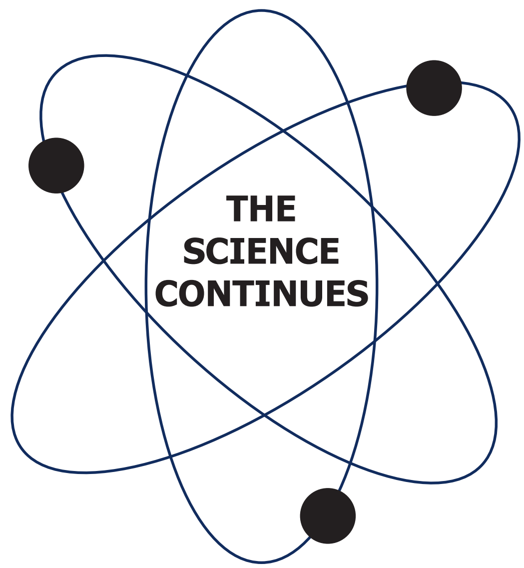
Groundwater

Questions & Answers

Groundwater at the Nevada National Security Site: What's Important to Know?

Your Groundwater is Safe*: Public water supplies are safe from the impacts of historic underground nuclear testing. Current research shows contaminated groundwater exceeding safe drinking water safety standards will not reach public water supplies.*

The Science Continues*: As part of a long-term monitoring program, ongoing scientific studies will continue into the future to identify where contaminated groundwater is located, in which direction it flows and its rate of movement.*



A Major Success*: After decades of characterization and analysis that shows contaminated groundwater poses no risk to the public, and upon validated scientific reviews by independent experts and regulators, the Department of Energy Environmental Management Nevada Program successfully transitioned the first groundwater characterization area into long-term monitoring.*

Terminology defined! See the back cover for the definitions of select terminology used in this information packet.

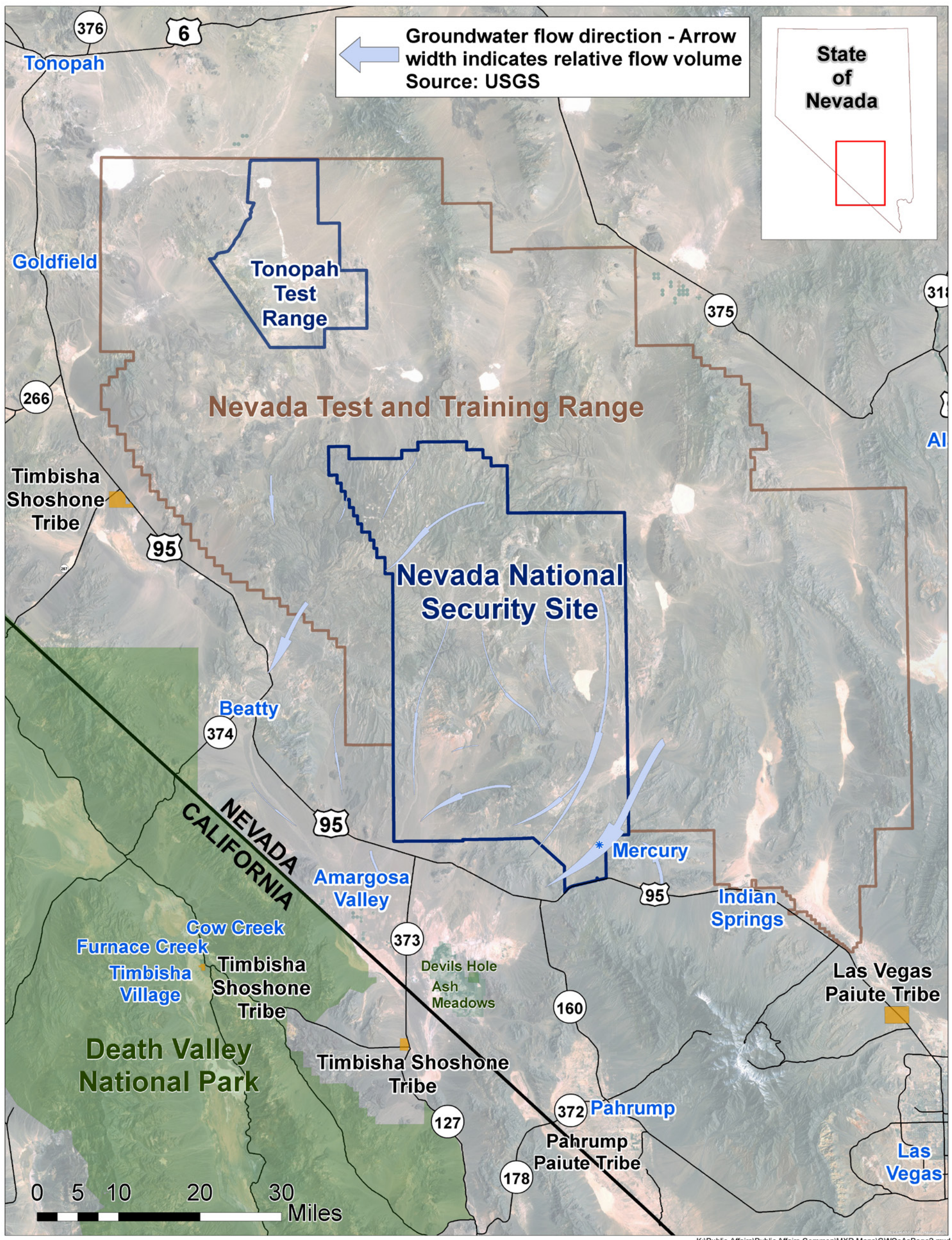
For more than 60 years, the Department of Energy has been studying groundwater at the Nevada National Security Site (NNSS) in order to understand the effects of historic underground nuclear testing. Today, the Department of Energy Environmental Management (EM) Nevada Program employs a comprehensive strategy focused on **drilling** and **sampling wells**, **data interpretation**, **computer modeling**, **routine monitoring**, and **restricted access**. The goal is to establish an effective, long-term monitoring network based upon collected data.

Current research shows the public water supply is safe from the impacts of historic underground nuclear testing.

Important Facts:

- 828 underground nuclear tests conducted at the NNSS from 1951 to 1992
- About one-third of tests occurred near, below, or within the water table
- Much of the contaminants are trapped in the test cavity
- Some contaminants were released into the groundwater
- Risks associated with contamination remain low due to slow groundwater movement, the immobility of some contaminants, radioactive decay, and long distances to publicly-accessible groundwater supplies

The EM Nevada Program makes it a priority to keep the public informed about groundwater characterization activities. For additional photos, videos, and other information, visit www.nnss.gov/pages/programs/em/GroundwaterCharacterization.html.



Regional Groundwater Flow for the NNSS (Source: U.S. Geological Survey, 2010)

Q How will the government protect the public from contaminated groundwater?

A The most current scientific data available shows there is no risk to the public from groundwater contaminated by historical underground nuclear testing. For this reason, and since there is no proven, cost-effective technology to remove or stabilize the radiological contaminants, the strategy agreed to with the State of Nevada is to identify contaminant boundaries, restrict access to contaminated groundwater and implement a long-term monitoring program.

A well located along the NNSS boundary northeast of Beatty, Nevada, is sampled under the NNSS Routine Radiological Environmental Monitoring Plan in conjunction with the Integrated Groundwater Sampling Plan. Sampling results are used for ongoing scientific characterization of groundwater, to provide assurances of groundwater safety, and are published annually in the NNSS Environmental Report.

Q Are there any legal requirements in place to protect public interest?

A Yes. The Federal Facility Agreement and Consent Order, an enforceable agreement between the Department of Energy and the State of Nevada Division of Environmental Protection, inherently addresses all applicable national environmental compliance laws and regulations that cover legacy contamination. In addition to this agreement, the Safe Drinking Water Act sets standards for public water systems that protect public interests.

Q How will you know if NNSS contaminated groundwater is nearing a public water source?

A There are more than 100 wells available for sampling on and near the NNSS by the Department of Energy and through funding they provide for independent sampling by Nye County and the Community Environmental Monitoring Program. Both groundwater and surface water sources are routinely sampled for a variety of contaminants. This network of monitoring wells will provide early detection of any contaminant movement. If contaminants exceeding Safe Drinking Water Act limits are detected in wells beyond federal control, the EM Nevada Program will coordinate with the State of Nevada Division of Environmental Protection and implement protective actions to ensure public safety. In addition, computer models will be updated with the new information and corresponding changes, such as sampling frequency, will be made.

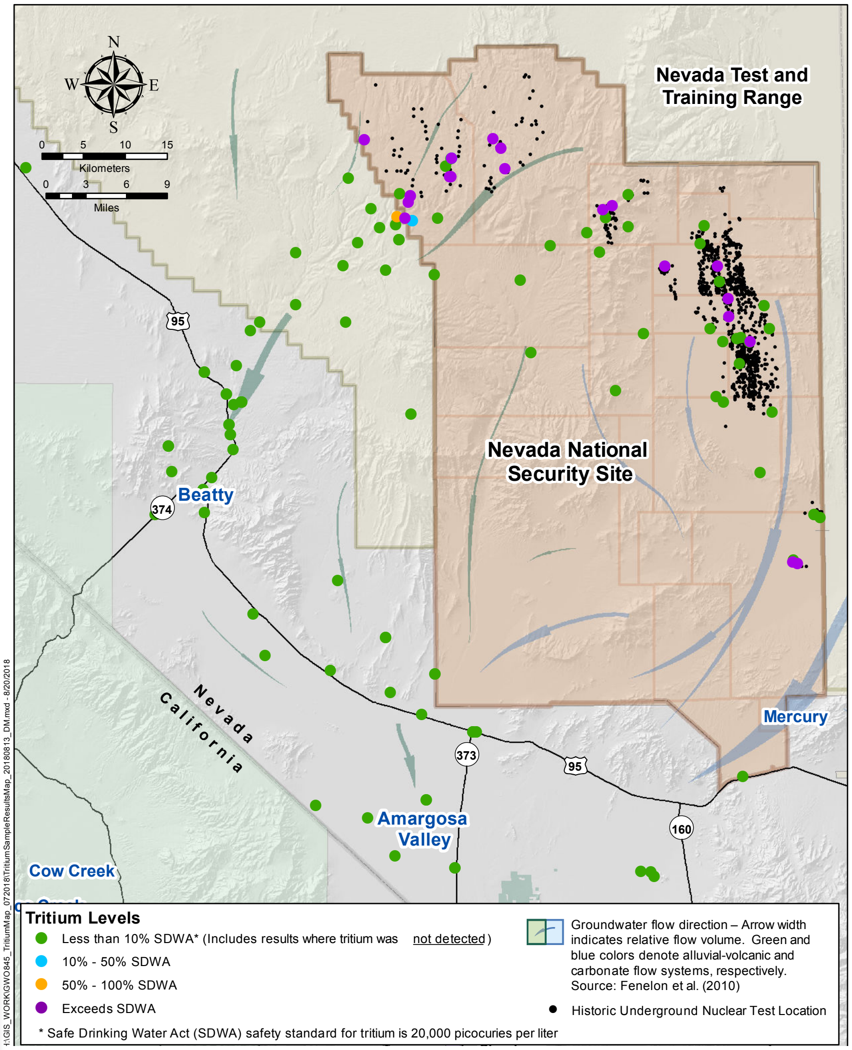
Did You Know?

Water sample results are available in the annual NNSS Environmental Report at www.nnss.gov/pages/resources/library/NNSSER.html

Has contamination from historic underground nuclear tests been found in groundwater beyond the NNSS boundary?

Yes. Consistent with computer model forecasts, detectable levels of tritium were initially found in wells located on the restricted U.S. Air Force land adjacent to the NNSS in October 2009. To date, sampling of groundwater wells off the NNSS indicate tritium levels in these wells comply with U.S. Environmental Protection Agency Safe Drinking Water Act (SDWA) safety standards, and all sampling results are verified by an independent laboratory. Contamination from historic underground nuclear testing has not been found in any wells beyond the U.S. Air Force land surrounding the Site. Wells where tritium exceeds 10% of the SDWA safety standard (2,000 picocuries per liter) are more than 12 miles from publicly accessible wells where tritium has not been detected. In addition, ongoing scientific studies indicate that contaminated groundwater at levels exceeding the SDWA safety standard for all radionuclides is not expected to reach publicly accessible areas.

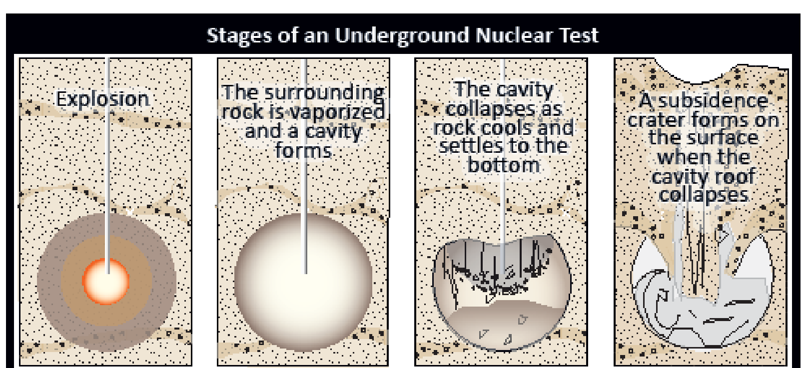
Contamination from historic underground nuclear testing has not been found in any wells beyond the U.S. Air Force land surrounding the NNSS.



Tritium Results for Groundwater Sampling as of August 2018 (includes independent sampling conducted by Nye County)

What radionuclides were released into groundwater during underground testing?

Tritium (a radioactive form of hydrogen) is the most common radionuclide found in groundwater at the NNSS and is the primary contaminant of study. This is because it is mobile in groundwater and, therefore, a leading indicator that other contaminants may be present. Other contaminants released into groundwater include radioisotopes of carbon, iodine, chlorine, technetium, plutonium, cesium and strontium.



Did You Know?

Much of the radionuclides released during underground nuclear testing are trapped in the melt glass of the nuclear test cavity and surrounding rock.

Q In what direction does NNSS groundwater flow?

A Analyses of data collected for more than 60 years indicate the groundwater in the eastern portion of the NNSS eventually discharges to the Ash Meadows/Devils Hole or Death Valley areas. The groundwater in the northwestern portion of the NNSS locally discharges to springs in Oasis Valley.

Nye County sampling an Oasis Valley well under the Tritium Sampling and Monitoring Program

Q Is radioactive contamination moving in groundwater?

A Yes. Some radionuclides, mostly tritium, move with the groundwater. The migration of radionuclides depends on the characteristics of each radionuclide and its surrounding environment. Much of the radionuclides are trapped in the melt glass of the nuclear test cavity and surrounding rock. Though tritium is the most mobile in groundwater, it decays rapidly and is not expected to be present when groundwater reaches publicly accessible wells.

Q Does contaminated groundwater at the NNSS pose a health risk to the public?

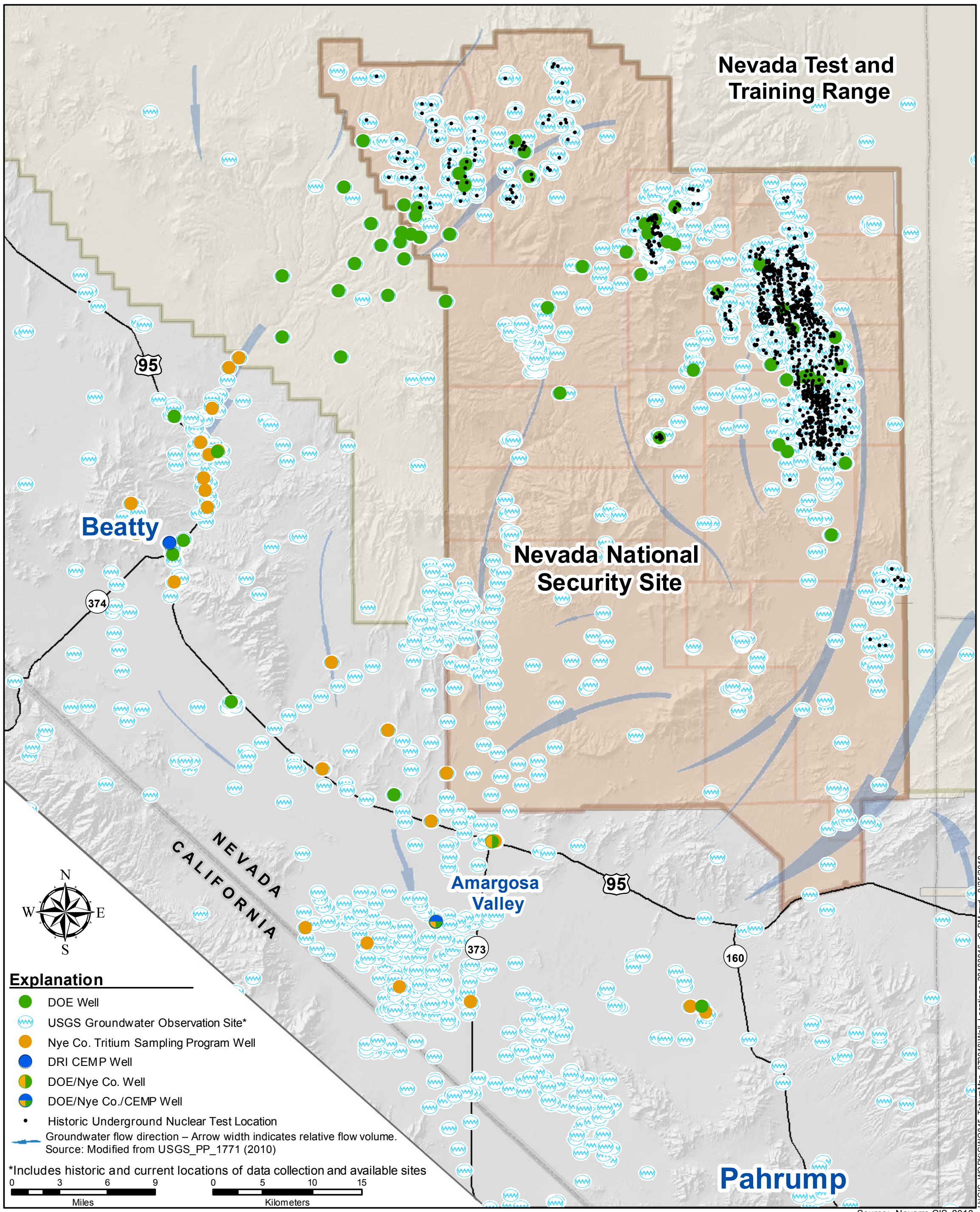
A No. Contaminated groundwater at levels exceeding Safe Drinking Water Act safety standards is not expected to reach publicly-accessible areas. In fact, water drawn from permitted wells located on the NNSS comply with applicable National Primary Drinking Water Quality Standards.

Q How fast is the groundwater moving?

A Estimated velocities (speed) range from a few feet per year up to 300 feet per year. Velocity of groundwater flow varies based on the geology, hydraulic properties (i.e., ability of water to flow through rock), and elevation of the water table.

Q How is groundwater sampled?

A Groundwater is sampled to measure groundwater chemistry, fluid levels, and temperature. Well samples are sent to Nevada-certified, independent laboratories for analysis. The Department of Energy Integrated Groundwater Sampling Plan provides a comprehensive approach for collecting and analyzing samples from a radiological water sampling network of more than 80 wells. Results are published annually in the NNSS Environmental Report (www.nnss.gov/pages/resources/library/NNSSER.html).



Locations Available for Sampling On and Near the NNSS

Q What would happen if groundwater contamination is found in a publicly-accessible well beyond the boundaries of the NNSS and adjacent Air Force land?

A If groundwater contaminants from NNSS activities were verified at a publicly-accessible water source and the levels exceeded Safe Drinking Water Act standards, the Department of Energy would work with the State of Nevada to implement enhanced monitoring, shut down, and/or pursue an alternate water supply, as appropriate to meet the requirements of the Safe Drinking Water Act. Scientific information gathered to date indicates that NNSS groundwater contamination will not reach public water supplies.

Construction costs for each well, which can include excavation, equipment, and various infrastructure needs, are between $4 million to $6 million.

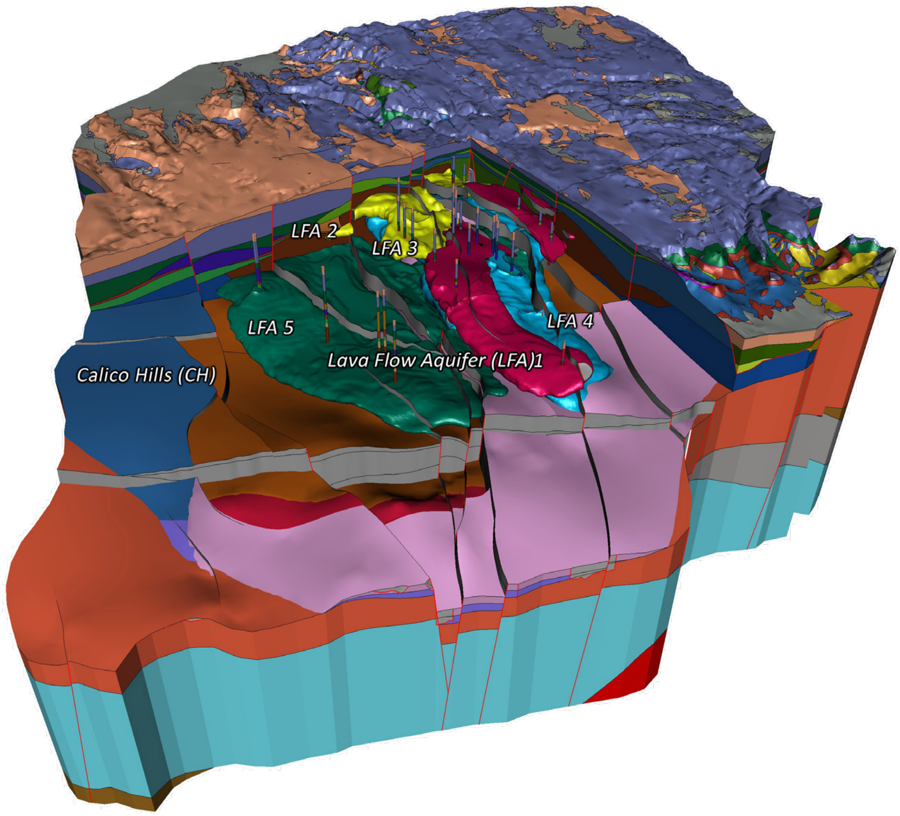
ER-4-1 well drilling on Yucca Flat at the NNSS

Q How are well sites chosen?

A Groundwater characterization wells are typically installed at locations where additional sampling data would most enhance computer models, which are a key component for ensuring the safety of public water supplies. The 2015 - 2016 drilling campaign installed one well on Pahute Mesa and three in Yucca Flat. Hydrologic and geologic samples and data gathered during drilling provide input into the models and give scientists a clearer understanding of how groundwater moves through the subsurface.

In addition, a well site may be selected to better characterize the spatial distribution of tritium in the aquifers, such as on Pahute Mesa.

Stakeholder input has also played a role in the well selection process. The Nevada Site Specific Advisory Board, a group of volunteers from communities near the NNSS, was instrumental in selecting the location of a well drilled on Pahute Mesa in 2009.



Computer Model of Pahute Mesa Geology

Q What are computer models and how do they help protect the public?

A Computer models are programs that simulate groundwater flow and contaminant transport. They give scientists detailed glimpses into areas that are otherwise inaccessible. Computer models are especially useful to NNSS scientists, as complex geology and vast size make its subsurface challenging to map. Information gathered from drilling, sampling, research, and analysis all become data points in the computer model. These models help scientists forecast where contaminants in groundwater may migrate and how fast they are traveling. These forecasts are continually refined as new data is gathered.

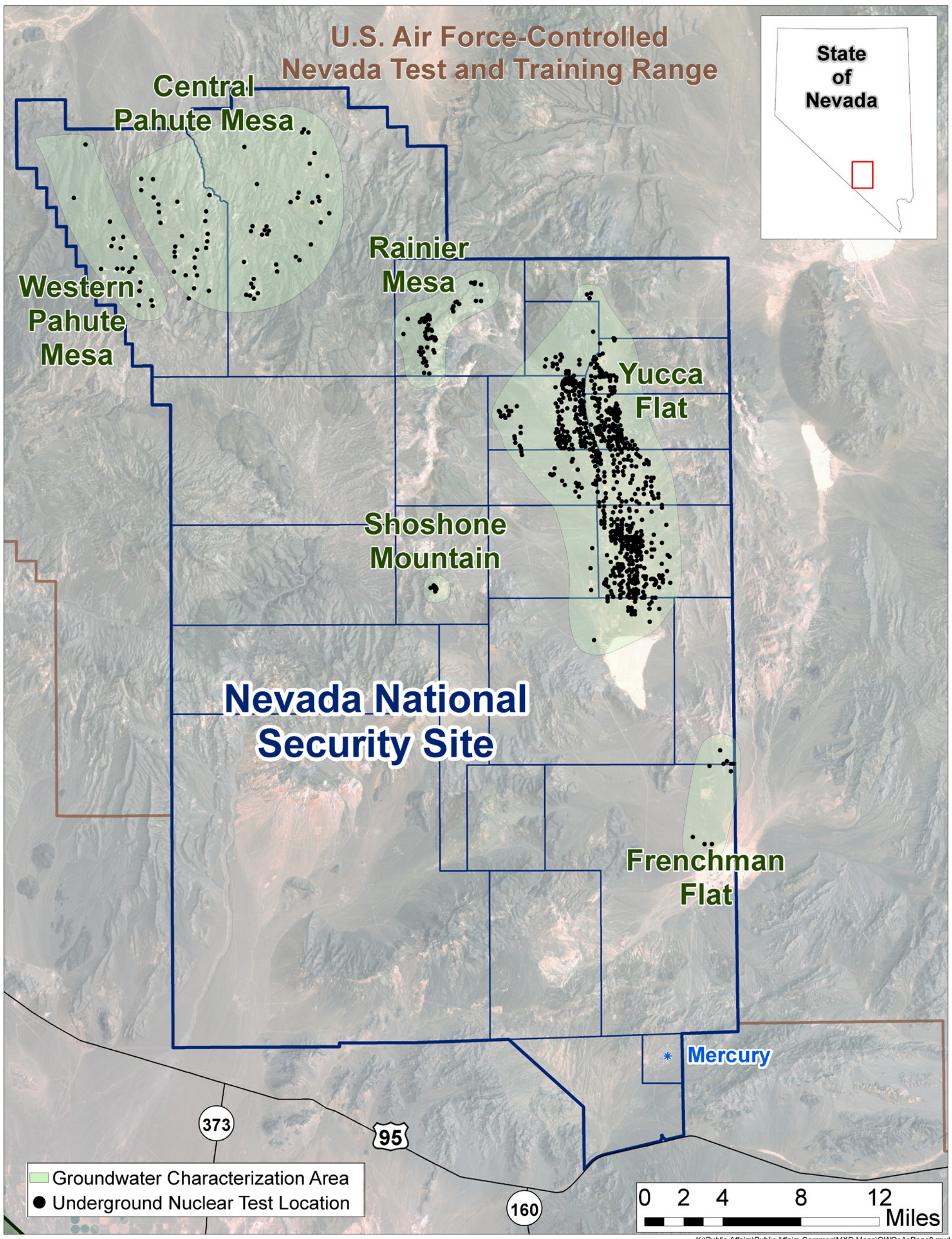
Q When do groundwater characterization studies transition to long-term monitoring?

A After an independent scientific panel successfully completes a review of NNSS groundwater investigations, the Department of Energy conducts a thorough evaluation of the computer models. If sampling data is consistent with model results and accepted by the State of Nevada Division of Environmental Protection, groundwater characterization activities transition to long-term monitoring. During long-term monitoring, sampling results will be periodically reviewed by the EM Nevada Program and State of Nevada Division of Environmental Protection. The results will be compared to model predictions to ensure the nature of groundwater flow and extent of contaminant transport is within the range of expectations.

Q How do scientists characterize groundwater in such a vast and complex environment?

A Scientists explore groundwater flow patterns on a regional scale before focusing on specific underground test areas to characterize the groundwater. This is accomplished to understand the impacts of underground nuclear tests conducted at depths ranging from approximately 90 to 4,800 feet below the surface of the 1,360 square mile NNSS. Teams comprised of federal, contractor and national laboratory scientists, and specialists in the fields of hydrology, geology, chemistry and drilling work collaboratively to understand the nature and extent of groundwater contamination. Because NNSS geology consists of more than 300 different geologic units representing more than 500 million years of geologic history, the test areas are grouped by location and similar geology. The characterization areas are:

- **Western and Central Pahute Mesa**
- **Yucca Flat/Climax Mine**
- **Rainier Mesa and Shoshone Mountain**
- **Frenchman Flat**

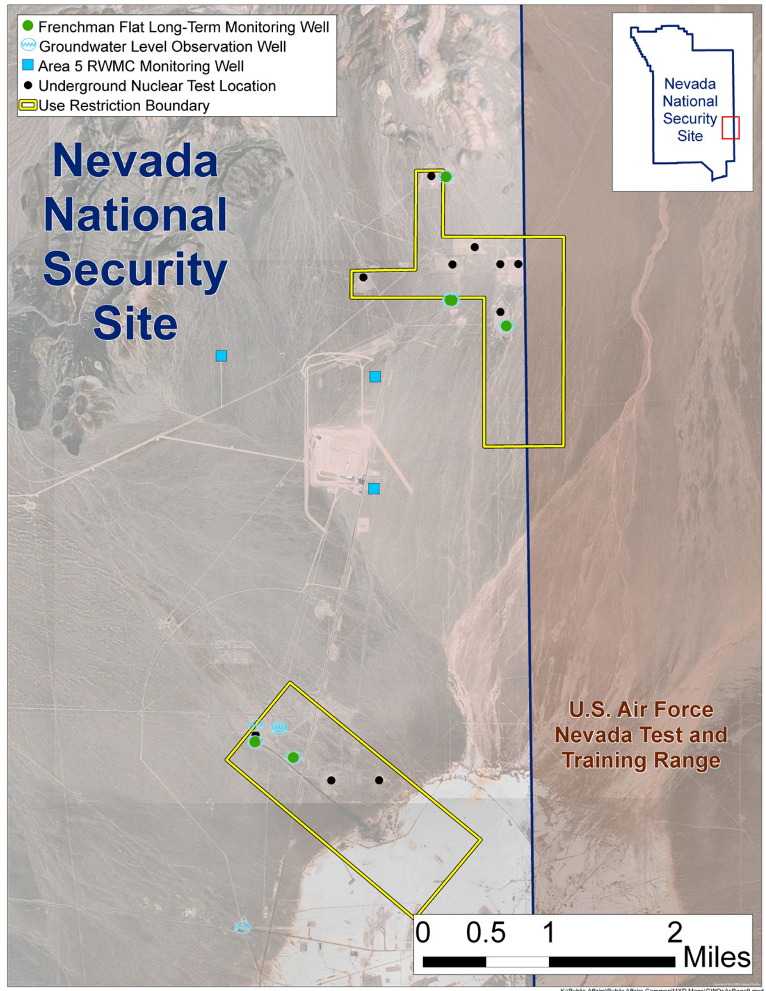


Each area is analyzed and evaluated through the collection of field data (samples) that are used to create three-dimensional computer models. Scientists use the models to estimate groundwater flow and transport parameters, and to forecast potential transport of radionuclides. Ongoing groundwater monitoring is used to evaluate model predictions and ensure compliance with regulatory requirements. These processes are the foundation of the regulatory phases outlined in the *Federal Facility Agreement and Consent Order*:

- **Investigation Stage**
- **Decision/Action Stage**
- **Closure Stage**

A Major Success at Frenchman Flat

The Nevada Division of Environmental Protection approved the Closure Report for the Frenchman Flat groundwater characterization area in 2016. The Closure Stage involves long-term monitoring, use restrictions, and institutional controls to protect the public and environment from potential exposure to contaminated groundwater. Three types of monitoring are performed for Frenchman Flat: water quality, water level, and institutional control. The Frenchman Flat monitoring report is published to the Office of Scientific and Technical Information website (view the 2017 report on OSTI.gov) and sampling results are also published in the NNSS Environmental Report on www.nnss.gov.



Did You Know?

10 underground nuclear tests were conducted at Frenchman Flat between 1965 and 1971.

The groundwater characterization strategy required the completion and approval of specific steps before transitioning to long-term monitoring of Frenchman Flat:

- Refining the regulatory process.
- A peer review process of external and internal committees to provide confidence that the strategy is protective of the public and the environment.
- State-of-the-art methodologies developed and applied by a highly technical team of experts from numerous scientific organizations.

Key Findings:

Contaminated groundwater is not expected to leave the Frenchman Flat basin.

Modeling indicates that radionuclides in groundwater will travel less than 1 mile in 1,000 years.

Transitioning Frenchman Flat provided an understanding of the necessary balance of modeling, monitoring, and restricted access that is protective of public health and the environment.

This experience will help guide the other groundwater investigation areas to advance toward closure.

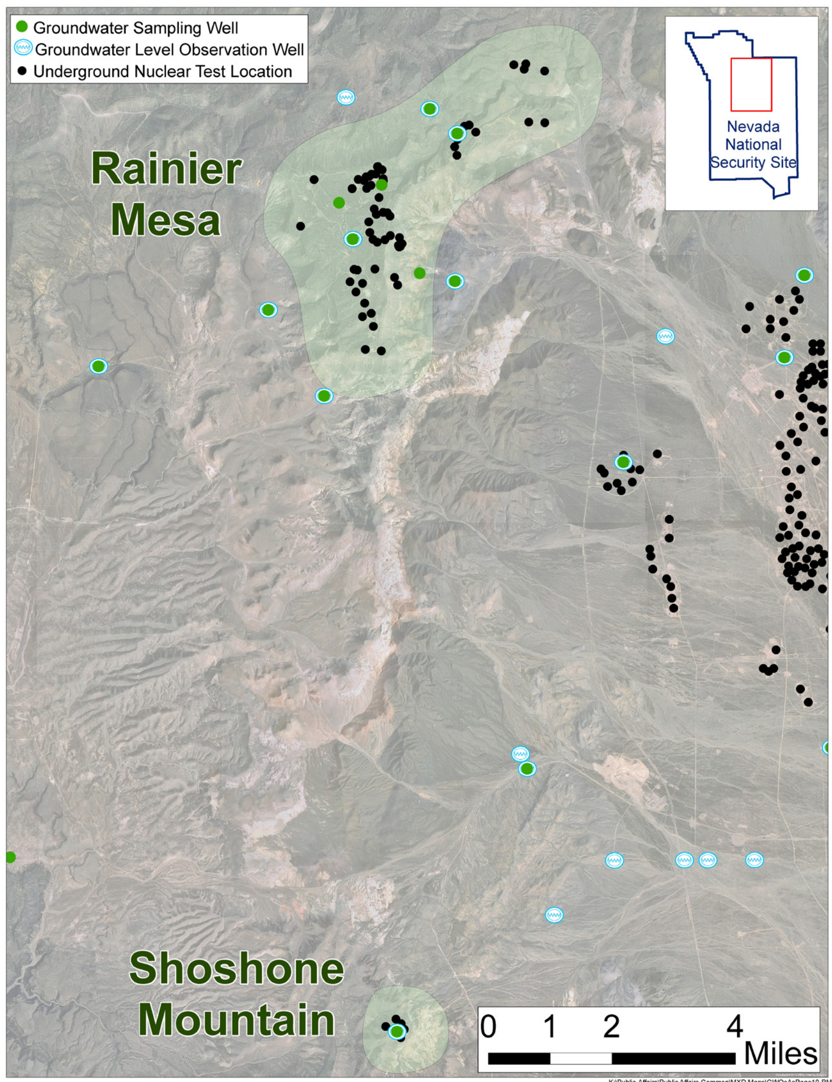
Independent Peer Review of the Rainier Mesa and Shoshone Mountain Alternative Modeling Strategy

The Rainier Mesa and Shoshone Mountain groundwater characterization areas are geographically isolated and complex. Though 67 underground nuclear tests were conducted in these areas, all were located above the regional groundwater system, either in shallow "perched" groundwater or unsaturated rock. The resulting release of radionuclides below the surface of Rainier Mesa and Shoshone Mountain is low (less than one percent of the total underground radionuclide inventory, by curies, the largest fraction of which is tritium) and separated from deeper regional aquifers.

Because of these unique attributes, an Alternative Modeling Strategy (AMS) is being pursued to aid in the evaluation of potential exposure pathways and support future monitoring strategies. Regulatory concurrence to pursue the AMS was obtained in 2013 and followed by a peer review of the supporting science by independent experts with backgrounds in geology, hydrogeology, and environmental cleanup and regulation. As a result of the 2018 peer review assessment, the EM Nevada Program is performing additional tasks that will be submitted to the State of Nevada for final approval.

Did You Know?

67 underground nuclear tests were conducted at Rainier Mesa and Shoshone Mountain between 1957 and 1992.



Key Findings for Rainier Mesa and Shoshone Mountain:

There has been minimal movement of contaminants away from the detonation locations.

State approval of the Alternative Modeling Strategy will usher in the transition to long-term monitoring.

The Alternative Modeling Strategy for Rainier Mesa and Shoshone Mountain provides an efficient transition to long-term monitoring while maintaining human health and environmental protections.

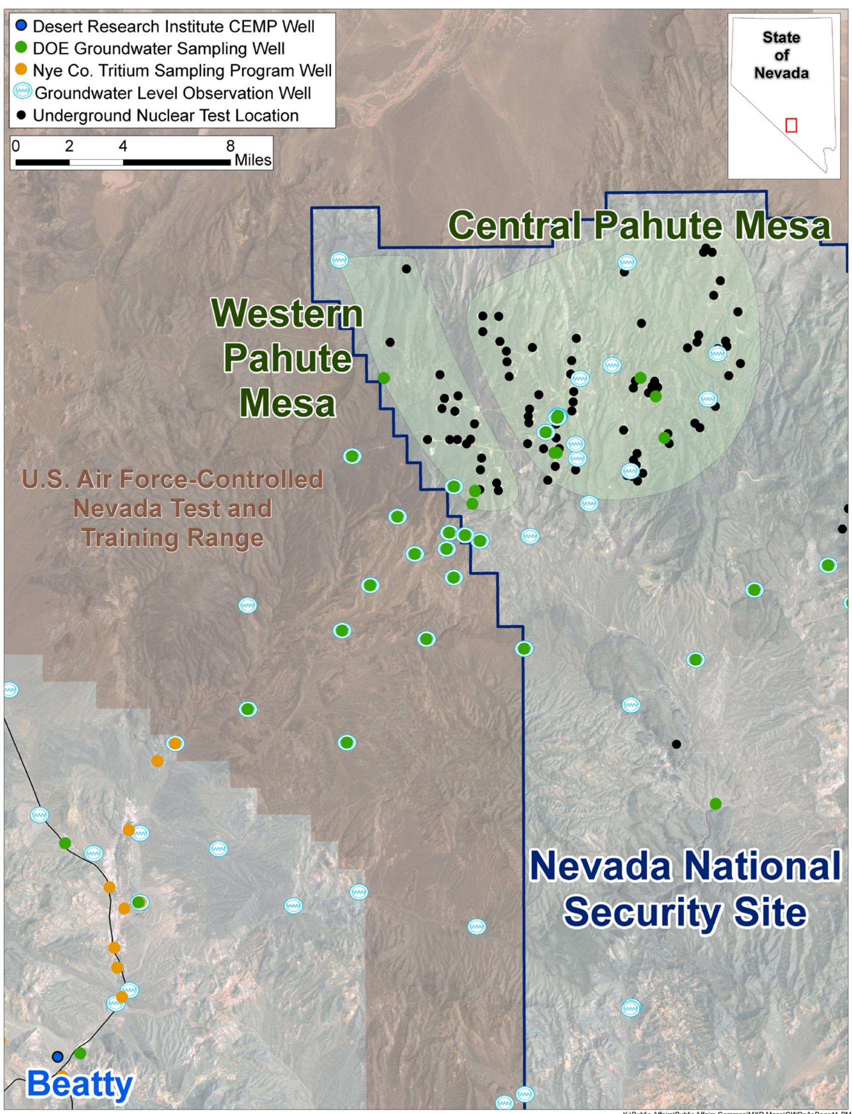
Western and Central Pahute Mesa Groundwater Characterization Area

Underground nuclear testing on Pahute Mesa was primarily associated with the Department of Energy weapons program. Each test was either a Weapons Related test, a joint United States-United Kingdom (US-UK) test, or was part of some special program that involved the use of nuclear devices (e.g., seismic study or potential peaceful use). Most tests on Pahute Mesa were detonated in deep shafts drilled into volcanic rock above or below the water table. Many larger yield tests were conducted on Pahute Mesa where about two-thirds of the total NNSS underground radionuclide inventory was deposited, including about 70% of the tritium inventory at or below the water table (more than 2,000 feet).

Because Pahute Mesa groundwater flows toward Oasis Valley and the town of Beatty, Nevada, more extensive characterization efforts are being conducted to ensure the public is not at risk for accessing contaminated groundwater.

Did You Know?

82 underground nuclear tests were conducted at Pahute Mesa between 1965 and 1992.



Key Findings:

Away from underground test cavities but still on federally-controlled land, tritium is the only test-related radionuclide that has been measured in groundwater at concentrations in excess of safe drinking water limits.

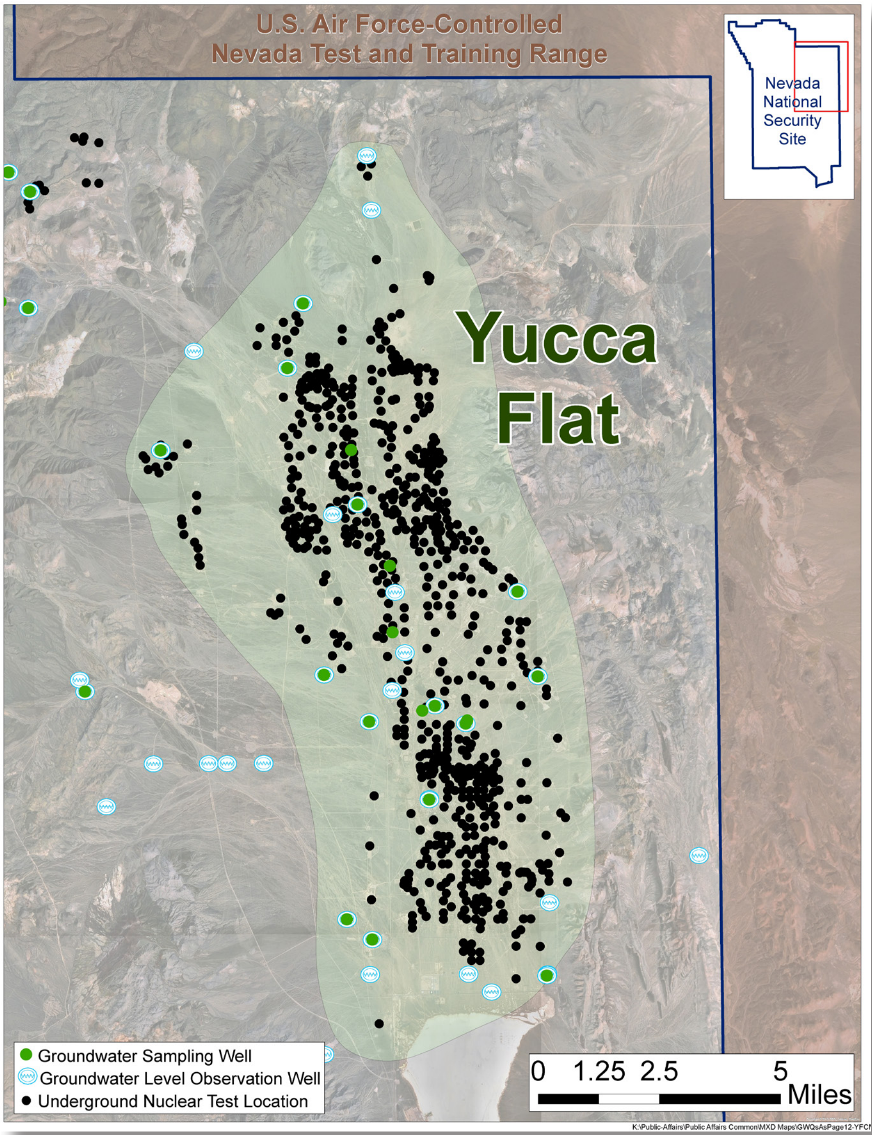
At the present rate of movement, tritium at concentrations in excess of safe drinking water limits IS NOT expected to travel beyond federally-controlled land surrounding the NNSS.

Western and Central Pahute Mesa are progressing through the Investigation Stage with internal peer reviews beginning in 2019.

Yucca Flat Groundwater Characterization Area

The overwhelming majority of tests conducted in the Yucca Flat area were above the water table. As such, about two-thirds of the radionuclide inventory deposited under Yucca Flat was also above the water table which is ~1,600 feet below the surface. However, the smaller yield tests (ranging from less than 1 kiloton to a maximum of 500 kt) performed in Yucca Flat left behind 75% of all plutonium released below the surface of the NNSS.

In April 2014, an independent, external peer review team representing the fields of geochemistry, radiochemistry, hydrology, hydrogeology and computer modeling evaluated the Yucca Flat Flow and Transport Model—a set of representations, including complex subsurface geologic models and mathematical models of groundwater flow and contaminant transport. Years of intensive drilling and data collection went into the making of the model. The models are used to analyze the movement of radioactive contaminants in groundwater and to guide regulatory decisions for ensuring that the public is protected from accessing contaminated groundwater.



Did You Know?

659 underground nuclear tests were conducted in the Yucca Flat area between 1957 and 1992.

Yucca Flat is undergoing model evaluation as part of the Decision/ Action Stage and will transition into long-term monitoring once State of Nevada approval is granted.

Key Findings:

Following the independent, external peer review and EM Nevada's response, in 2016, the State of Nevada approved the transition to the Decision/Action Stage.

Contaminated groundwater in the Yucca Flat area is not observed to be moving in the Lower Carbonate Aquifer that flows south and west toward Death Valley

NNSS Groundwater Sampling and Reporting: Key Organizations and Resources

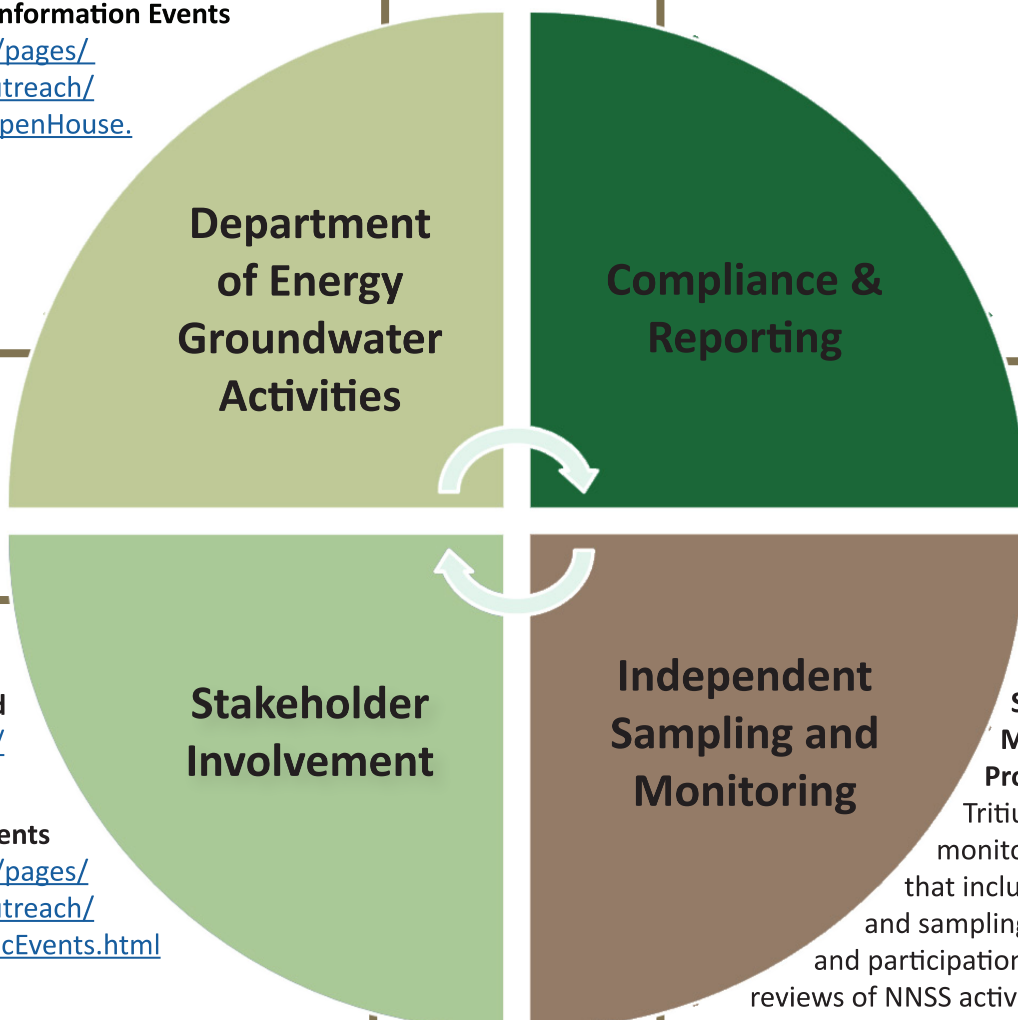
EM Nevada Program Groundwater Characterization Strategy
www.nnss.gov/pages/programs/em/GroundwaterCharacterization.html

Integrated Groundwater Sampling Plan
www.osti.gov/servlets/purl/1431347

Groundwater Information Events
www.nnss.gov/pages/PublicAffairsOutreach/GroundwaterOpenHouse.html

Federal Facility Agreement and Consent Order (FFACO)
www.nnss.gov/docs/doc_environmental/FFACO_Document.pdf

NNSS Environmental Report
www.nnss.gov/pages/resources/library/NNSSER.html



Nevada Site Specific Advisory Board
www.nnss.gov/NSSAB

Community Events
www.nnss.gov/pages/PublicAffairsOutreach/UpcomingPublicEvents.html

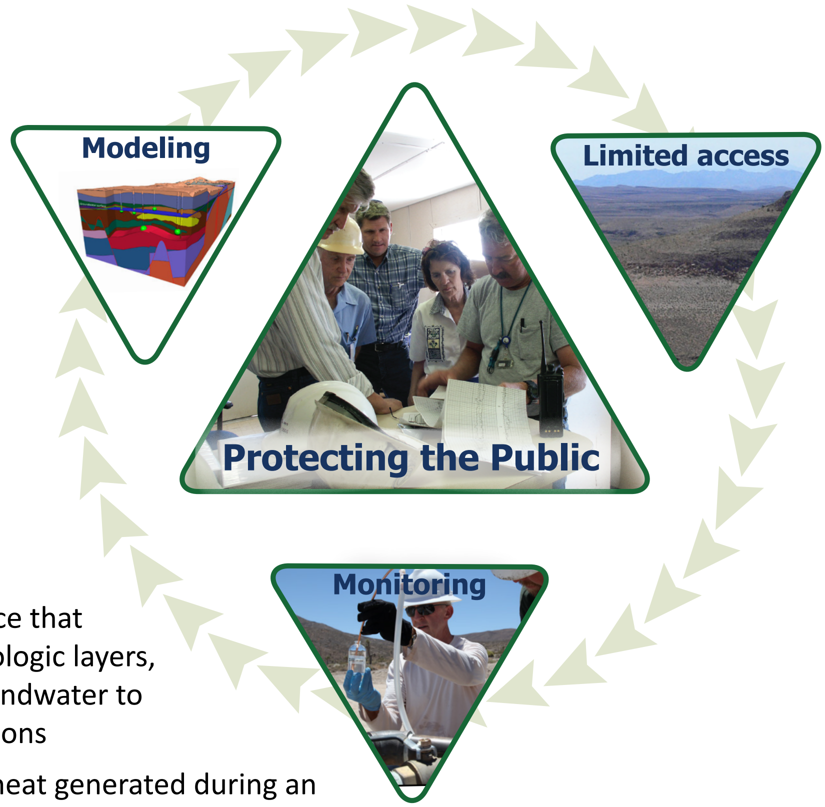
Fact Sheets
www.nnss.gov/pages/resources/library/FactSheets.html

News
www.nnss.gov/pages/News/news.html

Nye County Tritium Sampling and Monitoring Program
Tritium groundwater monitoring program that includes selection and sampling of wells and participation in technical reviews of NNSS activities.

Community Environmental Monitoring Program (CEMP)
Community-based network of monitoring stations managed by the Desert Research Institute and staffed by communities.
https://cemp.dri.edu/

Definitions



Computer model - three-dimensional representation of the subsurface (based on sampling data) used by experts to make projections about where and how quickly contaminants are moving with the groundwater

Contaminant - any substance found at a particular location where it is not naturally occurring

Curie/picocurie - general unit of measurement for levels of radioactivity, most often used to measure radioactivity in water; one trillion picocuries (pCi) equals a curie (Ci)

Groundwater - water beneath the earth's surface that moves through pore spaces and fractures in geologic layers, such as volcanic rock and soil, which cause groundwater to move at different speeds and in different directions

Melt glass - Rock and soil fused by the intense heat generated during an underground nuclear detonation

Radionuclide - radioactive atom that can be produced through nuclear experiments, medical testing, or natural means

Tritium - a radioactive form of hydrogen with a half-life of 12.3 years that is mobile in groundwater and, as a result of underground nuclear testing, the most common radionuclide found in groundwater at the NNSS

Water table - very top portion of the groundwater layer where rock and soil are completely saturated with water

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For additional information or questions relating to groundwater at the Nevada National Security Site, contact:

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