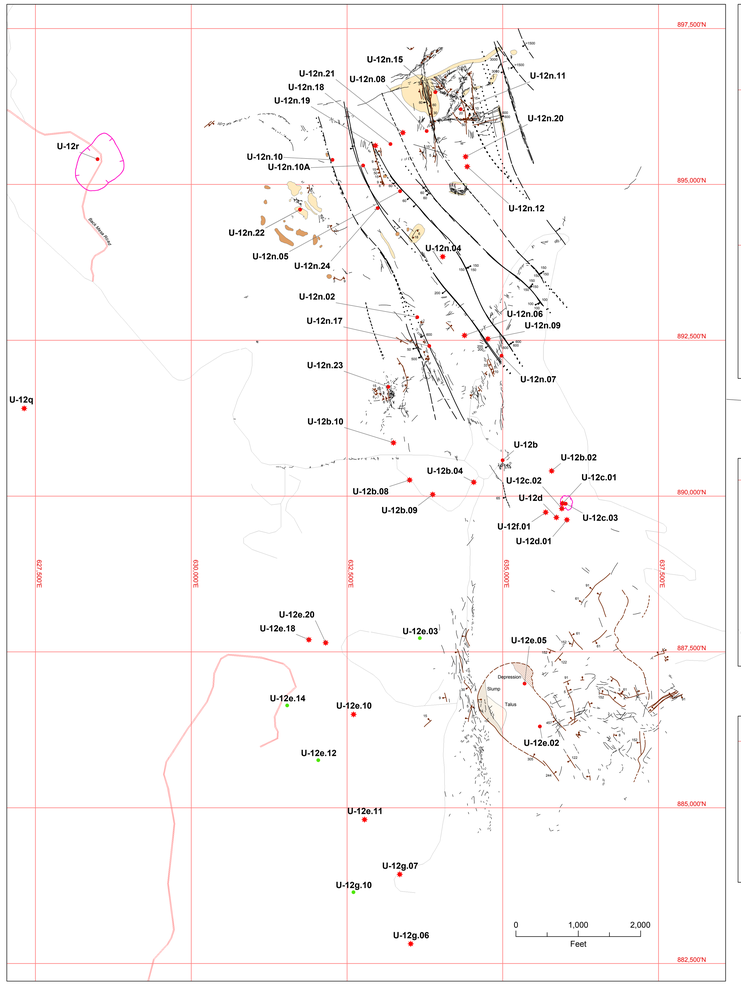
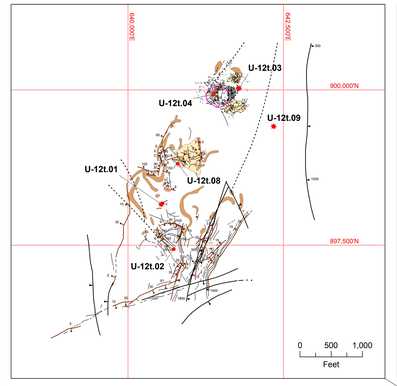
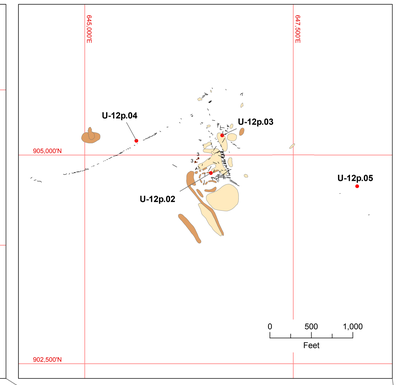
## Rainier/Aqueduct Mesa (SW)



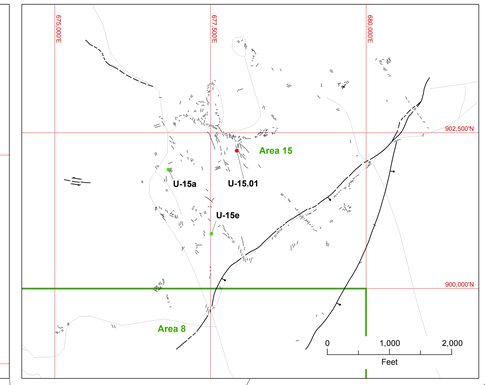

## Rainier/Aqueduct Mesa (Central)



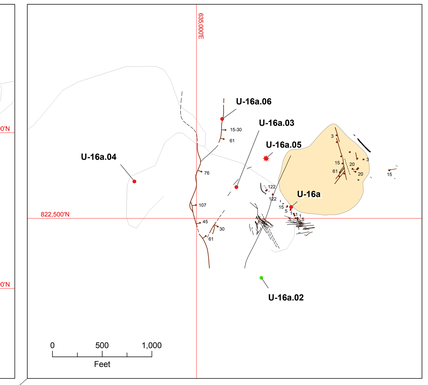

## Rainier/Aqueduct Mesa (NE)



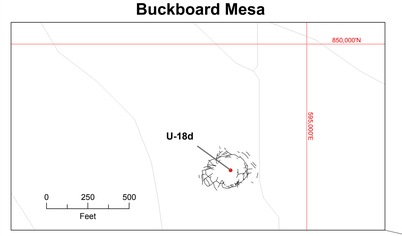

## Climax Stock



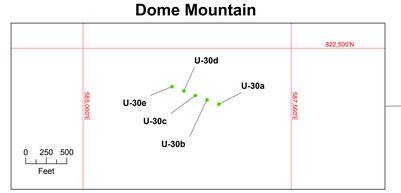

## Shoshone Mountain

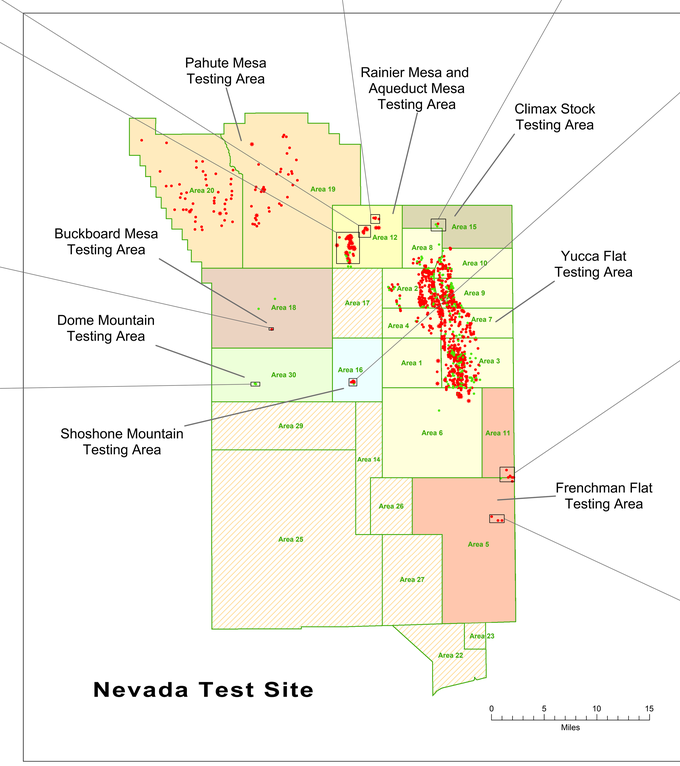



## Buckboard Mesa

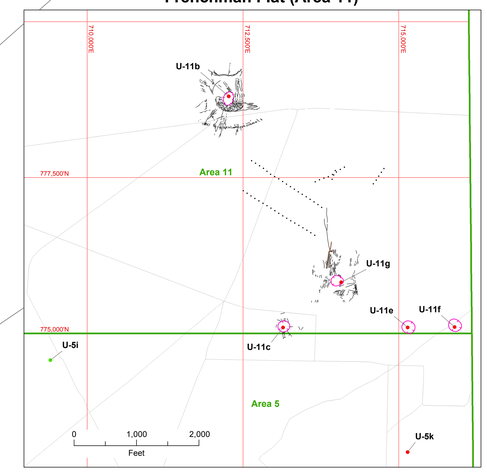



## Dome Mountain

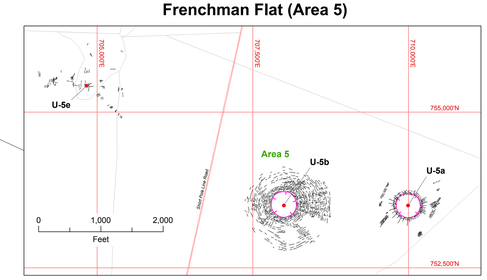



## Frenchman Flat (Area 11)




## Frenchman Flat (Area 5)




### About the Map

This multi-panel map illustrates the surface effects caused by underground nuclear testing in the Rainier/Aqueduct Mesa, Frenchman Flat, Shoshone Mountain, Climax Stock, Buckboard Mesa, and Dome Mountain areas of the Nevada Test Site. The locations of these testing areas are shown on the central inset map of the Nevada Test Site (NTS). Extent rectangles and leader lines show the sizes, extents, and locations of the surrounding large-scale surface effects maps. The locations of detonation sites used for underground testing within the various Operational Areas and Testing Areas of the NTS are also shown on the central inset map. A comprehensive explanation of map symbols (at right) describes the symbols, line styles, line colors, and area fill patterns used to distinguish between the different detonation sites and mapped surface effects presented on these maps.

This report is the third in a three-part series of U.S. Geological Survey (USGS) Open-File Reports. Together, these reports illustrate the surface effects caused by underground testing throughout the NTS. USGS Open-File Report (OFR) 00-176 (Grasso, 2000, Plate 1) shows the surface effects mapped for detonations conducted at Yucca Flat, the most extensively used testing area of the NTS. USGS OFR 01-272 (Grasso, 2001, Plate 1) shows the surface effects mapped for detonations conducted within the Pahute Mesa testing area. This report shows the surface effects mapped for detonations conducted within the remaining testing areas of the NTS as listed. Each of these published map reports was produced using the digital map databases contained in the GIS Surface Effects Map Archive of the NTS (Grasso, 2003, *in review*).

The maps presented here provide a comprehensive view of the surface effects produced by, and mapped for, all of the detonations conducted within these testing areas. Mapped surface effects include cracks, cracks within sinks, faults, collapse sinks, movements on pre-existing faults, and ground disturbances. Pre-existing faults are shown in black as fault (*known*), fault (*known, uncertain*), and fault (*known, concealed*), where these feature types were mapped and included on the original surface effects maps. Similarly, areas of ground disturbances are shown as color- and pattern-filled regions to distinguish the locations of mapped rock spall and disturbed ground surface effects, as shown on the original surface effects maps. Observed and measured displacements on faults are shown, as originally mapped, using ball-and-bar symbols. Fault displacements are labeled, *in centimeters*, where originally measured and mapped.

All maps are displayed in their original map coordinate system; that is Nevada State Plane (central), North American Datum 1927, in feet. A 2,500-foot coordinate grid with northing and easting labels (*in red*) is included on each of the large-scale surface effects maps. These maps range in scale from 1:3,000 to 1:8,000. The central inset map of the NTS is shown at a scale of 1:250,000. Specific map scales are as follows: (1) Rainier/Aqueduct Mesa (SW and Central), 1:8,000; (2) Rainier/Aqueduct Mesa (NE), 1:6,000; (3) Climax Stock, 1:8,000; (4) Shoshone Mountain, 1:5,000; (5) Buckboard Mesa, 1:3,000; (6) Dome Mountain, 1:6,000; and (7) Frenchman Flat (Area 5 and Area 11), 1:8,000.

### A Brief History of Surface Effects Mapping

In 1951, the *Nevada Proving Ground*, now known as the Nevada Test Site, was established as a continental location for testing nuclear devices (Allen and others, 1997). The USGS became involved with the nuclear testing program in 1957 as part of an aggressive effort to map the geology of the NTS (Garcia, 1997). The USGS, with support from the U.S. Atomic Energy Commission, the U.S. Energy Research and Development Administration, and the U.S. Department of Energy (DOE), began a research program to evaluate the geophysics, hydrology, and geology of the NTS. One component of this work involved mapping the surface effects caused by underground nuclear testing. By 1992, the year that the Comprehensive Nuclear Test Ban Treaty was signed, thus, prohibiting all underground nuclear testing, more than two-thirds of all underground nuclear detonations conducted at the NTS were mapped for surface effects. These maps afford a snapshot in time of the effects caused by underground testing at the NTS.

### Methods

Detonations conducted in the Rainier/Aqueduct Mesa, Frenchman Flat, Shoshone Mountain, Climax Stock, Buckboard Mesa, and Dome Mountain testing areas produced the surface effects shown on the large-scale maps presented here. Scientists of the USGS, Lawrence Radiation Laboratory, and various other agencies including Fenix & Scisson and Raytheon Services Nevada (now Bechtel Nevada) used on-site field mapping, stereoscopic aerial photographic, and photogrammetric methods (Garcia, 1997) to painstakingly map these effects shortly following each detonation. All observed and identified surface effects were mapped directly onto topographic maps or aerial photographs at scales ranging from 1:1,200 to 1:2,400. Pre- and post-detonation aerial photographs were taken to record the explosion-induced surface effects. Post-detonation field mapping on a pre-detonation photograph revealed any new surface effects caused by the test and showed the presence of any reactivated surface effects (that is, movements on pre-existing features). A second map was produced using a post-detonation aerial photograph and, in some cases, a photogrammetric plotter. The two maps were subsequently compared and any differences were checked in the field. A final map was ultimately produced.

The timing of these activities was especially critical. Any post-detonation weather occurrence or construction activity would have easily destroyed any resultant surface effects, and thus, the effects of these detonations would have been lost.

### Acknowledgements

While some of the original surface effects maps were published as USGS Open-File Reports and Professional Papers, many were only stored as unpublished maps, reports, memos, and field notes at various storage facilities of the NTS, USGS, and Bechtel Nevada. For this reason, considerable time and effort was required to locate and validate all available map data. The author wishes to thank Margaret Townsend for conducting the vital detective work to locate the original surface effects maps and to verify their authenticity. From these maps, the digital maps shown here were prepared. The author also wishes to acknowledge Margaret's efforts in reviewing and verifying the accuracy of these maps as each was prepared for transfer to the GIS Surface Effects Map Archive. This meticulous work required considerable attention to detail.

This report was prepared in cooperation with the U.S. Department of Energy, National Nuclear Security Administration, Nevada Operations Office, under Interagency Agreement DE-AI08-01NV13944. Special thanks are due to Bonnie Thompson, USGS, and Steve Leedom, DOE, for their undying support for this project.

### About the GIS Surface Effects Map Archive

The digital surface effects map data used to construct the maps shown in this report are part of a comprehensive Geographic Information System (GIS) map archive. This archive preserves, in readily accessible format, all of the original surface effects maps produced for underground detonations conducted at the NTS. For each test, every attempt was made to locate the final version of the surface effects map (preferably the master drawing for clarity) and to verify its authenticity. One by one, these original surface effects maps were digitally reproduced and transferred to the archive for permanent storage.

Digital reproduction of these maps involved a sequence of steps including high-resolution scanning, georeferencing, large-scale digitizing, and data-entry into detailed attribute tables and databases. Upon completion, each new digital map was subjected to a series of reviews and accuracy verifications before final transfer to the archive.

The GIS Surface Effects Map Archive not only stores and preserves the original surface effects maps of the NTS, but also provides direct access to these map data. Users can query, retrieve, and display individual or composite surface effects maps (*as presented here*) or perform advanced analysis and management tasks. In its entirety the archive contains surface effects map data for 688 investigated detonations conducted at the NTS. The central inset map displays the locations of these detonations and indicates whether they where mapped for surface effects.

### References

Allen, B.M., Drellack, S.L., Jr., Townsend, M.J., 1997, Surface Effects of Underground Nuclear Explosions: U.S. Department of Energy Report DOE/NV/11718-122, 147 p.

Garcia, M.N., 1997, Field and Photogrammetric Methods for Mapping Nuclear Induced Surface Effects at the Nevada Test Site, Nye County, Nevada: U.S. Geological Survey Open-File Report 97-695, 18 p.

Grasso, D.N., 2000, Geologic Surface Effects of Underground Nuclear Testing, Yucca Flat, Nevada Test Site, Nevada: USGS Open-File Report 00-176, 20 p., 7 figs., 1 table, 1 map plate.

Grasso, D.N., 2001, GIS Surface Effects Archive of Underground Nuclear Detonations Conducted at Yucca Flat and Pahute Mesa, Nevada Test Site, Nevada: USGS Open-File Report 01-272, 34 p., 8 figs., 5 table, 1 map plate, 1 CD-ROM.

Grasso, D.N., 2003, GIS Surface Effects Map Archive, Nevada Test Site, Nevada: USGS Open-File Report 03-xxx, CD-ROM, *in review*.

U.S. Department of Energy, 1994, United States Nuclear Tests, July 1945 through September 1992, DOE/NV-209, Revision 14 Available from U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia.

### Explanation of Map Symbols

**Detonation Sites**

| | | |
|---|---|---|
| U-24g | Mapped--surface effects | Detonation mapped for surface effects (Surface effects observed and mapped) |
| U-30n | Mapped--no surface effects | Detonation mapped for surface effects (No surface effects observed or mapped) |
| U-9e | Not mapped | Detonation not mapped for surface effects (No surface effects map produced or available) |

**Surface Effects**

| | |
|---|---|
| Crack | Surface crack or fracture caused by detonation |
| Crack within sink | Surface crack caused by detonation; occurs within collapse sink of subsequent detonation |
| Fault | Fault caused by detonation; Bar-and-ball symbol on downthrown side; Label in centimeters where measured |
| Sink | Collapse sink caused by detonation; hachures on downthrown side |
| Fault (known) | Mapped in Rainier/Aqueduct Mesa Testing Area; Bar-and-ball symbol on downthrown side; Label in centimeters where measured |
| Fault (known, uncertain) | Mapped in Rainier/Aqueduct Mesa Testing Area |
| Fault (known, concealed) | Mapped in Rainier/Aqueduct Mesa Testing Area |

**Surface Effects Areas**

| | |
|---|---|
| Rock Spall | Area of rock spall mapped in Rainier/Aqueduct Mesa Testing Area |
| Disturbed Ground | Area of disturbed ground mapped in Rainier/Aqueduct Mesa and Shoshone Mountain Testing Areas |

**Base Maps**

- Nevada Test Site Operational Area Boundaries
- Nevada State Plane Map Coordinate Grid (2,500 ft)
- Roads (primary and secondary)
- Roads and Trails (unpaved)

# Geologic Surface Effects of Underground Nuclear Testing

## Buckboard Mesa, Climax Stock, Dome Mountain, Frenchman Flat, Rainier/Aqueduct Mesa, and Shoshone Mountain, Nevada Test Site, Nevada

By Dennis N. Grasso, 2003

For sale by U.S. Geological Survey, Map Distribution, Box 25286, Federal Center, Denver, CO 80225 1-888-ASK-USGS
A Portable Document Format (PDF) file for this map is available at http://pubs.usgs.gov/of/2003/ofr-03-125/

This map is preliminary and has not been reviewed for conformity with the U.S. Geological Survey editorial standards or with the North American Stratigraphic Code.
Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.
This map was produced on request, directly from digital files, on an electronic plotter.